UCLA Institute of Transportation Studies

beyond Copenhagen

Walking & cycling success stories from cities worldwide

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Adam Millard-Ball
Monisha Reginald
Yasmina Yusuf
UCLA Luskin School of Public Affairs

Christopher Bian
Willa Ng
Google


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Executive Summary

Walking and cycling are the ultimate in sustainable transportation. From a societal perspective, they are practically zero carbon, and emit no harmful air pollutants. They require minimal space on the street and for parked bicycles. And it costs cities little to provide infrastructure for sidewalks and bicycle lanes. From the individual perspective, traveling by foot or bicycle is free or low cost. And it helps people integrate physical activity into their daily routines.

How can mayors, city officials, and other policymakers realize this potential and encourage more people to walk and cycle in safety? This playbook uses a new source—Google Environmental Insights Explorer—to provide data-driven guidance on how to encourage active transportation in cities around the world. Based on data on walking and cycling in 11,587 cities from 121 countries across six continents, it highlights success stories from a range of geographic and socio-economic contexts, including cities whose efforts have flown under the radar and attracted little attention to date.

Our results demonstrate that mayors, city planners, and other local officials have two important ways to promote walking and cycling. First, they can make cities denser. Higher population densities bring destinations closer together, making it feasible to walk and cycle for many trips that would otherwise require a car or public transport.

Second, cities can redesign streets to make active travel safer and more comfortable. Our dataset highlights the role of bicycle lanes and paths, particularly protected lanes, dedicated bridges, and express bicycle networks with higher design standards. But other aspects of street design—sidewalks, safe crossings, and traffic calming measures such as raised intersections—are also important for active travel.

Policy at the national level matters too. Most significantly, higher gasoline prices encourage people to walk and cycle, suggesting that a broader set of price incentives (such as tolls and parking charges) can lead to shifts in travel away from cars and towards walking and cycling.

Danish and Dutch cities are well known for their superb infrastructure that supports active travel. Our results show that their reputation is well deserved, but that cities can also look to a wider range of role models for inspiration. Dedicated bicycle infrastructure is one important pathway to a bicycle-friendly city, but an alternative approach is exemplified by Japanese cities such as Osaka. There, bicycling is primarily facilitated by a network of narrow, low-speed, low-traffic streets.

The wider message for local policymakers is that they have many models from which to seek inspiration. Copenhagen and Amsterdam may resonate with some mayors and city transport planners, but other cities in many parts of the world have pursued similar approaches with less fanfare. And cities such as Osaka highlight the potential of an alternative pathway with less extensive walking and cycling infrastructure, but a network of slow streets where different road users coexist.

Introduction

Walking and cycling are the ultimate in sustainable transportation. From a societal perspective, they are practically zero carbon, and emit no harmful air pollutants. They require minimal space on the street and for parked bicycles. And it costs cities little to provide infrastructure for sidewalks and bicycle lanes. From the individual perspective, traveling by foot, wheelchair, or bicycle is free or low cost. And it helps people integrate physical activity into their daily routines.

The potential for walking and cycling and related modes such as wheelchairs—which we call "active transportation" throughout this playbook—to take center stage is demonstrated in cities worldwide. Amsterdam and Copenhagen are known to tourists and urban planners worldwide for their bicycle infrastructure. Throngs of pedestrians are a hallmark of popular images of New York and Tokyo. These and other case studies suggest that active transportation could reduce urban transport emissions by between 2% and 10%, according to the Intergovernmental Panel on Climate Change (IPCC).[1] On top of the climate benefits, planning for active transportation can help reduce the immense toll of road traffic fatalities—1.19 million deaths in 2023, of whom 23% were pedestrians and a further 6% were cyclists.[2]

[1] IPCC. 2022. *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press, p. 1063.

[2] WHO. 2023. *Global Status Report on Road Safety 2023*. Geneva: World Health Organization.

How can mayors, city officials, and other policymakers realize this potential and encourage more people to walk and cycle in safety? A range of best practice guides, academic research, and technical assistance programs exist to help them promote active transportation. For example, multilateral agencies such as the World Bank, nonprofit organizations such as the Institute for Transportation and Development Policy, and networks such as C40 Cities provide guidebooks and often in-person assistance to city officials.

A lack of data, however, has limited the usefulness of these resources. Fundamentally, most cities do not know how often and how far people walk or cycle—let alone the effectiveness of specific policies or infrastructure designs *(see Box 1)*. As a result, it's not clear whether well-known case studies are truly those with the best track record, or have simply received the most publicity for their efforts.

What's more, case studies of best practices and academic research tend to focus on northern Europe, and to a lesser extent, North America. But often, policymakers look for inspiration from peer cities—similar in population size, income levels, and urban planning traditions, and located in the same geographic region. For urban policymakers in many parts of the world, particularly in the Global South, there is little information on active transportation planning in their peer cities, and guides on best practices that highlight the northern European experience may be of limited relevance.

Planners often focus on the superb cycling infrastructure in Copenhagen, but overlook best practices from elsewhere in the world.
Photo credit: Kristoffer Trolle, CC-BY 2.0

About this playbook

This playbook uses a new source—Google Environmental Insights Explorer (*see Box 1*)—to provide data-driven guidance on how to encourage active transportation in cities around the world. Because it is based on data on walking and cycling in 11,587 cities from 121 countries across six continents, it can highlight success stories from a range of geographic and socio-economic contexts, including cities whose efforts have flown under the radar and attracted little attention to date.

Part One quantitatively analyzes the factors that are associated with mode share in the 11,587 cities in the sample. It highlights the role of infrastructure and population density, as well as national-level factors such as fuel prices.

Part Two provides vignettes of eight high-performing cities, selected through a data-driven process. Each vignette gives an overview of the policy initiatives that have led to remarkably large shares of trips being made by foot and bicycle. The vignettes show that walking and bicycling infrastructure can be implemented in cities of all sizes in all parts of the world, from Osaka to Leiden. And they highlight the role of advocacy organizations, road safety initiatives, bicycle sharing programs, and traffic calming measures.

Raised crosswalks in Casablanca, Morocco
Photo credit: Adam Millard-Ball

What our findings mean for cities

Francis Road, Leyton, in London—one of the high-performing cities profiled in Part Two
Photo credit: Dan Bowditch

Together with existing research and policy guidance, our findings point to specific steps for cities wanting to increase walking and biking:

1. Redesign streets.

Sidewalks, safe crossings, and bicycle lanes that are physically protected from car traffic give people the confidence to walk and cycle. Narrower streets and lanes can do the same through slowing down cars. The *Global Street Design Guide* gives specific guidance for cities in all parts of the world.

2. Increase densities.

Walking and biking are fueled by density, which brings destinations closer together. Cities can support greater densities through adjusting land-use regulations—relaxing height limits and eliminating requirements for parking, for example.

3. Put safety first.

Globally, more than one million people die each year from road traffic crashes. Pedestrians and cyclists are the most vulnerable users of the road, especially in low-income countries. Thus, road safety is normally the immediate priority. But Vision Zero and other safety-focused plans in cities such as Hoboken in the United States and Buenos Aires in Argentina have brought the added benefit of boosting active travel—safer streets mean more walking and cycling.

4. Focus on walking.

While all types of active travel bring health and environmental benefits, walking accounts for more than twice as much travel as cycling. Improving the safety and comfort of walking can therefore benefit the most people. But there are synergies: the policies that encourage people to walk—density, slower traffic speeds, and redesigned streets—are the same as those that promote cycling too.

Cycling in Paris
Photo credit: Donald Shoup

5. Look beyond Copenhagen (and Amsterdam).

Large, northern European cities such as Copenhagen and Amsterdam are some of the best-known case studies for successful cycling policies. But mayors and other policymakers may find more context-appropriate inspiration in their region, in success stories such as Osaka, Montreal, and Buenos Aires.

6. Climate is no excuse.

Rain and snow have no detectable impact on walking and cycling rates, and cold winter temperatures have a relatively small effect. Meanwhile, some of the highest rates of active travel are found in the snow of Montreal and Copenhagen, and in the heat and humidity of Kolkata and Dhaka. People adapt to their local climate, and planners can promote active travel everywhere.

7. Seek support from above.

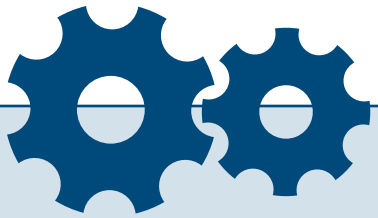
Cities can use the evidence in this playbook to seek funding for street redesigns and other active travel infrastructure from their national governments, and from development banks and other international organizations. National-level policies such as motor fuel taxes can also support active travel directly through making driving more expensive.

8. Cost doesn't need to be prohibitive.

While walking and biking infrastructure can be expensive, it doesn't need to be. In cities such as Hoboken, low-cost measures have included traffic cones to create temporary mini-roundabouts, and plastic posts to increase visibility by preventing parking close to intersections. Pilot initiatives allow cities to start small, iterate, and adapt.

9. Temporary initiatives can encourage active travel.

On certain days, weeks, or months, cities can dedicate major roads for exclusive use by pedestrians and bicycles. Montreal, for example, pedestrianizes a number of streets throughout the summer months to encourage not just active travel but also economic activity. Cities can also organize engagement events such as the annual Sustainable Mobility Week in Buenos Aires, where in 2023, spaces that were dedicated to the car such as parking lots were used to promote other forms of transportation.



Resources and further reading

C40 Cities. 2021. *How to achieve a walking and cycling transformation in your city.* https://www.c40knowledgehub.org/s/article/How-to-achieve-a-walking-and-cycling-transformation-in-your-city

Global Designing Cities Initiative. 2016. *Global Street Design Guide*. https://globaldesigningcities.org/publication/global-street-design-guide/

Institute for Transportation and Development Policy. 2022. *Making the Economic Case for Cycling*. https://itdp.org/publication/economics-of-cycling/

World Bank. 2023. *The Path Less Travelled: Scaling Up Active Mobility to Capture Economic and Climate Benefits*. https://openknowledge.worldbank.org/handle/10986/40672

World Resources Institute. 2021. *4 Ways to Design Safe Streets for Cyclists*. https://www.wri.org/insights/ways-cities-design-safer-roads-cyclists

Box 1: EIE: New data for walking and cycling

How often and how far do people travel on foot and by bicycle in cities around the world? Until now, such data have been scarce, fragmented, and inconsistently collected, making comparisons between cities challenging. For example:

- **National travel surveys** typically have sample sizes that are too small to analyze behavior at the level of individual cities
- **City-level surveys** are typically only done by larger, wealthier cities, and there is no centralized source of these data
- **Some datasets only consider the commute to work**, while others reflect non-commute trips as well
- **Definitions of a "city" vary**—some refer to metropolitan regions, and some to just the central city
- **Respondents often forget to mention trips** made on foot when completing a survey, and the way that questions are phrased can affect responses too

Environmental Insights Explorer (EIE) provides a new way of measuring the amount of walking and cycling, drawing on aggregated, anonymized, and differentially private Location History data from opted-in users. For each city, EIE quantifies the number of trips and the distance traveled by each mode in a given year. Data are aggregated to the city level, and represent the year 2023. Data are available for 11,587 cities from 121 countries, with China representing the most significant gap.

