



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Vision of China's future urban construction reform: In the perspective of comprehensive prevention and control for multi disasters

Jianguo Wang

School of Architecture, Southeast University, 2 Sipailou, Nanjing, 210096, China

ARTICLE INFO

Keywords:

COVID-19
Multi disasters
Prevention and control
Multiple objectives' optimization
Urban planning and design
Regulations reform

ABSTRACT

The COVID-19 pandemic has caused huge deaths, massive damage and losses around the world. Looking back in history, the motivation for construction and development of cities was to enhance disaster prevention capacity, while modern cities are built and developed to improve health and wellness for human beings. Each disaster would pose some new challenges to the urban planning and architectural design, such as COVID-19. Therefore, the dilemma of future multi disasters (e.g. epidemics) would lead to reflections on the revision or change of urban design regulations. For the post-epidemic era, a comprehensive and integrated prevention system should be established for multi urban disasters, which requires to be optimally formulated based on multiple objectives, i.e., on the balancing of disaster occurrence probability and stop loss cost. This will be realized thanks to the rapid development of digital like advanced technologies. Thus, this paper aims to provide a reference for the prevention and control of future city epidemics and disasters in responding to strategies of urban planning and design by considering the reform of urban construction related regulations, further to facilitate the creation of healthy and safe urban environments.

1. Introduction

Cities are generally defined as densely populated, well-developed commercial and industrial human settlement with large built-up areas. Throughout human history, human settlement may allow cities to operate with higher operation efficiency and greater economy scales compared to rural areas. However, urban regions are more prone to outbreaks of epidemic disease, which has led to much reflection and new explorations in urban construction (Kong et al., 2017; Megahed & Ghoneim, 2020; Spencer, Finucane, Fox, Saksena, & Sultana, 2020). With the further spread of this Novel Coronavirus diseases (namely COVID-19, and Global reporting data show that there have been 25,728, 392 confirmed cases, 17,938,474 cured cases and 856,470 death cases on 1 September 2020). (HYPERLINK <http://news.ifeng.com/c/special/7uLj4F83Cqm> <http://news.ifeng.com/c/special/7uLj4F83Cqm>), the epidemic has become a social and human crisis (Sannigrahi, Pilla, Basu, Basu, & Molter, 2020; Xu, Luo, Yu, & Cao, 2020). The epidemic has not only overwhelmed the health administrative department in the affected areas, but also caused significant losses to other departments, including the economy, education, tourism, and the construction industry (Goniewicz et al., 2020a, Goniewicz et al., 2020). According to the Congressional Research Service (2020), 24 % reduction of annual global

gross domestic product (GDP) was resulted from COVID-19, with an additional 13 %–32 % decline in global trade (Mollalo, Vahedi, & Rivera, 2020). As an important production department of the national economy, the epidemic outbreak has posed new challenges to the urban and architecture design (Allam & Jones, 2020; Haleem, Javaid, Vaishya, & Deshmukh, 2020). How to reduce the risk of epidemic spread and restore economic growth by optimizing urban planning and architectural design has become an urgent topic in the post-epidemic era (Megahed & Ghoneim, 2020). The purposes of this paper are to (1) call for the inclusion of epidemics and other diseases into urban disaster management strategies; (2) provide reference for the prevention and control of epidemic cities and even the response strategies to major urban disasters by considering the reform of urban construction; (3) help and facilitate the process for the creation of healthy and safe urban living environments.

2. Motivation for construction and development city throughout history: enhancing disaster prevention capacity and standards

Throughout history, urban planning and architectural design have always been concerned with the destruction caused by natural disasters in cities (Okubo, 2016). According to 'The Ten Books on Architecture'

E-mail addresses: wjg-cw@seu.edu.cn, wjgseu@163.com.

<https://doi.org/10.1016/j.scs.2020.102511>

Received 7 September 2020; Received in revised form 19 September 2020; Accepted 21 September 2020

Available online 26 September 2020

2210-6707/© 2020 Elsevier Ltd. All rights reserved.

written by Vitruvius, cities and towns should be built in "healthy locations, high altitude, no draft and fog, and oriented neither cool nor warm" (Kim, 2019). Historically, one of the important motivations of urban and architectural advances is the ability to improve disaster prevention capacity and standards (Megahed & Ghoneim, 2020). Each major epidemic brings new challenges to architecture and urban design, and its opportunities to update and improve concepts, methods and code standards (Ahsan, 2020; Randlemanana et al., 2019).

In 1478, the plague struck Milan, Italy and caused 22,000 deaths (the total population of Milan was about 150,000 at that time). Leonardo da Vinci then became interested in sanitation and urban planning and used sketches and written notes to show an ideal urban plan for buildings along the riverbanks (Joseph, 2012). Instead of focusing on cathedrals and palaces, this planning divided Milan into ten new towns, each with 5000 houses and a maximum of 30,000 inhabitants. This is the planning concept to reduce the risk of epidemic spread through cluster zoning for urban areas. From June to December 1665, the plague caused 90,000 deaths in London and in 1666 the Great Fire of London made 80,000 people homeless (Benevolo, 1983). Two catastrophes led Wren to devise a plan for the rebuilding of London (Morris, 1994), replacing "crowded buildings and crooked lanes" (Once responsible for the outbreak of the plague and the spread of fire) with "wide streets and rich spaces". This planning concept aimed to reduce the risk of disasters, casualties and economic losses, which has made an important impact on urban planning in later years.

