Health impacts of smog pollution: the human dimensions of exposure

China experienced unprecedented heavy smog pollution in the winter of 2016–17. Northern Chinese areas surrounding Beijing suffered most seriously. At the beginning of 2017, the Ministry of Science and Technology of China started to implement a special focus research programme on the causes and control technology of air pollution with financial input of ¥2·47 billion, and the Beijing Municipal Government released its 13th 5-year plan (2016–20) for environmental protection and ecosystem construction. Both events emphasised a series of plans, goals, and measures and aimed to understand why, how, and from where the smog arises. These questions are complicated to answer because the smog pollution has been attributed to various sources and mixed chemical reactions between the source pollutants.[1,2] At the same time, concerns over the health effects of heavy smog pollution are rising, increasing the need to better understand the interlinkages.

Existing knowledge on the health impacts of smog pollution is mostly based on statistical records of patients and mortalities, which are descriptive but lack deeper insights in the context of China. So far, no systematic understanding exists of the causal chain from smog conditions to human exposure and health outcomes (eg, diseases). Because there might be no immediate solution to stop smog pollution, it is especially important to reduce its impacts on humans as soon as possible.[3] But recent strategies of addressing smog are overwhelmingly focusing on the physical conditions of smog exposure and not on the human side.

One of the most pressing and urgent problems is that polluted air can severely endanger human health and life.[4] Individual residents who are affected by smog pollution can often do very little to prevent it, but they can apply adaptive and protective measures to reduce their risk. At the individual level, although people cannot prevent the smog, they can diminish their exposure to it. For example, people often prefer to drive instead of taking public transport to be less exposed to open air, which however goes against the government strategy of encouraging less driving to mitigate emissions that contribute to smog pollution. The real situation is much more complicated, as many people change their normal lifestyles and habits in response to poor air quality, whereas others continue outdoor activities and wear a mask. Thus our understanding on actual behaviour patterns of urban individuals is insufficient, and typical Chinese daily lifestyles differ from western ones.[5,6]

Only a few studies have discussed the interlinkages of travel behaviour and exposure to smog pollution.[7] But they did not focus on the related health risks. Many key questions remain to be answered: how long and to what degree are different urban residents exposed to smog concentrations? How could the individual exposure be measured considering local people's typical daily life habits? How does the accumulated exposure affect the human respiratory system? How promising are people's spontaneous measures (eg, wearing a mask or using indoor air purifiers)? What are the best strategies to avoid and prevent smog impacts? To address knowledge deficits on these aspects, new scientific approaches are needed.

Reduction of the health effects of smog will require a deeper understanding of the unprecedented complexity of exposure to smog pollution associated with individual actions.[8] Very little is known about these effects, in particular in the Chinese urban environment, since they are strongly related to people's culture and habits that lead to specific daily activities and behaviours. In addition, the human body has some capacity to adapt to smog impacts, but there are thresholds. Cumulative exposures that exceed such thresholds will threaten health. It is a challenge to quantify the accumulation of exposures, which highly depends on individual daily routes and behavioural routines. It is also a challenge to identify the relevance of exposure to sickness, as well as the biochemical reactions of pollutants in the body.

Many sectors of the Chinese society are acting to address the problem of smog pollution. Government departments have crafted several policies to reduce such issues as overconsumption of coal and energy and limit the number of cars on the road. Scientists are also actively proposing research projects for the coming years to investigate the sources and processes of smog development, to study the health effects of air pollution, and to improve technologies of monitoring,

forecasting, warning, controlling, and managing.[9] In many projects, indicators of fine particulate matter (<2·5 μm) concentration, meteorological conditions, number of patients, and mortalities are to be monitored and studied.

Apart from these actions, innovative and individual-based approaches are needed to assess accumulations of human exposure, study different behavioural patterns and responses of people, and understand the pollutants' impacts for specific physiological conditions of the human body. Priority actions include supporting individual-based monitoring and modelling of human exposure in urban context, assessing and improving the particulate-isolating efficiency of buildings and public facilities, and studying the effect of transportation infrastructures and travel patterns. Along with the development of positioning technology and big data resources generated in social media, combined with agent-based modelling and social network analysis, individual activities and their tracks could be recorded and analysed accurately. Combining these approaches with hospital patient reports and laboratory experiments will greatly help studying individual and collective exposure and health effects.

Additional support is also needed to commit to reduce people's exposures immediately. Some options could be encouraging the change of household coal or gas cook stoves to electrical ones (to reduce indoor exposures), adopting a flexible (home-based and office-based) work system when possible, and also raising public awareness about exposure reduction. We believe that efforts in understanding and reducing exposure to smog offer a no-regret solution that reduces both individual health risks and particulate emissions.

With these measures, we hope to improve understanding on the individual level health impacts of smog and reduce the actual health impacts, even if smog pollution itself is not mitigated in the near future. Smog pollution also happens in many other countries, including India and Brazil. Evaluation of public health intervention mechanisms and development of optimisation strategies could be used to reduce risks to specific groups globally.

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1 Huang R, Zhang Y, Bozzetti C, et al. High secondary aerosol contribution to particulate pollution during haze events in China. *Nature* 2015; **514:** 218–22.
2 Zheng M, Yan C, Li X. PM2·5 source apportionment in China. In: Hester R, Harrison R, Querol X (eds). Airborne particulate matter: sources, atmospheric processes and health. Cambridge: Royal Society of Chemistry, 2016: 293–314.
3 Xu B, Yang J, Zhang Y, Gong P. Healthy cities in China: a *Lancet* Commission. *Lancet* 2016; **388:** 1863–64.
4 Chan M, Solheim E, Taalas P. Working as one UN to address the root environmental causes of ill health. *Bull World Health Organ* 2017; **95:** 2.
5 Feng J, Dijst M, Prillwitz J, Wissink B. Travel time and distance in international perspective: a comparison between Nanjing (China) and the Randstad (The Netherlands). *Urban Studies* 2013; **50:** 2993–3010.
6 Zhao Y, Chai Y, Kwan M. Comparison of urban residents' travel behavior in China and the U.S.: a case study between Beijing and Chicago (in Chinese). *Geogr Res* 2014; **33:** 2275–85.
7 Guo W, Zhang Y, Chai Y. Measurement of residents' daily travel air pollution exposure and its mechanism: A case study of suburban communities in Beijing (in Chinese). *Geogr Res* 2015; **34:** 1310–18.
8 Kulmala K. Atmospheric chemistry: China's choking cocktail. *Nature* 2015; **526:** 497–99.
9 Tang T. Science and technology for smog control: where to spend the 2·47 billion CNY investment? (in Chinese). *Science and Technology Daily*, Jan 23, 2017.