



Green Streets, Healthy Hearts: Exploring the Roles of Urban Nature and Walkability in Cardiovascular Health

REVIEW

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ABSTRACT

With the growing evidence that connects urban environments with public health outcomes, the role of urban planning has become increasingly critical in addressing public health challenges. Cardiovascular diseases (CVDs) are the leading cause of mortality in urban areas and worldwide and are impacted by characteristics of the built environment, such as walkability and nature exposure. In this literature view, we explore the influence of the physical built environment, specifically green spaces and walkability, on cardiovascular health.

Results from prior studies show a clear reduction in cardiovascular disease-related risk factors, morbidity, and mortality in neighborhoods that integrate green spaces and/or walkability. Cumulative evidence suggests that urban environments that integrate green spaces (such as parks) and walkability (eg, safe sidewalks) can significantly improve cardiovascular health. Urban planning policies and strategies that prioritize the integration of green infrastructure and walkable designs can contribute to improving cardiovascular health in urban residents while also enhancing the overall well-being and quality of life.

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INTRODUCTION

IMPORTANCE OF URBAN PLANNING IN PUBLIC HEALTH

Approximately 56% of the world's population live in urban areas, and the United Nations (UN) projects that approximately 2.5 billion more people—roughly 70% of the total population—will be living in cities by 2050.^{1,2} With this continuing expansion of urban environments, the role of urban planning has become increasingly critical. Unfortunately, many cities are often characterized as being autocentric, with limited access to pedestrian infrastructure and urban nature, which are two of the most important environmental elements shown to promote multiple health behaviors and outcomes.³ Automobile-oriented urban development has further led to high levels of exposures to air pollution, noise, and heat, which can result in sedentary behavior, obesity, high blood pressure and, subsequently, higher rates of cardiovascular-related morbidity and mortality.³ Consequently, the creation of compact, destination-rich urban areas with accessible green spaces and rich pedestrian/bicycle infrastructure can promote sustainable mobility and active lifestyles and therefore contribute to improving both public health and environmental sustainability.⁴

Built environment and urban planning/design disciplines, such as urban design/planning, transportation planning/engineering, architecture, and landscape architecture, significantly influence public health by shaping the built environmental conditions in which people live, work, learn, and play. Effective urban planning/design strategies can enhance access to health care, promote physical activity, reduce exposure to environmental hazards, and facilitate social interactions and cohesion.⁵⁻⁸ By creating environments that encourage healthy behaviors and reduce health risks, these disciplines can contribute to preventing cardiovascular diseases, improving mental health, and enhancing overall quality of life.

SIGNIFICANCE OF CARDIOVASCULAR HEALTH

Cardiovascular diseases (CVDs) are the leading cause of mortality in urban areas and worldwide, accounting for approximately 18.6 million deaths globally each year. Risk factors for CVD include physical inactivity, poor diet, smoking, and exposure to pollution, all of which are influenced by the built environment and urban planning. Environmental factors tend to be readily modifiable, and community-level interventions have been shown to be more sustainable and cost-effective than individual-level interventions.⁹ Therefore, built environmental strategies addressing cardiovascular health problems offer promising opportunities to mitigate these risk factors and promote heart health.¹⁰

This review aims to explore the influence of the built environment, specifically green spaces and walkability, on cardiovascular health. Green spaces and walkability are selected because these two environmental features often drive physical activity behaviors that put residents at lower risk for cardiovascular disease.¹¹ By examining the impact of green spaces and walkability on cardiovascular outcomes, the article highlights the importance of integrating green infrastructure and walkable designs in urban planning to promote heart health.

URBAN PLANNING AND CARDIOVASCULAR HEALTH

IMPACT OF THE BUILT ENVIRONMENT ON PHYSICAL ACTIVITY LEVELS

Physical activity can contribute to the prevention and management of CVD, including the prevention of risk factors (primordial prevention).¹² However, it is increasingly difficult for the majority of adults to meet the physical activity guidelines of 150 minutes per week. Neighborhood environments have been shown to directly influence physical activity levels by determining the availability and quality of spaces available for exercise and recreation as well as opportunities for active transportation such as walking and bicycling.^{13,14} Walking and bicycling are two of the most popular forms of physical activity that can contribute to reducing the risks of CVDs, lowering blood pressure, and improving cholesterol levels, leading to overall cardiovascular health.¹⁵ Therefore, creating walkable/bikeable communities has strong potential for improving cardiovascular health.