3. Motivation for construction and development of modern city: improving public health and wellness

Severe public health problems and their response have not only contributed to the formation and development of the modern public health discipline, but also indirectly led to the birth of modern urban planning. Therefore, modern urban planning and design need to pay constant attention to public health and environmental health conditions, in addition to social, economic and technological development motivations (Peng, Song, Elizabeth, & Lancet, 2012). In the pre-industrial era, extreme overcrowding, lack of necessary sanitation, and lack of health knowledge were the main causes of poor living conditions in Europe's industrial cities (Benevolo, 1983). In 1854, cholera epidemic in London was mainly caused by contamination of drinking water with faecal matter (Howard, Rip, Vinten-Johansen, & Lancet, 2000). In addition, the main transmission methods of typhoid fever, bacterial dysentery (Hu et al., 2018) and hepatitis A (Leblanc, Gagné, Poitras, & Brassard, 2019) were also through water and even contacting with infected water, e.g., the pathogen of schistosomiasis could enter the body through water and mucous membranes of the skin (Oyeyemi, Olowookere, Ezekiel, Oso, & Odaibo, 2018). In 1986, Norwalk virus gastroenteritis broke out in the Minnesota area of the United States along with the food-borne transmission route (Levine, Stephenson, & Craun, 1991). Other epidemics have been linked to droplet infections (Association, N. J. J. o. t. A. M., 1955), such as the 1910–1911 "bubonic plague" epidemic in northeastern China (Li, 2020), which caused more than 60,000 deaths due to poor health care and facilities. In 2003, the outbreak of SARS in mainland China was mainly transmitted by close airborne droplets and aerosols, without excluding close contacting method (Hui, Azhar, Memish, & Zumla, 2020). The urban construction and development process has taken water and food-related infectious diseases into account. Nevertheless, the ability to respond to infectious respiratory pathogens was under incomprehensive situation. To address the common public safety risks faced by human beings, urban planning and urban space governance systems should be closely related to public health and wellness, and returning to the field of human safety, health and environmental ecology science rather than only focusing on socio-economic development.

In recent years, urban air pollution (e.g., PM_{2.5}, PM₁₀, ozone, NO₂, CO, etc.) (Cao et al., 2017; Tang et al., 2020) and heat island effect

continue to be intensified which have seriously threaten the progress of sustainable urban development (Li, Yi, Zhang, & Zhou, 2020; Li, Sun, Li, & Gao, 2020; Li, Chow et al., 2020). Modern cities generally adopt the functional zoning based on "work, residence, recreation and transportation", and the leading factors of planning and design are 'sunshine, air and greenery' as proposed in the Athens Charter of 1933 (Le, 1973). An important catalytic factor is how to create a healthy living environment. By linking and interacting human beings with nature and the environment (e.g. physical environment, ecological environment, etc.), a harmonious and unified ideal environmental state can be formed, thus implementing scientific urban planning, optimizing habitat construction, and improving urban health. China now has a clear disciplinary field of "healthy city" (Chen, 2015). Chinese government has issued *The 'Healthy China 2030' Plan Outline* (*The "Healthy China 2030" Plan Outline, 2016*), and the *Guiding Opinions on the Development of Healthy Cities and Healthy Villages* (*Guiding Opinions on the Development of Healthy Cities and Healthy Villages, 2016*), with identification of 38 healthy cities for pilot construction (HYPERLINK <http://www.nhc.gov.cn/jkj>), to form a corresponding healthy city planning system. By integrating the concept of safety and health into public health facilities, living environment as well as urban planning and construction, it can effectively support and stimulate the sustainable development of cities.

