Chapter 8. Long-term urban planning: reducing heat risks

Summary

Urban management and planning are key areas for the long-term mitigation of health risks from heat. The urban structure can aggravate heat risks due to the characteristics of the built environment and the UHI effect. Increasingly solid evidence shows that urban green space protects from heat, as do other interventions related to the form, composition and functionality of buildings and urban canyons. Increasing the overall albedo (reflection) of city surfaces, the availability and accessibility of water bodies, and climate change adaptation activities in periurban areas constitute promising alternatives to reduce the effective exposure of city residents to hazardous heat.

Despite their health protection potential, however, urban planning interventions related to HHAPs continue to be infrequent, and they remain the least implemented HHAP core element. A lack of tools for intersectoral action frequently prevents health systems from integrating health protection considerations successfully into mainstream urban planning and management.

Key messages

- The urban structure, its materials and landscapes can aggravate heat risks.
- Several urban planning and management interventions can contribute to reducing heat risks in cities.
- Urban management interventions such as green spaces, reflective urban materials and modifications to urban form and structure have been proved to reduce thermal stress and should be advocated from a public health perspective.
- Urban greening may also be associated with exposure to health risks, but the evidence on this link is weaker and less consistent than the evidence of its health benefits.
- Heat reduction urban management solutions need to be assessed for local conditions.
- Tools for intersectoral action are lacking to allow public health agencies to influence urban management decisions in order to protect health from heat.

8.1 Introduction: urban planning in the WHO guidance on HHAPs

Urban planning and management were recognized jointly as a core element of an HHAP in the WHO Regional Office for Europe's guidance on heat–health action planning (Matthies et al., 2008). The areas of action proposed within this element were described generically, and included both building-specific and city-level interventions. The latter included:

- increasing albedo of buildings (including cool roofs) and of other urban elements such as pavements;
- urban greening, including green roofs;
- creating water bodies in the city (also known as "blue infrastructure").

Highlighting the urban management component of prevention of the health impacts of heat was fully justified in the guidance, and a further decade of evidence has strengthened the case for city-level interventions against heat exposure – particularly to mitigate the UHI effect. This affects cities worldwide, but is especially prevalent in the dense and heavily populated urban settings that are common in Europe.

A large amount of current evidence is available on what works to reduce heat gains and overheating of the built environment, at least from the physical, engineering and architectural perspectives. The institutions typically in charge of HHAPs, however, are seldom able to promote such changes in cities effectively. Health authorities rarely hold formal competences over housing or buildings other than health facilities. Interventions in the built environment are labour-intensive and costly, often offering scarce incentives or profits for private actors. Formalized health impact assessments of proposed building interventions are still rare within the WHO European Region, yet such systemic interventions would generate significant benefits that would last for decades; they should therefore be implemented whenever urban planning and renewal projects allow.

Unsurprisingly, urban planning is one of the core HHAP elements that has trailed behind others in terms of implementation. Bittner et al. (2014) found greater implementation of the more basic elements (agreeing on a lead body, setting up alert systems and creating health information plans) than of those requiring more resources and longer time periods for implementation (thus requiring broad and long-term political support) or going beyond the competencies of health systems (such as urban management). In addition, urban layouts planned and established decades ago and old building infrastructures may be difficult to adapt and improve in terms of thermal features, which practically restricts urban planning interventions to new developments and urban renewal projects. This situation has not changed significantly: 38% of respondents to WHO's 2019 survey of heat–health action planning said that interventions of long-term urban planning measures to combat heat had been implemented. The survey also revealed that involvement of local authorities (which typically manage urban planning interventions) in HHAPs is still relatively low, particularly concerning specification of local government roles and responsibilities.

This chapter presents a succinct compilation of updated evidence on UHI effects, followed by a description of the main interventions to reduce urban overheating.