A key advantage of EIE for the purposes of this playbook is its global consistency in methods and the definition of a trip. Although the lack of an authoritative reference dataset makes it impossible to benchmark EIE against the "true" numbers, there is a strong correlation between EIE and other sources of pedestrian and bicycle travel data. For more details of these comparisons, see the Appendix.

Part One: Worldwide Patterns

Where people walk and cycle the most

Walking accounts for 14.3% of trips in cities in the EIE dataset, and cycling a further 2.1%. As a share of distance traveled, the proportions are 2.0% for walking and 0.9% for cycling, reflecting the shorter lengths of these trips.

At the country level, the Netherlands and Denmark have the highest shares of travel by bicycle—no surprise given their international reputations for cycling infrastructure. But countries such as Afghanistan, Belgium, Bangladesh, and Sweden also have high shares of travel by bicycle (*Figure 1*). At the city level, northern European cities tend to have the most bicycling, but clusters of high-cycling cities are also evident in Latin America, Japan, Bangladesh, and Morocco (*Figure 2*).

The countries with high shares of travel on foot—particularly Haiti, Afghanistan, Senegal, Slovakia, Serbia, and Ukraine[3] (*Figure 3*)—are less well known for their transportation planning and street design efforts. This perhaps reflects the lower profile of pedestrian travel in the news media and planning discourse, even though walking accounts for 7 times as many trips and 2.3 times as many kilometers as cycling. The cities where walking is most prevalent are overwhelmingly found in Europe, although as with bicycling, smaller clusters exist in North and Latin America, Japan, and Bangladesh (*Figure 4*).

The countries with the highest shares of *trips* made by cycling and walking are similar to the countries that stand out with regards to shares of *travel* by active modes. The Netherlands, Denmark, and Belgium have some of the most cycling across both measures and

[3] The share of kilometers traveled by walking in Ukraine was similar in 2018, 2019, and 2022, indicating that the rate of walking is not being driven by war in the country.

Ukraine, Belarus, and Spain are three of the countries with the most walking across both measures.

Even within a single country, there is enormous variation in active travel between different cities, reflecting the importance of local-level decisions on infrastructure and land use (*Figure 5*). Cycling mode share ranges from virtually zero in thousands of cities to more than one-quarter of kilometers and trips in Dutch cities such as Groningen and Houten. Even in the Netherlands, the share of travel by bicycle ranges from 2% to 36% (in Wageningen) and the share of trips made by bicycle ranges from 5% to 40% (with the highest cycling share again found in Wageningen).

The outliers (indicated by the dots in Figure 5) are particularly notable in the Netherlands and Germany. In Germany, the median city has a share of travel by bicycle of just 4%, but the share exceeds 10% in the outliers such as Münster. For walking, outliers include Santiago de Compostela and Logroño (Spain) and Sidi Taibi (near Rabat, Morocco). There are also notable outliers for the percent of trips made by active modes, particularly in Japan (*Figure 6*). In Japan, the median city has a cycling mode share of about 3% of trips, but the outliers, particularly certain suburbs of Osaka such as Kadoma and Moriguchi, exceed 20%. For walking, the outliers include Cachan (a suburb of Paris, France) and Stratford-upon-Avon (UK).

Overall, the EIE data back up the well-known bicycling success stories in cities such as Copenhagen and Amsterdam. But they also highlight a wider range of less well-known examples of cities where active travel plays a major role, from Dhaka to Münster and from Kabul to Vancouver. And the outliers in Figures 5 and 6 show that even in countries such as Belgium where most cities have relatively low rates of active travel, there are exceptional cities such as Leuven that their neighbors can look to for inspiration.

Box 2: Calculating the share of active travel

Urban planners often refer to the proportion of *trips* that are made by a particular mode of travel, such as foot or bicycle. Here, we focus on the proportion of the *distance traveled* that is made by a particular mode. We refer to this simply as the share of *travel* in the text. While both measures—trip share and travel share—are important, travel is more closely related to outcomes such as physical activity and climate change.

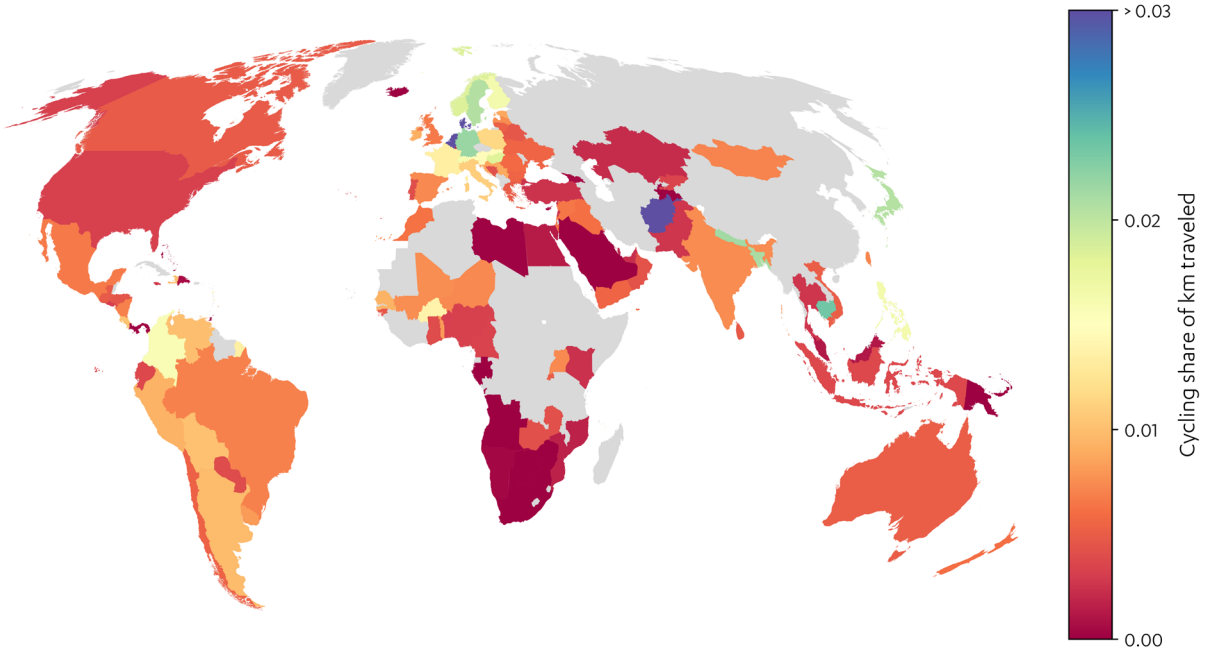


Figure 1. Share of kilometers traveled by bicycle—countries. For each country, the data includes cities in the EIE dataset only. Adapted from Millard-Ball et al. (2025). https://doi.org/10.1073/pnas.2422334122.

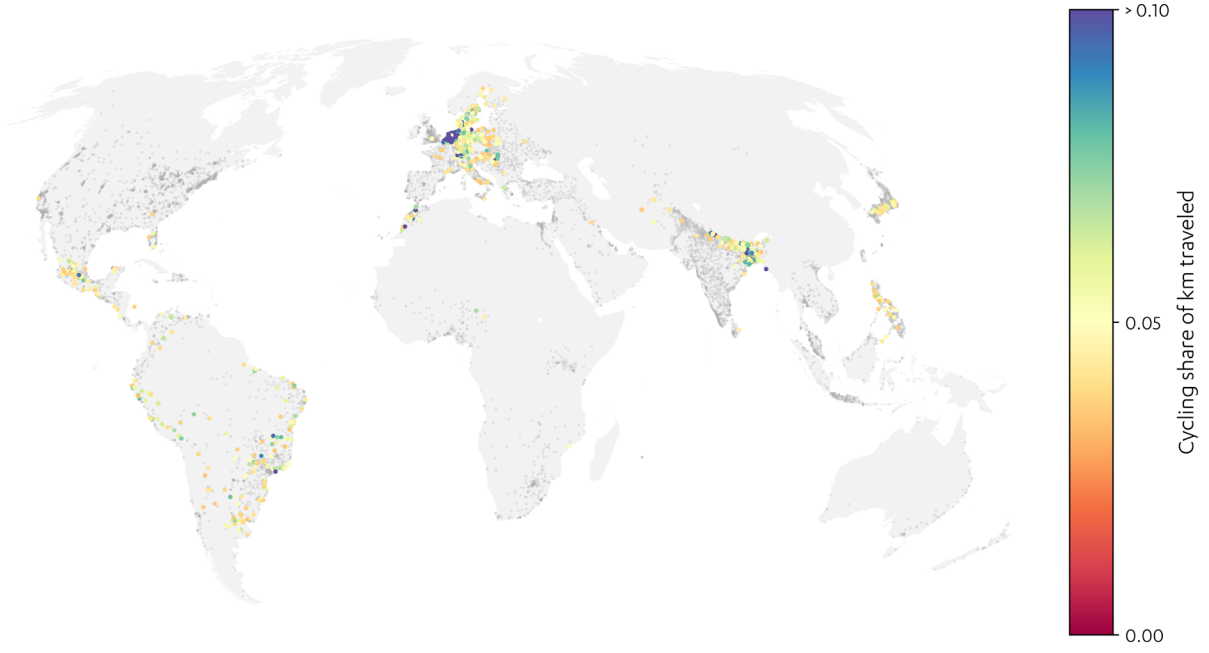


Figure 2. Share of kilometers traveled by bicycle—cities. The top 10% of cities are highlighted in color; other cities in the EIE dataset are shown in gray. Adapted from Millard-Ball et al. (2025). https://doi.org/10.1073/pnas.2422334122.