4. Reflections on the reform of urban construction in the post-epidemic era

Natural disasters, such as floods, typhoons and earthquakes, are characterized by high frequency of occurrence, wide geographical distribution and large economic losses, which can seriously endanger the health and life safety of human (Boustan, Kahn, Rhode, & Yanguas, 2020). According to relevant data from China's Ministry of Emergency Management, various natural disasters caused 130 million people affected in 2019, with economic losses reaching 327.09 billion RMB (HYPERLINK <http://www.chinanews.com/cj/2020/01-12/9057691.shtml>). Compared to natural disasters, this epidemic caused by COVID-19 lacks early warning and prediction system, and has typical human-to-human characteristics (HYPERLINK <http://www.cdc.gov/coronavirus/2019-ncov/about/transmission.html>), and even large spatial spread phenomenon of 'cross-city and cross-province' due to high-speed rail, aviation and other modern modes of transportation (Kraemer et al., 2020; Nadim & Chattopadhyay, 2020). There is no clear physical boundary limit. Facing with the future dilemma of uncertain disaster and epidemic outbreak (which may occur at any time), the modern city and even the construction of "healthy city" may reveal many shortcomings in planning and design. In order to improve the city's ability to deal with the urgent and critical tasks, theoretical research and practical exploration of city construction changes will become an important issue in the post-epidemic era, which also brings worthy issues of reflection for construction and design of modern city, such as epidemic prevention and management of cities in the digital era (HYPERLINK <https://www.securityroundtable.org/cybersecurity-lessons-from-the-coronavirus/>) (HYPERLINK <https://fritsahlefeldt.com/2020/04/28/antivirus-architecture-as-urban-design/>), public health and epidemic prevention infrastructure improvement (HYPERLINK <https://www.curbed.com/2020/3/17/21178962/design-pandemics-coronavirus-quarantine>), and the improvement of public health and epidemic prevention infrastructure, as well as the challenges of updating architectural design codes in the post-epidemic era. In conjunction with the fast development of information technologies in the digital era, except for strengthening control at the urban grassroots level, it is of great importance to better use emerging information technologies and platforms such as the Internet, the Internet of Things, big data and intelligent monitoring and control (Fang, Huang, Zhang, & Nitivattananon, 2020; Pan et al., 2020), further allowing these data to serve for precise epidemic prevention and decision support (Yin, Zhang, & Dong, 2020).

4.1. Model reform of urban governance and disaster prevention driven by the digital age

Under the situation of the accelerating spread of global epidemic, the short-term prevention and control of the epidemic is very difficult or even impossible to be completely terminated, which is likely to be in the state of longer period of time due to the complexity, long-term and arduous characteristic of epidemic prevention and control. With the arrival of the normalization phase of epidemic prevention, human's production and life styles have undergone significant changes. Virtue of the Internet of Things, it has gradually become an indispensable part of people's working life to use the Internet and other high-tech achievements (Goniewicz et al., 2020a, Goniewicz et al., 2020), telecommuting (Golden & Eddleston, 2020), electronic payment, block-chain sales (Alam Khan, Asif, Ahmad, Alharbi, & Aljuaid, 2020) etc., which would largely affect the epidemic state of urban management and urban design. Under the condition of epidemic prevention normalization, high-tech means (such as the Internet of Things and the Internet) play important roles to ensure the safety and health of personnel, e.g., designing an efficient tool for viral genome analysis and application in tracing SARS-CoV-2 transmission (Zhou, Qiu, Pu, Huang, & Ge, 2020), proposing dynamic clustering framework for moderating the adverse impact of COVID-19 based on healthcare and simulated mobility data (Rahman et al., 2020), developing intelligent ventilation monitoring and control systems (Cao & Ren, 2018) etc. However, these technologies can also significantly change the organization of urban personnel activities (Hadjidemetriou, Sasidharan, Kouyialis, & Parlikad, 2020), meanwhile strengthening the activity characteristics to be more informative, remote, efficient, and transparent (Kraemer et al., 2020). The complex and integrated functions (from urban people flow, logistics, information flow, capital flow and technology flow) would determine the structural characteristics of urban space, showing the coexistence of material space (physical space) and virtual cyberspace (virtual city) (Plane & Mu, 2020). In urban design, we need to consider the quantitative impact of epidemic normalization, Internet of Things and Internet technologies on the structural characteristics of urban space and complex dynamic flows (including people, information, materials, etc.). We also need to combine virtual space theory with traditional physical space design methods to form a new urban design method system for use under new situations (Sanchez-Sepulveda, Fonseca, Franquesa, & Redondo, 2019). The integration of big data (Rahman et al., 2020), GIS (Geographic Information System) (Badach, Voordeckers, Nyka, & Van Acker, 2020), dynamic simulation methods for virtual space (Sanchez-Sepulveda et al., 2019; Singh, Kaur, & Kumar, 2020) as well as fast prediction models (Cao, Yu, & Luo, 2020; Feng, Yu, & Cao, 2019) can be used to build a quantitative group-tool for urban design under the normalization phase of epidemics. Taking satellite cloud map from remote sensing technology and GPS (Global Positioning System) data as input variables, the thematic visualization map of the studied area can be finally output (Shao, Huq, Cai, Altan, & Li, 2020). By inputting environmental parameters (e.g., temperature and wind speed), the multiple digital maps can be superimposed to analyze the spatially variable data and then form the feature graphics of regional environmental data parametric (Woodfine, MacLeod, & Mackay, 2002). The Building Information Model (BIM) of the construction sector has integrated the complex network of professional technique systems (building-based) with the real-time linkage of modification and optimization, to complete the comprehensive optimization for buildings in high probability. Besides, the City Information Model (CIM) associated with the smart city has appeared, which actually forms a 'digital cloud' to present the mesh structure and relationship between city construction system and sub-system through overall interaction of 'point, line, network, and cloud'.

