Plenary II

The Spatial Syntax of Health:

On the dynamic interplay between human bodies and human environments

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ABSTRACT

The need to consider the organic and biological contingencies of place when undertaking health research was central to this keynote session. Laura Vaughan's talk in the first half of the keynote covered two key aspects of urbanism in space syntax theory: first, that how where you live shapes your social, economic and health outcomes; and second, how the position of that location within the wider city is of equal importance, since being spatially segregated from life beyond your neighbourhood can have just as profound an effect on life outcomes as the circumstances of the street where you live.

Professor Vaughan's keynote covered the history of mapping health from the early 19th century till today, to show how a specifically socio-spatial approach can enrich research into patterns of disease. Bringing a space syntax lens to health studies, by taking account of the configuration of the built environment, we can start to find ways to make significant contributions to make environments healthier. Mapping of non-communicable disease also reveals the important role of the environment – which can either enable healthy lifestyles or have a negative impact on it.

The talk from Rosie McEachan highlighted the revolutionary approach of the Born in Bradford cohort study, which follows the lives of over 60,000 residents living in a multi-cultural, deprived city in the North of England to find out why some families stay healthy and why others fall ill. Using a City Collaboratory approach, the project works with the local government authority, health, education and voluntary sector providers across Bradford district to develop, implement and evaluate programmes to improve population health. With a focus on environmental

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determinants of health she described how the evidence collected from their 'people-powered' research programme led to policy change in the city.

The two speakers then jointly outlined the benefits and challenges of working across disciplines. Starting with the strengths and mutual learning to be found in interdisciplinary research, the presentation will outline the critical differences, such as in concepts, in timing, as well as epistemological differences. Issues of how each discipline meets the demands of producing evidence of what works, when research timescales differ from the policy-maker's requirement to address an urgent societal/political/economic challenge are one of the matters that was discussed. Lastly, how academic researchers can make what they do useful, developing relationships with decision-makers for example, closed the session.

KEYWORDS
Environmental Health, Social Cartography, Population Health, Community Participation, Bradford

1 ON THE DYNAMIC INTERPLAY BETWEEN HUMAN BODIES AND HUMAN ENVIRONMENTS

1.1 Introduction: How is health a spatial issue

Nikolas Rose and Des Fitzgerald recently stated that we should consider the organic and biological contingencies of place when undertaking health research (Rose and Fitzgerald, 2022). In fact, we can go back millennia to find writings on how health is bound up in environmental disadvantage. Indeed, some historians cite 'On Airs, Waters, and Places' (Hippocrates c. 400 BCE) as the first to assess climatic, topographical and geographical conditions to seek patterns of disease in local populations, while an architectural treatise by Sir Balthazar Gerbier from 1663 highlighted how building on low ground, by the river, "makes work for physicians, apothecaries, surgeons, coffin and grave-makers" (Gerbier, 1663).

By the nineteenth century doctors were seeking to improve their practice by searching for regularities in socio-medical phenomena by plotting them on maps. The maps were used by doctors as a tool for seeking causal relationships in the variety of environmental factors which may have led to outbreaks of disease. One of the earliest was drawn by Seaman, in his 1798 inquiry into the causes of yellow fever in the area around Wall Street, of New York. As was pointed out in *Mapping Society* (Vaughan, 2018), dozens if not hundreds of maps were

subsequently drawn up in the following decades in an attempt to analyse the causes of infectious disease (Figure 1). Yet it was only with John Snow's famous 1854 map of cholera in Soho, that spatial analysis of health data shifted into a mode recognisable today, with supporting statistics used to draw conclusions that the causes of the cholera outbreak of the previous year could be attributed to the water being drawn from a single pump in Broad Street.