This positive relationship between neighborhood environment and physical activity has been explored extensively in literature. One systematic review that evaluated how built environmental factors relate to physical activity concluded that residents living in neighborhoods with diverse housing types, mixed land use, high housing density, and access to natural spaces had increased physical activity, especially walking.¹⁶ In another cross-sectional study, which evaluated this relationship from a global lens, the authors arrived at a similar conclusion after analyzing data of 6,822 adults (ages 18 to 66 years) from 10 countries in 5 continents: Neighborhood environmental features such as the number of parks and walkability have the potential to contribute substantially to physical activity.¹⁷ In fact, this same study noted that the difference in physical activity between participants living in the most and least activity-friendly neighborhoods ranged from 68 min/week to 89 min/week, representing about 45% to 59% of the 150 min/week recommended by guidelines.¹⁷

Enhancing the built environment through open space and street connectivity may be particularly beneficial for improving physical activity in disadvantaged populations such as those having low socioeconomic status.¹⁸ In general, availability of and access to recreational facilities have consistently been shown to increase physical activity levels in adults, adolescents, and children.^{19,20} Urban planning research efforts have focused on leveraging opportunities in land use and design policies to increase walking and bicycling.

RELATIONSHIP BETWEEN BUILT ENVIRONMENT AND CARDIOVASCULAR DISEASE

The built environment encompasses all physical aspects of an urban area, including buildings, roads, parks, and other infrastructures. The built environment generally plays a crucial role in shaping CVD health outcomes, but the mechanism by which this process occurs needs further characterization in literature.²¹ Nonetheless, the active use of the environment, often facilitated by environmental characteristics such as walkability and greenspace, promote a more active lifestyle as it increases propensity and opportunities for exercise and physical activity.²¹

Studies have shown that well-planned environments with ample green spaces and pedestrian-friendly infrastructure can reduce the risk of CVD.²² Properly designed urban areas with access to green spaces and recreational facilities are linked to lower rates of obesity, hypertension, and cardiovascular diseases (myocardial infarction, coronary heart disease, congestive heart failure, angina, and stroke).²³ In particular, Gascon et al. reported an inverse association between higher greenspace exposure and CVD mortality after reviewing 12 eligible studies conducted in North America, Europe, and Oceania, with study populations ranging from 1,645 up to more than 43 million individuals.^{21,24} Another review article that included eight cohort studies in a meta-analysis found that a 0.1 unit increase of normalized difference vegetation

index (NDVI, which measures the health and density of vegetation) was associated with a reduced risk of all-cause mortality and stroke mortality in older individuals.²⁵ In a recent systematic review that involved 63 studies across 21 geographical locations spanning years 2012 to 2023, there was substantive evidence of the association between attributes of the urban environment (greenness and walkability) with cardiovascular risk factors (hypertension and arterial stiffness) and major CVD events including mortality (Table 1).²⁶

ASSESSING URBAN GREENERY/GREEN SPACE/NATURE

METHODOLOGIES FOR EVALUATING URBAN GREENERY

Greenspaces incorporate vegetation, trees, urban parks, residential vegetation, and green infrastructure into urban design, promoting ecological benefits and enhancing aesthetic appeal. However, the process of evaluating urban greenery is quite complex, heterogeneous, and context specific. Even with the positive benefits of green spaces on cardiovascular health, developing a single uniform metric of greenness to measure the amount, type, and quality of nature that is effective for promoting walking and healthy behaviors that prevent CVD has been difficult. Nonetheless, several aerial and eye-level methodologies, including satellite imagery analysis, field surveys, proximity assessments, density counts, and the use of indices—such as the NDVI, Green View Index, Natural Space Index, Recreational Amenity Index, Population Weighted Greenness Value, Enhanced Vegetation Index, and nature scores—have been used to measure urban greenery.¹¹ These methods are useful for quantifying green spaces and assessing their impact on environmental and health outcomes. In reality, aerial-based measures like NDVI or enhanced vegetation index are the most popular, even though eye-level measures such as

