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Viewpoint
How high can we go? Urban density, infectious versus chronic disease, and the adaptive resilience of cities

Limits to density

Quarantined in a London hotel and swabbed by a barrier-suited doctor, I was a test case in the UK's epidemic response process. In early February 2020 I gave little thought to the connection with the workshop I had just attended in Haifa's Technion, where Rachelle Alterman had invited a multidisciplinary team to guide the Israeli government's response to an epidemic of tall buildings. *How high should we go?* In 2014 I co-organised an NUS–HKU–MIT workshop at the National University of Singapore and asked the question '*How low can we go?*' The focus was the inverse to the height question: what natural, governmental or moral laws define the minimum land consumption per capita sufferable?

Urban density is back on the agenda

A century and a half ago, the origins of modern town planning were very much focused on population density. Modern town planning in Britain started as a public-health concern. Like the physical planning in overcrowded, insanitary cities of currently underdeveloped economies, the concern was slum clearance, infrastructure upgrading, and humane housing for the working poor. It was a problem then and now because the poor, it seems, will live at inhumane density and environmental quality in pursuit of betterment.

What is the limit to urban density? The answer, as always in the history of cities: health. Not public health, but private health.

Urban planning as public-health intervention

Left to the subjective calculus that drives people to cities, individuals will evidently accept space deprivation to the point of morbidity and even mortality. Michael Todaro's (1969) net present value model of rural–urban migration offers an explanation. Hope value helps the poor tolerate levels of environmental health that are not

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sufficient to sustain individual life and productivity. Public-health policy, including urban planning, will always therefore be invented. Under-consuming space to the point of ill health may be bearable for some individuals but not for society. It under-reproduces the labour force, spreads disease and is morally repugnant. Individual health may be the ultimate limit on urban density, but public health is the binding limit in cities that are able to organise collective action. Anthropologist Margaret Mead identified a mended femur as the earliest archaeological evidence of civilisation. Animals with a broken femur don't survive. Public-health and urban planning interventions are as old as civilisation. Their rediscovered common heritage and purpose in recent years have massively accelerated in 2020. The re-engagement has been driven by big data, better algorithms and a new understanding that urban design might well be one of the most powerful public-health interventions (Ezzati et al., 2018). The new alliance has focused on the modern 'urban plagues': chronic diseases of sedentary living, including mental health, cardio-vascular and respiratory disease, diabetes and obesity (Sarkar et al., 2014; Frank et al., 2016; Sallis et al., 2016). Our cities are far healthier now, but we have momentarily been beaten by an old-style plague: a new pathogen.

The discovery of pathogens helped change the shape of cities. There is a direct link between John Snow's 1854 crude GIS analysis of a cholera outbreak in London's Soho and the Parker Morris standards of post-war UK public housing (DoE, 1961) and the slum clearance and New Town projects of the twentieth century. How will the experience of living through an apocalyptic pathogen attack change cities in the twenty-first century?

High-income high-density cities

In advanced economies the answer is not going to be lower densities. A recent study measuring the effect of population density in the USA on COVID-19 dynamics showed a significant but mild positive statistical association (Barr and Tassier, 2020). Density of people is only one factor determining the infection reproduction rate *R*. Another is the number of vulnerable people remaining in a population, and this reduces as a city becomes infected, making the dynamic complex. Another complexity is that high-density, high-income cities tend also to be highly connected cities and connectivity influences the risk of a pandemic landing in a city. It is unlikely that any feasible reconfiguration of housing and built environments will, on its own, reduce the risk of epidemic. Hong Kong has one of the most successful COVID-19 containment stories. With densities of ~7,000 people per square kilometre (p/km$^{2)}$ (whole territory), ~17,000 p/km^2 (HK Island), and ~130,000 p/km^2 in low-income Mong Kok, HKSAR had 1,036 confirmed cases out of 7.4 million people and four deaths by the end of April 2020. Sharing an elevator and living at an average of 17 square metres per person is evidently not, *ceteris paribus*, a public-health risk, even during the worst pandemic in a hundred years.

That is not to say that the pandemic will not influence specific components of advanced cities. The world will learn lessons from Singapore's deadly tolerance of ultra-high-density migrant-worker dormitories. The planning and design of elderly-care homes in Europe, which some reports say account for 50 per cent of deaths (Birnbaum and Booth, 2020), may change. I predict a rapid rise in salutogenic planned elderly neighbourhoods. Hospital and prison designs and locations may change. A prolonged pandemic threat may have an impact on mass-transit design and operation. The 'sardine-tin' commutes in Paris, London, New York and Tokyo might be viewed at some point like the horrors of crowded Victorian working-class tenements, hostels and workhouses. We may wonder that we ever accepted such risk and privation in travelling, like memories of driving without seatbelts, travelling on non-air-conditioned trains and buses and on international flights with smoking at the rear. What could replace over-packed transit cars apart from longer trains and platforms and a total redesign of circulation areas? With the advent of clean energy, a revival in private transport seems likely. The main private advantages of individualised over shared transport are privacy and flexibility. It will be politically easy to remove the last bastion of uncivilised urban crowdedness if the technology becomes available. As well as electric and hydrogen-powered transport innovations, people- and freight-carrying drones are just around the corner, with Mercedes and other consortia already having prototypes. HKUrbanlab researchers recently had a conversation with planners in the mega-city of Shenzhen about future-proofing the city's strategic spatial plan. Personal drone transport will undoubtedly arrive within the plan's 30-year horizon. Will drone and other automated transport systems reshape cities in the way railways did in the second half of the nineteenth century, with mode-transfer stations located around the city's edge, as with the stations in nineteenth-century London? Will there be drone flight corridors from these to the city fringe and associated massive reshaping of built-up areas, as happened to accommodate links between London's main stations and the open countryside after about 1850?