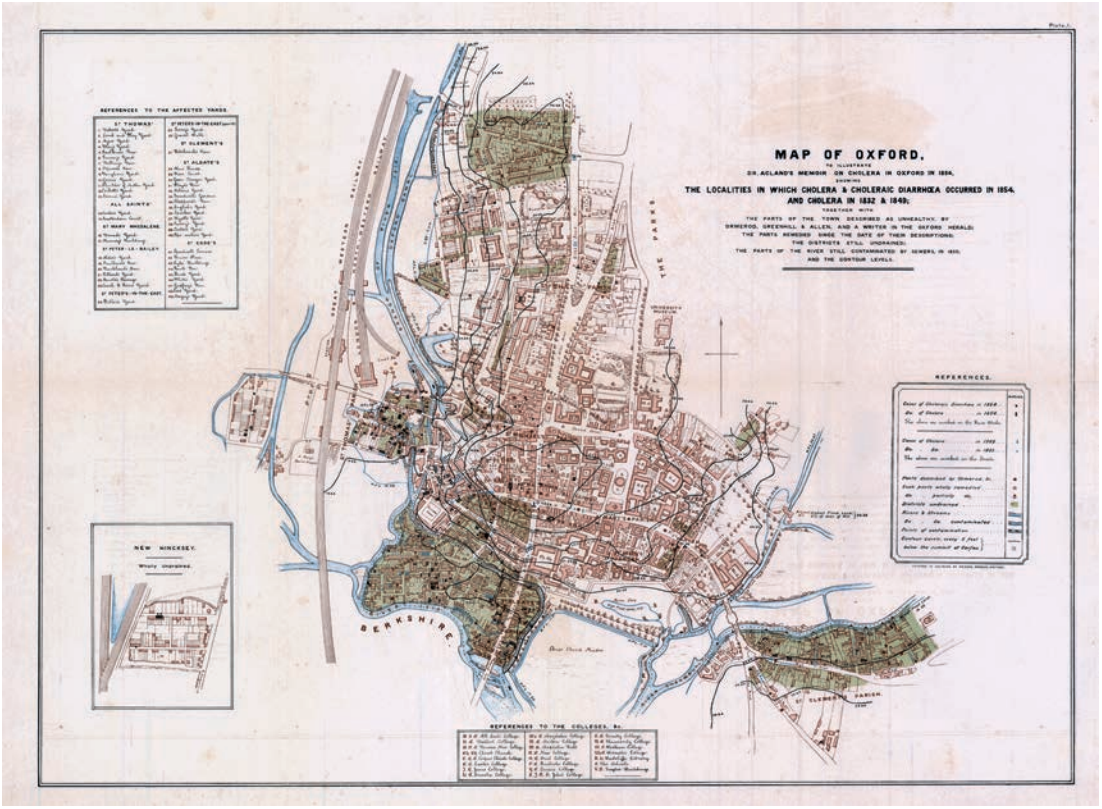


Figure 1: Map of Oxford. From Acland's Memoir on the Cholera at Oxford, in the Year 1854, with Considerations Suggested by the Epidemic (London: John Churchill, 1856). Image from http://libweb5.princeton.edu/visual_materials/maps/websites/thematic-maps/quantitative/medicine/medicine.html.

In the subsequent decades diseases started to be attributed to specific external causes. It was becoming clearer that overcrowding, the overly dense packing of people in space, a want of light, air, ventilation or proper convenience, or to any other sanitary defects were bad for health – though, as Robin Evans pointed out in his classic paper, Rookeries and Model Dwellings, using terms such as rabbit warren, or rookery, shows how the concerns were just as much about apparent moral degradation as a concern with disease (Evans, 1978). Not just at building scale, but the spatial configuration of city streets was increasingly being understood as shaping patterns of disease.

Although not fully understood as such at the time, the efforts put into mapping disease by nineteenth century medical cartographers were resulting in better understanding of how the environment shapes patterns of disease. For example, the mapping of the setting of a devastating outbreak of yellow fever in New Orleans, 1853 demonstrated a clear association between topography and spatial layout (Stevenson, 1965); the same was found in an analysis of typhoid in Wellington, New Zealand 1890. See Figure 2 and Schrader, 2016.

