Environmental Science & Technology

POLICY ANALYSIS

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Understanding and Harnessing the Health Effects of Rapid Urbanization in China

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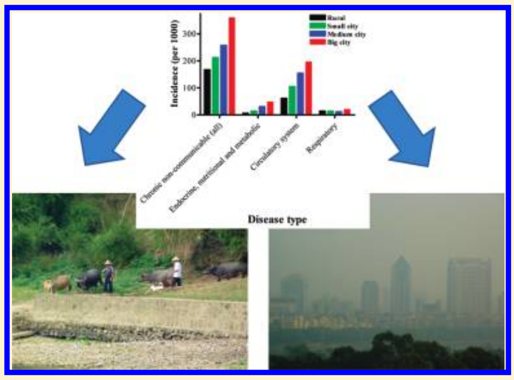
ABSTRACT: China is undergoing a rapid transition from a rural to an urban society. This societal change is a consequence of a national drive toward economic prosperity. Rapid urbanization impacts on infrastructure, environmental health and human wellbeing. Unlike many cases of urban expansion, Chinese urbanization has led to containment, rather than to increase, in the spread of infectious diseases. Conversely, the incidence of chronic conditions such as cardiovascular and metabolic diseases has risen, with higher rates occurring in urban regions. This rural—urban gradient in disease incidence seems not to be a reflection simply of more aggressive diagnosis or healthcare access. Other diseases exhibit little rural versus urban differences (e.g., liver cancer or respiratory disease), or even occur at a higher rate in the rural population (e.g., esophageal cancer). This article examines the impact of this changing demographic on environmental health and human wellbeing in China. Lessons learned from epidemiological studies mostly carried out in Europe and the U.S. may not be directly transferable to China. We advocate that there is now a need to establish robust systems of accurate data collection, a Chinese biobank network to facilitate the profiling of human health effects, and relevant randomized controlled trials to identify effective interventions in the Chinese urbanized setting. Such studies could allow for the future implementation of disease-preventive strategies.



INTRODUCTORY REMARKS

China is fast becoming an example of the inevitable trend toward increasing urbanization. To maximize the beneficial aspects of urbanization on human development,[1] there needs to be careful study and acquisition of information regarding this process by investigators from diverse sciences;[2] such data can then be used by policy makers. Urbanization is a complex phenomenon, associated with a large array of changes in environmental and lifestyle factors that have been implicated as causes of major noncommunicable diseases such as coronary heart disease, diabetes and cancer. However, attributing diseases to specific environmental influences has proved elusive.[3] Many studies have described apparent urban versus rural differences in disease incidence and some epidemiological studies of chronic diseases show demographic differences in incidence; in particular, migrants to high-risk regions acquire a similar disease incidence profile to host populations, probably as a consequence of altered environmental influences and lifestyle factors.[4] However, it is unclear whether urban versus rural differences reflect: (1) causal associations with individual-level environmental and lifestyle exposures; (2) differences in community-level macro-environment exposures such as access to healthcare provision,[5] education, housing, transportation, and communication; (3) confounding, diagnosis bias and measurement (primarily reporting) errors; or (4) (possibly) a combination of all of those. With more than half of the world's population now urbanized, implementing appropriate policies to protect the environmental health of this expanding demographic, both at the individual and the community level, is important. The challenge is establishing actual risk factors and effective interventions rather than selectively reporting associations gleaned from comparisons of extreme groups[6] and false positives.[7]

FEATURES OF URBANIZATION IN CHINA

The proportion of the urbanized population in China has increased from 18% in 1978 to 47% in 2009 (Figure 1). It is expected that some 350 million people will be added to the country's urban population by 2025, and 1 billion people will live in Chinese cities by 2030.[8,9] This rapid rate is a consequence of the government's 30-year policy of pursuing urbanization; currently, China has 28 city clusters of varying degrees of size and

Received: February 5, 2011
Accepted: April 25, 2011
Revised: April 11, 2011
Published: May 04, 2011

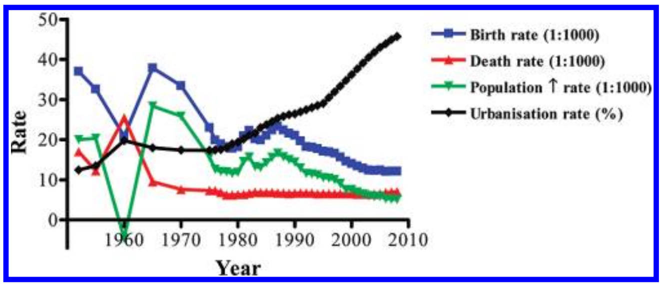


Figure 1. Changing demographic in China over the last 40 years.