8.2 Urban determinants of heat exposure and risk

The urban structure can aggravate heat risks, especially during the night due to the absorption and slow release of heat from buildings and other heat-retaining surfaces, the residual heat from energy use and the lack of humidity on the land's surface (Bohnenstengel et al., 2011; Wilby et al., 2011; Heaviside, Macintyre & Vardoulakis, 2017). This phenomenon is known as the UHI effect, and can result in effective night-time air temperature differentials of 3–12 ºC in large cities compared with surrounding rural areas (Memon, Leung & Chunho, 2008), making citizens in the urban areas more vulnerable to the effects of heat (Tan et al., 2010; Burkart et al., 2011).

The intensity of the UHI effect depends on many factors, among which are the local weather conditions, land cover/land use, anthropogenic heat emissions and other microclimatic conditions. As a result, during a heat-wave event, the extremely hot temperatures manifested are not evenly distributed over an urban area. In addition, cities consist of environments that are intensely modified by humans, which may lead to hotspots where the temperature is even higher. Thus, UHIs exhibit strong temporal variations and intra-urban variability (Wilhelmi & Hayden, 2010; Harlan et al., 2013), with higher temperatures determined by urban characteristics such as the use of dark-coloured paving or asphalt, heat generated by vehicles, air conditioners and industrial facilities, and a lack of vegetation.

The effect on local air temperatures of land cover, buildings and impervious and green surfaces has been well documented (Chun & Guldmann, 2014). Expansions of the built-up area to natural surfaces such as vegetation, ground or water trigger changes in the surface energy balance, which may lead to higher surface and air temperatures. Conversely, an increase in vegetated areas and green corridors may lower the heating of urban areas (Bowler et al., 2010; Ng et al., 2012; Yan et al., 2014). The effect of urban geometry (height and mass of buildings) on radiation and airflow also plays a key role in the formation of local climates (Lobaccaro et al., 2019), together with other urban landscape parameters such as surface albedo, mean building height and the sky view factor.

The UHI effect is a result of urbanization and is associated with a range of issues such as increased energy demand and environmental degradation, as well as impacts on human health such as thermal discomfort and increased mortality during heat-waves (Tan et al., 2010; Uejio et al., 2011). Factors like high concentrations of air pollution, wet climates and high humidity can also aggravate the human health impacts of extreme heat in cities (EEA, 2017). The effects of UHIs are significantly increased in parts of cities with high population density, as these tend to lack green spaces (Zhao et al., 2014). As a consequence, not all citizens in an urban agglomeration are exposed to the same heat stress. Their exposure depends on the locations and features of their residence and work address, and their time-activity patterns. Furthermore, some population subgroups (such as elderly people and those with chronic health conditions) are more sensitive to the effects of heat (see further details in Chapter 6).

Another issue associated with urban form, as well as with the use of space, is anthropogenic heat. A lot of common activities and sectors within urban settings can contribute to the UHI effect through waste heat emissions. Beside the waste heat from cooling mentioned in Chapter 5, two other major sources of anthropogenic heat in cities are motor vehicle exhaust fumes and various types of industrial and commercial activities. The effect of this input is much smaller than that of solar heat inputs on the whole, however, and how it translates into increased temperatures in cities depends on multiple factors (Santamouris, 2015).

The study of UHI effects and interventions to minimize them is hampered by a lack of current appropriate urban temperature data. Assessment of the urban thermal environment requires temperature datasets that can capture the diurnal evolution of a city's hotspots. To achieve this, the data must combine high spatial and temporal resolution (Keramitsoglou et al., 2016). Relatively little long-term observational information on the spatial variability of local climates within cities is currently available. The climatological description of a city is often based on one or a few meteorological stations and therefore not representative of the whole. Another issue is that information about the spatial variability in local climate usually applies to a limited period of time. Remotely sensed satellite-derived thermal data of high spatiotemporal resolution have, however, been proposed as a prominent solution to facilitate the study of UHI effects (Pichierri, Bonafoni & Biondi, 2012; Keramitsoglou et al., 2017). Such temperature information could enable assessment of UHIs in real time, and would contribute to the timely generation of relevant higher-value products and services for energy demand and human health studies.