4.2. Improvement for the infrastructure of the urban space and the development of regulations

Studies have shown that urban water systems (Fenaux et al., 2019), indoor air conditioning (Xu et al., 2020) and ventilation systems (Berlanga et al., 2018), etc., play an important role in the transmission of viruses and the increase in the number of infections. Improving the social distance and ventilation effectiveness can prevent the spread of COVID-19 transmission (Sun & Zhai, 2020). The HVAC (Heating Ventilation and Air Conditioning) system is essential to reduce the viruses' transmission (R, R, & Haghghat, 2020). With regard to the adaptive optimization of street systems for old cities, urban villages, traditional residential settlements and various remaining public deficiencies, the construction of daily-life facilities must be put on the agenda, e.g., 1) paying attention to the separation of rainwater and sewage for the water and sewerage systems, 2) optimizing ventilation systems to improve air quality (including proper duct sealing for bathroom and kitchen exhausts, selection of high-quality check valves, regular cleaning or replacement of indoor air conditioning equipment, and prevention of short-circuiting of airflow in air supply and exhaust vents), 3) increasing the number of health facilities (such as new centrally-located hospitals for infectious diseases, health facilities that have been converted from other public services, etc.), 4) avoiding the densely populated areas and water sources that may pose hazards, and establishing necessary spaces of emergency shelters to deal with sudden disasters. This is the most important rational core concept of modern urban planning and design aiming for the improvement of the urban habitat performance. Moreover, it should be one of the urgent steps to develop more detailed environmental and health-related regulations. In addition to the construction of infrastructure in urban spaces, a national science popularization mechanism should be established for the general public, which should increase the intensity and depth of science and epidemic prevention efforts. The education sector needs to incorporate the epidemic prevention system and related scientific knowledge into primary, middle and high school teaching materials, so that the public can efficiently raise awareness of epidemic prevention and receive general health knowledge (Xu et al., 2020).

4.3. Optimization and updates of standards for various building designs and construction

Currently, China promulgated a series of policies on: urban planning and construction (Several Opinions of the CPC Central Committee and the State Council on Further Strengthening the Administration of Urban Planning and Construction, 2016); the construction of new types of urbanization and integrated development of urban and rural areas (Key tasks for the new type of urbanization and the integrated development of urban and rural areas by 2020, (National Development and Reform Commission, 2020)); the construction of regional integration in the Yangtze River Delta (The Outline of the Regional Integration Development Plan for the Yangtze River Delta, (The CPC Central Committee and the State Council, 2019), and the construction of digital transportation (Outline of digital transportation Development Plan, 2019). Many researches provide design recommendations for different cases, such as urban traffic (Shen et al., 2020), office building (Shan et al., 2020), urban underground (Yuan et al., 2020), courtyard (Leng, Wang, & Liu, 2020) and ventilation system (Han et al., 2020). Current design codes for cities and buildings can provide specific design recommendations based on the types of hazards, which are basically limited to human defense, earthquakes, fires, floods, etc. However, infectious disease disasters will pose a greater risk to public safety. Unfortunately norms or regulations on urban planning for infectious disease disasters are still lacking. In addition, the existing prevention codes of building design and construction are individually proposed for different disasters, and not formulated comprehensively for the prevention and control of multi disasters. For the post-epidemic era of urban construction, urban

development should be comprehensive and holistic, to balance the relationship between short-term costs and long-term benefits for the codes of urban construction, and balance the probability of disasters and stop-loss costs. It is recommended that various types of building design and construction codes to be reorganized and updated. Attention should be paid to the epidemic safety of public buildings and environmental spaces with high sensitivity of health and safety, high density of occupancy and long stays, such as free-trade market buildings, various types of theatrical and office buildings, high-density residential communities etc. Especially attention should be paid for the public buildings, i.e., sanitary conditions, waste and environmental pollution disposal measures etc. The revision and update of the corresponding codes would be able to provide important reference to improve the ability to deal with highly uncertain urban emergencies and disasters.

5. Conclusions

Cities are typically complex mega-systems with a complex mix of urban disaster/hazard types. The development of standards for disaster prevention should be based on the balance between the probability of a disaster occurring and the cost of stop loss. For large-probability and periodic occurring disasters (such as floods, windstorms, and earthquakes), standards and regulatory goals should be clearly set for urban and rural development ([Technical Guidelines for standardization administration of Work Safety in urban Rail transit Project Construction, 2020](#)). Flood protection standards can be divided into 100-years, 50-years and 20-years cycles according to the size and importance of the city ([Ministry of Housing and Urban-Rural Development, PRC, 2020](#)). As for the specific types of 'urban disease' with a small probability of occurrence and a large probability of negative effects and impacts especially for certain types of man-made and preventable disasters, such as fire, smog, water pollution and infectious diseases, the future urban planning and design should require more scientific and comprehensive knowledge, diagnosis and early warning from a professional perspective.