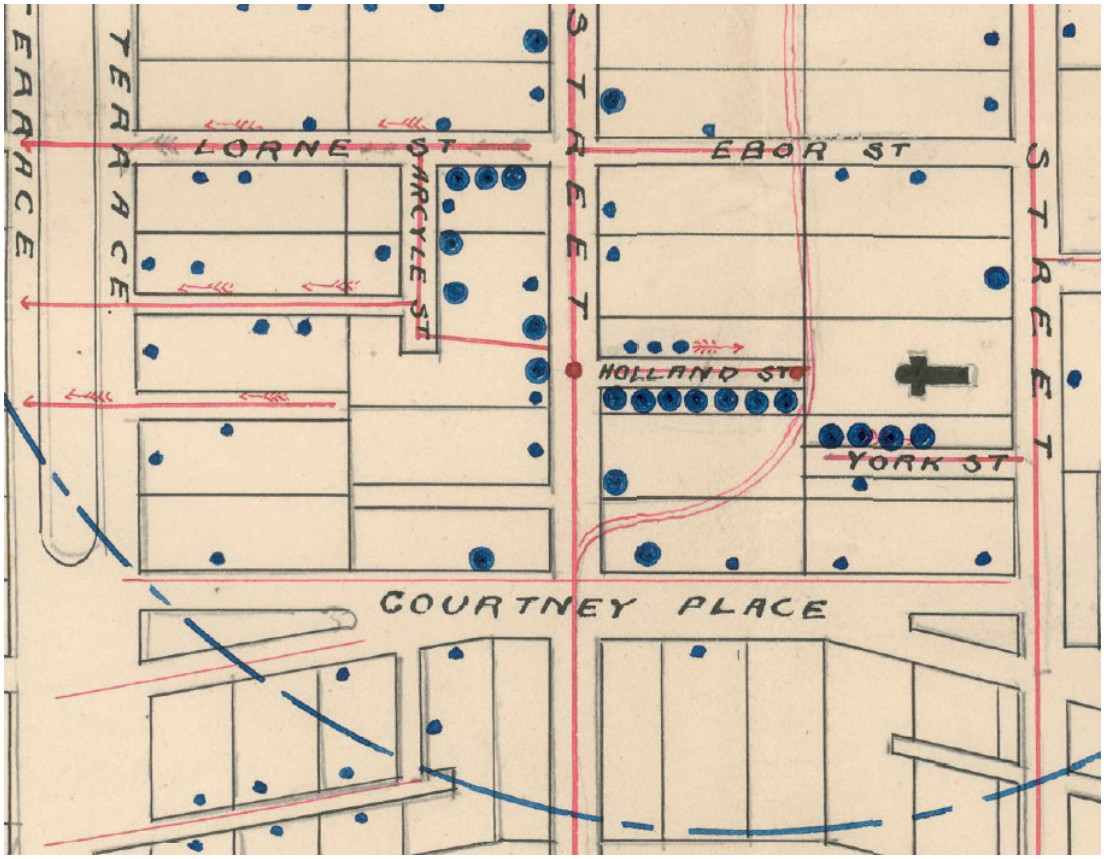


Figure 2: Section of map of central Wellington drawn up by the city's medical officer, William Chapple, to show the location of typhoid between 1890 and 1892, highlighting a leaking sewer as the apparent cause. Source: Wellington City Archives. Reference: 00233:34:1892/740 typhoid map

We should not forget that spatial conditions can have a variety of unexpected outcomes: in the case of the outbreak of bubonic plague in the crowded streets of Johannesburg, 1904, it was somewhat ironic that the consequence of the city's racial housing laws was that rather than spreading around the city, disease was contained within its ethnic communities (Evans et al., 2018).

Similarly, the long-term impact of spatial conditions needs to be better understood. One important instance is redlining the US. Recent studies of rates of mortality and morbidity in

formally redlined areas substantiates the idea that spatial patterns are persistent over time, with people suffering from disease today that can be attributed to an area's formerly redlined status in the past (Hoffman et al., 2020). Environmental conditions are similarly critical in other sorts of disease mapping, whether it is studying climatic conditions and tree canopy coverage in analysis of excess deaths from heat waves in Paris (Dousset et al., 2011), or in earlier work by Dorling and colleagues on childhood poverty-related disease. The latter – as has been written about at length before – revealed the problem of spatial persistence in health disparities in an early study of the Charles Booth maps of poverty (Dorling et al., 2000; see also Vaughan, 2008 and subsequent publications by the author).

Equally important to temporal persistence are spatial inequalities. Understanding how poverty, health and the environment interrelate is usefully illustrated by analysis which shows disparity of health outcomes across a country, or even more narrowly, within cities. Ultimately, we hope to link this strand of research to the longstanding interest we have in the positive role high streets can play in people's lives: as places good for health and wellbeing as well as economically and socially.

1.2 Mapping health

It is no coincidence that John Snow's pioneering work on mapping disease in the 1850s is still known to public health experts today. Since that time, health has gradually been understood as a problem that has spatial and environmental determinants. The mapping of disease evolved first to identify clusters of disease, then as a diagnostic tool to investigate interaction with environmental conditions, through to contemporary applications of mapping to record and track both communicable and non-communicable disease. Taking the example of research into the spread of malaria, still a matter of suffering for millions of people worldwide, is illustrated by a recent study that mapped anonymized mobile phone location data with genetic data of the parasite that causes the disease (Wesolowski et al., 2012).

Mapping of non-communicable disease, such as obesity also reveals the important role of the environment, which can either enable healthy lifestyles – for example by providing safe places to socialise and be active; or hinder health – for example by creating so-called obesogenic environments. Throughout the twentieth century we see public health experimentation in preventative healthcare, such as in the Pioneer Health Centre, set up in a south London suburb in 1926. The Born in Bradford project builds on this approach in many ways, as will be explained below.

Some of the most challenging aspects of built environment research is considering the interaction between urban planning and design decisions and mental health – for example, to what extent does an environment that gives rise to opportunities for interaction, shape rates of social isolation and its associated problems of poor mental health? Our recent study attempts to shed light on whether proximity to green spaces is good for mental health, taking advantage of the best geographical analysis that allows us to map house moves, to put some precise numbers on this challenging form of analysis (Subiza-Pérez et al., 2024) and we are collaborating with mental health colleagues on how the environment shapes loneliness and social isolation (Hsueh et al., 2022).

In another recent development at the Lab, a walkability index was developed to inform interventions in cities. The model has been to assess where to make investments in improving the public realm of areas that are walkable, but are in have high levels of motorised traffic (Dhanani et al., 2017). Our work on assessing community severance is another example where interdisciplinary health research has resulted in publicly available toolkits (Anciaes et al., 2017).

In our most recent collaboration with Connected Bradford, a whole-city dataset, we have developed environmental indicators for Bradford, Liverpool and beyond to help pinpoint the multiple problems of dealing with health in place. See Figure 3 and Krenz et al., 2023. This approach allows us to research in a novel way: 1) we consider individual addresses, rather than area averages; 2) we use a distance decay method to differentiate between land use points that are nearby vs. those that are farther away (as distinct from using standard cut-off distances of 800m, 1500m and so on).