8.3 Interventions to reduce urban overheating

8.3.1 Urban greening and urban blue infrastructure

Substituting greenery for typical urban surfaces and materials contributes to decreasing the UHI effect. This is indisputable, and the scientific, technical and public health discussion is about how to translate that reduction in heat into a protective factor. In general, evidence is increasing that availability and accessibility of green spaces can reduce the risk of heat-related cardiovascular and all-cause mortality in the vicinity of such spaces (Gronlund et al., 2015; Murage et al., 2020; Gascon et al., 2016). In addition, a multitude of psychological and well-being benefits have also been observed. A full exploration of all the health and well-being benefits of greenness in cities is beyond the scope of this publication, but a comprehensive review was conducted by the WHO Regional Office for Europe (2016).

A multitude of modelling studies link increases in urban green spaces with reductions in effective temperature, and link those with reductions in projected heat-related mortality and morbidity. Studies have predicted health benefits from heat reduction via greening in a multitude of urban settings throughout the WHO European Region (Salata et al., 2017; Pascal, Laaidi & Beaudeau, 2019; Venter, Krog & Barton, 2020). Aside from model predictions, reductions in heat-related health impacts are also observed at the population level. A recent study covering cities across 22 OECD countries (among them 100 cities in eight countries in the WHO European Region) found that those surrounded by a predominantly rural region and those with larger green surfaces showed lower heat-related mortality (Sera et al., 2019).

Much of the evidence on health benefits from urban interventions to reduce the UHI effect is based on modelling rather than epidemiological evidence, however. There is a risk that models fail to capture the complexity of urban interactions, thus limiting their usefulness in practice for public policy design. Studying the actual causal links and evidence-based empirical effects of urban greening interventions on heat-related health impacts is challenging. While landscape and infrastructure modifications such as green and blue spaces, green roofs and others are commonly expected to reduce heat-related health risks, the actual effect of the interventions is difficult to prove (Hondula, Davis & Georgescu, 2018). For example, proximity to urban green and blue spaces was associated (adjusting for confounding factors) with decreased mortality for elderly populations in Lisbon, Portugal (Burkart et al., 2016), and the health benefit was still seen several kilometres away. Similar results were observed in

Spain (de Keijzer et al., 2017); but in both cases, the authors acknowledged that the complexity of the relationships involved made determining a causal relationship difficult.

Green spaces include a wide variety of alternatives, from grass or isolated trees to full urban forests, and consequently provide different degrees of cooling. Vegetation structure, composition and management matter greatly, so great care is required in the planning of urban greening if cooling is one of the main objectives (Vieira et al., 2018). Moreover, different patterns in greening interventions also influence the cooling in adjacent areas (Aram et al., 2019). For example, a study in Leipzig, Germany, found that cooling effects were greater in urban forests than in parks; that cooling increased with increasing size but differently in forests and parks, whereas the influence of shape was the same for forests and parks; and that the characteristics of the green spaces were more important than the characteristics of the residential surroundings in terms of cooling effects (Jaganmohan et al., 2016). More research is needed to determine how those patterns and factors influence the distribution of heat-related health risks.

Urban greening may also be associated with exposure to health risks, including increased exposure to pesticides, allergenic pollen, disease vectors, faecal pathogens in soils and injuries (WHO Regional Office for Europe, 2016). The evidence of health risks from urban green spaces is weaker and less consistent than the evidence of health benefits, however. For instance, some studies found that green spaces are linked to an increased risk of allergies, while others found protective effects (Fuertes et al., 2016; Ruokolainen, 2017). Moreover, with adequate design, management and maintenance, the potential for health risks from green spaces can be adequately minimized.

The current evidence base does not yet allow specific recommendations to be made on how best to incorporate greening into an urban area in a way that maximizes health protection from heat. However, the WHO Regional Office for Europe review (2016) provides directions and examines important factors that can be used in decision-making. While green spaces are by far the best studied type of urban planning intervention against heat, important questions remain, including the following.

