

# 1. Introduction

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For in general you will find assimilated to the nature of the land both the physique and the characteristics of the inhabitants.

(Hippocrates, 1948: 137)

The first decade of the twenty-first century was for British urban planning something of a rerun of the first decade of the twentieth century: planning was heralded as a powerful new antidote to urban public health problems. A hundred years ago, the cause was the abysmal conditions in cities that had emerged by the middle of the nineteenth century and the consequent successive waves of public health-related legislation that eventually gave rise to the modern British planning system at the dawn of the new century. This time around, it was an epidemic in obesity allied with growing concerns over the health outcomes of unequal cities, marginalized groups and problem neighbourhoods and a shift in perspective amongst epidemiologists that favoured a holistic view of health, health problems and interventions and led them to view urban planning as the ultimate public health intervention:

Understanding the urban factors that are risk or protective factors for health can capitalize on the positive aspects of urban living and lead to the development of appropriate interventions and preventive measures. Given the growing predominance of the urban living, interventions that take into account features of the urban environment have the potential to be widely applicable and to influence the health of vast number of people. (Vlahov and Galea, 2003)

In the United Kingdom, the relationship between urban planning and public health has come under renewed focus by medical and planning academics (H. Barton and Tsourou, 2000; Kidd, 2007; H. Barton, 2009; Herrick, 2009; Townshend and Lake, 2009; B. Evans et al., 2012) and public health and planning policy makers (National Heart Forum, 2007; Department of Health, 2008; NICE, 2008; RTPI, 2009). Britain is not alone in this: the same connections are being made across Europe, Australia, New Zealand (National Heart Foundation of Australia, 2004; Public Health Advisory Committee, 2008; Healthy Spaces and Places, 2009; WHO Europe, 2010) and the USA (Greenberg et al., 1994; Diez Roux, 2001, 2002; Dannenberg et al., 2003; Frank et al., 2003; Corburn,

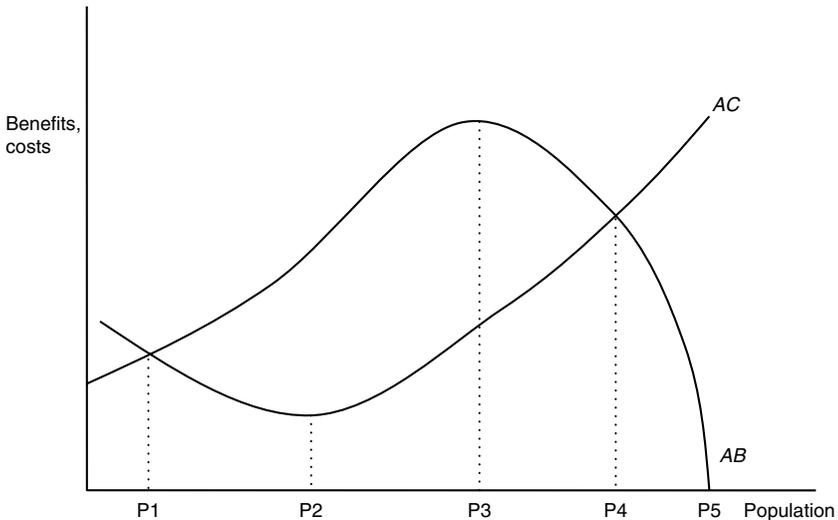
2004; Sallis et al., 2012). The developed world has been rediscovering one of the forgotten fundamental purposes of city planning. The modern scholarship picks up from that of the early pioneering ecological health studies aimed at deciphering the disparities in health and mortality. The earliest studies were conducted in the seventeenth century; John Graunt ([1662] 1939) reported on the social distribution of death from plague in London, while William Petty enumerated the costs of mortality (Petty and Hull, 1899). Towards the late nineteenth century (1886–91), Charles Booth (1889), a social reformer, conducted a detailed survey to measure and map the incidence and causes of poverty in inner London, which formed the basis of the contemporary Registrar General's social class scheme.