Low-income high-density cities

In emerging economies, COVID-19 could well be a turning point for urban planning, equivalent to that of the insanitary cities of Europe a century ago. If India, set to become the second global economic power by 2050 (PricewaterhouseCoopers, 2017), can build 1,000 smart cities (Government of India, MUD, 2015), it can surely invent an urban planning regime that rescues the poor from deadly levels of space privation. Epidemics and other natural disasters have always reshaped cities. Hong Kong's much-lauded public housing system (housing over 40 per cent of the population) was triggered by squatter fires in the 1950s. There have been seven cholera pandemics since the disease was first identified in South Asia in 1817. The first three killed 15 million in India, and local outbreaks from ongoing endemic cholera still kill between 20,000 and 140,000 each year, with 1.3 million to 4 million annual cases (World Health Organisation, 2019). The first three cholera pandemics led mainly to changes in medication (cinnamon was popular), quarantine and crowd control by local and colonial authorities, but the next four pandemics led to widespread modernisation of urban infrastructure in the developing world.

Re-engineering premodern cities to combat waterborne pathogens requires civil engineering and land-use planning. Re-engineering cities to reduce risks from airborne pathogens and carcinogens requires air pollution mitigation. New laws have emerged in the past 3 months in China governing the risks of animal- and food-borne pathogens. Wet-market planning, regulations and closure will have subtle but non-systemic effects on the organisation of some Asian cities.

Infectious versus chronic disease and urban density

Reshaping cities to become less dense may actually have negative health effects. In a series of papers in *Lancet Planetary Health*, researchers at the Healthy High-Density Cities (HHDC) Lab at the University of Hong Kong show that living at higher density means lower odds of suffering from a chronic disease in the UK, controlling for other factors. Figure 1 illustrates this for three measures of obesity in UK cities, in one of the largest built-environment-density studies ever undertaken (Sarkar et al., 2017). A growing body of scientific evidence suggests that higher urban densities are good for urban living in multiple domains, including social, economic, food security, energy, health and longevity. Hong Kong, Asia's most iconic vertical city, has the longest life expectancy of all countries in the world, at 84.7 years (mean M+F, 2020). Much new evidence would have to come from COVID-19 research before a shift to de-densifying for pandemic risk reduction overturns the now well-established healthy compact-city planning doctrine.

Pathogens and urban infrastructure

Infectious diseases caused by parasites, viruses and bacteria are spread by living pathogen-transmitting vectors such as mosquitoes and fleas, by air- and water-borne particles and by direct human-to-human contact. As such, they travel through the city via the same infrastructure systems that keep a city working. They are passed on in the metro systems (Kang et al., 2018), via banknotes (Heshiki et al., 2017) and in public spaces. Beyond upgrading water and sanitation infrastructure, how might these shared spaces be better pandemic-proofed? Social-distancing laws are one answer