- What arrangements and types of urban green space (for example, trees versus grass) are more effective to prevent heat-related mortality and morbidity?
- What is the maximum protective effect that could be expected from large deployments of green spaces?
- What are the potential benefits and costs of alternative interventions, including access to AC and actions targeting the workplace?

In addition to the health-protecting effect of green spaces, an increasing number of studies are focusing on the ecosystem services of blue infrastructure. As with green spaces, a multitude of modelling studies have looked into the benefits of reduced heat load through urban water bodies. The results vary; for instance, small but significant cooling effects of water bodies were calculated for Vienna, Austria (Žuvela-Aloise et al., 2016) but in the Netherlands models suggested that local thermal effects of small water bodies can be considered negligible in design practice (Jacobs et al., 2020). A recent meta-analysis (Gunawardena, Wells & Kershaw, 2017) found that inadequately designed blue spaces may actually exacerbate heat stress during oppressive conditions. Moreover, as in the case of urban greening, some health risks may increase through the use of water bodies. These could include drownings and injuries, recreational water infectious illnesses, excessive ultraviolet light exposure and vector breeding (WHO, 2020). Adequate maintenance, management and safety measures can help reduce most of these risks, however. Box 13 sets out a case study of the influence of existing urban green spaces on heat risks.

Box 13. The influence of existing urban green spaces on heat risks compared to socioeconomic and demographic factors

López-Bueno et al. (2020) analysed the roles of income level, proportion of the population over 65 years of age, existence of AC units and hectares of green zones simultaneously in the impact of heat on daily mortality in districts in Madrid, Spain, between 2010 and 2013. In the raw primary model analysing the relationship between the pattern of risk and the hectares of green zones found in each district, they observed that an increase in green zones decreased the probability of detecting heat impacts. The effect disappeared in the adjusted model, however, suggesting a complex interaction between urban planning and sociodemographic factors in relation to heat risks to health.

In this study, household income was the strongest predictor of risk. In turn, household income was directly related to availability of AC. Although green zones mitigated the impact of heat-waves, their role was not more determinant than that of income level or AC in homes. Recent evidence shows that as homes install AC systems, the association between green zones and heat mortality becomes weaker, while the association between green zones and energy savings during heat-waves becomes stronger (McDonald et al., 2020). Therefore, the protective effect of green zones is reflected indirectly in terms of the greater need for energy to reach a comfortable temperature in the home. In addition, the presence of green zones reduces the levels of air pollution in cities (Rafael et al., 2020) and contributes to improved physical condition and mental health (Andreucci et al., 2019; Marcheggiani et al., 2019).

8.3.2 Pavement and outdoor urban landscape materials

Several of the interventions mentioned at the building scale can also be applied to other surfaces in the urban landscape beyond buildings themselves. This is especially the case for pavements and public surfaces, and in particular for interventions to reduce their ability to absorb and retain heat and to increase their albedo by, for example, using reflective materials or lighter colours. Indeed, large-scale deployments of interventions to increase albedo in pavements could result in important effects to reduce the UHI effect (Akbari, Damon Matthews & Seto, 2012). Some studies suggest that increased rooftop albedo may have a measurable heat-related mortality reduction: increasing rooftop albedo from 0.32 to 0.90 could result in around 45 avoided heat-related deaths per year in New York City (Susca, 2012). Increasing albedo may be an effective city-wide strategy in some types of urban settings for reducing heat-related health risks (Silva, Phelan & Golden, 2010), particularly in areas where substantially increasing green spaces may not be possible. An increase in reflective surfaces at the city level to reduce UHI intensity may have unintended consequences, however, in terms of increasing concentrations of some air pollutants like ozone, a secondary pollutant whose formation is aided by sunlight – both direct and reflected on surfaces (Fallmann, Forkel & Emeis, 2016).

As with other urban level interventions against overheating, material and landscape decisions must be tailored to local circumstances and conditions. All advantages and disadvantages, benefits and costs should be taken into account before undertaking such interventions. The German HHAP (see Box 14) constitutes an example of general recommendations to be tailored to local conditions.