Although urban planning ([Guidelines of the National Development and Reform Commission on Fostering and Developing modern Metropolitan Areas, 2019](#)), urban design (Reply of the State Council on the Master Plan for Xiongan New Area in Hebei (2018-2035), [State Council of the People's Republic of China, 2019](#)) and architectural design (Ministry of Housing and Urban-Rural Development of the People's Republic of China on the issue of industrial standards "Office Building Design Standards, [Ministry of Housing and Urban-Rural Development, 2019](#)) have formed systematic environmental hygiene and health standards, urban decision makers still need to take reasonable responsibility for the transformation of digital information and other high-tech tools facing the break out of disasters and epidemics at any time ([Rahman et al., 2020](#)). For instance, 'Internet + community' public service platform, a number of community living service centers, the construction of community education, culture, medical care, elderly care, home economics, sports and other life service facilities can be well established to both improve social services and create a convenient consumption circle. The formulation of building specifications should take into account the improvement of integrated disaster prevention and construction goals, which include the quality of urban and rural living environment, the level of public health security, and the ability to prevent major disasters. Constructive measures and standards (in history) for preventing and delaying epidemic diseases mainly include: water and sewerage systems in urban and rural areas (separation of rain and sewage) ([Sheela et al., 2017](#); [Zhu & Chang, 2020](#)), residential spacing related to the health of sunlight, the layout of cities and buildings relating to ventilation orientation. Nowadays, green building, ecological city, healthy city and other related theories and practical exploration have come into the world ([Li, Yi et al., 2020](#), [Li, Sun et al., 2020](#); [Li, Chow et al., 2020](#); [Ahad, Paiva, Tripathi, & Feroz, 2020](#); [Lilis, Conus, Asadi, & Kayal, 2017](#)). For the post-epidemic era, urban development needs to be

optimally formulated based on multiple objectives, through establishing emergency control mechanisms, balancing short-term costs and long-term benefits, providing appropriate financial support, and building a comprehensive and integrated prevention system for urban disaster.

To sum up, the mechanical mind which was once effective in the era of modernism (e.g. the rational-centric model of urban construction based on formulas, theorems, rules and the like certainty and continuity), is no longer fully capable of coping with the today's 'black swan' sudden disasters (meteorological, epidemiological, etc.) that are increasingly subject to a high degree of uncertainty, along with 'frog boiling' and 'grey rhino' urban disasters (i.e. cumulative outbreaks). With the increasingly in-depth of digital era development, a 'digital cloud' can be formed through CIM technology, which is able to realize the cross-validation of information from different systems and the use of iterative algorithms to obtain the optimal value interval with the interaction of 'point, line, network and cloud'. Then, based on the existing scientific planning and prevention for several single disaster targets, it is possible to construct more complex prevention and control modes for integrated urban disaster preparedness. This could further achieve a compatible unity with instrumental-rational and value-rational multi-objectives posed by the probability theory and 'Positive-sum Game' ideology through which the comprehensive optimal of the global system should be put in priority based on the balancing of disaster occurrence probability and stop loss cost.

Declaration of Competing Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Acknowledgement

The authors would like to acknowledge the financial support from the 13th Five Year National Science and Technology Support Key Project of China (No. 2017YPC0702500)

References

- Ahad, M. A., Paiva, S., Tripathi, G., & Feroz, N. (2020). Enabling technologies and sustainable smart cities. *Sustainable Cities and Society*, 61, Article 102301.
- Ahsan, M. M. (2020). Strategic decisions on urban built environment to pandemics in Turkey: Lessons from COVID-19. *Journal of Urban Management*. <https://doi.org/10.1016/j.jum.2020.07.001>. In press.
- Alam Khan, F., Asif, M., Ahmad, A., Alharbi, M., & Aljuaid, H. (2020). Blockchain technology, improvement suggestions, security challenges on smart grid and its application in healthcare for sustainable development. *Sustainable Cities and Society*, 55, Article 102018.
- Allam, Z., & Jones, D. S. (2020). Pandemic stricken cities on lockdown. Where are our planning and design professionals [now, then and into the future]? *Land Use Policy*, 97, Article 104805.
- Association, N. J. J. o. t. A. M. (1955). *Airborne contagion and air hygiene: An ecological study of droplet infections*, 159 (p. 90).
- Badach, J., Voordeckers, D., Nyka, L., & Van Acker, M. (2020). A framework for air quality management zones - useful GIS-based tool for urban planning: Case studies in Antwerp and Gdańsk. *Building and Environment*, 174, Article 106743.
- Benevolo, L. J. C. V. (1983). *Die Geschichte der Stadt*, 24, 1-5.
- Berlanga, F. A., de Adana, M. R., Olmedo, I., Villafreua, J. M., San José, J. F., & Castro, F. (2018). Experimental evaluation of thermal comfort, ventilation performance indices and exposure to airborne contaminant in an airborne infection isolation room equipped with a displacement air distribution system. *Energy and Buildings*, 158, 209-221.
- Boustan, L. P., Kahn, M. E., Rhode, P. W., & Yanguas, M. L. (2020). The effect of natural disasters on economic activity in US counties: A century of data. *Journal of Urban Economics*, 118, Article 103257.
- Cao, S.-J., & Ren, C. (2018). Ventilation control strategy using low-dimensional linear ventilation models and artificial neural network. *Building and Environment*, 144, 316-333.
- Cao, S. J., Kong, X. R., Li, L., Zhang, W., Ye, Z. P., & Deng, Y. (2017). An investigation of the PM2.5 and NO2 concentrations and their human health impacts in the metro subway system of Suzhou, China. *Environmental Science Processes & Impacts*, 19, 666-675.
- Cao, S.-J., Yu, C. W., & Luo, X. (2020). New and emerging building ventilation technologies. *Indoor and Built Environment*, 29, 483-484.