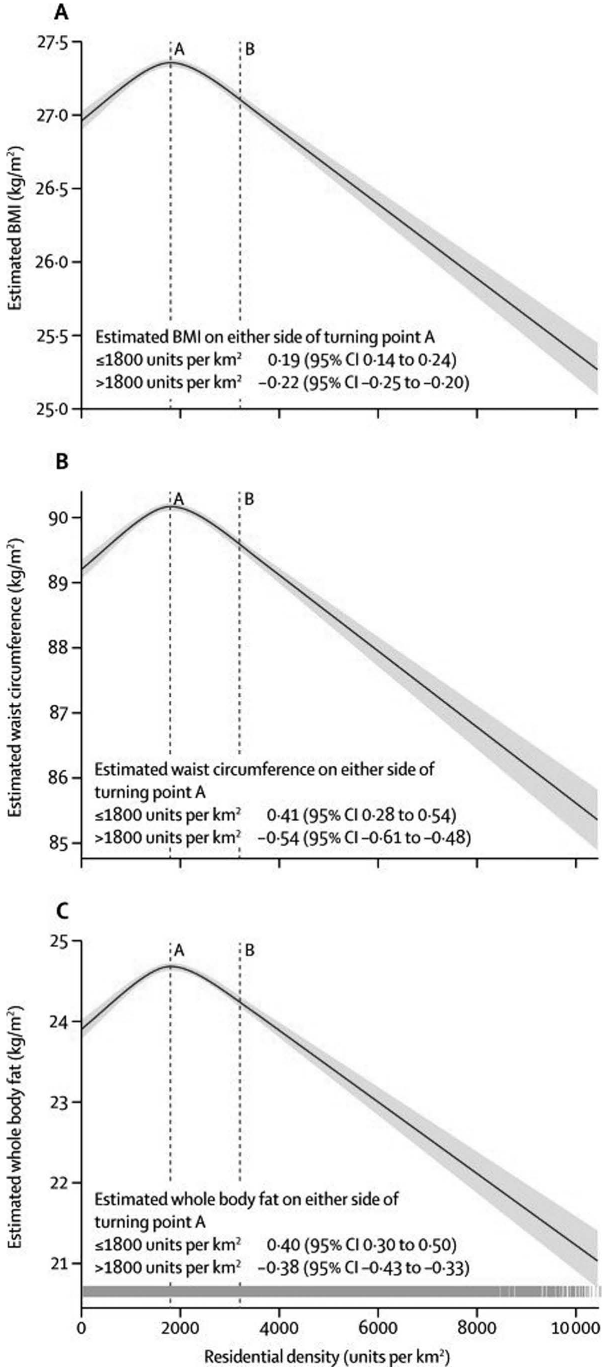

Figure 1 Higher densities mean more walkable destinations and lower odds of chronic disease like obesity
Source: Sarkar et al. (2017)

(Xue et al., 2020), and while these are temporary in the current pandemic as they were in the seventeenth-century bubonic plague, might some become more permanent, by regulation or custom? What new technologies and practices might emerge? Urban ventilation planning at building, public-space, street and whole-city scales (Ren et al., 2018) may become *de rigueur*; air quality and heat being critical factors in infectious and chronic disease and mortality risk in vulnerable groups (Goggins et al., 2012). A technology to emerge from almost nowhere in 2020 is virus-tracing and warning systems (Schuldenfrei et al., 2020), equivalent, perhaps, to innovations in urban water technology of the twentieth century. 5G-enhanced sensing that alerts us to an approaching 'infected' phone has already been invented; it is the privacy, not the technical issues, that limit this technology currently. In pandemic-era cities, individuals will be expected to self-organise safely through virus-risk public spaces, just as cars self-organise on collision-risk road systems via well-understood and policed rules.

Scientific paradigm shifts

Public parks, massive civic utility works and more salutogenic housing came from a London cholera epidemic and from a paradigm shift in medical science from miasma theory to germ theory. It is not just the manifestation of the disease that shapes cities, but also the underlying scientific paradigm. Since the advent of germ theory in the mid-nineteenth century, public-health and epidemiology paradigms have shifted further, to embrace risk-factor science (embedding biological risk within natural, built and social environment risks), genetic science and now epigenetic science and microbial ecological science (Heshiki et al., 2017; Kang et al., 2018). What scientific insights might be discovered through COVID-19, 100 years after the last great pandemic and in an era of vastly more sophisticated knowledge and techniques? What new conversations will be opened about redesigning buildings, spaces, neighbourhoods, distribution systems, shared facilities and entire cities and systems of cities? Before John Snow, it was simply not appreciated that infectious disease was caused by shared water delivery systems. Have we learned everything we can ever know about how the behaviour of pathogens, the human body and mind, and groups of humans and pathogens respond to the built environment? Probably not. In one of our earlier studies at HKU's HHDC Lab, we found that obesity in the elderly falls, not rises, with distance from a park, controlling for factors such as other health conditions, age, smoking etc. (Sarkar et al., 2013). For the elderly, the exercise benefits of a park lie not in park-based activities (the elderly tend to sit down when they arrive), but in the walking to and fro. When the thousands of COVID-19 studies have been published, what may we learn, for example, about gene–environment (natural, social, built) interactions between mental health, lockdown quarantine, epidemic curves and elderly-community neighbourhood design? In an echo of John Snow's work in the 1850s, another recent HHDC paper mapped microbial ecology on HK's metro lines, identifying daily microbial and pathogen 'commutes'. We identified the microbes that share the MTR with HK's workers and mapped microbial daily movements, mixes and places of origin and destination, and identified pathogenic and antibiotic-resistant strains (Kang et al., 2018). Microbial warning systems may one day join air-quality and road congestion real-time systems to guide safe and efficient movement through the city.

Physical versus institutional order

COVID-19 will not stop the inexorable trend towards larger and denser cities. The human tolerance of risk in pursuit of wealth and well-being is too high for that. Cities are in essence a coming together of humanity to facilitate labour specialisation and economic advancement, and the pull has always been relentless and sacrificial. History also shows that individuals are willing to tolerate high levels of rights infringement as the price of personal and familial advancement. We might predict that the most immediate and possibly long-lasting impact of the pandemic on urban order will not be changes to physical order but to institutional order. Governments around the world have already shown their eagerness to use the crisis to impose new levels of social control. The draconian land-rights nationalisation of England's 1947 Town and Country Planning Act is an example of government over-reaching at a time of crisis and then not letting go. Watch for regulations on movement of people and goods that start as crisis response and then become permanent.

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