# The Integration of Urban Green Infrastructure and Its Effects on Physical Health of Adults

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#### <u>Abstract</u>

This review examines the influence of Urban Green Infrastructure (UGI) on adult physical health in the context of increasing urbanization. With urban regions projected to house 69% of the global population by 2050, understanding the correlation between UGI, urban environments, and public health is crucial. The Hamilton Sustainability Action Project (HSAP), a non-profit organization dedicated to providing students with meaningful, action-based volunteer experiences, has identified a need to better understand this relationship. By partnering with sustainable organizations such as Cycle Hamilton, Trees for Hamilton, and Royal Botanic Gardens, HSAP has promoted UGI initiatives like planting trees in wetlands and hospitals. To further incentivize more organizations to join their mission of making Hamilton more sustainable, HSAP seeks research to highlight the benefits of UGI on adult physical health. This review prepared by the McMaster Life Sciences department emphasizes the positive link between accessible urban green spaces and increased physical activity among adults, thereby mitigating risks associated with physical inactivity, obesity, and chronic diseases. However, significant knowledge gaps persist, particularly regarding how different types of UGI impact specific health conditions, long-term effects, socioeconomic and gender disparities, and scaling challenges from local to citywide levels. Bridging these gaps necessitates interdisciplinary collaboration and comprehensive research efforts to inform evidence-based policies and targeted interventions.

Keywords: Literature Review, Green Infrastructure, Urbanization, Physical Health, Adults

#### **Introduction**

The number of people living in cities increased by 25% between 1990 and 2000.<sup>1</sup> By 2050, urban regions are predicted to house 69% of the world population, or 6.3 billion people.<sup>2</sup> There has been extensive research done on the relationship between nature and the health and well-being of individuals. However, less emphasis is on the additional physical health benefits that can be obtained through the increased usage of green infrastructure. Green infrastructure is a broad word that refers to a variety of technologies and practices that mimic natural processes. Some examples include green roofs, rain gardens, and permeable payments which are increasingly relevant in the context of urbanization. Urbanization is the process by which cities expand and a greater proportion of the population migrate there. This gradual growth has prompted the scientific community to investigate and examine the salutogenic consequences of the urban environment. In this review we will be defining urban green infrastructure as a network of natural areas and green technology that provide environmental, economic, social and health benefits for urban development.<sup>2</sup> Furthermore, physical health is defined as a dynamic state involving the preservation and development of biological, physiological, and mental functions, with the absence of diseases or painful conditions.<sup>2</sup>

Cities contribute significantly to climate change-related health issues since they consume a big portion of the world's natural resources. Urbanization has improved population health by increasing access to key healthcare services and providing better career and education possibilities. Considering the vast amount of medical care through hospitals and clinics in urban regions, a greater number of people have better access to healthcare services. However, rapidly developing cities pose additional public health risks. This may include lack of physical activity, imbalanced eating behaviors, pollution, traffic, and deterioration; all of which contribute to an increase in the prevalence of a wide range of diseases and conditions related to musculoskeletal, cardiovascular, and respiratory complications.<sup>3</sup> Urbanization may also be a risk factor for chronic noncommunicable diseases and other causes of impairment, such as traffic accidents and violent crime.<sup>3</sup> Physical inactivity affects a third of individuals worldwide, and numerous studies have revealed that it not only causes obesity and chronic diseases, but also raises the likelihood of cancer and premature mortality.<sup>4</sup> Furthermore, an obesity epidemic in the United States and around the world is evident. Obesity-related yearly expenses in the United States alone reached \$117 billion in 2004 and are projected to increase.<sup>2</sup> Access to green infrastructure can influence outdoor leisure time and the forms of physical exercise taken by individuals. Several studies have highlighted that green spaces can boost overall well-being, promote physical activity, reduce illness, and increase life expectancy.<sup>1</sup> Green infrastructure, including greenways and parks, can help address this issue by promoting physical activity through walking, jogging, and cycling.<sup>2</sup> It is further possible that different forms of green space will enable varying durations and intensities of physical activity. This literature review aims to examine the effects of integration of urban green infrastructure on physical health of adults.

## **Questions Addressed**

The main question we specifically plan on addressing is what effect does the integration of Urban Green Infrastructure (UGI) have on the physical health of adults. To complement this we will further look into how green infrastructure encourages physical activity and addresses the problem of physical inactivity. A secondary research question will explore the barriers to creating green infrastructure, as well as evidence that challenges its purported benefits.