	URBAN GREENERY	WALKABILITY
Definitions	The incorporation of vegetation, trees, urban parks, residential vegetation, and green infrastructure into urban design, promoting ecological benefits, and enhancing aesthetic appeal	The extent of friendliness the built environment of a neighborhood is to walking, considering factors such as sidewalk quality, pedestrian safety, traffic density, and access to amenities
Measures	Normalized difference vegetative index (NDVI), green view index (GVI), natural space index (NSI), recreational amenity index (RAI), population weighted greenness value, enhanced vegetation index (EVI), and nature scores	Walk score
Associations with cardiovascular (CV) health	Positive relationship between greenspace and cardiovascular (CV) outcomes including reducing CV disease risks, CV disease morbidity, and CV mortality	Walkability has shown associations with lower risks of hypertension, arterial stiffness, and major CV disease events

Table 1 Overview of urban greenery and walkability.

Google Street View best measure the visual exposure to greenery.¹¹ Thus, most publications qualify urban greenery from the aerial-perception like the NDVI because of its lengthy history, simplicity, and reliance on multi-spectral band transformation to quickly delineate vegetation and vegetative stress.¹¹ Nature scores are also another metric gaining popularity for measuring urban greenery. Utilizing machine learning models, nature scores are created from weighted datasets containing factors such as amount of vegetation using satellite images, parks, tree canopy cover, noise levels, artificial light, air pollution, buildings, roads, and aerial and street view images.^{27,28} Nature scores range from 0 to 100, with higher nature scores indicating better integration of natural elements in urban planning, which can positively impact residents' health and well-being.¹⁰

ROLE OF GREEN SPACES IN MITIGATING CARDIOVASCULAR RISK FACTORS

Many studies have shown the positive relationship between greenspace and cardiovascular outcomes including CVD morbidity and cardiovascular mortality. These associations have been established through ecological, multilevel, and experimental studies, among other types. Access to green spaces has been associated with lower levels of cardiovascular risk factors such as hypertension and cholesterol. The presence of vegetation and natural elements in urban areas can also improve air quality by filtering pollutants, thereby reducing respiratory and cardiovascular problems.

In a large meta-analysis that covered 18 countries and 100 million persons, a 0.1 increase in NDVI was significantly associated with 2% to 3% lower odds of CVD mortality (OR 0.97; 95% CI, 0.96-0.99), ischemic heart disease mortality (OR 0.98; 95% CI, 0.96-1.00), cerebrovascular disease mortality (OR 0.98; 95% CI, 0.97-1.00), and stroke incidence/prevalence (OR 0.98; 95% CI, 0.96-0.99) (Figure 1).²⁹ In another study that included

roughly 1.07 million patients from a large metropolitan urban hospital, the prevalence of cardiovascular risk factors (hypertension, diabetes, dyslipidemia, obesity, smoking) and CVD (coronary artery disease, peripheral artery disease, and stroke) was significantly lower in patients living in neighborhoods with high nature scores (Figure 2).¹⁰ Patients living in neighborhoods with the highest nature score had 9% lower odds of any cardiovascular risk factor and 4% lower odds of any CVD compared to those living in neighborhoods with the lowest nature scores. The study found that higher nature scores were associated with a lower prevalence of CVD and risk factors, highlighting the importance of integrating green spaces in urban planning. In another systematic review study that evaluated 63 studies published between 2012 and 2023, there was moderately consistent evidence of protective associations of greenness with cardiovascular risks and major CVD events, including CVD mortality, ischemic heart disease mortality, and stroke hospitalization.³⁰ The favorable cardiovascular outcome associated with greenspaces has not only been seen in the general population but also has been noted in special populations such as those living with diabetes mellitus and cancer.^{31,32}