Taking one of the indicators, proximity to fast food, we can add a greater nuance to this vast research enterprise by looking at the proportion of fast food from all food available. The latter stems from our approach that suggests that it isn't access to unhealthy food that is necessarily the problem, but rather situations where there is much more unhealthy food, than healthy food in the vicinity – so an absence of dietary choice. Setting these data against poverty statistics and then against health outcomes enabled us to analyse in much greater precision the relationship between diet and poor health in children (Krenz et al., 2022).

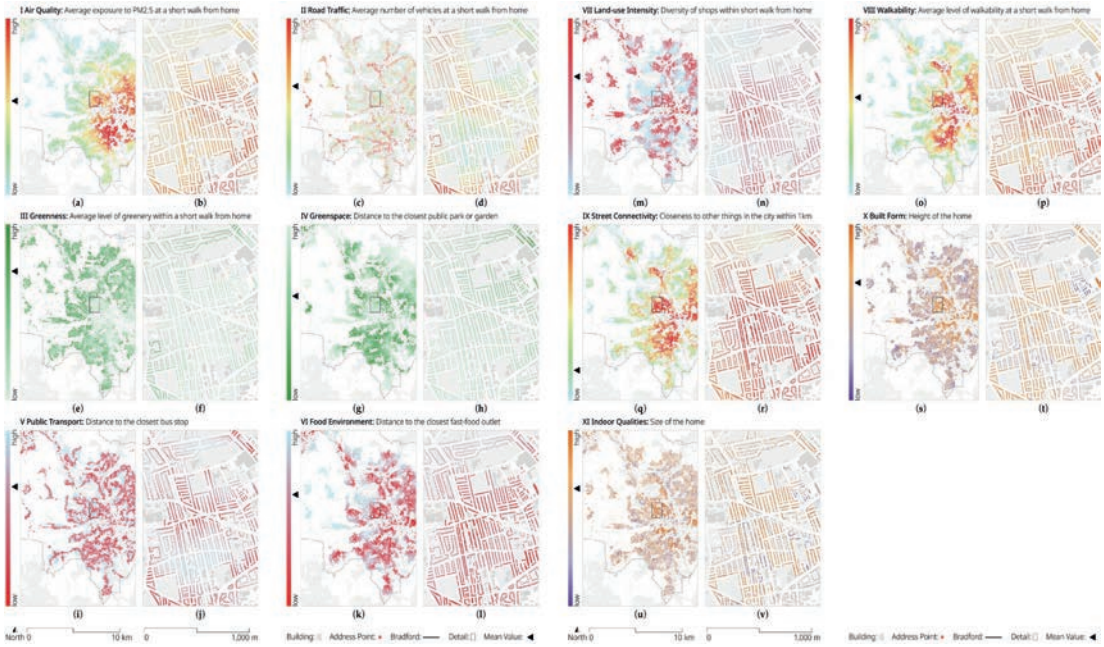


Figure 3: Environmental indicators for 11 domains of the built environment in Bradford, UK (Krenz et al., 2023)

Future research will also look at access to healthy food that takes account of culturally relevant dietary needs. One approach takes a notional food baskets and surveys food shops in an area to assess the cost of affordable food that is relevant to the people in question (for example yams or rice may be a more important staple than potatoes for some groups). See studies on 'food deserts' by ethnic group (e.g. Scholes et al., 2014).

1.3 Conclusions to part 1: configuring healthy places

The translation of research into practice dates from the 19th century, when public health was a research-driven policy domain, with edicts regarding clean water and clean air continues till today, alongside new ideas such as recommendations regarding healthy high streets for their importance both for mental and physical health.

Well-designed high streets can be seen as a public health asset. They can provide public space that is inclusive of people from all backgrounds and ages – and accessible to people of all levels of mobility; they can provide a centre for people to gather, to feel relaxed and to connect with others socially. They are therefore important both for physical and for mental wellbeing. (Grimsey et al., 2018)

Recent work highlights how we need to evaluate accessibility through public space in a way that is closer to what people may perceive and experience in their everyday life (Koch and Legeby, 2022). It goes without saying that these are intersectional problems: women with disabilities, or from ethnic minority backgrounds, may find many of these problems to be intensified for all sorts of reasons, so analysis of access to urban resources for people with different status in the city is vital (Rokem and Vaughan, 2017).

A classic film by Robert Vas, *Refuge England* (1959), shows a fictitious Hungarian refugee arriving in London at Waterloo Station with only an incomplete address, Love Lane. We follow him as he wanders round London's streets trying to find the elusive street, encountering hostility, or simply indifference. The film highlights the protagonist's despair at repeatedly failing to find his destination. Film critics have commented that there is an element of flâneur to his wandering, although one might argue that the focused, determined quest to find a home in a strange city hardly corresponds to the 'loafing' aspect to wandering that *flâneur* suggests. Indeed, even less so would be the case for a female migrant

As Janet Wolff has written, the concept of flâneur fails to describe the particularly female experience in modern times (Wolff, 1985). It certainly overlooks the experience of the poorer migrants who populate cities today. Thus, we need an approach to mapping the urban ecology that allows us to capture the spatial complexities of the city as it is experienced by all its dwellers.