#### **Relationship of the Question to Prior Studies**

Despite certain methodological challenges of the studies included, the findings indicate almost unambiguously that urban greenspaces have potentially favorable benefits on physical health. Past research and reviews have covered a wide range of topics, including environmental, physical, children, and mental health. Furthermore, there has been extensive research done on the relationship between nature and the health and well-being of individuals. However, less emphasis is on the additional physical health benefits that can be obtained through the increased usage of green infrastructure. Previous research failed to demonstrate unambiguously the beneficial effect of urban green infrastructure on physical health solely in detail.

#### **Methodology**

To address our primary concerns, we conducted a systematic search on Google Scholar in October 2023. We focused on literature published between 1997 and 2023 to capture recent and relevant data. Our search was guided by the key themes of physical health, adults, urban environments, greenspace, and green infrastructure. To enhance the precision and efficiency of our search, we utilized Google Scholar's advanced search options, employing Boolean operators (e.g., AND, OR, NOT) and proximity operators (e.g., NEAR) to refine our results.

#### Inclusion Criteria:

We included studies that:

- 1. Investigated the relationship between urban green infrastructure and physical health.
- 2. Focused on adult populations.
- 3. Were conducted in urban settings.
- 4. Presented primary research findings or detailed meta-analyses.

#### Exclusion Criteria:

We excluded studies that:

- 1. Focused on non-physical health outcomes (e.g., mental health, social well-being).
- 2. Did not provide sufficient methodological detail to assess quality.
- 3. Were purely theoretical or opinion-based without empirical data.

#### Results of the Search

Our search yielded 86 studies, of which 23 met the inclusion criteria. The remaining studies were excluded for reasons such as focus on non-physical health outcomes (n=32), rural or mixed settings (n=18), or lack of methodological detail (n=13).

## **Hypothesis**

The research team hypothesizes that integration of urban green infrastructure is positively associated with improved physical health among adults. This assumption is based on research done by Wang et al. as they demonstrated increased physical activity levels in areas with green urban infrastructure.<sup>4</sup> Building on this hypothesis, Gianfredi et al. demonstrated that green spaces can boost overall well-being, promote physical activity, reduce illness, and increase life expectancy.<sup>1</sup> Finally, research by Kim & Miller shows how urban green infrastructure can promote physical activity through walking, jogging, and cycling.<sup>2</sup>

#### **1.0 Accepted Ideas In The Field**

#### 1.1 Empirical evidence of urban green infrastructure and physical activity

When synthesizing the available body of literature, countless prominent trends and patterns emerged. Remarkably, the results highlighted several key ideas on the accepted understanding of urban green infrastructure and its positive association with physical health among adults. Firstly, Wang et al. conducted research which revealed that accessibility to urban green spaces served as a significant enhancer on the physical activity of residents living in Nanning, China.<sup>4</sup> This further validates the importance of urban green infrastructure as a key facilitator to physical activity. In addition, a study done by Kim & Miller revealed similar patterns after observing the behavior of visitors in two locations: Huckleberry Trail and Heritage Community Park.<sup>2</sup> The study highlights the distance individuals had to travel to visit both of these locations with individuals walking much farther for Heritage Community Park. This longer walk was directly associated with less frequent visits at Heritage Community Park, further leading to less physical activity from individuals living close to that park. It was also highlighted in the study that individuals who visited Huckleberry Trail typically either ran or walked at the site, due to the location being closeby to the individuals, whereas individuals at Heritage Community park were typically relaxing. Finally, the same trend can also be seen in a review study done by Gianfredi et al. where it was concluded that individuals living in a radius of 0.5-1 km of urban green space had significantly higher levels of physical activity, as compared to those living much farther away.<sup>1</sup> Moreover, this confirms the association of accessibility to urban green spaces with higher physical activity levels, a trend observed commonly among various research studies.