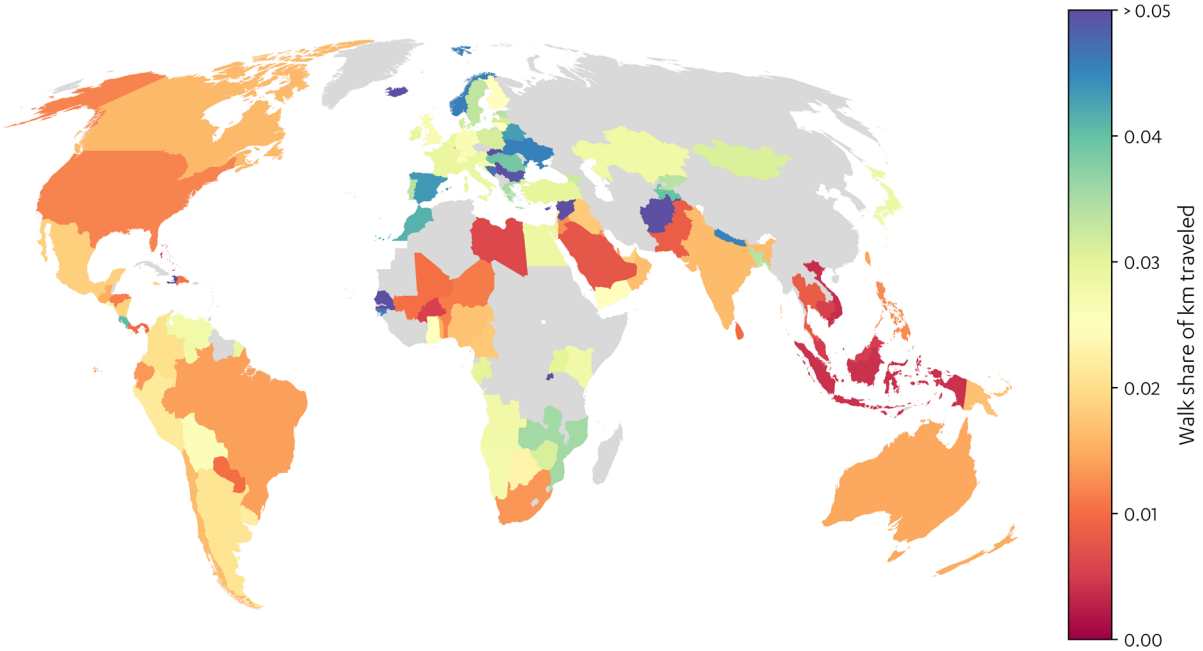


Figure 3. Share of kilometers traveled by foot—countries. For each country, the data includes cities in the EIE dataset only. Adapted from Millard-Ball et al. (2025). https://doi.org/10.1073/pnas.2422334122.

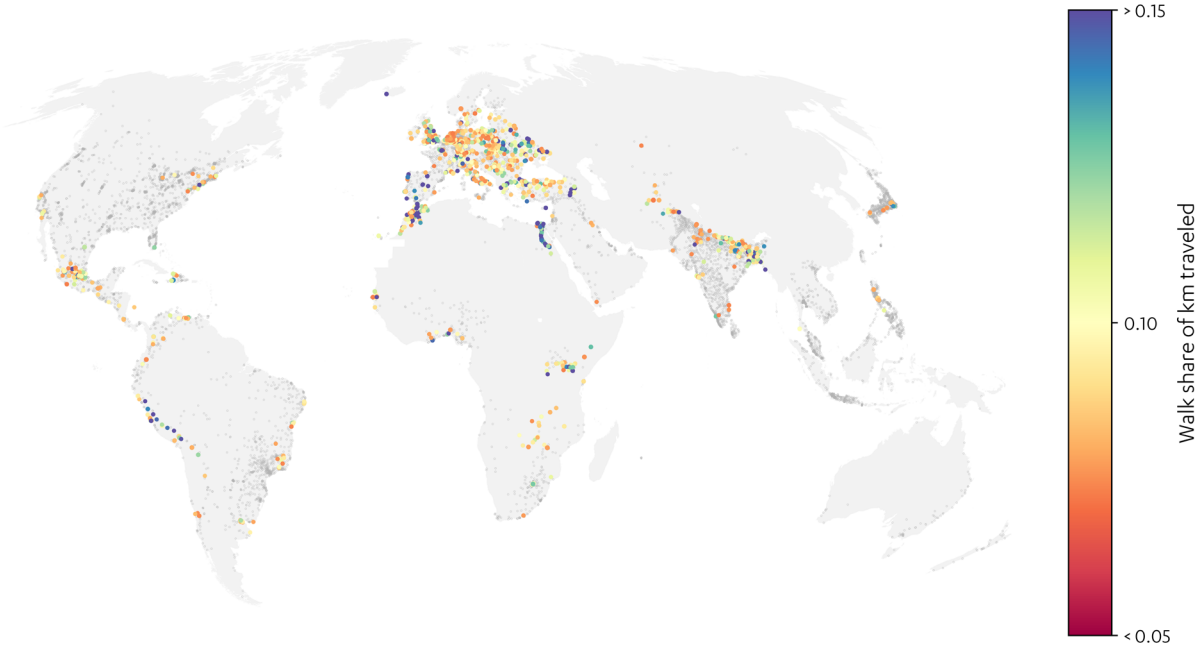


Figure 4. Share of kilometers traveled by foot—cities. The top 10% of cities are highlighted in color; other cities in the EIE dataset are shown in gray. Adapted from Millard-Ball et al. (2025). https://doi.org/10.1073/pnas.2422334122.

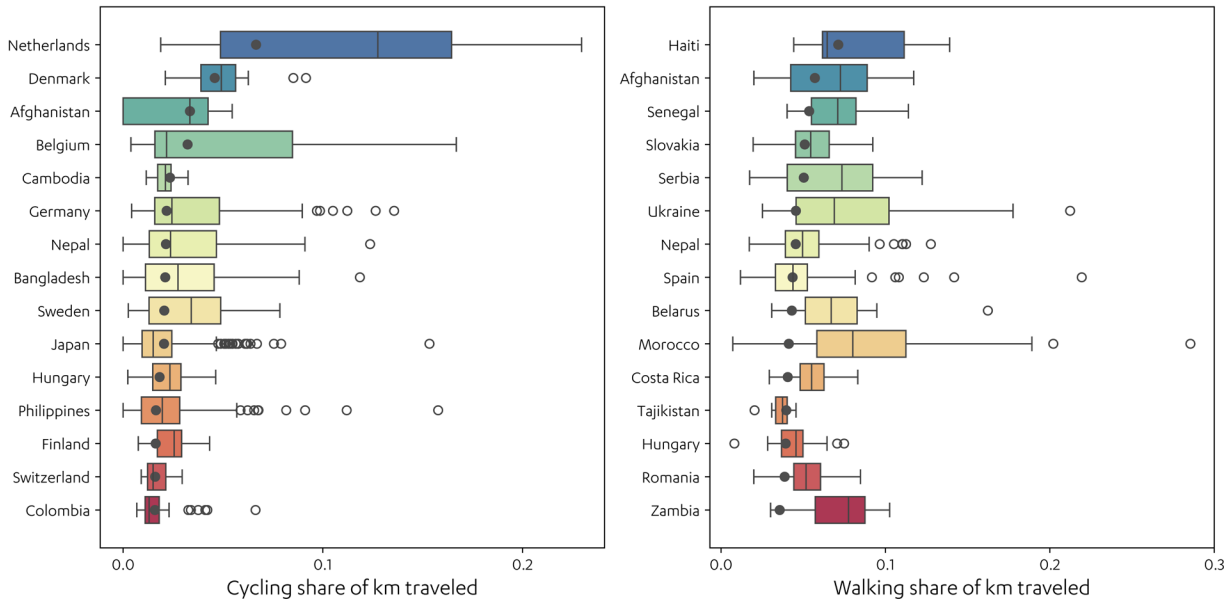


Figure 5. Distribution of city mode share (kilometers). Countries are ordered by the average share of kilometers traveled by bicycle (*left*) and on foot (*right*). For each country, the box shows the distribution of city-level mode shares, with the horizontal lines denoting the median city in each country, and the individual dots marking the outliers. The solid circle shows the mean. Adapted from Millard-Ball et al. (2025). https://doi.org/10.1073/pnas.2422334122.

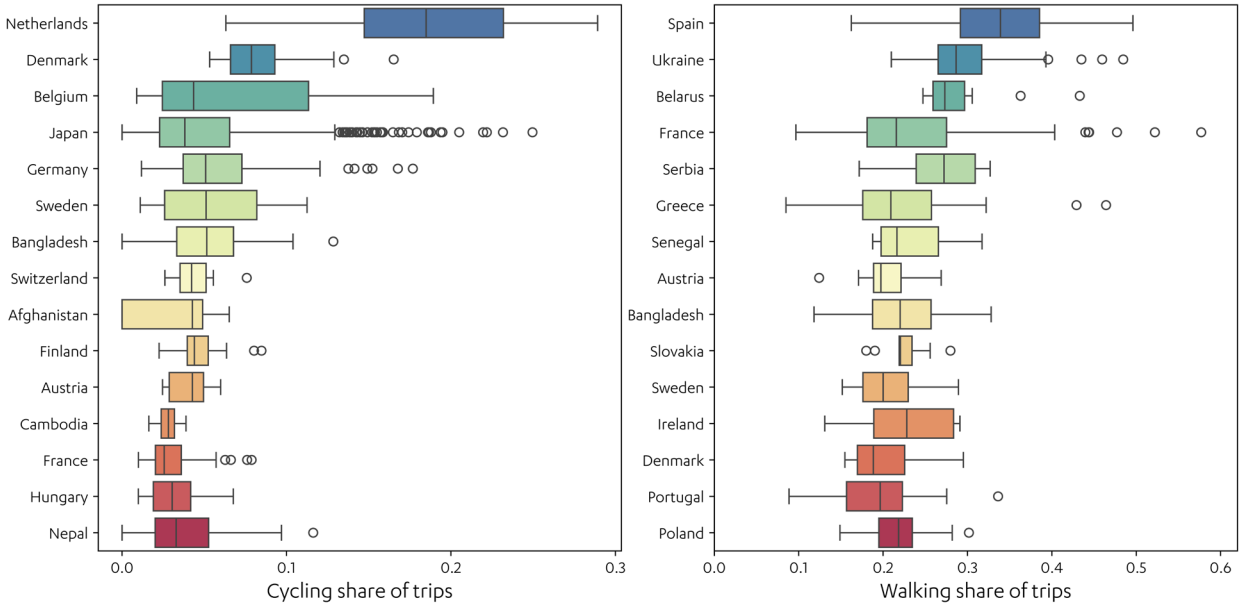


Figure 6. Distribution of city mode share (trips). Countries are ordered by the average share of trips made by bicycle (*left*) and on foot (*right*). For each country, the box shows the distribution of city-level mode shares, with the horizontal lines denoting the median city in each country, and the individual dots marking the outliers.