- Chen, Z. (2015). *Healthy china 2020 strategic research report*.
- Fang, L., Huang, J., Zhang, Z., & Nitiwattananon, V. (2020). Data-driven framework for delineating urban population dynamic patterns: Case study on Xiamen Island, China. *Sustainable Cities and Society*, 62, Article 102365.
- Fenaux, H., Chassaing, M., Berger, S., Gantzer, C., Bertrand, I., & Schvoerer, E. (2019). Transmission of hepatitis E virus by water: An issue still pending in industrialized countries. *Water Research*, 151, 144–157.
- Feng, Z., Yu, C. W., & Cao, S.-J. (2019). Fast prediction for indoor environment: Models assessment. *Indoor and Built Environment*, 28, 727–730.
- Golden, T. D., & Eddleston, K. A. (2020). Is there a price telecommuters pay? Examining the relationship between telecommuting and objective career success. *Journal of Vocational Behavior*, 116, Article 103348.
- Goniewicz, K., Khorram-Manesh, A., Hertelendy, A. J., Goniewicz, M., Naylor, K., & Burkle, F. M., Jr. (2020a). *Current response and management decisions of the European union to the COVID-19 outbreak: A review*.
- Goniewicz, K., Khorram-Manesh, A., Hertelendy, A. J., Goniewicz, M., Naylor, K., & Burkle, F. M. (2020). Current response and management decisions of the European union to the COVID-19 outbreak: A review. *Sustainability*, 12(9). <https://doi.org/10.3390/su12093838>
- Hadjidemetriou, G. M., Sasidharan, M., Kouyialis, G., & Parlidak, A. K. (2020). The impact of government measures and human mobility trend on COVID-19 related deaths in the UK. *Transportation Research Interdisciplinary Perspectives*, 6, Article 100167.
- Haleem, A., Javaid, M., Vaishya, R., & Deshmukh, S. G. (2020). Areas of academic research with the impact of COVID-19. *The American Journal of Emergency Medicine*, 38, 1524–1526.
- Han, O., Zhang, Y., Li, A., Li, J., Li, Y., & Liu, H. (2020). Experimental and numerical study on heavy gas contaminant dispersion and ventilation design for industrial buildings. *Sustainable Cities and Society*, 55, Article 102016.
- Howard, B., Rip, M. R., Vinten-Johansen, P., & Lancet, A. J. (2000). *Map-making and myth-making in Broad Street: The London cholera epidemic* (p. 1854).
- Hu, X., Ding, G., Zhang, Y., Liu, Q., Jiang, B., & Ni, W. (2018). Assessment on the burden of bacillary dysentery associated with floods during 2005–2009 in Zhengzhou City, China, using a time-series analysis. *Journal of Infection and Public Health*, 11, 500–506.
- Hui, D. S., Azhar, E. I., Memish, Z. A., & Zumla, A. (2020). Human coronavirus infections—Severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS), and SARS-CoV-2. *Reference module in biomedical sciences*. Elsevier.
- Joseph, P. B. (2012). *Encyclopedia of the black death*. Santa Barbara, Calif: ABC-CLIO.
- Kim, W. (2019). *The ten books of architecture*. 1. Cham: Springer International Publishing.
- Kong, S., Tan, X., Deng, Z., Xie, Y., Yang, F., & Zheng, Z. (2017). Establishment of first engineering specifications for environmental modification to eliminate schistosomiasis epidemic foci in urban areas. *Acta Tropica*, 172, 132–138.
- Kraemer, M. U. G., Yang, C.-H., Gutierrez, B., Wu, C.-H., Klein, B., Pigott, D. M., et al. (2020). The effect of human mobility and control measures on the COVID-19 epidemic in China. *Science*, 6490, 493–496.
- Le, C. J. A. C. (1973). *The Athens charter*.
- Leblanc, D., Gagné, M.-J., Poitras, É., & Brassard, J. (2019). Persistence of murine norovirus, bovine rotavirus, and hepatitis A virus on stainless steel surfaces, in spring water, and on blueberries. *Food Microbiology*, 84, Article 103257.
- Leng, J., Wang, Q., & Liu, K. (2020). Sustainable design of courtyard environment: From the perspectives of airborne diseases control and human health. *Sustainable Cities and Society*, 62, Article 102405.
- Levine, W. C., Stephenson, W. T., & Craun, G. F. (1991). Waterborne disease outbreaks, 1986–1988. *Journal of Food Protection*, 54, 71–78.
- Li, S. J. (2020). *Bubonic plague in nineteenth-century China*. Stanford University Press.
- Li, Z., Chow, D. H. C., Ding, D., Ying, J., Hu, Y., Chen, H., et al. (2020). The development and realisation of a multi-faceted system for green building planning: A case in Ningbo using the fuzzy analytical hierarchy process. *Energy and Buildings*, 226, Article 110371.
- Li, Y., Sun, Y., Li, J., & Gao, C. (2020). Socioeconomic drivers of urban heat island effect: Empirical evidence from major Chinese cities. *Sustainable Cities and Society*, 63, Article 102425.
- Li, W., Yi, P., Zhang, D., & Zhou, Y. (2020). Assessment of coordinated development between social economy and ecological environment: Case study of resource-based cities in Northeastern China. *Sustainable Cities and Society*, 59, Article 102208.
- Lilis, G., Conus, G., Asadi, N., & Kayal, M. (2017). Towards the next generation of intelligent building: An assessment study of current automation and future IoT based systems with a proposal for transitional design. *Sustainable Cities and Society*, 28, 473–481.
- Megahed, N. A., & Ghoneim, E. M. (2020). Antivirus-built environment: Lessons learned from Covid-19 pandemic. *Sustainable Cities and Society*, 61, Article 102350.
- Ministry of Housing and Urban-Rural Development, P. R. C. (2019). *Ministry of housing and urban-rural development of the People's Republic of China on the issue of industrial standards "Office building design standards"*. http://www.gov.cn/zhengce/zhengceku/2020-04/03/content_5498866.htm.
- Ministry of Housing and Urban-Rural Development, P. R. C. (2020). *Technical guidelines for standardization administration of Work Safety in urban rail transit project construction*. <http://www.mohurd.gov.cn/wjfb/202007/W020200713032023.pdf>.
- Ministry of Housing and Urban-Rural Development, PRC. (2020). *Ministry of housing and urban-rural development, PRCGB50201-52014*. <http://download.mohurd.gov.cn/bzgg/gjzb/GB50201-2014%E9%98%B2%E6%B4%AA%E6%A0%87%E5%87%86.pdf>.
- Ministry of Transport. (2019). *Outline of digital transportation development plan*. http://www.gov.cn/zhengce/zhengceku/2019-07/25/content_5455536.htm.