The relationship between health and urban development pattern has not had to be rediscovered in countries at a less advanced stage of economic and urban development. Cities in developing countries, as with European cities 150 years ago, have always been intrinsically unhealthy. The proportion of urban population increased from slightly below 20 per cent to 36 per cent over the period 1960–2000 in both Asia and Africa (Bloom et al., 2008). Increasing competition for space in the cities results in socio-spatial stratifications wherein residents of the poorer neighbourhoods typically experience inadequate housing and sanitation, lack of access to potable water, overcrowding, pollution, substance use, crime and the associated health costs. Induced behavioural changes result in sedentary lifestyles manifested by physical inactivity, psychosocial stress, increased dependence on junk or otherwise poor-quality food, and tobacco use: potential precursors for chronic non-communicable diseases. For example, the estimated mortality from cardiovascular disease in 1990 was 70 per cent higher in the developing countries (at 8–9 million fatalities) relative to developed countries at 5.3 million deaths over the same period (A.D. Lopez, 1993). A study found comparatively higher incidence rates of hypertension in the urban areas of India and sub-Saharan Africa than in the rural areas (Srinath Reddy et al., 2005; Addo et al., 2007). Another study, conducted in China, indicates that the propensity to report poor health increases with increasing degree of urbanization. Incidence rates of obesity and hypertension were also comparatively higher in urban populations than their rural counterparts (Van de Poel et al., 2012). Another longitudinal study, conducted in eight provinces of China, reported a 14 per cent increase in car ownership between 1989 and 1997 and an associated 1.8 kilogram greater weight gain, while the likelihood of becoming obese during that time period doubled (A.C. Bell et al., 2002; F.B. Hu, 2011). The world's slum population is increasing despite the rapid progress in urban environmental quality made in some parts of the developing world. The population of slum dwellers has risen from 0.75 billion in 1990 to 1 billion today, and this

has been projected to further rise to 1.4 billion by 2020 (Lopez Moreno and Warah, 2006). The ubiquitous slum and informal settlement problems that accompany rapid urban and economic development have usually helped keep sanitation and health improvement a fundamental objective of urban planning in such countries. Even in China, where there are no informal squatter settlements, the wholesale redevelopment of the so-called 'villages in the city' is driven in part by public health concerns and exactly mirrors the slum removal and city beautification and modernization movement of early- and mid-twentieth-century Europe (Wu et al., 2010).

The ongoing link between built environment and health in developing countries and the rediscovery of the same in developed countries are a challenge for urban planners, not least because they have spent very little time during the last hundred years of fashioning their craft developing a parallel science of healthy cities. This is especially so of planning in the West. Most urban planning scholarship in the universities has very little to do with empirically testing the relationship between built-form parameters (referred to as urban *morphometrics* in this book) and urban performance parameters such as health outcomes. That is something that is thankfully beginning to be redressed, and one of the aims of this book is to review progress to date and point the way forward in particular directions. First, however, we place the problem in a broader context of a simple model of urban costs and benefits in order to make the point that urban public health is something that should be optimized, not necessarily maximized.

Cities exist as a result of individuals co-locating in pursuit of wealth and welfare. They form and grow because of the economies of agglomeration. For firms, labour is cheaper in cities than in dispersed locations, as are the specialized inputs needed to make things and deliver services. For individuals, consuming is cheaper in cities because of economies in scale in consumption, producing better education and better health care, for example. Competition among consumers makes cities more innovative than dispersed locations, as producers of services and goods have to be creative in meeting people's needs and wants in order to stay in business. Competition among producers of goods and services keeps prices lower in cities than in small settlements. The advantages of living in cities over living in dispersed locations are also advantages of living in larger cities over smaller cities. Choice and price of inputs, products and services are all improved, in principle, as the number of individuals and firms clustering together in ever greater concentration rises. Economics and spatial optimization drives urban growth and, as an urban economy deepens, so does the division of labour, as people are able to develop more and more specialized skills (C. Webster and Lai, 2003). They invest in their own skills in pursuit of a labour premium but can only do this as far as they find ways



Notes: P1 = minimum city size, P2 = lowest-cost city size, P3 = city size giving maximum welfare to existing citizens, P4 = optimal city size, AB = average net benefits, AC = average costs.

Source: Derived from Alonso (1971); Richardson (1978); reproduced from Webster and Lai (2003).