What explains walking and cycling rates?

Bicycle parking near Utsunomiya train station, Japan
Photo credit: CelloSong, CC BY-SA 4.0

What explains the success of certain cities in fostering active travel? To some extent, it's shaped by national-level factors such as the price of gasoline, income levels, and the age structure of the population. But the wide variation in walking and cycling rates between cities in the same country highlights the importance of city-level factors. Previous research[4] has identified how:

- **Population density** brings destinations closer together, making walking and cycling feasible for more trips
- **Connected streets**—a gridiron pattern rather than culs-de-sac, for example—provide direct routes and reduce travel distances, enabling more walking and cycling trips
- **Street design** incorporating sidewalks, bicycle lanes, and pedestrian and bicycle paths helps keep road users safe and encourages active travel
- **Public transport** can be complementary to walking and cycling, enabling people to live without a car, and most riders will walk or cycle at each end of the bus or train trip
- **The physical geography** of a city—extreme temperatures, rain and snow, and steep slopes—can make it uncomfortable to walk or cycle

Our statistical modeling (explained briefly in *Box 3*) analyzes the contribution of each of these factors. Overall, the results (*Figure 7*) highlight the importance of urban form, particularly population density, and the design of city streets, as indicated by the number of bicycle lanes. But Figure 7 also shows the role of broader transportation policies and infrastructure that incentivize alternatives to the private car, such as higher gasoline prices and the presence of subways or other urban rail services.

[4]For example: Pucher, John R., and Ralph Buehler (eds). 2021. *Cycling for Sustainable Cities*. The MIT Press; Heinen, Eva, Bert Van Wee, and Kees Maat. 2010. "Commuting by Bicycle: An Overview of the Literature." *Transport Reviews* 30 (1): 59–96. https://doi.org/10.1080/01441640903187001 .

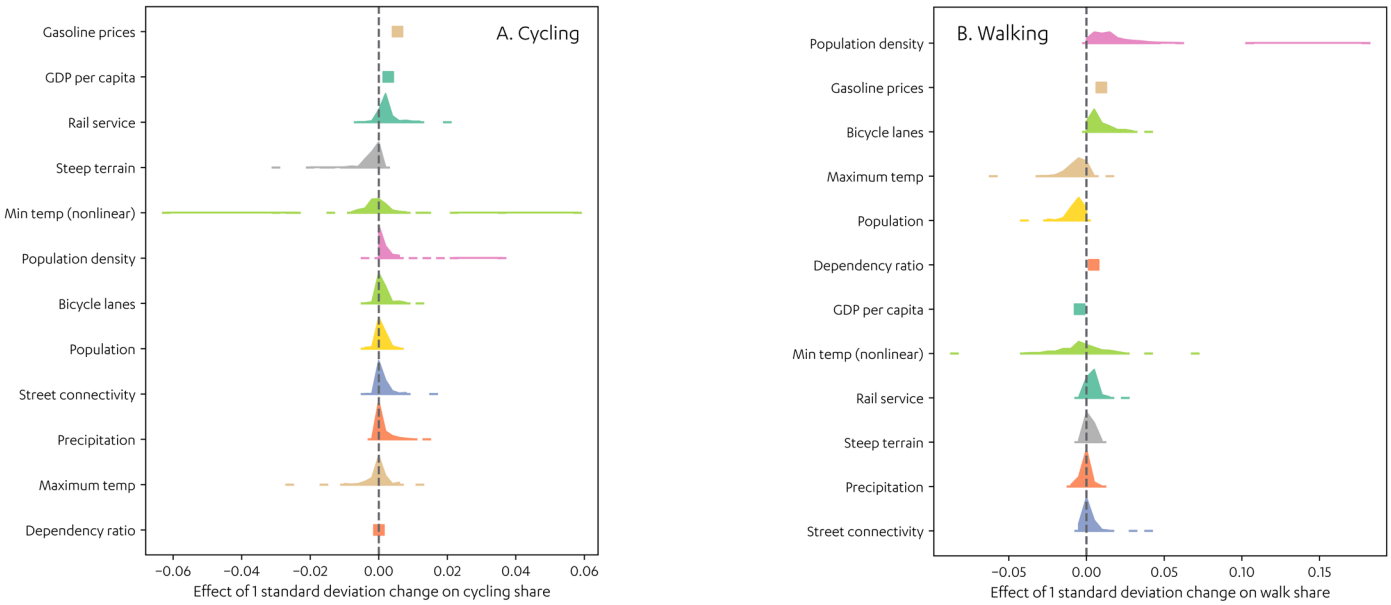


Figure 7. Factors influencing active travel. Each coefficient represents the impact of a one-standard deviation change in each variable on the share of kilometers traveled by cycling (*left*) and walking (*right*). For each city-variable such as density, the model estimates a separate coefficient for each country. The shaded area shows the distribution of country-level coefficients; for density, for example, the effect on walking ranges from about zero to about 0.07 for most countries, with even larger effects in a few outliers. For country-level variables such as gasoline prices, there is only a single coefficient. Variables are ordered by the size of their effect in the median country—gasoline prices and density have the greatest impact on walking, and gasoline prices and income (GDP per capita) on cycling. Adapted from Millard-Ball et al. (2025). https://doi.org/10.1073/pnas.2422334122.

Box 3: Statistical modeling of active travel

The analysis presented in this section uses a statistical method called *Bayesian hierarchical modeling*. We model the association between the share of kilometers traveled by bicycle and on foot (the dependent variables), and a series of city- and country-level variables. These include:

- **Characteristics of urban form:** population density, total population (which captures the effects of scale), and the connectivity of the street network
- **Physical geography:** topography, temperature, and precipitation
- **Transportation infrastructure:** the length of all bicycle lanes and paths normalized by the total length of roads in the city, and whether a city has rail service
- **National-level factors**: GDP per capita, gasoline prices, and the dependency ratio (the size of the population that is younger than 15 or older than 64 compared to the size of the working-age population)

We also control for whether the EIE data includes trips across the city boundary (in- and outbound), or is limited to trips within the city. Importantly, the effect of each variable varies by country. For example, higher densities might be associated with more walking in some countries, but not others. For more details, see the Appendix and Millard-Ball et al. 2025, Global health and climate benefits from walking and cycling infrastructure, *Proceedings of the National Academy of Sciences* 122: e2422334122. https://doi.org/10.1073/pnas.2422334122.

National influences

Of all the variables in the model, **gasoline prices** have the largest association with the share of travel by cycling, and the second largest with walking. A one-standard deviation increase in the price per liter (equivalent to US $0.40) is associated with a 1.0 percentage point increase in walking, and a 0.5 percentage point increase in cycling. As driving gets more expensive, individuals choose to travel on foot and by bicycle instead.

GDP per capita is associated with a higher share of travel by bicycle, although the effect is small and within the uncertainty of the statistical model. A one-standard deviation increase in the natural log of GDP per capita, or the equivalent of going from the income levels of India to those of Brazil or going from the income levels of Brazil to those of Japan, is associated with a 0.3 percentage point increase in the travel share by bicycling. The effect of GDP on walking is negative but also small (0.4 percentage points) and statistically uncertain. Much research highlights a decline in walking as countries get richer, but our findings suggest that factors such as population density, rather than income, are a primary cause of declines in walking associated with rising incomes.

The **dependency ratio**—a measure of the population's age structure—is associated with more walking in the model, but not with cycling. As the share of a country's population that is younger than 15 or older than 64 increases, walking increases but there is no effect on cycling, which may be because these populations are less likely to be able to drive but also may be less likely to feel comfortable cycling than walking. This does not mean that urban planning and design cannot encourage older and younger people to cycle—northern European cities abound in evidence to the contrary—but rather that they may need safe infrastructure to choose to cycle.

Urban form

Population density has a strong association with the proportion of travel by foot. This is no surprise, and is informed by both theory and a body of research evidence—higher density brings destinations closer together, within walking distance, and also makes car travel slower and more expensive. A one-standard deviation increase in the natural log of density—moving from the density of Seattle to that of San Francisco or moving from the density of San Francisco to that of Taipei—increases the share of travel by walking by 1.3 percentage points in the median country. Higher density is also associated with a greater share of cycling travel, although to a lesser extent than for walking (0.1 percentage points in the median country).

Total population decreases the proportion of travel by foot, likely due to scale effects. Cities with higher populations may have a higher variety of work, shopping, and commercial opportunities, causing people to travel longer, less walkable distances.

While **connected streets** are shown to promote walking and cycling in many other studies, these effects are not large in our model.

Transportation systems

The extent of **bicycle lanes** is one of the most important factors associated with higher rates of walking. Bicycle lanes are unlikely to directly influence walking, and so our bicycle lanes variable is likely proxying for a wider set of street design practices with which bicycle lanes are correlated, such as sidewalks and crossings. In the median country, a one-standard deviation increase in the availability of bicycle lanes—moving from the infrastructure of Los Angeles to that of San Francisco—increases the share of travel on foot by 0.6 percentage points in the median country, and the

share of travel by bicycle by 0.1 percentage points. In the median city, this effect would translate into about 13,000 additional kilometers of bicycle travel annually for each new kilometer of bicycle lanes. However, this estimate represents *average* effects. The relationship between the total length of bicycle lanes and the expected increase in bicycle travel depends on the strength of the effect in each country as well as the length of a city's road network and the volume of travel in that city, with larger effects occurring in cities with more travel per kilometer of road (such as Los Angeles). Moreover, the increase in bicycling will depend on the quality and placement of new bicycle facilities, as well as their length.

Cities with **rail service** also have higher rates of cycling. Rather than competing with active travel, rail has a complementary effect—perhaps as people cycle to and from the train station, or because rail reduces the need for people to purchase a private car.