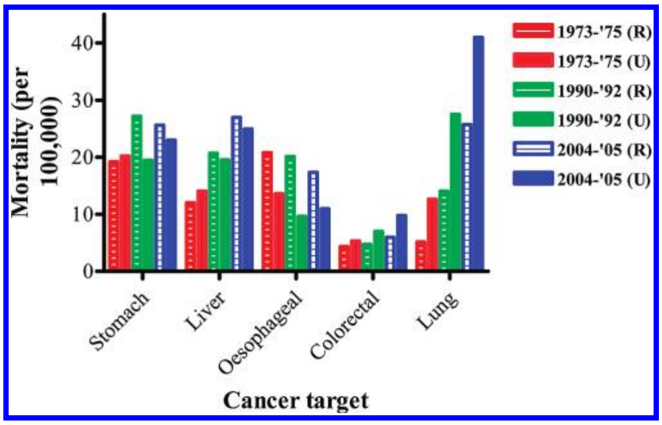


Figure 2. Rural (R) versus urban (U) differences in mortality rate (per 100 000) in five of the top ten most common cancers in China over the last 40 years. Data obtained from China Health Statistics Yearbook 2009 (http://www.moh.gov.cn/publicfiles/business/htmlfiles/zwgkzt/ptjnj/200908/42635.htm).

development, most still rapidly developing. This is occurring against a backdrop of a declining birth rate (Figure 1). Rapid Chinese urbanization is characterized by a mixture of the occasional carefully planned eco-cities (e.g., Hangzhuo and Kunming), alongside a mass of rapid expansion developments with more poorly developed infrastructure.[10] The most important driver of urbanization is the natural population growth in these expanding cities.[1] Moreover, uncontrolled expansion of Chinese cities appears to rapidly eat into surrounding rural areas; this is in contrast to the U.K. green belt policy for controlling urban growth. Such expansion has left very little distance between individual cities; often less than 10 km in the Pearl River delta.[11] Over the last 60 years, Beijing's urban area coverage has increased 17-fold. Finally, current demographic statistics only regard urban dwellers as those born and registered within the particular municipality, excluding migrant workers.[12,13] Over the next 20 years, 20 million migrant workers are expected to settle in cities every year.[9]

These cities will continue to grow to support the rapid economic expansion of the country.[14] As a result, it is envisaged that there will be dramatic short-term changes in environmental conditions associated with developing urbanicity (i.e., the degree to which a geographical unit is urban) [15] in China.

CHINESE URBANIZATION AND HEALTH: COMPLEX RELATIONSHIPS?

Comparing the China experience with that previously observed in Europe or the Americas will be interesting in terms of whether there are parallels or differences. For instance, obesity appears to increase with increasing socio-economic class in 21st-century Chinese,[18] whereas there is an inverse correlation among Europeans.[17] The impact of socio-economic effects on health can be complex in urban populations.[18] Higher income should theoretically improve many health outcomes, but it may also support an unhealthy lifestyle,[16] as poor early life conditions increase the risk of obesity in a subsequently more socio-economically developed environment.[19] Increasing socio-economic status may result in an elevated risk of chronic pathologies,[20] but this may not apply to all chronic conditions. Smoking rate is higher in rural than urban China;[21] paradoxically, this contradicts the observed mortality from lung cancer which is higher in urban rather than rural settings (Figure 2). An increase in general affluence across the population has resulted in a convergence of levels of hypertension/high blood lipids between rural and urban in China,[16,22] and differences in rural versus urban populations may even depend on how exactly urbanization is defined.[15] Moreover, climate, lifestyle, diet, and obesity rates are different between various regions in China.[23,24] Even defining urbanicity is challenging given the multifarious features of urbanization in China. A determination of how each of the features of urbanization may influence disease susceptibility has not yet been done.[25] In response to these new challenges, we propose the concept of environmental health profiling, which refers to the ability of a society to assess and control factors that can potentially affect human health.