## 1.2 Therapeutic benefits of green spaces on cardiac rehabilitation

Delving further on the topic of human health, green spaces have shown countless benefits on treating specific illnesses. In fact, a study conducted by Söderback et al. looked at the effects of horticultural therapy through activities such as gardening on brain damage.<sup>5</sup> The study revealed positive benefits of nature on various specific ailments. These included mental hearing, sensory stimulation, and sensory-motor function, all of which provided positive effects in improving brain damage in combination.<sup>5</sup> Another study also used the same methodology of horticultural therapy on over a 100 cardiac rehabilitation patients, and concluded an overall decrease in heart rate and mood disturbances.<sup>6</sup> This methodology extends further with chronic musculoskeletal pain, which also benefited in a study conducted by Verra et al. where approximately 80 patients showed improvements in physical pain behaviors.<sup>7</sup> A recurring pattern can be noticed amongst the use of horticultural therapy, or the use of green spaces in nature, where patients facing various types of illnesses see positive benefits by utilizing it. This further enhances the idea of incorporating urban green infrastructure to improve physical human health.

#### 1.3 UGI's association with cardiorespiratory health

Two significant diseases that arise from the lack of physical inactivity, include cardiovascular and respiratory disease.<sup>8</sup> Urban green infrastructure has continuously shown to reduce the risk of these diseases over a period of time. More specifically, a study done by O'Hara et al. publicized that the implementation of urban green roofs in urban hospitals lead to not only an increase in physical activity, but also a reduction in cardiovascular and respiratory diseases.<sup>9</sup> This study highlighted the increased risk of cardiovascular and respiratory diseases which developed through the lack of interaction with the natural world, furthering the individual's quality of life.<sup>9</sup> It is also important to add that O'hara et al. specified other illnesses that saw a reduction in risk from urban green roofs, including diabetes, hypertension, and specific cancers such as breast and colon.<sup>9</sup> Adding on, Tamosiunas et al. investigated the effects of urban green space use on cardiovascular health of adults in Kaunas, Lithuania, and brought to light that high park users had a much less chance of cardiovascular risk factors, as compared to low park users.<sup>10</sup> This same trend was also observed in a research study by Yang et al. which concluded that adults living in China who had much more green space exposure showed an overall total reduction in total cholesterol and glucose levels, both of which are key factors in cardiorespiratory health.<sup>11</sup> To further add, a systematic review conducted by Liu et al. analyzed data of over a 100 million people across 18 countries on increased urban green space exposure and its effects on

cardiovascular disease.<sup>12</sup> It was again revealed that the exposure to green spaces was correlated with much lower odds of cardiovascular disease mortality, stroke prevalence, and ischemic heart disease mortality.<sup>12</sup> From the combination of research, it is clear to see the recurring theme of urban green infrastructure and the positive benefits it has had on the cardiorespiratory health of individuals.

#### 1.4 Critical examination of the challenges in green infrastructure implementation

Though the benefits of implementing green infrastructure are clear, the inherent challenges in its implementation are evident due to the complexity of planning and policy-making. Recent research by Parker & Zingoni de Baro indicated the high maintenance costs that are associated with public open spaces, along with its practical application which often face both logistical, and socio-political hurdles.<sup>13</sup> Moreover, the complex relationship between public open spaces and the quality of green infrastructure underscores the difficulty to measure and maintain such initiatives, especially when they are balanced against economic restrains.<sup>13</sup> Therefore, while urban green infrastructure research is expanding and showing positive consequences, the challenges in its practical application cannot be overlooked, further necessitating a more comprehensive understanding in its implementation.

#### 2.0 Unresolved Questions in the Field & Problems in Solving Them

#### 2.1 Long-term effects of urban green infrastructure

Furthermore, there is a lack of understanding regarding the long-term effects of urban green infrastructure on the physical health of adults.<sup>14</sup> Specifically, more comprehensive research is needed during critical periods of life. Studies have not looked at how exposure to urban green infrastructure during early childhood can affect physical health into adulthood. As outlined by Jimenez et al. this aspect of research is understudied.<sup>14</sup>

Addressing this knowledge gap may require longitudinal studies, which are critical for understanding long-term trends and developments. However, these studies face several challenges. Firstly, they involve significant time commitments and resources.<sup>3</sup> Furthermore, they also require sustained funding over extended periods.<sup>3</sup> To overcome these challenges, more literature reviews need to be conducted. Another challenge associated with this knowledge gap is attrition bias. The extended duration of longitudinal studies increases the likelihood of participant dropout, which can lead to inaccurate conclusions.<sup>15</sup>

#### 2.2 Socioeconomic disparities

Extending this argument, it's important to look at socio-economic factors when examining the relationship between urban green infrastructure and its effects on the physical health of adults, an area which is a major knowledge gap. Existing literature demonstrated by Bartley et al. has shown a clear association between socio-econmic status (SES) and mortality risk among servants observed in London.<sup>16</sup> Furthermore, there has been evidence showing the change of physical activity levels due to socio-economic factors causing a shift towards more inactive lifestyles.<sup>17</sup> However, there is a lack of detailed studies and comprehensive analysis regarding how these socioeconomic factors influence the relationship between green spaces and physical health.