Physical geography

Of the city-level factors in the model, **steep terrain** has one of the largest associations with cycling. Cities with flatter topography have higher shares of travel by bicycle. However, the association between terrain and walking is minimal.

One might expect the climate—**temperature and precipitation**—to have a major impact on active travel. However, in our model, there is a negligible association between precipitation (measured as the natural log of average annual precipitation) and the shares of travel by walking and cycling. Hotter temperatures (measured as the average temperature in the hottest month of the year in each city) decrease walking, but have no effect on travel by bicycle. In the median country, a one standard deviation increase in the temperature—equivalent to a 4.7°C/8.5°F increase in the temperature during the hottest month of the year—decreases travel by walking by 0.5 percentage points.

Colder temperatures (measured as the average temperature in the coldest month of the year in each city) have a more modest effect and only reduce walking and cycling in colder climates.

A considerable amount of research highlights the impact of weather on daily and seasonal travel decisions. For example, people are less likely to cycle on rainy days, or in the winter in colder climates.[5] Our results suggest that over the course of the year, however, people at least partially adapt to the climate, particularly to precipitation and cold. For example, in cities with snowy winters, residents might cycle more in the summer to compensate, while in wetter cities, they might be more inclined to walk or cycle in light rain and invest in protective clothing.

Contextual impacts of density and street design

Our model allows the impact of our city-level variables such as density and bicycle lanes to vary by country. The variation in the size of the effect across countries is illustrated by the shaded areas in Figure 7—the more elongated the area, the more that the effects of that variable are different in different countries.

The varying effects of density across countries are shown in the map in Figure 10, and for select countries in Figure 8. The effect of density on walking is largest in European countries, particularly France and Germany, in Japan, and in North and South America. For cycling, the effect of density is more muted, except in Europe and in Asian countries such as Japan, the Philippines, and Bangladesh.

Another way to see the relationship is through the predictive plots for select countries shown in Figure 8.

[5] Heinen, Eva, Bert Van Wee, and Kees Maat. 2010. "Commuting by Bicycle: An Overview of the Literature." *Transport Reviews* 30 (1): 59–96. https://doi.org/10.1080/01441640903187001.

The effect of density on cycling rates in Japan, and on walking rates in Germany, Japan, and the United States is clearly visible. In Germany, where the effect is the largest, a one-standard deviation increase) is associated with the share of travel by walking rising by about 4%.

More broadly, our statistical model allows us to analyze how national-level variables such as GDP mediate the impacts of city-level variables such as density. We see a clear trend: in countries with higher GDP per capita, density has a stronger association with walking rates (*Figure 9*). In the lowest-income countries, there is a negligible effect. For cycling rates, the effect of density also increases as GDP per capita rises, but this effect is more muted than it is for walking.

A similar analysis shows how the impacts of bicycle lanes vary across countries (*Figure 11*). (Again, bicycle lanes in our model are likely proxying for a broader set of pedestrian- and bicycle-friendly street design practices.) Bicycle lanes have a strong effect on walking, but more so in countries in Africa and South Asia, such as Afghanistan and Nigeria. One interpretation is that these countries have more cross-city variation in street design, whereas most large cities in Western Europe have near-universal sidewalk provision and other infrastructure to facilitate walking. In terms of cycling rates, bicycle lanes have the strongest effects in Japan, but are otherwise generally more important in Europe and Latin America.

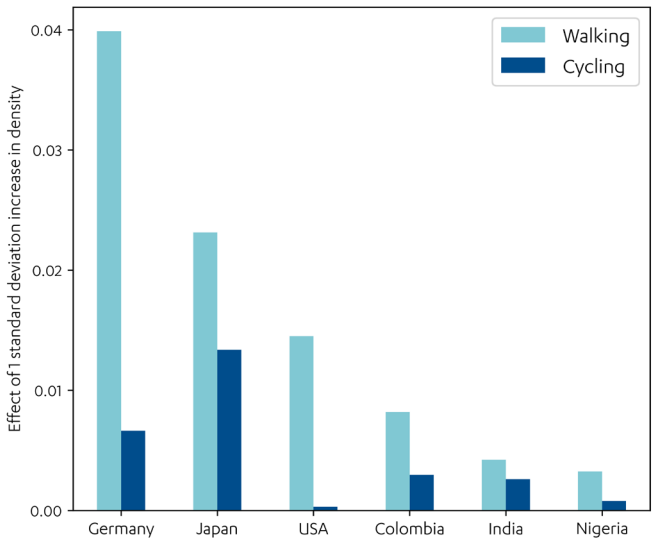


Figure 8. Variation in the effects of density, select countries. The bars represent the predicted impact of a one standard deviation increase in density for the share of kilometers traveled by walking (*light blue bars*) and cycling (*dark blue bars*). Adapted from Millard-Ball et al. (2025). https://doi.org/10.1073/pnas.2422334122.

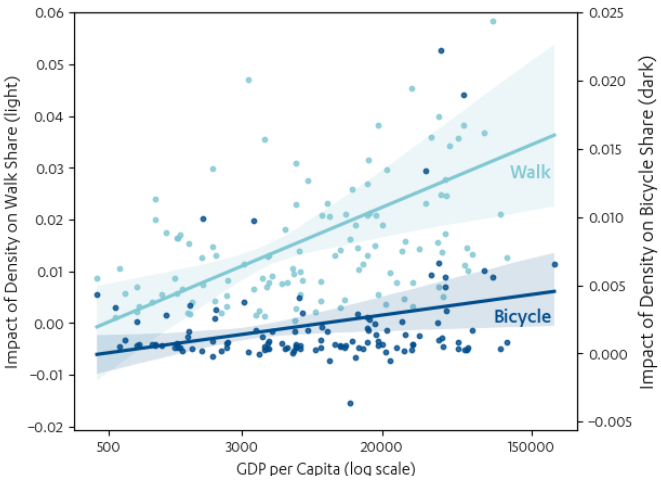


Figure 9. Effects of density vs GDP per capita. For walking trips (*light blue line*), the effects of density are greater in higher-income countries. For cycling (*dark blue line*), the effect is more muted. Each dot indicates a country-specific coefficient. Adapted from Millard-Ball et al. (2025). https://doi.org/10.1073/pnas.2422334122.

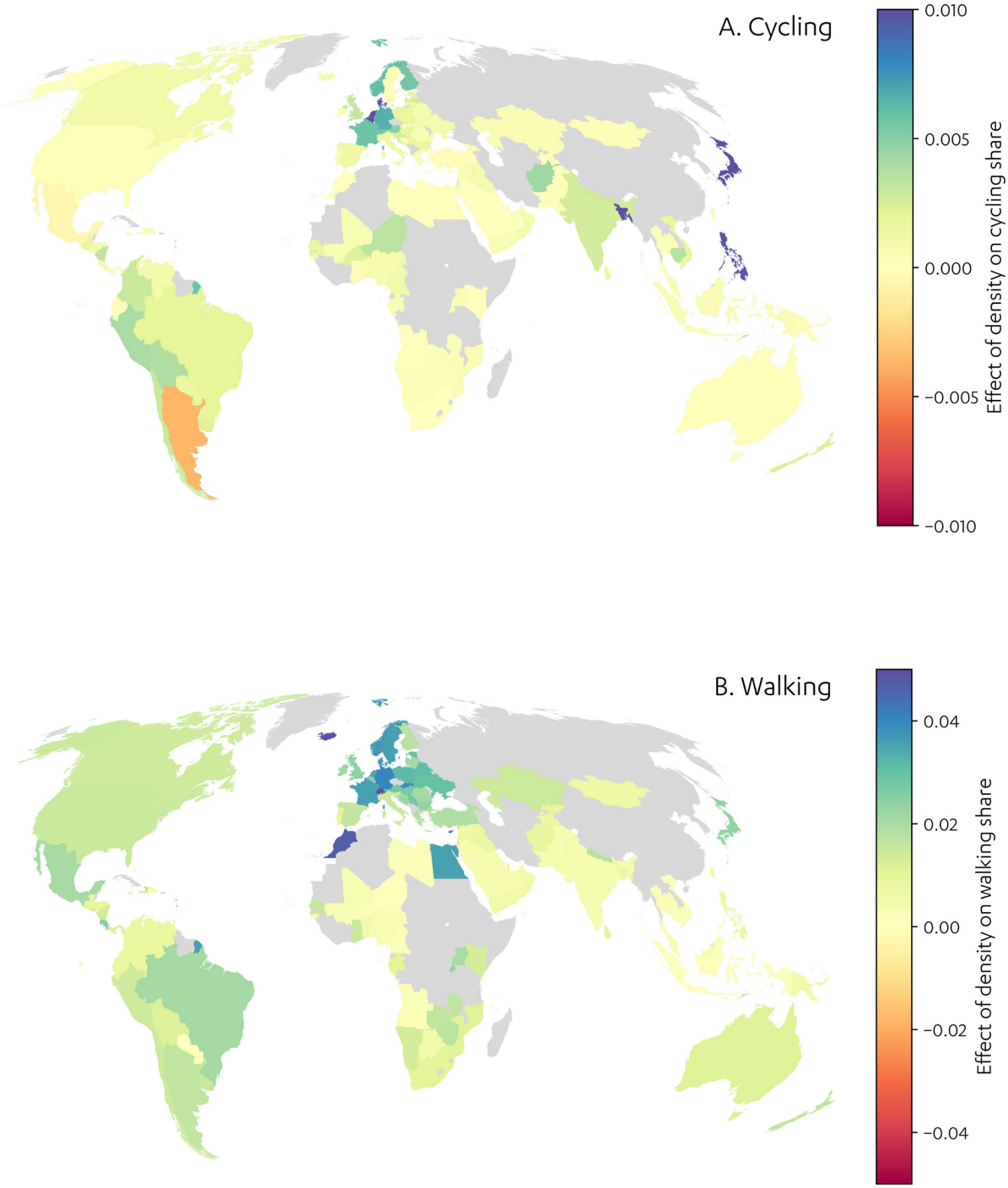


Figure 10. Variation in the effects of density. The association between the share of kilometers traveled by bicycle (*top*) and on foot (*bottom*) is greatest in countries that are shaded blue. The effects on walking are particularly strong in Europe, Japan, and North and South America. Adapted from Millard-Ball et al. (2025). https://doi.org/10.1073/pnas.2422334122.