- Mollalo, A., Vahedi, B., & Rivera, K. M. (2020). GIS-based spatial modeling of COVID-19 incidence rate in the continental United States. *The Science of the Total Environment*, 728, Article 138884.
- Morris, A. E. J. (1994). *History of urban form: Before the industrial revolutions*. Prentice Hall.
- Nadim, S. S., & Chattopadhyay, J. (2020). Occurrence of backward bifurcation and prediction of disease transmission with imperfect lockdown: A case study on COVID-19. *Chaos, Solitons, and Fractals*, 140, Article 110163.
- National Development and Reform Commission. (2019). *Guidelines of the national development and reform commission on fostering and developing modern metropolitan areas*. http://www.gov.cn/zhengce/zhengceku/2019-09/29/content_5434981.htm.
- National Development and Reform Commission. Key tasks for the new type of urbanization and the integrated development of urban and rural areas by 2020, 2020. http://www.gov.cn/zhengce/zhengceku/2020-04/09/content_5500696.htm.
- National Patriotic Health Campaign Committee. (2016). *Guiding opinions on the development of healthy cities and healthy villages*. <http://www.kfawb.gov.cn/uploadfile/2018/0408/20180408102720788.pdf>.
- Okubo, T. (2016). Traditional wisdom for disaster mitigation in history of Japanese Architectures and historic cities. *Journal of Cultural Heritage*, 20, 715–724.
- Oyeyemi, O., Olowookere, D., Ezekiel, C., Oso, G., & Odaiabo, A. (2018). The impact of chemotherapy, education and community water supply on schistosomiasis control in a Southwestern Nigerian village. *Infection Disease & Health*, 23, 121–123.
- Pan, X., Ojcius, D. M., Gao, T., Li, Z., Pan, C., & Pan, C. (2020). Lessons learned from the 2019-nCoV epidemic on prevention of future infectious diseases. *Microbes and Infection*, 22, 86–91.
- Peng, G., Song, L., Elizabeth, C., & Lancet, a. J. (2012). Urbanisation and health in China. *The Lancet*, 379, 843–852.
- Plane, D. A., & Mu, W. (2020). A people-based density perspective on physical/virtual world spaces in the microcosmic city. *Land Use Policy*, Article 104462.
- R, A. A. R., R, V., & Haghight, F. (2020). The contribution of dry indoor built environment on the spread of Coronavirus: Data from various Indian states. *Sustainable Cities and Society*, 62, Article 102371.
- Rahman, M. A., Zaman, N., Asyhari, A. T., Al-Turjman, F., Alam Bhuiyan, M. Z., & Zolkipli, M. F. (2020). Data-driven dynamic clustering framework for mitigating the adverse economic impact of Covid-19 lockdown practices. *Sustainable Cities and Society*, 62, Article 102372.
- Randremanana, R., Andrianavoimanana, V., Nikolay, B., Ramasindrazana, B., Paireau, J., ten Bosch, Q. A., et al. (2019). Epidemiological characteristics of an urban plague epidemic in Madagascar, August–November, 2017: An outbreak report. *The Lancet Infectious Diseases*, 19, 537–545.
- Sanchez-Sepulveda, M., Fonseca, D., Franquesa, J., & Redondo, E. (2019). Virtual interactive innovations applied for digital urban transformations. Mixed approach. *Future Generation Computer Systems*, 91, 371–381.
- Sannigrahi, Srikanta, Pilla, Francesco, Basu, Bidroha, Basu, Arunima Sarkar, & Molter, Anna (2020). Examining the association between socio-demographic composition and COVID-19 fatalities in the European region using spatial regression approach. *Sustainable Cities and Society*, 62, Article 102418.
- Shan, X., Luo, N., Sun, K., Hong, T., Lee, Y.-K., & Lu, W.-Z. (2020). Coupling CFD and building energy modelling to optimize the operation of a large open office space for occupant comfort. *Sustainable Cities and Society*, 60, Article 102257.
- Shao, Z., Huq, M. E., Cai, B., Altan, O., & Li, Y. (2020). Integrated remote sensing and GIS approach using Fuzzy-AHP to Delineate and identify groundwater potential zones in semi-arid Shanxi Province, China. *Environmental Modelling & Software*, Article 104868.
- Sheela, A. M., Ghermandi, A., Vineetha, P., Sheeja, R. V., Justus, J., & Ajaykrishna, K. (2017). Assessment of relation of land use characteristics with vector-borne diseases in tropical areas. *Land Use Policy*, 63, 369–380.
- Shen, T., Hong, Y., Thompson, M. M., Liu, J., Huo, X., & Wu, L. (2020). How does parking availability interplay with the land use and affect traffic congestion in urban areas? The case study of Xi'an, China. *Sustainable Cities and Society*, 57, Article 102126.
- Singh, P., Kaur, A., & Kumar, N. (2020). A reliable and cost-efficient code dissemination scheme for smart sensing devices with mobile vehicles in smart cities. *Sustainable Cities and Society*, 62, Article 102374.
- Spencer, J. H., Finucane, M. L., Fox, J. M., Saksena, S., & Sultana, N. (2020). Emerging infectious disease, the household built environment characteristics, and urban planning: Evidence on avian influenza in Vietnam. *Landscape and Urban Planning*, 193, Article 103681.
- State Council of the People's Republic of China. (2019). *Reply of the state council on the master plan for Xiongan new area in Hebei (2018-2035)*. http://www.gov.cn/zhengce/zhengceku/2019-01/02/content_5354222.htm.
- Sun, C., & Zhai, Z. (2020). The efficacy of social distance and ventilation effectiveness in preventing COVID-19 transmission. *Sustainable Cities and Society*, 62, Article 102390.
- Tang, X., Gao, X., Li, C., Zhou, Q., Ren, C., & Feng, Z. (2020). Study on spatiotemporal distribution of airborne ozone pollution in subtropical region considering socioeconomic driving impacts: A case study in Guangzhou, China. *Sustainable Cities and Society*, 54, Article 101989.
- The Central Committee of the Communist Party of China and the State Council. (2016). *The "Healthy China 2030" plan outline*. http://www.gov.cn/zhengce/2016-10/25/content_5124174.htm.
- The CPC Central Committee and the State Council. (2019). *The outline of the regional integration development plan for the Yangtze River Delta*. http://www.gov.cn/gongbao/content/2019/content_5462503.htm.
- The CPC Central Committee and the State Council. (2016). *Several opinions of the CPC central committee and the state council on further strengthening the administration of urban planning and construction*. http://www.gov.cn/zhengce/2016-02/21/content_5044367.htm.