Urban greenspaces support cardiovascular health via multiple pathways, including alleviating stress and increasing positive disposition, improving sleep, enriching outdoor settings used for recreational purposes, and mitigating adverse effect of heat and air pollution.³¹

WALKABILITY AND CARDIOVASCULAR HEALTH

DEFINITION AND COMPONENTS OF WALKABILITY

Walkability refers to how friendly a neighborhood's built environment is to walking, considering factors such as

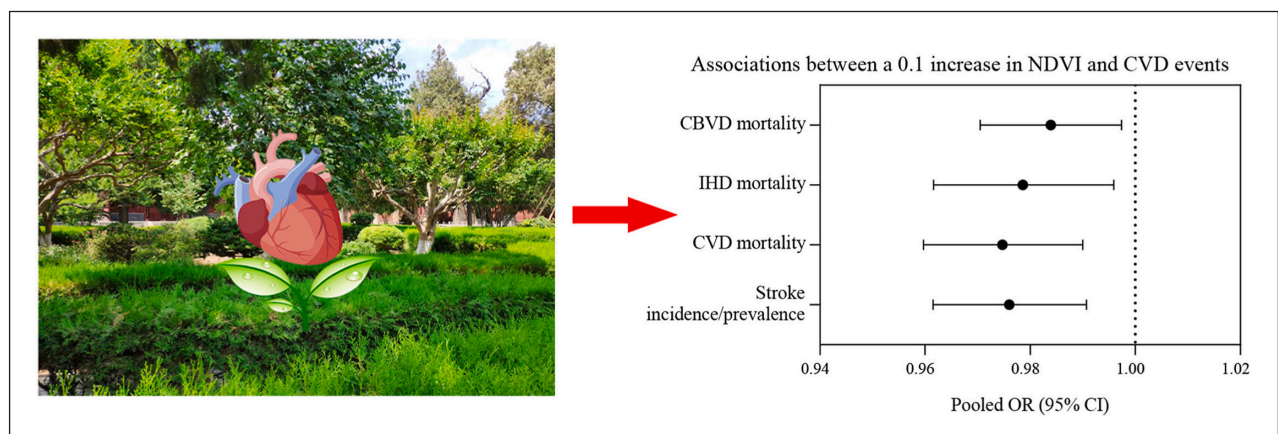


Figure 1 Association between normalized difference vegetative index (NDVI) and cardiovascular disease (CVD) events. Adapted from Liu et al. (2022) with permission from the publisher. Copyright from © 2022 Elsevier.