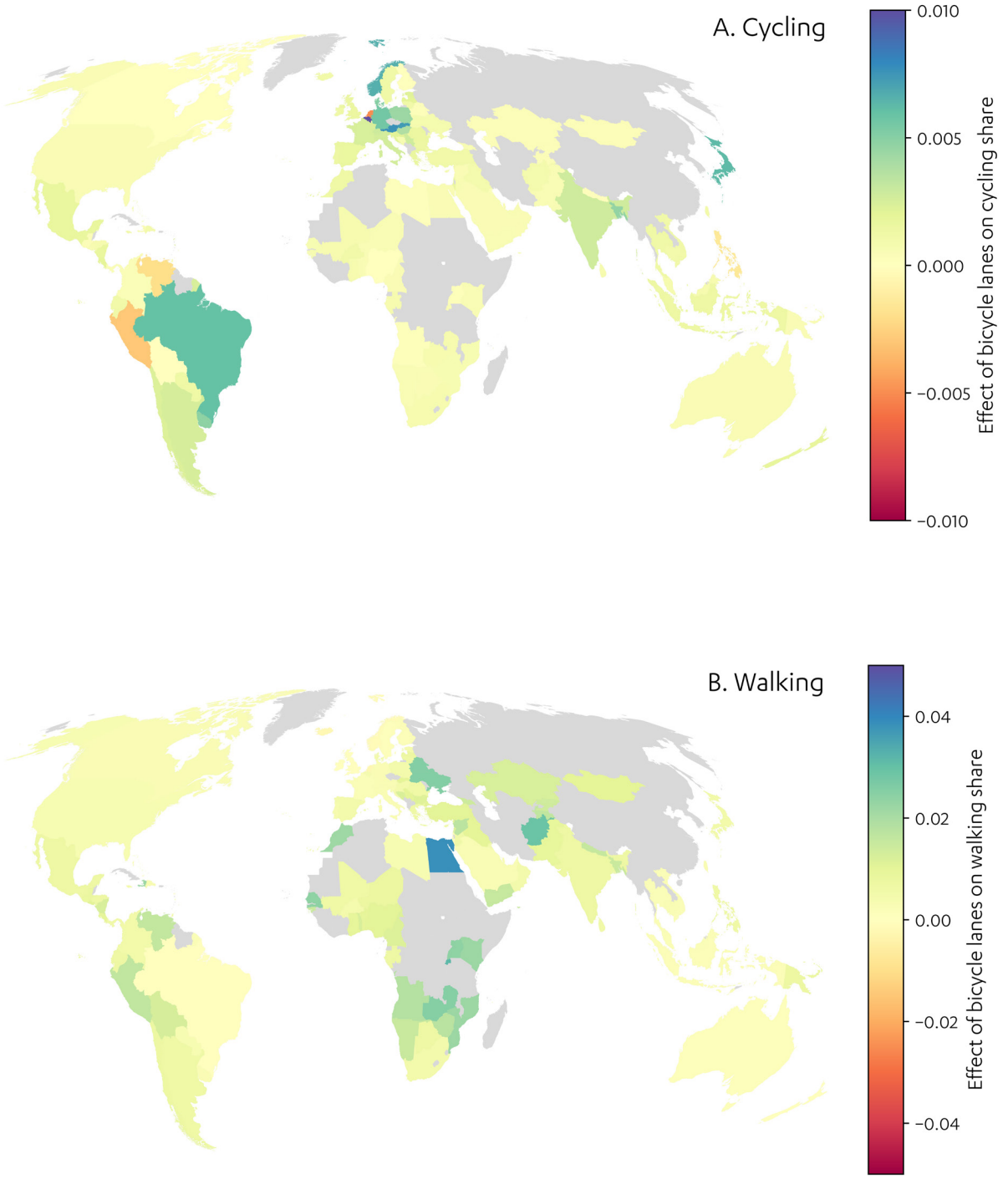


Figure 11. Variation in the effects of bicycle lanes. The association between the share of trips made by bicycle (*top*) and on foot (*bottom*) is greatest in countries that are shaded blue. The effects on walking are particularly strong in Africa and South Asia while the effects on biking are particularly strong in Europe and Latin America. Adapted from Millard-Ball et al. (2025). https://doi.org/10.1073/pnas.2422334122.

Part Two: Success Stories

This section complements the statistical analysis in Part One with brief vignettes of eight city success stories. The cities (*Figure 12*) were chosen based on a data-driven process (*Box 4*).

The vignettes that follow are based on desk reviews of planning documents, newspaper articles, policy reports, and similar sources, followed by interviews or discussions with planners working in each city. The aim is to highlight how different cities, in both planned and unplanned ways, encourage active travel, and to identify policy approaches that have brought success in different geographic and socioeconomic contexts.

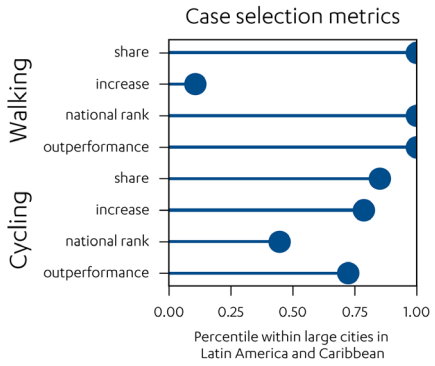
Figure 12. Locations of city case vignettes

Box 4: Case selection

The eight case vignettes were chosen based on the following criteria:

- **Share:** Shares of trips made by walking and cycling, compared to all cities in the EIE dataset
- **Increase:** Increase in the shares of trips made by walking and cycling between 2018 and 2022
- **National rank:** Shares of trips made by walking and cycling, compared to all cities in that country
- **Outperformance:** The shares of trips made by walking and cycling, compared to the predictions of an earlier version of the statistical model (i.e., the most positive outliers)

These criteria generated a shortlist of cities. The final eight were chosen with the aim of showcasing efforts from a range of city population sizes and geographic contexts.



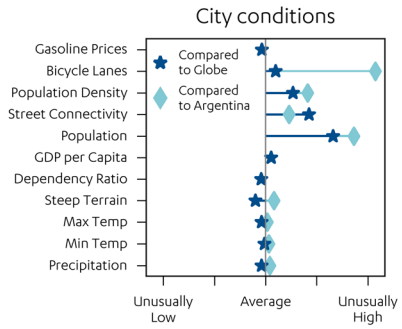
For each vignette, a data panel shows why that city was selected, in terms of its ranking compared to other cities of a similar size in that geographic region. The example from Buenos Aires *(left)* shows that the city has the highest performance on the walking share compared to other large cities in Latin America and the Caribbean and compared to other cities within Argentina, and outperformed the model's predictions. Buenos Aires also lies in the top 25% for three of the cycling criteria.

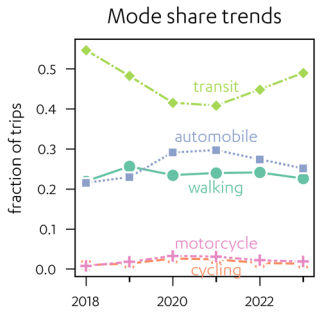
For consistency, the mode shares that we report for each city are Google EIE estimates. The population estimates are for 2020 and are derived by Google EIE from WorldPop (https://www.worldpop.org/). Note that the city boundaries defined by Google may reflect a different administrative unit than the one used for other purposes, and thus population and mode share may differ from official city data.

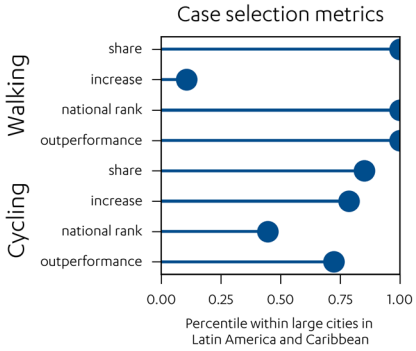
Buenos Aires, Argentina

Population: 3,049,010
Walk share: 23% of trips
Cycling share: 1% of trips
Google estimates

Buenos Aires has prioritized non-motorized transport as a way to achieve the city's climate action plan and sustainable mobility plan. The city has built over 307 km of bicycle lanes with plans for an additional 30 km in 2024. The focus has been on protected bicycle lanes which prioritize connectivity to central areas, transit connections, and areas where there are a high number of workers and students. The city is also turning its attention to filling gaps in the network and to maintenance—for example, to ensure smoother pavement on bicycle lanes.







Key Takeaways

- Focused on pedestrian and bicycle safety by developing protected bicycle lanes and expanding sidewalks
- Leveraged international organizations and networks to expand its bicycle and pedestrian infrastructure
- Stronger cooperation between city and wider metropolitan region needed to expand active travel infrastructure

Bicycle sharing

In 2010 the city launched a bikeshare program—Ecobici—which has since expanded to 3000 bicycles and 200 stations. To support the maintenance of the bikeshare scheme as well as the development of bicycle and pedestrian infrastructure, the city received a USD 50 million loan for transport infrastructure upgrades from the International Finance Corporation in 2017. In 2019 Tembici—another bikeshare scheme popular across the continent— was brought in. To further encourage bicycle use, the scheme offered free cycling lessons to children on the weekend.

Political support

Substantial increases in bicycle ridership following the construction of protected lanes on major streets such as Avenida Corrientes have helped solidify political support for bicycle infrastructure, despite initial controversy. While the city of Buenos Aires has made

Before and after pedestrian intervention
Photo credit: Buenos Aires Ciudad

significant progress in strengthening active travel infrastructure, however, the wider metropolitan area has lagged behind. Support for active travel has also ebbed and flowed depending on the priorities of the mayor and the national government.

Pedestrian infrastructure

The city has widened sidewalks and restricted private vehicles in the Microcentro—the historical, financial and administrative center which is highly trafficked by pedestrians. The main focus of the city has been on enhancing pedestrian safety, and since 2012, the city has worked together with the *comunas* (neighborhoods) on this issue. For example, on one major avenue, Diagonal Norte, almost an acre of space has been converted to a pedestrian plaza that aims to enhance pedestrian safety (*see photo*). These spaces use reflective paint and shorten the street crossings to reduce conflict between pedestrians, cyclists, and cars. On Avenida Warnes, these interventions have reduced collisions by almost 40%. The city's pedestrian master plan provides a framework and prioritization for these street redesign and safety efforts.