And so, to the future of research in this area. I argue that health research needs to measure the specific characteristics of the urban environment as an inhabited space, capturing its capacity for reconnecting, overcoming, enjoying, or dealing with adversity. This is where I see the potential for fruitful collaborations between the health sciences and space syntax, which seeks to measure the built environment at a level of resolution that should allow for a more precise description of the vital city. This is where my ongoing collaboration with Professor Rosie McEachan comes to bear.

2 HOW DO PLACES AFFECT OUR HEALTH? AND WHAT CAN WE DO ABOUT IT? BY ROSEMARY MCEACHAN

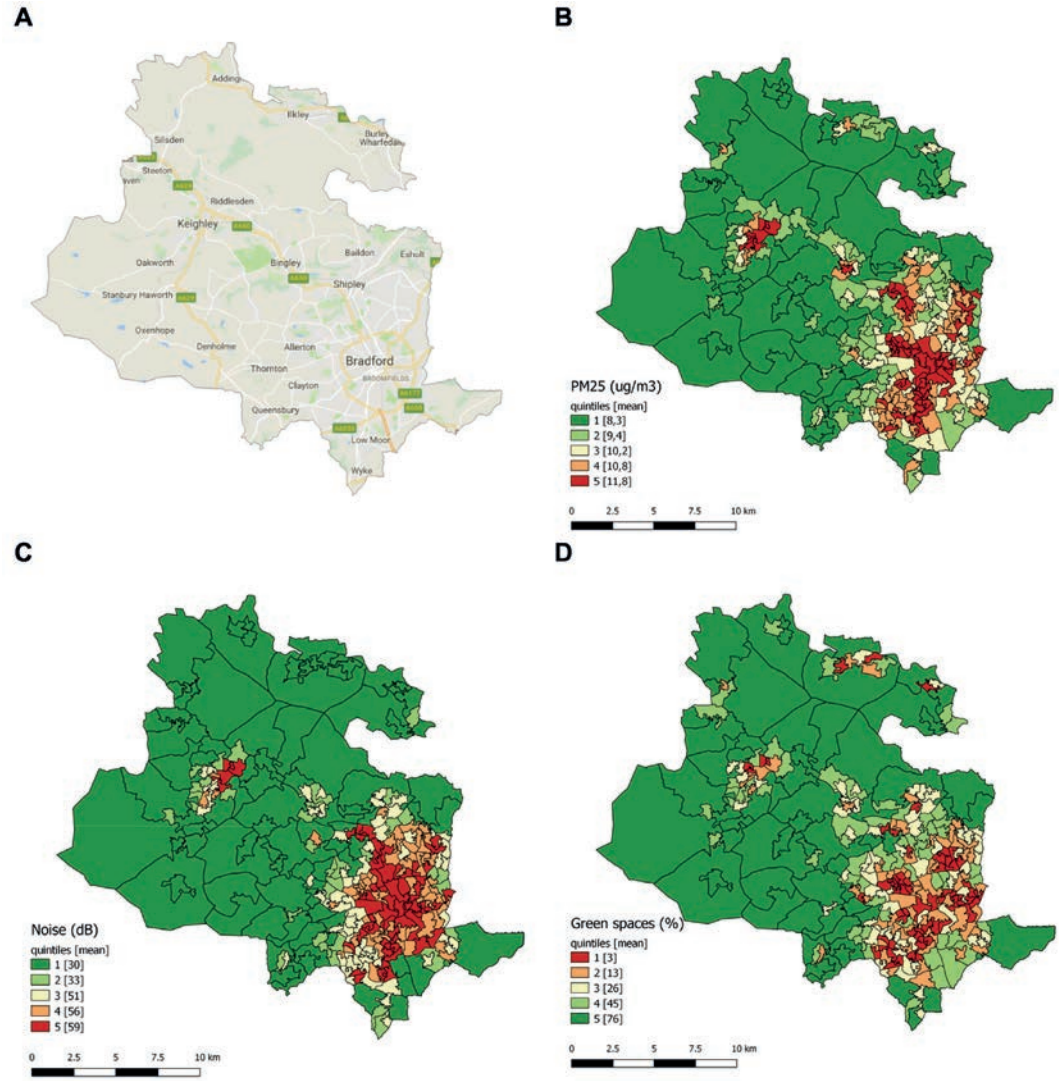
2.1 Introduction

The key to public health is to support families to live healthy and productive lives, and putting in place support and initiatives to prevent ill-health and health inequalities. Much of health burden experienced in the higher income countries from conditions such as obesity, diabetes and mental ill-health is preventable. Risk factors for these illnesses include lack of physical activity, smoking, drug and alcohol use, and unhealthy diets. And the burden of this preventable illness is not equal. In the UK, like many other countries in Europe, communities who are living in the most deprived areas experience the worst ill-health (Marmot, 2005).

