# Climate and Health in Cities:
## A Challenge for the Built Environment

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**The built environment is an important contributor to both climate change and public health. Transportation, land use, and buildings are three factors significantly impacting environmental and human health in urban areas. Health and built environment experts should actively collaborate to both cool cities and increase positive health outcomes.**

### Introduction

Extensive literature has shown the connection between the built environment and health outcomes, and we are becoming increasingly aware of the health impacts of climate change [1, 2]. While the focus on the built environment and health started with a concentration on health outcomes and homes—particularly in the context of the poor housing conditions of the industrial revolution such as overcrowding, bad maintenance practices, and poor air quality—the breadth and depth of the topic has grown rapidly. Increasing evidence is emerging to show that different elements of buildings—construction, material extraction, operations, and transportation—also impact human health, broadening researchers' attention, awareness, and understanding of the topic.

The United Nations Environment Programme notes that "Cities are a key contributor to climate change, as urban activities are major sources of greenhouse gas emissions. Estimates suggest that cities are responsible for 75 percent of global CO2 emissions, with transport and buildings being among the largest contributors" [3]. Climate change will likely cause extreme heat and increased air pollution and extreme weather events in urban areas, all of which would negatively impact population health. Cooling our cities is critical, not only for the state of the climate crisis, but also for the health of the occupants both within and outside urban areas. The design and implementation of the built environment has started to focus on its health impacts through a lens of doing less harm, but could in fact be a positive contributor to both climate mitigation and health outcomes through a salutogenic (supporting health and well-being) lens.

There are a number of critical factors that can address energy efficiency in our urban environments and buildings, from houses to hospitals to offices; each of these factors addresses an issue impacting population health. Younger and coauthors identified three primary factors that can impact both climate change and public health: transportation, land use, and buildings [1]. These factors are incredibly interconnected and represent a host of design problems situated in complex contexts, often with unstable and unanticipated interactions.

### Transportation

Transportation is one of the key elements of cities impacting both climate change and public health. Car-centric communities are heavy in pollution, emissions, and fuel consumption, all of which are neither energy efficient nor good for human health. Public transit helps to mitigate many environmental concerns, capitalizing on density to lessen the environmental impacts. As self-driving cars, light rail commuter systems, other innovative and more efficient transportation options become more readily available, and increased density reduces transportation need, cities can become even more energy efficient and less burdened by transportation-related pollution.

Transportation also has a significant impact on health (Figure 1). Some green building rating systems, such as the Living Building Challenge [4], emphasize human-powered living, focusing on transportation provided by individual locomotion. Walking or biking to work is a more sustainable method of transportation in terms of environmental impact, followed closely by public transit. Human-powered living can also significantly impact human health simply by requiring and affording more physical activity. Even public transit requires more walking to and from transit hubs than typically found with single-occupancy vehicles. Design strategies such as green infrastructure and greenways can encourage walking and biking, while also helping to cool urban areas. Planning that includes bicycle networks and Complete Street policies that encourage streets to be designed for safe access and use by all regardless of ability or transportation mode also foster environments that can increase rates of utilitarian, recreational, and leisure physical activity. These alternative methods of getting around neighborhoods and

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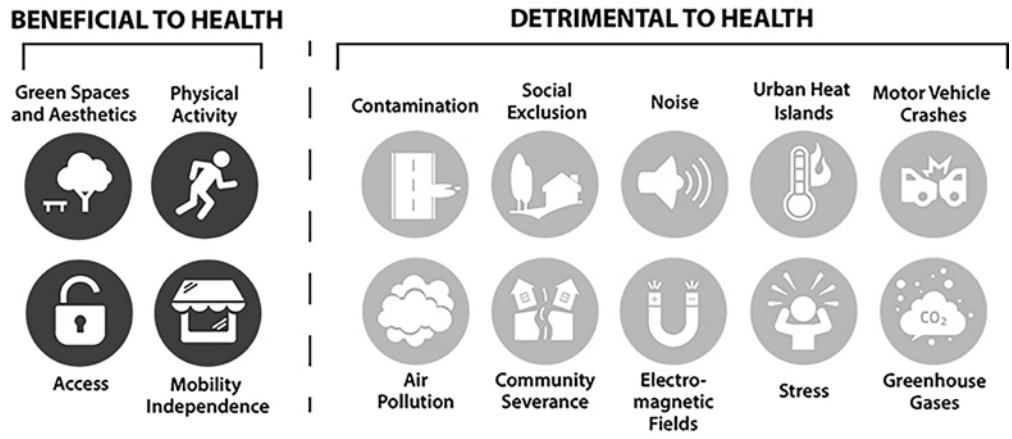
**FIGURE 1.**
**An Illustration Tying Transportation to Health**