Box 14. Recommendations for action on long-term urban planning and building in the German HHAP

The German HHAP recommends the following measures related to buildings:

- developing heat protection requirements for buildings (such as thermoglass, integrated lamella blinds in windows, roof overhangs to provide shade and shade on roofs through solar energy installations);
- undertaking technical construction measures – for example, ventilation technology, heating and cooling coils, fans and possibly AC systems, especially in sensitive areas;
- ensuring heat-appropriate planning of new buildings (including consideration of architecture, width/height ratio, street development, orientation and site) in urban and rural areas;
- using construction materials that reduce heat and avoiding materials that store heat;
- installing drinking-water dispensers in buildings and public spaces;
- establishing and using cooling centres – for example, public cool spaces in government offices, shopping malls, church buildings, bookshops and train stations.

It also recommends a number of urban and building planning measures:

- conserving and creating shaded green spaces and parks, preferably with cooling evaporation areas such as bodies of water or water features;
- setting up generous shaded areas (with structural measures such as pavilions, roofing, awnings, sunshades or sails and with landscape planning such as replanting or conserving trees with thick foliage);
- installing humidifiers in outdoor facilities and on terraces;
- reducing heat by creating or keeping clear air channels and areas where cold air is produced;
- reducing the degree of soil sealing in open and public squares to avoid build-up of heat and ultraviolet radiation from reflection;
- encouraging planting of trees and shrubbery, as well as setting up roof gardens (taking care to select plants low in allergens that can tolerate heat and dry conditions);
- installing canopies and roof structures that provide shade, preferably using materials that reduce exposure to ultraviolet radiation;
- installing fixed drinking-water dispensers in public spaces.

Further information can be found on the website of the Centre of Excellence For Climate Change Impacts and Adaptation (KomPass, 2020).

Source: BMU (2017).

8.3.3 Urban form and structure

The natural and artificial morphology of urban settings influence parameters relevant to their inhabitants' thermal comfort, such as air temperature, relative humidity, wind velocity and others (Lobaccaro et al., 2019). In other words, the political and design decisions that determine changes in the physical form of cities can improve urban microclimates. For example, studies show that the ratio of average height of buildings to the width of the streets between them strongly affects the temperatures experienced by pedestrians, with wider streets generally being warmer in daytime and cooling down more quickly at night than narrower ones, and with upper walls receiving more radiation in daytime but cooling down more quickly than lower walls (Chen et al., 2020; Wai et al., 2020).

Also important are the orientation of the buildings and the streets. A study in Bilbao, Spain (Lobaccaro et al., 2019), found that for the best orientation (that least prone to dangerous overheating: north-west/south-east), the duration of the peak heat period lasted for only one hour, while for the worst orientation (the most heat-prone: north-east/south-west), the thermal discomfort persisted for over 10 hours in all urban canyons. The same study found that within a given type of urban morphology (for example, compact or open-set, low-rise, mid-rise or high-rise), the location and distribution of green spaces can make a significant difference in terms of cooling potential. Solutions connected to increasing wind velocity may be more applicable in warm countries, as creating increasing wind conditions in cities in cold countries might not be optimal in the winter season. Generally, all potential urban management solutions to reduce heat need to be assessed for the local conditions.

A noteworthy avenue for consideration of urban level infrastructure planning is the "superblock" model – an innovative urban and transport planning strategy that aims to reclaim public space for people; reduce motorized transport; promote sustainable mobility and active lifestyles; provide urban greening; and mitigate effects of climate change (Rueda, 2019). In essence, the superblocks would prioritize internal non-motorized transportation, pedestrian areas and green spaces against a looser conventional traffic network. A study in Barcelona assessed that applying this model could avoid 667 premature deaths (95% CI: 235–1098), of which at least 117 (95% CI: 101–37) would be heat-related (Mueller et al., 2020).