The importance of the places in which we live as drivers of population health has been well-understood by policy makers and researchers since the first Marmot review of the 'social determinants of health' was published (Marmot et al., 2010). Features of the local environment including access to high quality green spaces, healthy food environments, housing, transport were identified as key for health. However, the review also showed that deprived communities are disproportionately exposed to multiple environmental burdens, further exacerbating health inequalities.

The City of Bradford, located in the north of England, UK is home to a population of over 546,000. It is a vibrant multi-ethnic city, with 57% of the population identifying as white British, and 25% as of Pakistani origin. It is one of the youngest cities in the UK with 15% of the population under the age of 15. However, the latest statistics from the UK Government OHID show that like many urban areas, it is has challenges. Levels of ill-health in the city are above national averages. A third of families living in the most deprived decile of areas in England according to the index of multiple deprivation, and there are high levels of inequality with families the poorest areas living on average 20 less years of healthy life than those in the most affluent areas.[1] There are also high levels of environmental burdens such as pollution, noise and lack of green spaces, which tend to cluster in the most deprived areas (see Figure 4).

[1] https://ubd.bradford.gov.uk/about-us/poverty-in-bradford-district/; https://bdcpartnership.co.uk/strategic-initiatives/ria/ric/.



A=Major road network of the Bradford district.
B=$PM_{2.5}$ concentrations (2009/ 2010) at LSOA level.
C=Noise levels L_{den} (2006) at LSOA level.
D=% green space (2012) at LSOA level.

Figure 4. Major road network and environmental exposures at LSOA level (reused from Mueller et al., 2018)

Bradford is home to the longitudinal applied research programme Born in Bradford (BiB), which has been tracking the health and wellbeing families living in the city since 2007 (see Figure 2). Between 2007-2011 it recruited 12,453 women with 13,776 pregnancies and 3448 of their partners to a long-term study of factors which influence health and happiness (Mceachan et al., 2024). It hosts the Connected Bradford database (Sohal et al., 2022), a population based routine linked dataset integrating data from multiple sources, including health, education and local authority sources, and more recently detailed environmental indicators, described in the first

part of this keynote (Krenz et al., 2023). BiB works closely with communities and decision makers to use findings to influence policy.

2.2 Current knowledge on how environments influence health

A major strand of research has been to understand how environments influence health. Our learning is summarised below:

Totality of exposure

Communities experience the places they live as an 'interacting system'. For example, high levels of pollution may go hand in hand with fewer green spaces, more traffic and noise, but greater walkability. In order to disentangle the full impact the environment has on health it is important to understand these factors in combination. The concept of the 'urban exposome' which encapsulates a range of different urban exposures has been instrumental in understanding the complex ways in which environments influence health. In partnership with other EU cohorts we have found the urban exposome to be linked to birthweight, children's brain development, childhood obesity and telomere length (an indicator of biological aging). See Clemente et al., 2019, Nieuwenhuijsen et al., 2019, Vrijheid et al., 2020, Binter et al., 2022.

It is quality rather than quantity that is important.

Much research has explored the impact of green spaces, often measured using a satellite-based measure of surrounding greenness e.g. vegetation, trees, grass) called the Normalised Difference Vegetation Index (NDVI), and / or access to major green spaces. However, these metrics fail to capture the lived experience of communities in these areas. In Bradford, deprived areas have lower levels of surrounding greenness, but greater access to formal green spaces (Subiza-Pérez et al., 2024). However, this greater accessibility does not necessarily equate to greater use. Green spaces in deprived areas tend to be of lower quality and there are a range of barriers which communities face in accessing them, including fear of antisocial behaviour, fly-tipping and littering (Cronin-de-Chavez et al., 2019), see Figure 5. Using data from the BiB cohort study, we found that community satisfaction with local green spaces was a more important predictor of children's mental health at age 4-5 that satellite derived metrics of green space, or level of green space use (Mceachan et al., 2018), and that dissatisfaction with local green spaces was also predictive of increased symptoms of anxiety amongst BiB cohort mothers. Methods of assessing the quality of local environments at scale, which incorporate community

priorities are few. (Subiza-Pérez et al., 2024). Addressing this will be important to fully understand the impact of local environments on health and wellbeing.