EMERGING URBAN HEALTH TRENDS IN 21ST CENTURY CHINA

Prosperity has resulted in general improvements in the quality of life[26] and increased healthcare provision[5] with decreasing infectious disease burden and mortality.[26,27] Health conditions in China have improved greatly with a current average life expectancy of 73 years,[26] a 5-year improvement compared with 18 years ago.[28] However, this could lead to a crisis of "diseases of affluence".[10] Figure 3A summarizes the national picture, suggesting a strong correlation between the degree of urbanization and, some key health and disease outcomes. Rates of chronic diseases are currently much greater in cities than in rural areas, particularly for circulatory system diseases and endocrine, nutritional, and metabolic diseases (Figure 3). This is unlikely to be simply a consequence of more aggressive diagnosis, since there is lack of rural versus urban differences in the incidence of respiratory diseases or in the incidence of liver cancer and a clearly higher rural level in esophageal cancer (Figure 2). The recorded incidence of circulatory system and endocrine, nutritional, and metabolic diseases increases sharply with degree of urbanization (Figure 3A). Moreover, the absolute differences in the urban versus rural gradient have become more prominent over time (Figure 3B). One should be aware that these differences reflect an ecological analysis, and thus, an ecological fallacy[29] cannot be fully excluded, unless one studies the individual microenvironment, but the differences shown here are too large to ignore.

It remains to be seen whether these changing patterns may also be a prelude to an increase in other diseases with a longer latency period from the causative event to disease manifestation. Malignancies, such as breast or prostate cancer, have shown 20−30% increases in reported rates during the past decade.[30] Nevertheless, prostate cancer rates still remain very low (more than 100-fold fewer reported cases) compared to men living in northern America.[31]

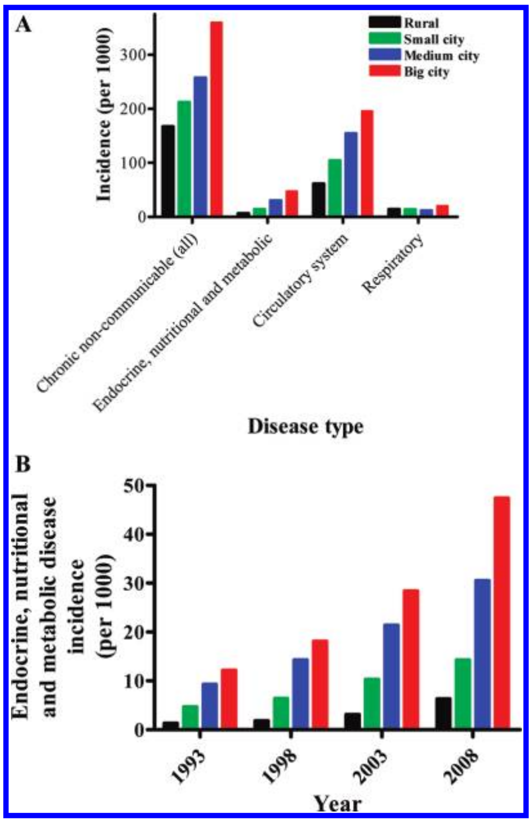


Figure 3. Noncommunicable disease incidence rates along a rural-urban gradient in China over the last 20 years. (A) Chronic disease incidence rates for 2008 for chronic noncommunicable disease, endocrine, nutritional and metabolic disease, circulatory system disease, and respiratory disease, and (B) temporal changes in endocrine, nutritional, and metabolic disease incidence rates from 1993 to 2008. Data are from China Health Statistics Year Book 2009 (http://www.moh.gov.cn/publicfiles/business/htmlfiles/zwgkzt/ptjnj/200908/42635.htm). City size is defined by population, with >1 million representing big, 0.3−1 million being medium, and <0.3 million being small.