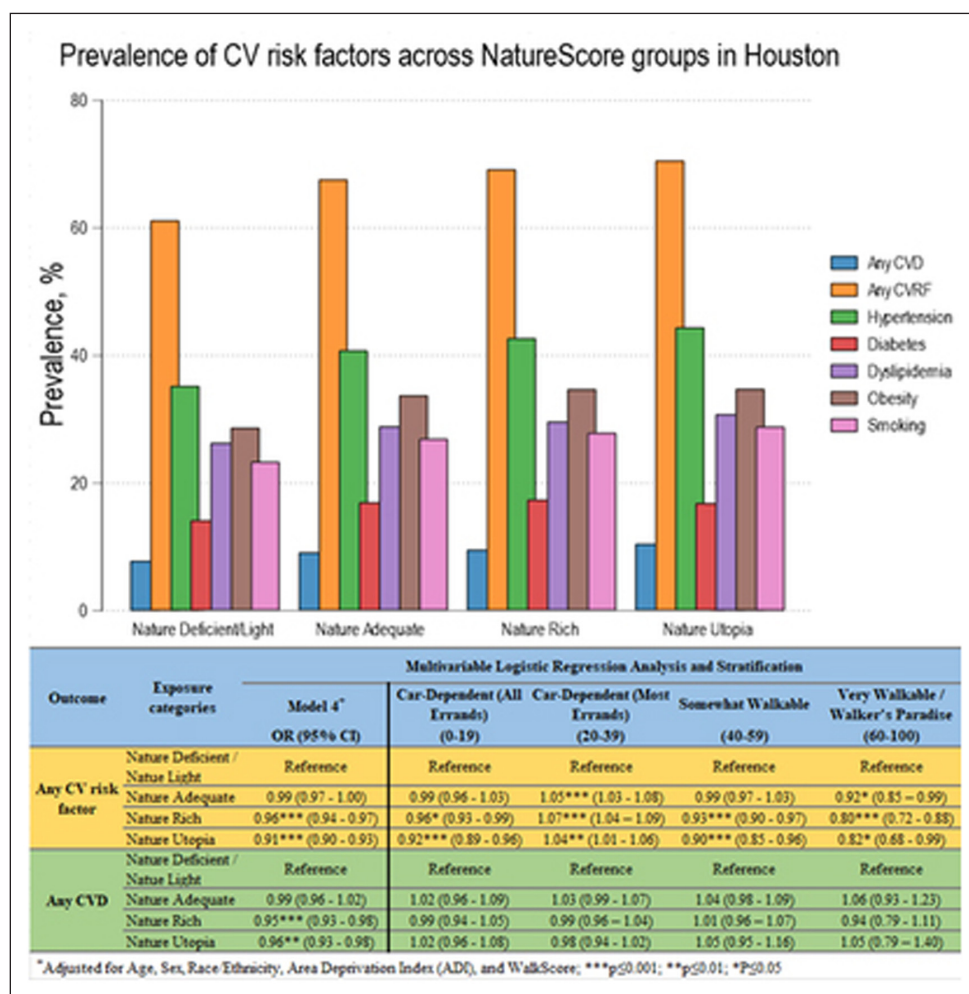


Figure 2 Prevalence of cardiovascular risk factors across NatureScore groups in Houston. Adapted from Makram et al. (2023) with permission from the publisher. Copyright © 2023, Wolters Kluwer Health.

sidewalk quality, pedestrian safety, traffic density, and access to amenities.³³ High walkability is characterized by well-maintained sidewalks, safe street crossings, and proximity to parks, shops, and public transportation. These components encourage walking and reduce reliance on cars, promoting physical activity and reducing pollution.³⁴ The measure of walkability is often operationalized by a walk score, which serves as a valid and reliable tool for measuring access to nearby walkable facilities. Walk scores may be calculated independently by the researcher or can be accessed publicly from Walk Score™ (www.walkscore.com),³⁵ which uses a patented system to calculate a “walkability” score. The Walk Score algorithm calculates this score of walkability using a decay function based on network distance to amenities. Pedestrian friendliness from analyzing population density and road metrics such as block length and intersection density are summed up in the final scores, which are normalized to yield a score range from 0 (least walkable) to 100 (most walkable).³⁵

RESEARCH ON THE ASSOCIATION BETWEEN WALKABILITY AND CARDIOVASCULAR HEALTH

Research consistently shows a positive association between walkability and cardiovascular health. One recently published study in Houston demonstrated that the prevalence of CVD risk factors was significantly lower among participants in the most walkable neighborhoods irrespective of atherosclerotic CVD status.³⁶ This study also demonstrated the relationship between neighborhood walkability and a favorable CVD risk profile by showing that adults living in the most walkable neighborhoods were more likely to have an optimal CVD risk profile than those in the least walkable neighborhoods (RRR 2.77; 95% CI, 2.64-2.91). At the national scale, another study has shown that prevalence of CVD risk factors decreases as walkability increases (Figure 3).³⁷ Specifically, in this study that incorporated a total of 70,123 census tracts nationwide, a comparison of the least walkable neighborhoods with the most walkable neighborhoods revealed a statistically significant decrease in the prevalence of CAD (7.0% to