Figure 1.1 Urban efficiency and city size

of meeting the demands of other individuals for ever more specialized goods and services. This virtuous deepening and diversification of human interaction is the blessing of the city. The city also has its curse, however. The curse of the city is the congestion (crowding) costs that set in at certain points as population density increases. Figure 1.1 is a classical model (after Alonso, Richardson and others) that hypothesizes the relationship of costs and benefits of agglomeration as a city grows in size. The average benefits (costs) of city living are the total benefits (costs) divided by the number of people and could be measured empirically in a number of ways.

Up to P3, the average benefits of living in the city continue to rise. After P3, each additional person has the effect of reducing the average benefits, because *crowding* effect has set in. Hospitals, clinics, general practitioner (GP) practices, and primary and secondary schools at some stage all get congested, like the roads that carry people to such services and enable people to live apart from their workplace. Investment in additional health care services and facilities, schools and roads moves P3 to the right, but, for any fixed stock of services and physical infrastructure, it is reasonable

to suppose that an inflection point is reached after which average benefits decline. Once a city is built, the cost of renewing and expanding infrastructure is a function of land price, which is itself a function of demand and therefore population and population density, so it becomes problematic to reinvest to avert the inflection point. All cities have their own demise built into their DNA. Set against the benefits curve in the figure is a cost curve – the cost of supplying urban infrastructure and services divided by the number of people sharing the costs. Up to P2, cost per person falls, as the cost of a fixed stock of infrastructure is shared by more people. At some stage, however, the average costs rise, as it becomes increasingly more expensive to purchase land, build facilities, manage them, diversify them, and innovate to meet increasingly demanding expectations. P3 is the optimal city size from the point of view of those who live in the city: the point of maximum distance between benefits and costs. It is the NIMBY size so vigorously pursued by so many local authorities in the South-East of England, for example. P4 is the socially optimal city size from the point of view of society as a whole: compared to P3, it has accommodated P4 – P3 additional people, all of whom experience net benefits. Beyond P4, the costs exceed the benefits. Rational people would not move to this city, and a rational and all-powerful government would stop a city at this size and start another one. A more enlightened rational and powerful government might insist that all cities stop at P3. Many cities in the world have clearly exceeded P4. Migrants keep flocking to them, however, because of the future value they place on urban life – the jobs they expect to get and the education and jobs they expect for their children. In the most crowded and extensive cities of the world, the health costs feature as a very significant part of the diseconomy of urban life beyond P4. The costs and benefits of size are unevenly distributed to a city's population spatially and socially. The urban sprawl and associated real estate developments in the megacities of the developing world create two contrasting configurations: the peripheral regions typically characterized by informal settlements lacking basic infrastructure and public services, with the suburban sprawl also accommodating the creation of mixed residential zones for high- and middle-income groups coexisting with high-priced commercial and retail complexes. Such spatial disparity in wealth and quality of life aggravates socio-economic segregation and health inequity with significant health costs (Frumkin, 2002; Frumkin et al., 2004). According to the latest projected estimates for 2015, the urban agglomerations of Lagos (20 501.35), Metro Manila (20 086.98), Mumbai (19 337.99), Surat (17 119.91) and Seoul (15 967.40) will have the highest population densities in persons per square kilometre (United Nations, 2012). Each of them belongs to a developing country in Asia or Africa. They could well be out-of-control primate

cities with no hope of servicing their populations adequately. They illustrate the power of the hope that governs mass rural–urban migration and the reality of hope deferred or lost as the net real benefits of urban living remain static or are squeezed beyond P4 in Figure 1.1 – squeezed towards parity with rural subsistence living (the ultimate alternative and opportunity cost facing the urban poor) or worse (since the transaction costs of relocating are high for most urban poor families and they are therefore, to a degree, trapped).

What, then, may be said about public health and urban planning on the basis of this simple but profound and resilient model?

First, at low levels of per capita investment in urban physical and social infrastructure, health risks soon surface as a limiting constraint to the benefits of urban agglomeration. This is where London was at the end of the nineteenth century and modern cities in less developed countries have been during the last 50 years or so of massive urbanization. Cities in developing countries typically find it difficult to raise sufficient tax revenues to provide for the health standards that the West has become accustomed to.