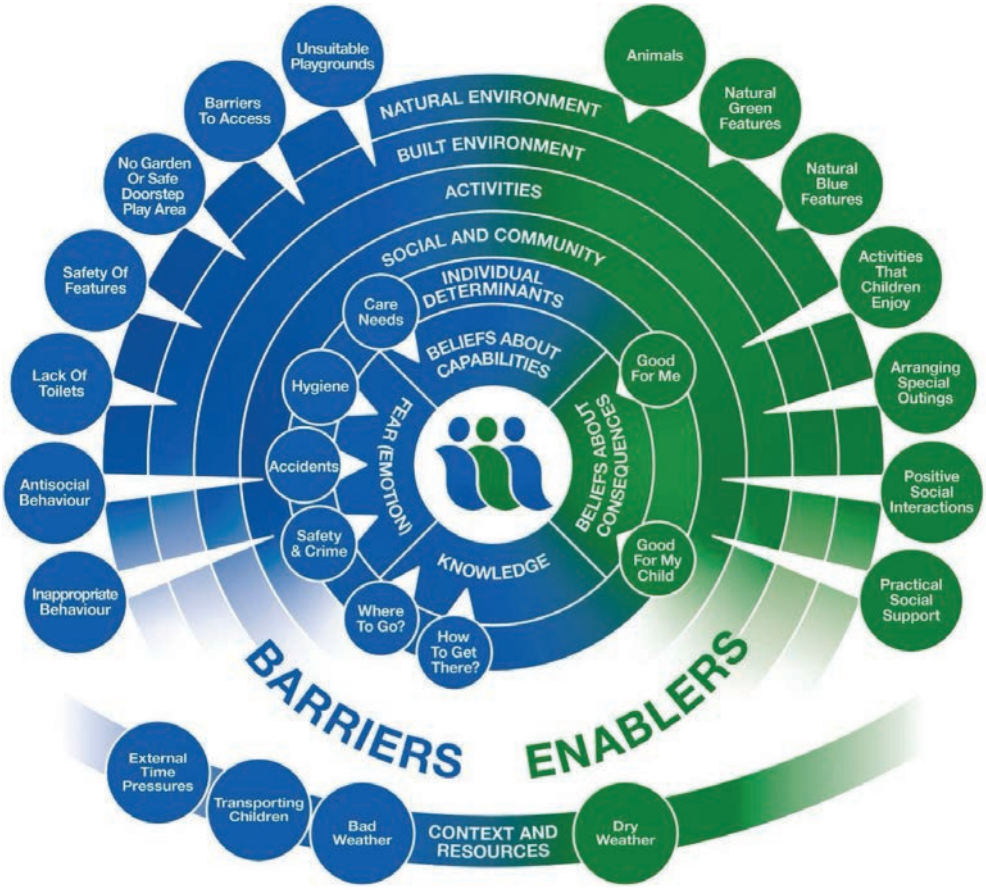


Figure 5: Barriers and enablers to green space use amongst multi-ethnic families with children aged 0-3 (From Cronin-De-Chavez et al., 2019)

Moving can be good (or bad) for health

Until recently, much epidemiological literature exploring associations between environment and health have focused on cross-sectional associations, limiting interpretations of potential causality. 'Big' population data such as the Connected Bradford dataset (Sohal et al., 2022), which can track the spatial movements of populations can offer us novel quasi-experimental approaches for exploring potential causal impacts. A recent analysis mentioned above by Subiza-Pérez and colleagues found healthy residents moving to a more polluted area were associated with a 10% increase in the chance of being prescribed medication for common mental disorder one year later. In contrast, moving to a greener area was associated with a 7% decrease in prescriptions (Subiza-Pérez et al., 2024). While they found no difference in the

impact of unhealthy environments for those with evidence of mental ill-health at baseline, they did find that residents with mental ill-health at baseline tended to move into more polluted parts of the city, which could potentially exacerbate existing illness. But moving home to escape unhealthy environments is a privilege afforded to communities with high levels of financial security, begging the question, who is left behind and what environments do they find themselves living in?

Entrenched spatial injustices persist and these have disproportionate impacts on vulnerable groups.

Figure 6 shows how many environmental stressors can cluster together within certain spatial areas, usually corresponding to the areas of greatest deprivation (Marmot et al., 2010). Using information from a variety of environmental indicator domains including pollution, traffic, lack of green space and poor food environments (defined as density of fast food outlets) McEachan et al (in preparation) explored how exposure to multiple 'risky' domains (defined as being in the top quintile for the district as a whole) varied for different ethnic and socio economic groups using data from N=4949 children enrolled in the BiB study. They found stark differences to exposure by ethnicity. Half of Pakistani origin children and one third of other ethnic minority children were living in areas with multiple environmental hazards, compared to only 7% of white British children. They did not find any patterns in exposure in relation to financial security, an individual level marker of socio-economic status. They found generally higher levels of healthcare use for ethnic minority children, but that the differences in comparison with white British children increased with increasing environmental burden, indicating they are being disproportionately impacted by these environmental stressors. It is not surprising to understand why ethnic minority children are exposed to more risky environments, when one considers the spatial characteristics of the areas in which they live (see Figure 3), which correspond to the unhealthiest areas of the city (Figure 1).