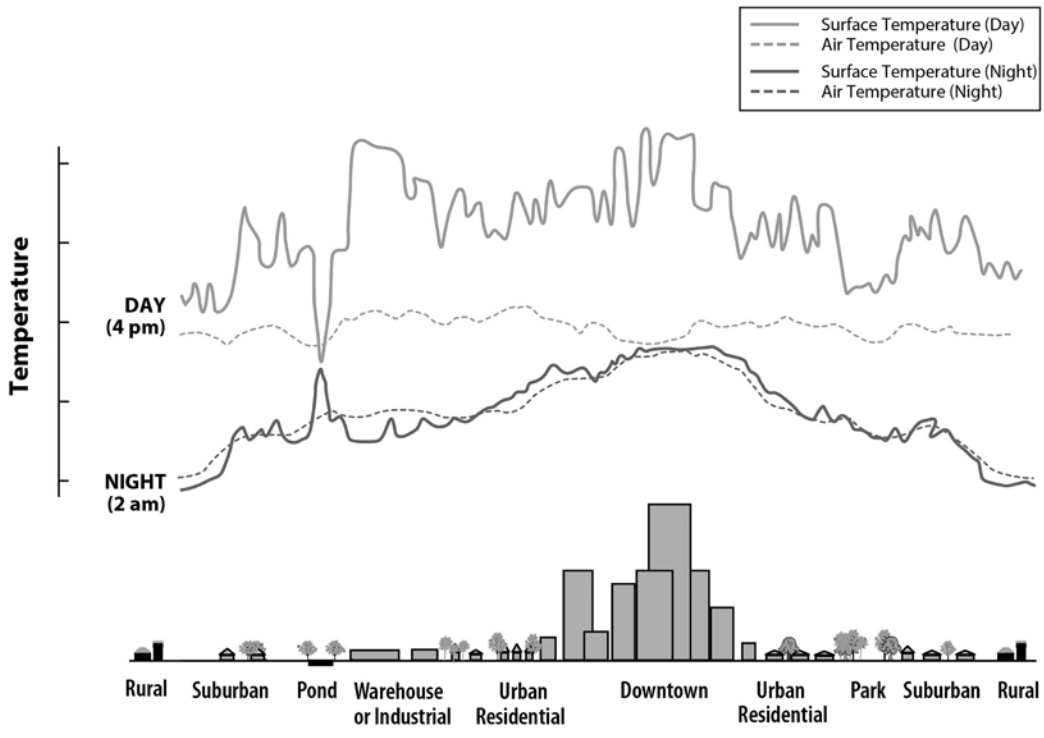

Source. Texas A&M Transportation Institute. (2020) https://ttti.tamu.edu/researcher/its-complicated-transportations-relationship-with-public-health/. Accessed June 15, 2020.

cities will help to lessen the impact on the environment through reduced use of fossil fuels and improved air quality, while also encouraging routine physical activity and increasing positive health outcomes.

## Prioritizing Nature

Prioritizing nature in cities, along with strategic use of land, offers important additional strategies both for cooling cities and increasing positive health outcomes. Urban green space decreases the overall temperature of cities, which often form what is known as heat islands [5]. As the pavement and sheer mass of built form within cities absorbs solar radiation, that heat is slowly released back into the urban environment (Figure 2). With the combination of solar heat gain and the heat of emissions from operating buildings, car engines, and people, the temperature of urban areas during

**FIGURE 2.**
**The Impact of Different Land Uses to the Air and Surface Temperatures of a City**




Source: USGS (2020) U.S. Environmental Protection Agency highlighting https://www.usgs.gov/media/images/urban-heat-islands. Accessed June 15, 2020.

the summers can soar. These intense temperatures increase the demand for additional cooling during the summer months [5], increasing energy consumption, and—as traditional coal-fired power plants are still our default—increasing emissions. According to the Environmental Protection Agency, "heat islands can also exacerbate the impact of heat waves," which are known to be particularly dangerous to vulnerable populations including children, the elderly, and underserved populations [5].

Tree canopies can help to significantly cool cities while also improving resident health. Wherever tree canopies provide shade, less solar rays reach that material, resulting in less solar heat gain, and therefore less heat emission [6]. In addition to reducing summer temperatures, vegetation can impact health factors as well, helping to filter or mitigate urban air pollution. Recent research indicates that "more tree cover, independent from green spaces, was related to better overall health, primarily mediated by lower overweight/obesity and better social cohesion, and to a lesser extent by less type 2 diabetes, high blood pressure, and asthma" [6].