Second, the West also finds it difficult to sustain the standards it has become accustomed to. Owing to rising labour costs, rising costs of medical technology, changing demographics and the high costs of organizing health care supply, for example, the cost of sustaining a city at P4 are probably on the increase (AC moves upwards). This leads to the intriguing hypothesis that rising health care costs imply the need for smaller cities. This is because higher health care costs that do not raise the benefits of urban living commensurately raise the general costs of supporting an urban population, and the higher the general costs the lower the population that can be efficiently accommodated for a given set of agglomeration benefits. It should be noted in this respect that, despite the huge inflow of public funds into the British National Health Service over the last decade (NHS expenditure increased by 70 per cent from £60 billion to £102 billion in the first decade of the twenty-first century), total UK NHS productivity has gone down by an average of 0.2 per cent per year over the period 2000–01 to 2010–11. Over the same period, productivity in hospitals fell by 1.4 per cent per year (Comptroller and Auditor General, 2010). The scientific relationship between health, health care costs and settlement size is an under-researched issue.

Third, investments in health care technology (as opposed to labour-related and other unproductive cost inflation) raise the benefits of living in cities (moving AB upwards in Figure 1.1). Specialized health and hospital services and the latest medical technology are classical agglomeration benefits represented by the AB curve. They are found in cities because of economies of consumption and production: larger concentrations of people

create demand for more costly and more diverse services and equipment, which can be provided in cities at a cheaper unit price.

Fourth, a long-standing and widespread urban planning doctrine (not a scientific principle) is to design cities at the neighbourhood scale around core services, especially primary schools, but also primary health care such as GP surgeries and clinics. Physical layouts of new urban development in many cities across the world are planned under certain assumptions about the numbers of homes and people efficiently clustered around a set of core neighbourhood services. One definition of a healthy city (in the sense of being well provided with health care facilities) is one in which health care services and facilities are organized in size and location in a way that optimizes their effectiveness. If the horizontal axis of Figure 1.1 is reinterpreted as being the population co-consuming a given health service or facility, then P4 is the optimal population catchment. If there are many such services in a city or region, then one of the tasks of urban planners working with health care planners is to coordinate with each other to ensure an optimal allocation of services across the population: something that inevitably leads to a hierarchy of services with local services nested within the catchment of services that require a larger threshold for efficient provision. This is never a perfectly efficient process, however, since health care facilities are lumpy and the services provided within them inevitably either over- or, more likely, under-supply the urban population, which is never exactly equal to the breakeven threshold of the bundle of services provided at a facility. It may be noted that market-like institutions introduced into public health organizations over recent decades can improve the efficiency of the spatial health economy. If health care buyers representing patients in one city can buy services supplied in another and patients assume some of the costs of being mobile customers, then there need not be such a closely matched or tightly designed configuration of health services and population and the intrinsic inefficiencies of inevitably lumpy health facility planning can be mitigated.

Fifth, and most important for the focus of this book, health problems are part of the cause of the benefits inflection in Figure 1.1. Some health problems are directly caused by crowding. Respiratory problems, stress and mental illness can be caused, or exacerbated, by living near or using overcrowded roads, for example (Babisch et al., 1990, 1999; Oftedal et al., 2003; Nordling et al., 2008; Pujades-Rodríguez et al., 2009). Mental health problems result from congestion in the labour and housing market. High-density living is associated with diseases related to dampness, airborne pollution, exposure to industrial waste-borne toxins and so on (Ginns and Gatrell, 1996; Elliott et al., 1999; Gómez-Jacinto and Hombrados-Mendieta, 2002).

This brings us to the main focus of the book: investigating the relationship between urban design (or, put another way, built environmental configuration or urban morphology) and health. Chapter 4 reviews this relationship at a fine level of detail. The aim is to offer a definitive review at this point of time which tries to capture all that is currently known of any significance about the relationship.