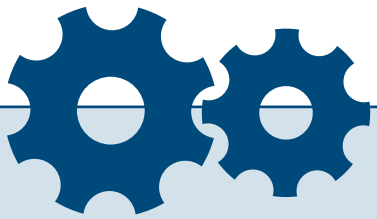
Campaigns

The city has launched a series of campaigns such as *Al girar, prioridad peatón* ("When turning, pedestrians have priority") to strengthen pedestrian safety through enhancing communication and education. The city also organizes engagement events such as the annual *La semana de la movilidad sustentable* ("Sustainable Mobility Week"). In 2023, spaces that were dedicated to the car such as parking lots were used to promote other forms of transportation.

International networks

The city has leveraged international networks such as C40 Cities and endorsed global protocols such as NACTO's *Global Street Design Guide* to raise funds and the profile of Buenos Aires as a pedestrian- and cycling-friendly city. As a case study, the Global Street Design Guide highlights Avenida 9 de Julio. This functioned as a highway through the city and in 2013 was transformed by a project to promote transit and pedestrian use. Bus routes were moved from narrow parallel streets to the avenue, and a central median for pedestrians was added.

Pedestrian enhancements in the Microcentro
Photo credit: Buenos Aires Ciudad



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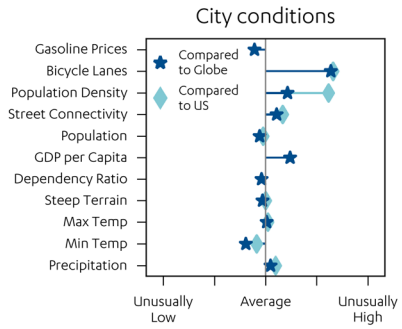
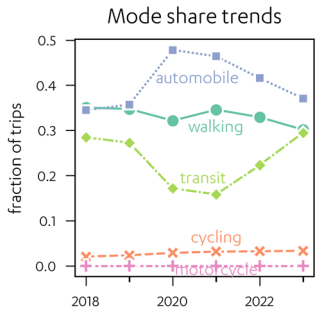
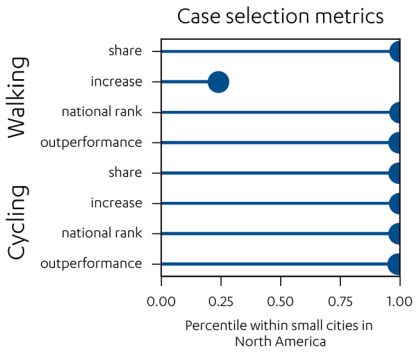
Hoboken, United States

Population: 58,600
Walk share: 30% of trips
Cycling share: 3% of trips
Google estimates

Hoboken is known as "The Mile Square City" as its land area is 1.3 square miles. Together with the city's high population density, this means that the majority of trips are short and can be taken by foot, bicycle, or public transit. Hoboken lies across the Hudson River from New York City, to which it is connected by rail and ferry, and so planning for active travel emphasizes first- and last-mile connections for commuters.







Key takeaways

- Compact and dense city in close proximity to New York City
- Achieved Vision Zero: ended traffic deaths over 7 consecutive years
- Cooperation with surrounding cities
- Low-cost solutions
- Prioritizing safety results in high bicycle mode share

Complete streets

The city developed a complete streets policy, which provides a roadmap for new designs, policies, ordinances and a checklist for implementation. One important aspect of the complete streets plan was the city's approach to pavement management. Hoboken prioritized investments based on pavement condition and designs that enabled more walkers and cyclists, ensuring that all projects provided some benefits for active travel.

Street design and infrastructure

Hoboken's bicycle and pedestrian plan was launched in 2010. To increase safety and boost non-motorized travel, the city has created an extensive network of bicycle lanes that covers 40% of total street miles. In addition to protected lanes, the city has implemented less expensive measures such as intersection daylighting (clearing obstructions, mainly parked cars, to increase visibility at intersections), and installed over 1800 bicycle parking spaces. Hoboken has also partnered with neighboring cities such as Jersey City to extend bicycle lanes across city boundaries. To promote safe walking, the city has built more than 230 curb extensions since 2010. These shorten crossing distances for pedestrians and provide space for amenities such as

plantings and benches. The city has prioritized building curb extensions in areas with high concentrations of pedestrian-involved crashes or that attract vulnerable road users, and those that incorporate green infrastructure in flood-prone areas. The city has also enhanced signage and improved crosswalks using longer-lasting and higher visibility markings.

Bicycle programs

Hoboken hosts 30 docking stations that are part of the regional Citi Bike program connecting New York City, Jersey City, and Hoboken. More than 1.4 million bikeshare trips have taken place in Hoboken since the current iteration of the bikeshare program launched in 2021. To further encourage biking, the city has teamed up with Bike Hoboken—a community-based organization—to organize community bicycle rides. A cycling safety education and a safety escort joined these monthly rides to help create awareness on the rules and laws that promote bicycle and pedestrian safety.

Vision Zero

As a result of these policies and as part of the city's Vision Zero initiative, which was launched in 2019 and aims to eliminate all traffic injuries and deaths by 2030, Hoboken saw no traffic deaths over seven consecutive years. The initiative identifies high-crash corridors and intersections where pedestrians or cyclists are particularly vulnerable and implements specific measures to reduce crashes. Another key to this success has been the "Twenty is Plenty" campaign, which reduced speed limits from 25 mph to 20 mph on city and county roads and to 15 mph on 76 blocks around schools. The city prioritizes investments around parks, schools, public housing, and other places that attract vulnerable road users. In addition, the city's police have enforced bicycle laws such as riding scooters or e-bikes on sidewalks, blocking pedestrian paths, and riding in the opposite direction of traffic. Violators face fines of up to $100.

The changes required to implement Vision Zero have seen some pushback, for example from business owners concerned about the removal of parking spaces to create bicycle lanes. To overcome these challenges, community engagement and broader stakeholder engagement have been an essential part of the vision. The city is currently revising its curbside management strategy to find ways to provide more curbside space, such as designated loading zones, to accommodate the recent surge in growth of deliveries for e-commerce. Without designated areas, delivery vehicles may block bicycle lanes, crosswalks, or bus stops, which creates safety issues for all road users. In addition, testing approaches through pilot projects has helped the city to cost effectively and quickly adapt based on community feedback and observed conditions.

Pilots

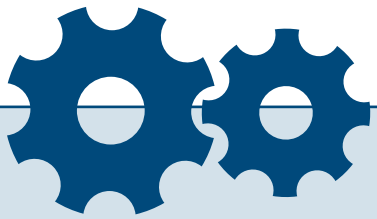
Hoboken has worked under major budget and capacity constraints. For example, the city had no transportation engineering or planning department until 2009. It used lower-cost measures such as cones to create temporary mini-roundabouts and plastic posts for daylighting—that is, preventing parking close to intersections. Thanks to the pilot project approach, the city was able to be selective about investments and focus on projects that had emerged from successful pilots.

Recognition

The city has been recognized as a Bronze Bicycle Friendly Community by the League of American Cyclists. The success of Hoboken shows what can be done with a limited budget and staff.

Painted curb extension with daylighting in Hoboken
Photo credit: City of Hoboken

Regional bikeshare in Hoboken
Photo credit: City of Hoboken



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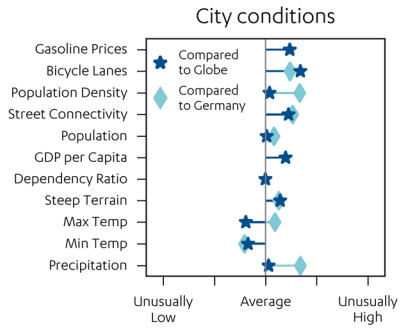
Konstanz, Germany

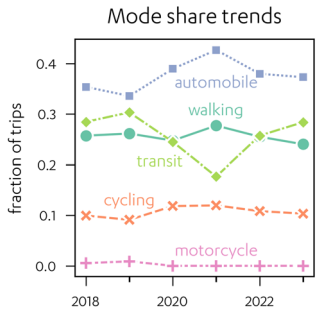
Population: 78,177
Walk share: 24% of trips
Cycling share: 10% of trips
Google estimates

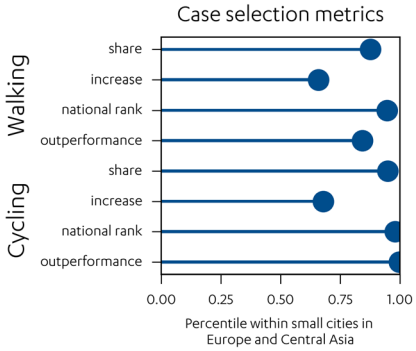
Konstanz calls itself a "Radstadt" or "Cycling City" and is recognized by the state of Baden-Württemberg as a bicycle-friendly municipality. Located on Lake Constance in southwest Germany, the city benefits from a beautiful landscape with many cycle paths that are continuously expanding.

Key Takeaways

- Konstanz calls itself a Cycling City
- Its bikeshare scheme offers different kinds of bicycles, including ones that can transport freight and larger items
- The city audits footpaths to ensure that they are accessible to all







Bicycle Infrastructure

Through the campaign *Handlungsprogramm Fahrradverkehr* ("Bicycle Action Program"), which was approved in 2016, €26 million has been allocated to improving and expanding the existing bicycle network throughout the city. The campaign emphasizes both push factors to discourage car use, and pull factors such as building bicycle parking and expanding dedicated lanes and bridges (*Fahrradbrücken*). One low-cost but effective design used in Konstanz is the *Fahrradstraße* ("bicycle street") on which bicycles have priority and cars are prohibited or restricted to certain groups (e.g., residents). The city also has a bikeshare scheme, where people can also rent bicycles with trailers to transport large items. Along cycling routes, the city has also installed "Service Points" with air pumps and basic tools for cyclists to maintain their bicycles.

Information

The city's website has maps of bicycle parking facilities, bicycle routes, and bicycle repair shops, and also lists the bicycle paths that are cleared of snow in winter. For tourists, the city has developed flyers in English that encourage people to cycle whilst visiting the city, highlighting the bicycle rental options, the most popular cycling paths, and key attractions that can be visited by bicycle. For new residents, the city provides a biking welcome pack, which includes a map of all the cycling routes. Furthermore, the city provides free monthly bicycle checks, where small repairs can be addressed immediately.

Pedestrian infrastructure

Konstanz also has a program for developing pedestrian infrastructure. The "*Handlungsprogramm Fußverkehr*" ("Pedestrian Action Program") aims for a barrier-free footpath network to allow all residents to enjoy the city. Different routes have been audited with teams of people, especially the elderly, to highlight any improvements that need to be made. Monthly updates are provided on the website on the development of the pedestrian network.