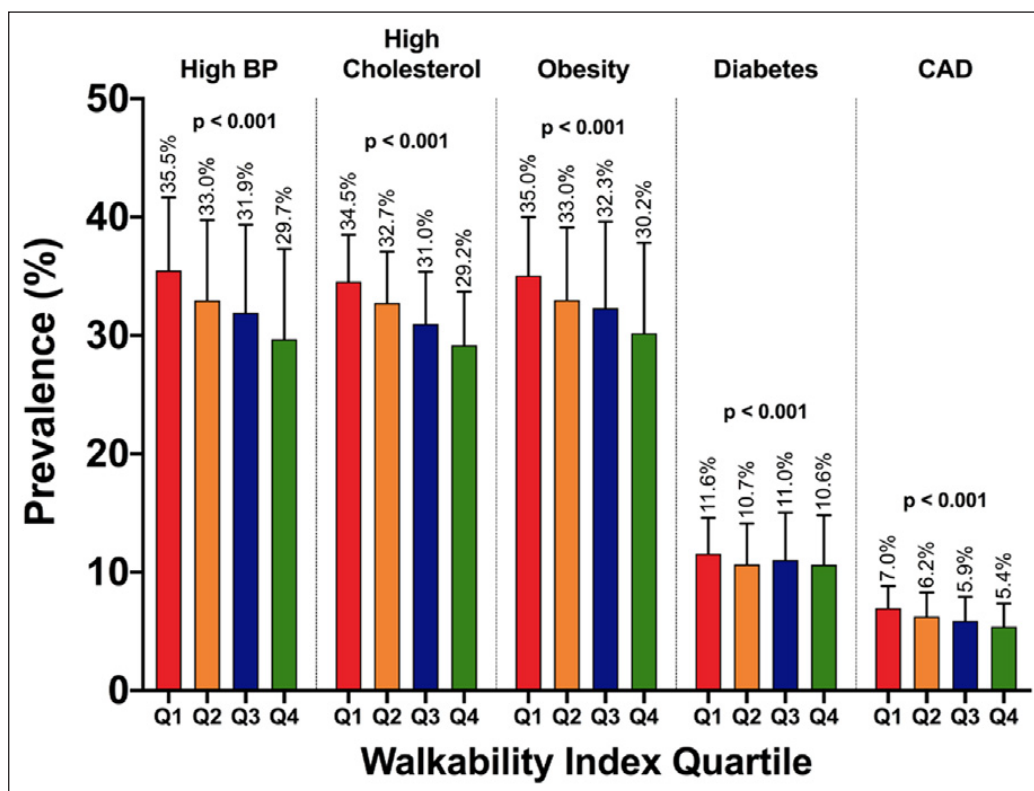


Figure 3 Mean prevalence of cardiovascular health outcomes and risk factors according to quartile of walkability index. Adapted from Makhoul et al. (2022) with permission from the publisher. Copyright © 2022 Elsevier Inc. BP: blood pressure; CAD: coronary artery disease. Error bars represent standard deviations. P values are from ANOVA tests

5.4%) and risk factors including hypertension (35.5% to 29.7%), high cholesterol (34.5% to 29.2%), obesity (35.0% to 30.2%), and diabetes (11.6% to 10.6%).³⁸ Walkability has also shown associations with lower risks of hypertension, arterial stiffness, and major CVD events.²⁷ Additionally, special population groups, such as patients with a history of cancer, have also asserted this relationship between neighborhood walkability and cardiovascular health. One such recently published study of patients with a history of cancer exemplified this relationship by showing that those residing in the most walkable neighborhoods versus the least walkable had 21% lower odds of hypertension, 33% lower odds of diabetes, 40% lower odds of obesity, and 16% lower odds of any CVD risk factor.³⁹

INTERVENTIONS TO IMPROVE WALKABILITY IN URBAN AREAS

Interventions to enhance walkability include improving sidewalk infrastructure, increasing the availability of pedestrian crossings, reducing traffic speed, and incorporating green spaces along walking paths. Urban planning policies that prioritize pedestrian-friendly designs and connectivity can significantly improve walkability and encourage physical activity, thereby reducing CVD risk factors.⁴⁰