8.3.4 Reducing UHIs at the regional scale

Interventions beyond the city limits can also contribute to reducing the UHI effect. This, in turn, has two aspects of relevance: interventions beyond the urban landscape itself, regardless of administrative boundaries; and interventions beyond administrative boundaries into (still urban, but less structured) areas of informal growth.

On interventions beyond the city landscape, it is worth highlighting the possibilities of periurban greening, which – alongside its effect of reducing UHIs – can contribute to reducing risks related to other meteorological extremes, such as floods and droughts, and climate change (EEA, 2012). Another example of interventions at the scale beyond city limits is the creation of wind corridors from surrounding green areas into the city, though these may not be suitable in colder countries. Several European cities have included wind corridor considerations into their planning, including Germany and the Netherlands (Filho et al., 2017). This has clear implications for intracity land use, which can have significant impacts on the local intensity of UHIs and related microclimates. Some evidence also exists that, in several cities, the residents who are most susceptible to the health impacts of heat actually reside in the periphery (Depietri, Welle & Renaud, 2013).

While less prevalent and massive than in other regions of the world, informal settlements beyond city limits are not uncommon throughout the WHO European Region. Their lack of planning, poor-quality dwellings and underserved status could make residents more vulnerable in some instances. Evidence on the health impacts of heat in these communities, as well as the potential effectiveness of adaptation – such as the promotion of periurban adaptation – is scarce, however.

8.3.5 Reducing heat risks through intersectoral action in urban planning

From the standpoint of public health interventions, the potential to influence urban form decision-making to minimize the health impacts of heat is limited. Those decisions are squarely outside the sphere of influence of the health sector; further, intersectoral coordination mechanisms for public health practitioners to feed health evidence into the decision cycle are rarely in evidence (Rantala, Bortz & Armada, 2014). If urban planning and management includes health considerations via intersectoral action, however, it can make long-lasting differences to health and well-being. At the general urban planning and management level, the inclusion of health in strategic environmental assessments is a good opportunity to influence the urban planning and policy cycle. WHO recommends various entry points for health throughout the strategic environmental assessment process (WHO Regional Office for Europe, 2019):

- at the screening phase – through the active involvement of health impact assessment experts, inclusion of health criteria in screening tools and similar;
- during scoping – by adequately covering health in the terms of reference, including the role and competencies of experts who will conduct the health-related assessment activities;
- during assessment and reporting – ensuring the quality and comprehensiveness of health-related assessments, including stakeholder engagement activities, disclosure of information, methodologies used, credibility of baseline and appropriateness of recommendations;
- in the process of consultation and participation – ensuring that health sector actors and advocates are actively engaged in the policy, planning and programme processes;
- during decision-making – actively engaging health sector actors in decision-making activities;
- as part of monitoring and evaluation – including health indicators in the monitoring and evaluation process.

At the project level, the health impact assessment of urban management interventions probably represents the best opportunity to feed heat and health considerations into the urban management and policy cycle. While still infrequent, Europe has some examples of the health impact assessment of urban interventions being a mandatory document for developers to present to the approving authority.

8.4 Conclusions

Modifying the built environment can help to reduce hazardous risks to health from heat significantly. A wide range of interventions is available; the best possible results are typically obtained through optimal combinations of various interventions, tailored to local conditions.

Urban greening is well supported by evidence as an effective strategy to reduce heat-related mortality, although the specific causality of this is poorly understood. Increasing the albedo of pavements and other city surfaces may be an effective complementary strategy. The morphology of urban areas has a clear influence on heat exposure, and although the possibility of successfully advocating modification of such factors is limited, it is important that health authorities and practitioners are aware of possible hotspots based on the relevant variables.

Beyond the city scale, various interventions can be implemented with effects on heat exposure reduction, such as periurban greening, establishment of wind corridors and adequate management of land use. From the standpoint of prevention, adequate intersectoral mechanisms for health authorities to promote these interventions, which lie squarely beyond their competencies, are lacking. Entry points can be found to include heat and health considerations, however, and to make a lasting difference.

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