UNRAVELING THE CAUSES

Chronic age-related diseases increasingly appear to have multigenic[32] and multiepigenetic components underlying their onset. These include genetic susceptibility factors, gene-environment interactions,[19] and lifestyle-related practices that can be transmitted across trans-generational social networks, as has been demonstrated for obesity.[33,34] Urbanization results in dietary and lifestyle changes (e.g., decreased activity levels) and occupation. For example, cereal and vegetables intake is ∼52% of the total dietary intake for urban populations in China, while it is ∼67% for the rural population; in the urban population in the last two decades, pork consumption increased 3.3-fold and, beef and lamb consumption increased 2.1-fold.[35] Consumption of processed meat in both settings remains unknown. Population density and local aesthetics can influence people's sense of wellbeing, stress and mental health. Diabetes is much higher in urban areas.[4] However, the advent of some risk factors can often be countered by effective public education and appropriate awareness with advice from medical and public health professionals.[36]

Urban consumerism can be associated with a markedly elevated generation of anthropogenic pollutants, either through lifestyle choices (e.g., car usage) or industry (e.g., factories, e-waste dismantling).[37] Increased incidence of certain chronic diseases such as cancer, cardiovascular disease or neurodegenerative disease may involve environmental factors − e.g., chemical contamination of foodstuffs, water and air, which are subject to national, provincial and local controls of varying stringency. Intensive consumption of energy and materials, and generation of waste in the urban setting could also change environmental factors affecting human health.

In an increasingly urbanized environment, exposures to certain chemical contaminants can become elevated unless proper measures are taken for their control or safe disposal. How such urban exposures interact with lifestyle factors can also be complex.[38] Chemical contaminants may become elevated in urban centers and peri-urban environments. Many standard air pollutants increase with degree of urbanization. These include particulate matter (PM), which has been among the highest in the world in China since economic expansion began in the 1980s,[39] NOx, SOx, and products of combustion.[40] Urbanization may affect water quality through an excess of contamination including endocrine disrupting chemicals, antibiotics, steroid hormones, and excess nutrients.[11,41,42] Soils and foodstuffs derived from urban areas or the nearby countryside can also be elevated in heavy metals, nutrients and other chemicals following atmospheric deposition, or irrigation with reclaimed water.[43−46] Elevated exposures to chemicals can also arise in indoor environments (e.g., from new building materials or furnishings).[40,47]

SCIENCE NEEDS AND POLICY RECOMMENDATIONS

The Chinese experience of rapid urbanization has been different to that observed in other developing countries in that its implementation has been driven toward increasing prosperity from a governmental level; therefore, China took steps to ensure that infectious diseases have been rigorously controlled in urban areas.[48,49] This is in contrast to other regions where emerging cities became foci of communicable disease spread.[50] The Chinese Government has responded positively to the World Health Organization's initiative to raise awareness of the potential adverse health effects of urbanization.[51] With the scale, the speed and the diversity of urbanization taking place, China will provide a major testbed toward the study of rapid urbanization and, consequently, the requirements for securing a safe and healthy urban environment. To unravel the complexity of the contribution of environmental factors in urbanized China, it is important to explore regional and city differences in health data. Scrutiny of the health statistics should be coupled with environmental quality data sets which are now emerging for China, as well as stratifying the population into cohorts according to socio-economic status or pre-existing ailments.[52,53] There are important regional differences in environmental quality and geochemistry. For instance, PAHs are particularly elevated as a consequence of coal burning in the north of China, and this is associated with a ∼3-fold increase in lung cancer in the exposed population in suburban Yuncheng (in Shanxi province) compared to the national average.[54] Among reports of localized contaminant hotspots (e.g., As, Cd, organic contaminants),[44] environmental concerns are becoming increasingly frequent in China,[40] but establishing clear links to disease incidence is fraught with difficulties.

Collection of environmental-chemical-concentration data is being undertaken at a fast pace in China, with a host of local, regional and national data sets emerging. However, simple