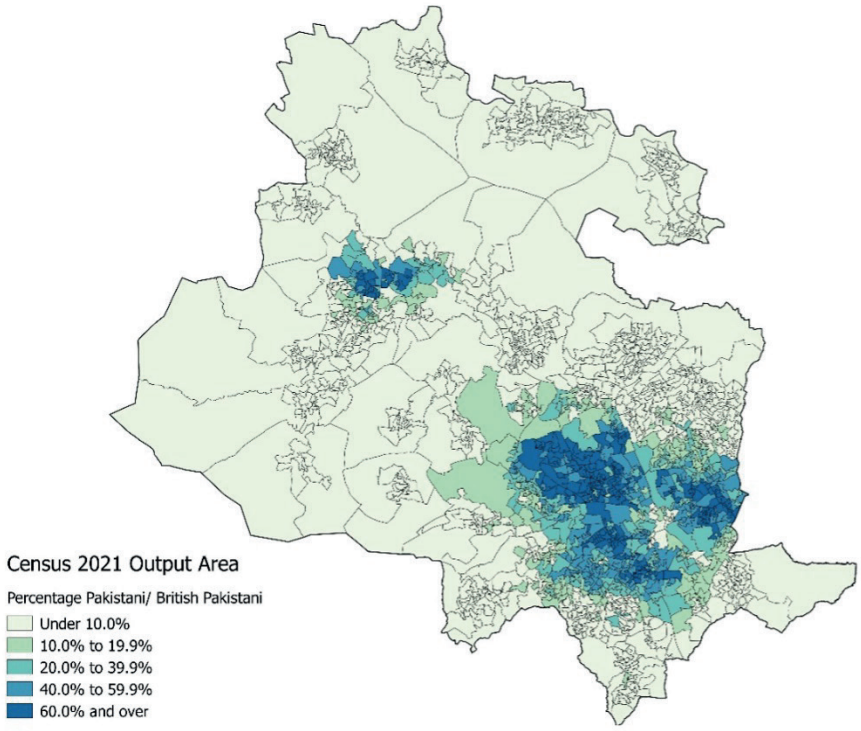


Figure 6: Percentage Pakistani/ British Pakistani by output area from 2021 Census, https://www.nomisweb.co.uk

Numbers only tell us part of the story

To truly understand the full impacts of the how the places we live impact on our health, and what we need to do to improve environments, we need to move beyond numbers and create a dialogue between communities, decision-makers and urban planners. For example, research with multi-ethnic and seldom heard communities living in deprived areas of Bradford has highlighted how local green spaces can become 'no-go' areas because of fear of crime:

"I don't think this place, this area is safe at all, this area is not safe, we've had stabbings, we've had gun shots, we've had fights, we've had drug dealing and I don't think this is an area, well this street, I don't think I'd allow my child to play on these streets…" P11 (Mum, Pakistani). (Cronin-de-Chavez et al., 2019).

Nothing about us, without us

It is clear that improving environments has the potential to offer a myriad of benefits to improving population health. But although the evidence on the importance of environmental

factors on health is clear, unfortunately there is less evidence on HOW we should intervene to improve environments – what evidence there is, is sparse and inconsistent (Ortegon-Sanchez et al., 2022) , partly due to a lack of systematic approaches for conducting built environment research into health (Ortegon-Sanchez et al., 2021). It is evident that co-production with communities, stakeholders and researchers is crucial to achieve acceptable, feasible, and sustainable changes. There is no one size fits all to co-production, but by building on core values of trust, reciprocity and agency and ensuring that seldom heard groups are included centrally will be good starting points. Table 1 outlines nine principles of co-production identified as part of the development of a wider co-production strategy to effect system-based change. We can show that by working hand-in-hand with local communities we can achieve healthy environments that suit their inhabitants.

TABLE 1: Nine guiding principles for co-production adapted from (Albert et al., 2023)

Principle 1:	Power should be shared amongst all partners
Principle 2:	Embrace a wide range of perspectives and skills
Principle 3:	Respect and value 'lived experience' and how different forms of knowledge can be expressed
Principle 4:	Ensure that there are benefits to all parties involved in co-production activities
Principle 5:	Go to communities. Do not expect people to come to you
Principle 6:	Work flexibly
Principle 7:	Avoid jargon and ensure communities have access to the right information at the right time
Principle 8:	Relationships with communities should be built for the long term
Principle 9:	Make sure co-production initiatives are adequately resources.

2.3 Can a research project change a city?

Born in Bradford has been working with the City of Bradford for nearly two decades, to improve the health and happiness of families living in the district. The cohort has led directly to over £100 million investment in child health interventions in the city. These investments take a systems approach and tackle wider determinants to prevent ill-health and have included a city-wide Clean Air Zone to reduce pollution, and refurbishment of over 40 urban green spaces. . Evaluation embedded into each of these new investments will provide decision makers with better evidence about how best to intervene to improve population health (McEachan et al., 2024).

BiB participants Aoife and Ciara (aged 6 years). Photo by Ian Beesley; from the Born in Bradford website, reproduced with permission

BiB participants Darwood and Ishaaq (aged 10 years). Photo by Ian Beesley; from the Born in Bradford website, reproduced with permission

By working with built environment specialists such as the UCL Space Syntax Lab, we will be able to obtain a more precise, realistic understanding of how environments actually affect people's lives, informing policy and improving the environments that we live in for future generations.

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