Access to extensive and high-quality datasets is necessary for comprehensive research that takes into account physical health outcomes, socio-economic variables, and UGI. However, as outlined by Lee & Maheswaran economic dimensions are highly difficult to measure due to data availability, and variability.<sup>18</sup> Furthermore, land availability presents another challenge in this gap since it could be hard to find adequate space for green infrastructure projects. Due to urban growth and unequal resource distribution, lower-income communities frequently have restricted access to well-maintained parks and nature areas, which negatively affects the well-being of the people.<sup>14</sup> For this reason, equitable land-use

planning is essential to guaranteeing that all communities, regardless of socioeconomic status, have access to nature and improving health outcomes.<sup>14</sup> Additionally, there are also cultural differences among the demographic groups that need to be considered. For example, some communities may have different cultural norms, historical backgrounds, or traditions that influence how they consider or use UGI.<sup>4</sup>

## 2.3 Generalizability and scaling limitations

Building upon this, research conducted by Wang et al. and others in the field of urban green infrastructure and health, reveals many unresolved questions and areas of debate that are important to consider for future studies.<sup>4</sup> While the study done by Wang and colleagues was quite informative it only lasted for five months, restricting the ability of establishing strong casualty and replicability in regards to the results.<sup>4</sup> Furthermore, the results found in the study cannot be generalized to other geographic locations. The study looked at 513 residents that were specifically chosen in China, impacting the applicability of the findings across various demographic groups.<sup>4</sup>

Continuing from the discussion of scaling issues identified in urban green space studies, it's relevant to consider the study conducted by Bixby et al. the research here further highlights the inconsistencies in regards to generalizing the results of green space research across different scales.<sup>19</sup> Previous research has demonstrated that there is an association regarding green space exposure with physical health benefits at the local level.<sup>2</sup> However, the study done by Bixby and colleagues found a contrasting perspective. Here, researchers found that urban green space observed at the community level does not transfer to city level.<sup>19</sup>

These inconsistencies highlight the need for a more comprehensive approach in studying urban green infrastructure. A key challenge in addressing this issue lies in the limited regional specificity of these results. Failing to consider regional differences will severely limit the relevance of these findings across various socio-cultural backgrounds,

environmental settings, and UGI types. Moreover, geographically bias is another challenge that neglects the diverse experiences and impacts of UGI in different locations. This points to an urgent need for more diverse research in the field of urban green infrastructure and physical health.

#### 2.4 Unclear impact of varying types of UGI on physical health conditions

Elaborating on this point, the variation of physical health benefits based on different types of urban green instructure continues to remain a question. For instance, green parks and greenways are known to promote physical activities such as walking, jogging and cycling, thereby offering direct physical health benefits.<sup>2</sup> In comparison, green roofs contribute to improving air quality, which could positively impact respiratory conditions.<sup>20</sup> This highlights a knowledge gap in understanding how diverse urban green infrastructure types can have varying physical health effects. Understanding these nuances is important for policy makers and sustainability planners as they cannot make informed decisions when implementing urban green infrastructure projects.

A problem in conducting this research is that comparing health outcomes across research is difficult due to the variety of assessment techniques and approaches. It is crucial yet difficult to standardize methods for evaluating health effects across various UGI types. Also, it is difficult to evaluate how cost-effectively various UGI varieties should be implemented in relation to their health advantages.<sup>20</sup> Allocating resources presents issues when evaluating the respective health consequences of the different types of UGIs and balancing the investment in each.<sup>20</sup>