comparisons of disease incidence with environmental quality indicators are insufficient. Chronic diseases are multistage and humans are an outbred species exhibiting marked interindividual susceptibility based on genetic and lifestyle factors. Additionally, such data sets are incomplete, fragmented across many different efforts, and may not be sufficiently rigorously controlled and standardized to generate a reliable comprehensive database of all exposures, the so-called exposome.[3] Comparisons across different databases with various methods, intensity and quality control in data collection may yield spurious impressions. A strategy for cross-talk to coordinate the sharing of accessible information between Ministries of Health and Environmental Protection in environmental and health monitoring in China is needed to ensure such a monitoring system is fit for purpose with reliable, standardized data collection. The goal should be to generate robust data, capable of revealing spatial and temporal trends in key quality indicators.[55] China is at the forefront in pioneering integrated sensor (e.g., strategically placed passive air samplers) and network systems (e.g., environmental modeling), which can be a major asset in future air and water monitoring. Such multimedia applications could also be exploited to assimilate information on lifestyle factors for individuals, for example, through the use of personal accelerometers, population sensors, computerized processing of food images, and other mobile phone-based technologies for capturing individual exposure data. China has also decisively entered the postgenomic era (the pregenomic era was characterized by the effort to sequence the human genome, while the postgenomic era can be broadly defined the subsequent efforts and approaches to extracting information and functionality from the sequence) with large-scale funding and support for many research efforts in genomics. The combination of large-scale genomic and environmental information will be essential in deciphering susceptibility to diseases risks. Results from European and American populations may not be relevant, as there can be major differences in the genetic risks conferred by common risk variants across different-ancestry populations.[56] In this regard, a large-scale national biobank network program would be a valuable asset.[57] Such biobanks (cryogenic repositories for biological samples that can, for instance, be used in prospective studies) should be initiated sooner rather than later, and should monitor both rapidly urbanized and remote rural regions. These biobanks could also incorporate nested randomized trials for deciphering the impact of specific exposures, but also with an ethical basis.[58] To balance the direction set by of the Ministry of Housing and Construction (which pursues a policy of increasing urbanization) with that of the planning regulators (the Ministries of Environmental Protection and Health), an overarching select committee of respected politicians and eminent scientists (some drawn from the international community) could supervise the implementation of such a facility. This would be analogous to the National Reform and Development Committee. This national biobank program should aim to generate a databank that is user-friendly and accessible to national and international end-users.

Biobank "data gathering" is not only an issue of scientific curiosity but needs to be combined with careful, systematic risk-based exposure assessment and environmental risk management, when appropriate. This requires quantitative assessment of sources, pathways, exposure and dose, to enable clear communication of risk to the public and urban planners, and to national-level decision-makers. There is an equally important requirement to be willing to present both emerging associations as well as null findings.[59] There is a danger at present that ill-informed expensive decisions may be made to manage chemical exposure and risk, without a sufficient documentation of the presence and magnitude of the risk. The establishment of a Chinese equivalent body of the U.S. National Institute of Environmental Health Sciences would help through targeted research programs and funding to direct studies into understanding how environment influences the development and progression of human disease. As quantitative scientific measures of relative risks are determined, consequent implementation of any abatement/mitigation strategies fall under the remit of other government agencies (e.g., National Reform and Development Committee, Ministry of Housing and Construction), with responsibility also placed on industry. Coupled with facility controls and improvement of environmental conditions, the biobank approach would provide valuable information for public health protection programs. The same judicious approach also applies to personal lifestyle exposures (e.g., diet and exercise) as well as community-based interventions that aim to modify behavior and practices; recommendations and public policy should be based on careful randomized evidence on the effectiveness of interventions that would aim to improve outcomes in the rapidly urbanized setting. This creates a need for the implementation of rigorous randomized controlled trials to improve the role of preventive medicine in urbanized China.

■ CONCLUDING REMARKS

"Environmental health profiling" is a global grand challenge for a healthy and sustainable society under rapidly changing climatic and environmental conditions. Environmental health encompasses an accessible healthcare system, access to education, a stable and healthy food supply [together with secure water (quantity and quality)], appropriate air and landscape quality, and sustainable mobility. While health policy in China has been vital in controlling infectious diseases, it needs to be instrumental in abating emerging health problems with judicious planning based on reliable evidence. Future science efforts should be focused on filling the gap between changing environmental factors and health outcomes, and should translate the information into implementable policies. Furthermore, the impact of these policies should also be monitored to ensure that eventually they do have the intended effects and appropriate corrections can be made in the future to ensure maximal benefits.

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■ ACKNOWLEDGMENT

We thank Dr. Xinhu Li and Mr. Gang Li for gathering the data. Our research is funded by the Chinese Academy of Sciences, U.K. EPSRC through the China Bridge project, and the Ministry of Science & Technology. K.C.J. is also partly supported by the Visiting Professorship for Senior International Scientists of the Chinese Academy of Sciences.

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NOTE ADDED AFTER ASAP PUBLICATION

There were reference citation errors, as well as errors to the reference list, in the version of this paper published May 4, 2011. The correct version published May 11, 2011.