INTERSECTION OF GREEN STREETS AND WALKABILITY

SYNERGIES BETWEEN GREEN INFRASTRUCTURE AND WALKABLE URBAN DESIGN

Both green infrastructure and walkable urban design are integral to creating healthy urban environments that encourage physical activity, reduce pollution, and improve mental health.⁴¹ Green infrastructure and walkable urban design work synergistically to enhance public health. Green streets with trees and vegetation provide shade, reduce urban heat, and improve air quality, making walking more enjoyable and reducing stress.⁴² Studies have shown that residents of neighborhoods with high levels of both greenery and walkability have lower rates of cardiovascular disease, obesity, and hypertension. Integrating these elements into urban design promotes a healthier lifestyle and enhances cardiovascular health outcomes.⁴⁰

EXAMPLES OF CITIES IMPLEMENTING GREEN STREETS TO ENHANCE WALKABILITY

Cities such as Copenhagen and Barcelona have successfully implemented green streets to enhance walkability. In Copenhagen, extensive green infrastructure and

pedestrian-friendly designs have created a highly walkable city, leading to increased physical activity and improved cardiovascular health. Barcelona's urban master plan integrates green spaces and walkable paths, promoting cardiovascular health among its residents.^{33,43}

CHALLENGES AND OPPORTUNITIES

BARRIERS TO IMPLEMENTING GREEN STREETS AND WALKABLE DESIGNS

Implementing green streets and walkable designs faces several barriers, including high costs, limited space, and resistance from stakeholders. Additionally, existing urban infrastructure may need significant modifications to accommodate new designs. Overcoming these barriers requires political will, public support, and innovative funding mechanisms.⁴⁴

STRATEGIES TO OVERCOME CHALLENGES

Strategies to overcome these challenges include engaging communities in the planning process, securing funding through public-private partnerships, and implementing pilot projects to demonstrate benefits. Education and advocacy can also play a critical role in garnering support from the public and policymakers.⁴⁵ In addition, interdisciplinary collaboration between urban planners, public health professionals, environmental scientists, and policymakers is essential for successful implementation. Such collaboration can lead to innovative solutions that address multiple aspects of urban health, from environmental sustainability to social equity.

FUTURE DIRECTIONS

EMERGING TRENDS IN URBAN PLANNING FOR CARDIOVASCULAR HEALTH

Emerging trends in urban planning for cardiovascular health include the use of smart city technologies to monitor and enhance green spaces and walkability. Integrating health data with urban planning tools can provide real-time feedback and facilitate the development of health-promoting environments.⁴⁶

RESEARCH GAPS AND AREAS FOR FURTHER INVESTIGATION

Research gaps include understanding the long-term impacts of green streets and walkable designs on cardiovascular health and exploring the effects of different types of green spaces. Further investigation is needed to

determine the most effective interventions and to develop standardized metrics for evaluating urban greenery and walkability.⁴⁷

POLICY IMPLICATIONS AND RECOMMENDATIONS

Current urban policies have resulted in spatially fragmented, and socially divisive cities that have negatively impacted health. Policies should prioritize the integration of green infrastructure and walkable designs in urban planning. Recommendations include adopting nature scores and walkability assessments in urban development projects, providing incentives for green building practices, and ensuring equitable access to green spaces for all residents.⁴⁸

CONCLUSION

SUMMARY OF KEY FINDINGS

Urban planning that integrates green streets and walkability can significantly improve cardiovascular health by promoting physical activity, reducing stress, and enhancing environmental quality. Nature scores and walkability assessments are effective tools for evaluating and improving urban environments. Integrating green spaces and walkability into urban planning is essential for creating healthy, sustainable cities. These strategies not only improve cardiovascular health but also enhance overall well-being and quality of life for urban residents.

Policymakers, urban planners, and public health professionals must collaborate to prioritize green infrastructure and walkable designs in urban development. By doing so, they can create environments that support cardiovascular health and foster vibrant, healthy communities.

KEY POINTS

- Cardiovascular diseases (CVDs) are the leading cause of mortality in urban areas and are impacted by characteristics of the built environment, such as walkability and nature exposure.
- Integrating green spaces and walkability into urban planning is essential for evaluating and improving urban environments.
- Collaborations among policymakers, urban planners, and public health professionals are needed to prioritize green infrastructure and walkable designs in urban development.


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COMPETING INTERESTS

The authors have no competing interests to declare.

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