- Woodfine, D., MacLeod, M., & Mackay, D. (2002). A regionally segmented national scale multimedia contaminant fate model for Canada with GIS data input and display. *Environmental Pollution*, 119, 341–355.
- Xu, C., Luo, X., Yu, C., & Cao, S.-J. (2020). The 2019-nCoV epidemic control strategies and future challenges of building healthy smart cities. *Indoor and Built Environment*, 29, 639–644.
- Yin, S., Zhang, N., & Dong, H. (2020). Preventing COVID-19 from the perspective of industrial information integration: Evaluation and continuous improvement of information networks for sustainable epidemic prevention. *Journal of Industrial Information Integration*, 19, Article 100157.
- Yuan, H., He, Y., Zhou, J., Li, Y., Cui, X., & Shen, Z. (2020). Research on compactness ratio model of urban underground space and compact development mechanism of rail transit station affected area. *Sustainable Cities and Society*, 55, Article 102043.
- Zhou, Z.-J., Qiu, Y., Pu, Y., Huang, X., & Ge, X.-Y. (2020). BioAider: An efficient tool for viral genome analysis and its application in tracing SARS-CoV-2 transmission. *Sustainable Cities and Society*, 63, Article 102466.
- Zhu, D., & Chang, Y.-J. (2020). Urban water security assessment in the context of sustainability and urban water management transitions: An empirical study in Shanghai. *Journal of Cleaner Production*, 275, Article 122968.