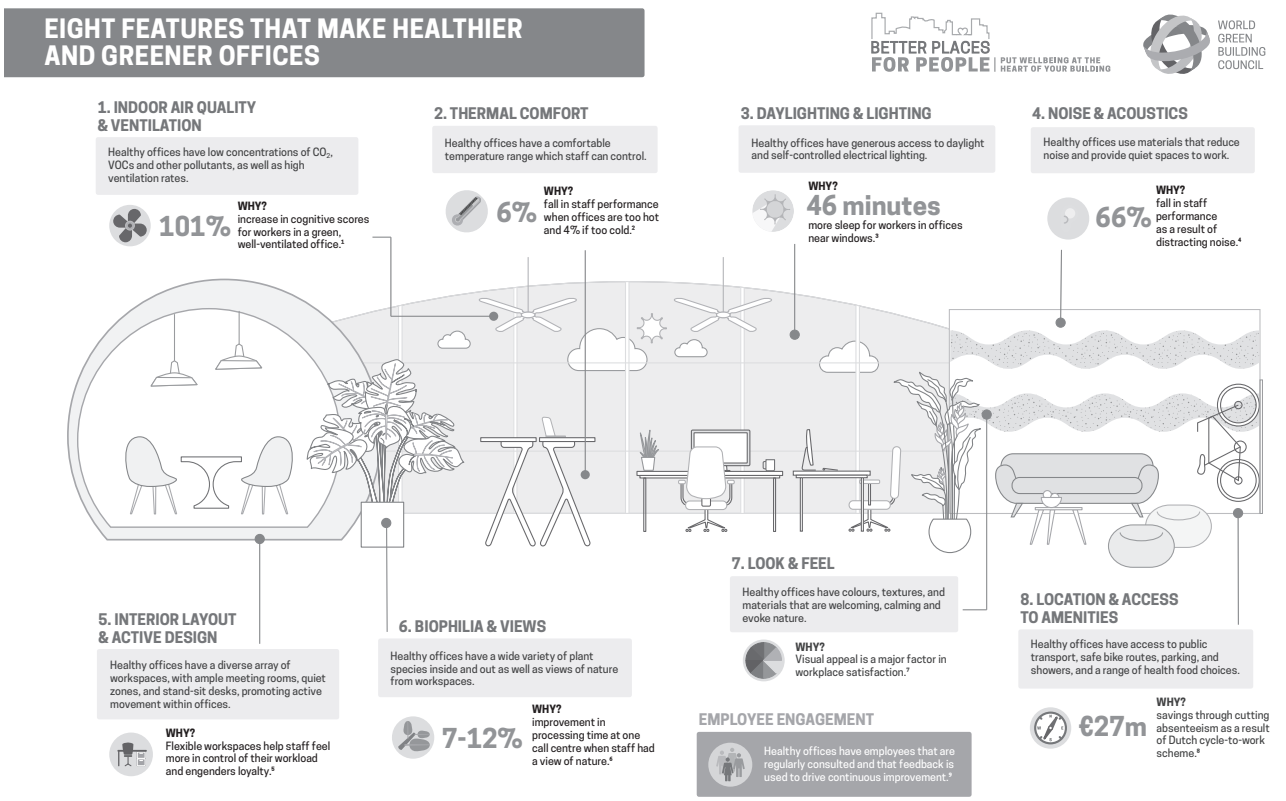
Physical activity is also closely tied to the availability of green space, such as greenways and park space [7, 8]. Urban residents with easy access to parks and green space are less likely to be obese or have cardiovascular issues [9]. Another study found that "higher levels of neighborhood green space were associated with significantly lower levels of depression, anxiety and stress" [10]. The prioritization of nature in urban areas is a win-win for the environment and public health—both physical and mental.

## Buildings

Buildings, with their intense energy consumption and largely encapsulated environment, are another important element both for cooling our cities and for increasing positive health outcomes. Energy efficiency in buildings can be increased by ensuring that buildings are built—and maintained and operated—to be high-performance (Figure 3). However, the construction and maintenance of buildings can also impact urban health. Construction pollution, embodied carbon, transportation, and energy efficiency are only a few factors embedded in building construction and operations that can impact population health in urban areas.

To evaluate buildings, both on environmental friendliness and health, a series of rating systems exist, including the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) [11], the International WELL Building Institute's WELL Building Standard [12], Fitwel [13], and the Living Building Challenge [4], to name only a few. Each type of building operates a bit differently—a residence runs differently than a hospital, which runs differently than

**FIGURE 3.**
**Key Features of Healthier and Greener Offices**




Source. World Green Building Council (2020) https://worldgbc.org/news-media/building-business-case-health-wellbeing-and-productivity-green-offices. Accessed June 15, 2020.

***Money* SIDEBAR**

a school; each building type has its own requirements for comfortable (or safe) airflows, daylighting, operable windows, room sizes, adjacencies, privacy, flexibility, security, and more. Despite these operational differences, however, there are a host of overarching issues that can both increase energy efficiency and improve public health.