## 2.5 Gender disparities

Developing this idea further, research conducted by Li et al. revealed clear gender disparities in how urban residents living in China perceive urban green infrastructure and its impact on their health and well being.<sup>21</sup> The study found that urban green infrastructure had a

greater influence on the subjective health and well being of males, whereas individual and family factors had a more significant impact on the health of females.<sup>21</sup> In comparison, research by Sillman et al. shows contradictory evidence.<sup>22</sup> The study's results showed that the relationship between urban green infrastructure and physical health were stronger for women than men when looking at all general physical health outcomes.<sup>22</sup> Notably, women showed a stronger protectiveness associated with UGI than men in consideration to mortality and obesity-related outcomes.<sup>22</sup> However, though this association was strong, it was only observed for women in Europe and North America, rather than across other continents.<sup>22</sup> Overall, these findings outline the need for more comprehensive gender-related association between urban green infrastructure and physical health.

A main challenge associated with gender-related research involves sociocultural norms. These social norms include societal values, traditions, beliefs, and behaviors that have the power to profoundly affect how individuals perceive, engage with, and react to UGI in their communities. For example, as outlined by Boakye et al. sociocultural norms may discourage outdoor physical activity for women in some places.<sup>23</sup> Additionally, discrepancies in research may arise from differences in study designs, methods, and sample sizes between studies. Producing reliable and similar results requires standardizing research techniques and resolving possible biases.

#### **Further Hypotheses to Investigate**

Future studies in the field of urban green infrastructure can explore forward-thinking hypotheses. The first hypothesis the group proposes is that different types of urban green infrastructure such as urban parks, green roofs, and greenways have distinct impacts on specific health conditions. This approach further enables a more targeted focus on urban planning strategies in the future. The second hypothesis the group proposes is that long term

exposure to urban green infrastructure positively influences physical health outcomes in adults. This approach would allow researchers to examine whether the prolonged exposure to urban green infrastructure results in sustained development of physical health by potentially reducing the risk of chronic diseases. Combining these hypotheses will enhance the current body of knowledge pertaining to urban green infrastructure and physical health, further laying the groundwork for more informed decisions and physical health related urban development policies.

#### **Conclusion**

Studies have reported findings that generally supported the view that green space has an overall beneficial health effect. Wang et al. found that access to urban green spaces increased physical activity among residents living in Nanning, China.<sup>4</sup> Similarly, research done by Kim & Miller relieved patterns of increased physical activity of visitors through walking, jogging and cycling from urban green infrastructure near Huckleberry Trail and Heritage Community Park.<sup>2</sup> Gianfredi et al. extended these findings demonstrating that green spaces can boost overall well-being, promote physical activity, reduce illness, and increase life expectancy.<sup>1</sup> Collectively these studies highlight the vital role of the integration of urban green infrastructure and its effects on physical health of adults. As a result, the research team hypothesizes that integration of urban green infrastructure is positively associated with improved physical health among adults. However, it is also important to address the unresolved questions and gaps of knowledge in the field of urban green infrastructure and health. Firstly, the long-term effects of urban green infrastructure on physical health is not well understood. Many studies focus on short-term outcomes, neglecting sustained research to determine whether the effects of UGI will continue over time. Socioeconomic factors exacerbate these gaps, research in this field fails to address how factors such as income, education, and occupation play a role in the relationship between physical health and UGI.<sup>18</sup>

Furthermore, while Wang et al. provides valuable insights, it is limited in scope due to duration and geographic focus.<sup>4</sup> This hinders the ability to generalize findings across different populations and locations. To add on, research conducted by Bixby et al. demonstrates the inconsistencies in the effect of green spaces when comparing local versus city-wide levels, showing the need for a more comprehensive approach in future studies.<sup>19</sup> The variation of the physical health benefits based on different types of urban green infrastructure is another notable knowledge gap. While some urban green infrastructure such as green parks and greenways can promote physical activities, others like green roofs may improve air quality.<sup>2,20</sup> Understanding these nuances is important for policy makers and sustainability planners to make informed decisions. Finally, gender specific UGI-health research varies globally, revealing a crucial knowledge gap in understanding this relationship.<sup>22</sup> Moving forward there are several areas of study that need further investigation to improve our understanding of the relationship between urban green infrastructure and its effects on the physical health of adults. Future research should prioritize the effects of different types of urban green infrastructure on specific physical health conditions and elucidating the long-term benefits to these green spaces. Through this research, urban development has the potential to transform into multifaceted spaces that specifically target physical human health, further marking a leap to a new-era of health-focused urban design.

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