We preface the scientific review in Chapter 4 with the observation that there seems to be a widespread intuitive belief that the design of the built environment has an effect on health outcomes. It is not surprising that urban planners have readily accepted this, since it bolsters their professional justification. That the epidemiological and medical practitioner community has accepted the belief is more significant in the sense that these professions have nothing to gain and possibly something to lose by admitting the built environment into the lexicon of their associative and causal models and intervention mechanisms. The relationship is an intuitive one: it is plausible and makes sufficient common sense for journalists to rally to the cause. The scientific basis for this belief is controvertible, however. Urban planners tend to work by doctrine, not by science. One objective of the book is to lay the science before the planning community and propose theoretical and empirical models that will help establish an empirical evidence base for healthy city planning. At most, there is a weak relationship between urban morphology and health outcomes. Weak relationships are important nevertheless. They can still guide our urban designs, plans and policies, thereby acting as crucial public health interventions aimed at minimizing health risks and hence costs. What we should be doing is to try to measure them more accurately so that we can progressively build up a knowledge base about healthy city attributes and performance.

To this end, the book introduces an approach to measuring morphometrics that goes beyond any other study yet published in terms of level of spatial detail and matching of this to individual health records. The book revolves around an ongoing research project based at Cardiff University, the University of Hong Kong and Cambridge University, the first phase of which involved what we have called the *spatial Design Network Analysis for Urban Health (sDNA-UH)*, a high-resolution GIS and network analysis model comprising a series of built environment (BE) morphological metrics (morphometrics) coupled with socio-demographic, lifestyle and health variables. The first phase of this study focused on one of the UK's most comprehensively studied epidemiology laboratories: the assembly constituency of Caerphilly, South Wales (83 600 inhabitants over 114.54 square kilometres, with a density of 727 inhabitants per square kilometre). UK Ordnance Survey MasterMap (OSM) data layers – the Topography

Layer, Integrated Transport Network (ITN) Layer and Address Layer 2 of Caerphilly – were employed as the base sources for built environment data, and a robust set of morphometrics were measured at the dwelling level as well as within specified street network buffers around an individual respondent's dwelling unit. GIS-based spatial analysis and network models have been employed to construct more than 100 objectively measured BE morphometrics for each member of the epidemiological study cohort, broadly categorized as: dwelling level, land use, street network accessibility, physical environment and area-level deprivation variables. These have been matched to individual socio-demographic and health data from a long-established panel study of elderly men to test the effects of the built environment on individual health within this sub-population at multiple spatial scales.

Chapter 2 traces the origins of public health and city planning and describes the evolving paradigms of epidemiology as definitions of health have changed in response to emerging social costs of urbanization and changing disease aetiology. It concludes by highlighting the contemporary shift towards a paradigm that is holistic and multidisciplinary, giving due credence to both biomedical and contextual (social, built and natural environmental) determinants of health.

Drawing together diverse strands of research evidence, we introduce the concept of the urban *health niche* as a fundamental public health planning paradigm in Chapter 3. The framework endeavours to integrate four key elements: (1) the multiple spatial scales at which various health-defining processes function; (2) levels of organization for studying health, from the individual to the population level; (3) the health-promoting and -inhibiting attributes of space; and (4) temporal dynamism. Given the complexity of the notion of a healthy city, we employ the concept of urban health niche to conceptualize a bottom-up model that incorporates and integrates the multiple, multi-level health determinants existing at the different spatial hierarchies in a city system.

Chapter 4 provides a systematic review of the epidemiologic, public health and health geography literature on built environment and health, following the urban health niche model. Determinants of health are discussed in detail at the housing, neighbourhood and city levels.

Chapter 5 discusses the methodology involved in the development of the spatial Design Network Analysis for Urban Health and its component morphometrics. State-of-the-art spatial and network analysis techniques are employed to quantify various facets of the urban environment that have the potential to influence an individual's health.

To illustrate the evidence-based approach to healthy city planning advocated in the early chapters of the book, Chapters 6–8 present a series

of epidemiological models that attempt to measure the degree of association between various parameterized features of the built environment and various health outcomes, specifically obesity and mental health outcomes.

In conclusion, Chapter 9 reflects on what has been achieved by the conceptual and empirical innovations presented in the book, sets out elements for an ongoing research agenda, and poses challenges for researchers, students, professionals and policy makers working in the healthy cities field.