Urban environments are largely made up of existing buildings. While it is difficult and expensive for existing buildings to work toward higher efficiency levels equal to those achieved in new construction, it is not feasible to simply replace all older building stock with new structures; that scenario is obviously cost-prohibitive, and would be terrible in terms of environmental issues such as embodied carbon, construction pollution and emissions, and resource consumption. In an ideal world, inefficient buildings could be fully retrofitted with more efficient envelopes (physical separators between conditioned and unconditioned environments), mechanical systems, and strategies such as

***Money* SIDEBAR *continued***

LED lighting. Unfortunately, even these changes are usually cost prohibitive to the owner. The goal, then, is to figure out how to minimize the gap between how an existing building is currently operating and how it *could* be operating ideally to minimize its impact on the environment and increase the health of its occupants. Some of the rating systems, such as LEED for Operations + Maintenance [11], focus on metrics that existing buildings can address to increase their efficiency in environmentally focused categories such as water, waste, and energy. Existing building owners and operators must learn how to retrofit, operate, and maintain their facilities in terms of energy efficiency and health.

The envelope of the building contains many issues impacting health and energy efficiency. Operable windows, daylighting, ventilation rates, and indoor air quality all address levels of occupant health in a building, and are largely determined by the design of the envelope. Most existing buildings, particularly in urban areas, have been designed to heavily rely for heating and cooling on mechanical systems, which conceptually allow for a more fine-tuned and comfortable

environment, controlling factors like humidity and temperature. There may not be any option to open a window, for better or worse. However, operable windows have the potential to improve thermal comfort and reduce cooling loads if properly designed and operated [14]. When outdoor air quality is high, operable windows can lower indoor contaminants such as carbon dioxide and volatile organic compounds (VOCs), such as formaldehyde, without bringing in outdoor air pollutants [15]. Mental and physical benefits have been associated with operable windows, which are starting to regain momentum in health care settings [16].

Indoor environmental quality is closely related to energy efficiency, though with an inverse relationship. For example, the more cubic feet per minute of fresh air brought into a space to help with occupant health, the more energy the building's HVAC system is going to expend, reducing energy efficiency. However, while there is a significant financial investment in building operations and maintenance over the life of a building, there is even more financial investment in employees in terms of salary, benefits, training time, turnover, health insurance, and productivity. The health of the occupant is not only important in terms of public health outcomes, but also in terms of fiscal responsibility. Simply put, healthy employees make good financial sense. This is the premise of the WELL Building Standard [12], which focuses solely on the health of the occupants. WELL does not care how much water is used, as long as the water is of good drinking quality, or how much energy is used as long as there are high levels of indoor air quality to support the health of the occupants.

There are a host of other issues in construction that deal with both energy consumption and human health, such as construction practices (emissions, embodied carbon, heavy equipment, transportation, application processes, etc.) and material selection (volatile organic compounds, off-gassing, extraction, etc.). Each of these topics and more are dealt with in detail in the different rating systems.

## COVID-19

COVID-19 is a new and pressing issue for the built environment, particularly in dense urban areas, and all the more important as communities begin to open back up while still trying to keep case numbers down and populations healthy. Dense urban buildings are perfect places to facilitate virus and bacteria transmission—not unlike an airplane or cruise ship—as they are contained environments with recirculated air, common surfaces, and spaces designed to increase collaboration and socialization. Even though coronavirus particles are too small to be snared by most MERV air filters generally used in HVAC systems, increased ventilation strategies can still help in reducing viral transmission [17], likely requiring increased energy and emissions. Increasing outside air flow, either mechanically or through operable windows, and increasing the rate of air exchanges can help to dilute virus particles indoors, though this increase in airflow could both disturb already settled particles and push them back into the air, as well as increase energy consumption [18]. Unless operable windows are used, energy consuption will rise. Increased humidity levels can also play a role in reducing viral transmission, with heavy air particles less likely to circulate [17, 18]; however, this will impact the comfort of the occupants. Interventions will more likely address filters and airflow, with an impact on energy consumption. While many of the precautions for COVID-19 deal with behaviors in buildings, like increased hand washing, wearing face masks, social distancing, and desk arrangement, there are operational strategies that can be implemented to help mitigate the risk of virus transmission. Unfortunately, in terms of climate change, many of these will likely increase energy use and emissions.

Ultimately, the relationships between urban environments, energy efficiency, and population health are both complex and synergistic. There are clear connections and there is clear urgency in terms of climate change and health. The bulk of the onus for this much-needed shift toward urban efficiency and health is on building owners and operators. While energy efficiency is a language that building operations and maintenance staff understand, health is outside the realm of expertise for design, construction, and maintenance teams. True change will come much more quickly if design and construction teams readily engage health officials and advisors in their design process to truly embrace the salutogenic potential of the buildings we inhabit. NCMJ

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