Focus on Density

The city's outward growth is constrained—it borders Switzerland to the south, Lake Constance to the east, and natural preservation areas on other sides. Konstanz has therefore grown in a compact way, taking the form of higher-density multi-storey housing rather than detached residences. As we show in this Playbook, density is one of the most important factors for encouraging active travel.

Cargo bicycles in the Konstanz bikeshare program
Photo credit: Stadt Konstanz

Fahrradstraßen (bicycle streets) give priority to bicycles and restrict car use
Photo credit: Stadt Konstanz

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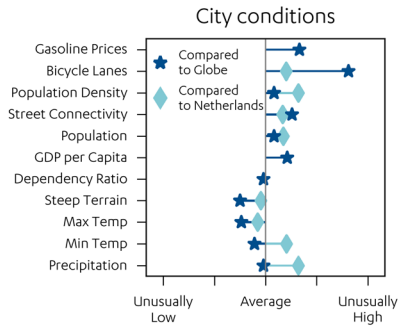
Leiden, The Netherlands

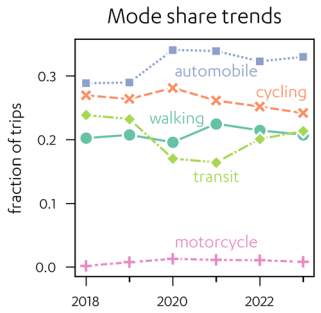
Population: 117,322
Walk share: 21% of trips
Cycling share: 24% of trips

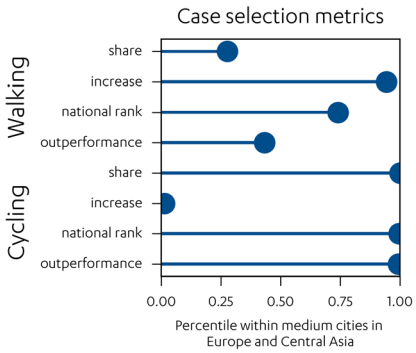
In Leiden, cycling and walking are the most popular modes of transport, and their share of travel is very high even by Dutch standards. This comes as no surprise given the structure of the city, with a compact, historic center that lends itself to active travel. In addition, the city has prioritized biking and walking infrastructure in its city plans and policies.

Key Takeaways

- Cycling and walking are the most popular modes of transit in Leiden
- The city has a low-car city agenda (*Agenda Autoluwe Binnenstad*) and is continuously expanding its cycling and pedestrian infrastructure
- Particular attention is paid to pedestrian and bicycle planning for vulnerable groups
- Neighborhoods are connected through Singelpark—a park that surrounds the inner city







Access to public transport

One of the city's major ambitions is to have a low-car city center (*Agenda Autoluwe Binnenstad*), where motorized vehicles are restricted although not prohibited. These initiatives aim to make the city less congested and safer and encourage public transport use and active travel. Parking lots have been built at the edge of the city center but still within walking distance. Much emphasis is put on using bicycles and walking for the "last mile" to and from public transportation to reduce the need for cars, including a pedestrian and bicycle "green carpet" from the central station to the heart of the inner city. In addition, bicycle parking and infrastructure across the city are continuously being improved (*see photo*). For example, the city has expanded the bicycle parking infrastructure at Leiden Lammenschans station on the southern edge of the city, whilst reducing the number of parking spaces for cars. Emphasis has been put on creating bicycle parking away from the street so that it does not interfere with pedestrian traffic.

Canalside street redesign on Oude Rijn, before and after
Photo credit: City of Leiden. Copyright Buro JP Leiden.

Bicycle infrastructure

According to the City of Leiden, 92% of residents own a bicycle, and 67% of them cycle daily. The city's bicycle infrastructure is extensive, with bicycle roundabouts and dedicated bicycle lanes being expanded as part of a €40 million investment plan from 2020 to 2030 (*Leiden Duurzaam Bereikbaar*). One notable project at Leiden University is adding 3,000 new bicycle parking spaces, with the rooftop designed as a green garden for public enjoyment (*Gorlaeus Bicycle Storage*). Safety is a key priority in this initiative, with a 2023 mobility survey showing that nearly 80% of residents already feel safe in traffic.

While cycling continues to grow in popularity, this has brought challenges, such as increased conflicts between cyclists and pedestrians. The city addresses this issue by emphasizing the importance of pedestrians in its Pedestrian Policy Program (*Beleidsprogramma Voetganger 2020-2030*). A range of innovative initiatives are being implemented to ensure walking is accessible to all. For instance, the city has developed several tourist routes such as the Rembrandt Walk and the Pilgrim Walk, offering visitors a chance to explore Leiden through unique perspectives.

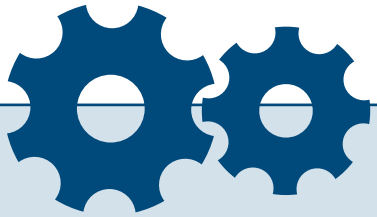
Public space

Leiden has been redesigning public spaces since the 1980s, often creating public space through removing parking from streets and squares. For example, parking has been removed on some streets alongside the city's canals (*see photo)*. The city's efforts are guided by its four-volume Handbook on the Quality of Public Space (*Handboek kwaliteit openbare ruimte*), which specifies details down to the types of bricks that are used for paving surfaces. Leiden also follows the STOMP modal hierarchy which prioritizes pedestrians (*Stappen*) followed by bicycles (*Trappen*), public transport (*Openbaar vervoer*), mobility as a service (*MaaS*), and private cars (*Privéauto*).

Green ring

The Singelpark—a park surrounding the inner city which connects different neighborhoods—has been recognized by the National Pedestrian Congress as the best Dutch walking initiative by being granted the "Loop Award 2020". The park, in development since 2019, creates a green ring around the city, making it easy to walk and cycle to different areas of Leiden without needing to go through the city center. Plans are underway for a second green ring that would connect the outer districts of the city in a similar fashion. Leiden also encourages cycling between cities and travelling to other cities by train and bicycle, for example through multiple intercity cycling routes and ample parking spaces at train stations. Nationally, the Dutch rail system also offers dedicated train carriages that can accommodate bicycles.

Future vision for the Singelpark: a continuous green ring surrounding the inner city
Photo credit: LOLA Landscape Architects, Studio Karst, Gemeente Leiden, and Vrienden van het Singelpark



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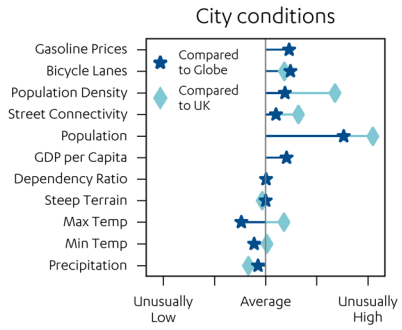
London, United Kingdom

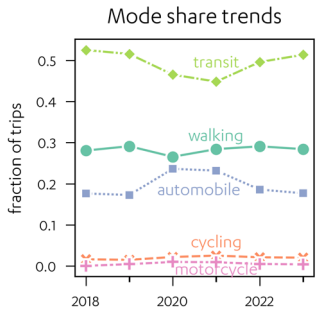
Population: 5,526,629
Walk share: 28% of trips
Cycling share: 2% of trips
Google estimates

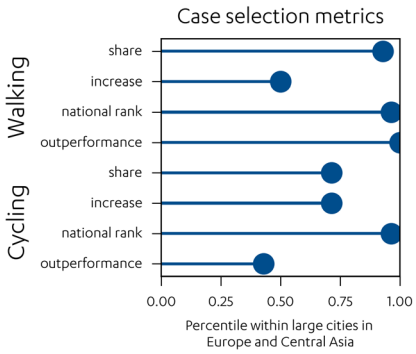
London's commitment to enhancing walking and cycling has been steadily increasing. In 2016 the Mayor appointed London's first Walking and Cycling Commissioner who is responsible for making the streets safer for pedestrians and cyclists. The Mayor's Transport Strategy, published in 2018, aims for 80 percent of trips to be made by walking, cycling and public transport by 2041.

Key Takeaways

- Single strategic transport authority which has strong collaborations with local boroughs and advocacy groups
- Mayor-appointed Walking and Cycling Commissioner to improve accountability
- Extensive planning framework includes action plans for walking, cycling, and road safety, design standards for infrastructure, toolkits to assist local planners, and specialist plans on topics from bicycle parking to promoting walking for leisure







Planning framework

Under this broad framework, Transport for London (TfL), the agency which plans and runs most transport services in the city, published the Walking Action Plan (2018), Cycling Action Plans (2018 and 2023), the Bus Action Plan (2022), and the safety-oriented Vision Zero Action Plan (2018). The city has also adopted the Healthy Streets Approach that recognizes how more pleasant, safe and attractive streets can get more people to walk, cycle, and take public transport. Health is therefore at the center of transport planning, with a particular focus on access for vulnerable and disadvantaged population groups.

A Mini Holland on Orford Road (top) and a Quieter Neighbourhood on Fox Lane (bottom)
Photo credit: Dan Bowditch

Pedestrian planning

TfL's Walking Action Plan sets out a range of actions that aim to make London the world's most walkable city, with targets for increasing walking and wheeling (e.g., wheelchair-based) trips and the proportion of journeys to primary schools made on foot. To support planners, TfL developed a Pedestrian Comfort Guide to ensure that new infrastructure meets the needs of pedestrians, and a Planning for Walking Toolkit that sets out quality standards for pedestrian infrastructure and guidance on how to deliver it. TfL also published a Leisure Walking Plan in 2022 that sets out priority actions to encourage people to walk for pleasure and to increase Londoners' access to green spaces and waterways such as canals. TfL provides funding and guidance to London's 33 local authorities, which have developed their own plans to encourage walking. For example, the City of London has a long-term programme implementing pedestrian priority schemes to enhance comfort, safety, and accessibility for people walking.

Pedestrian advocacy

Advocacy groups help push for greater attention to pedestrian travel. For example, London Living Streets has identified central London footways that form a network of quiet and interesting streets for walking and connect major places—mainline train stations, popular destinations and green spaces—with appealing and accessible streets. These advocacy groups meet representatives of TfL, the Greater London Authority, and London boroughs every quarter at the London Walking Forum, chaired by London's Walking and Cycling Commissioner, to discuss strategic priorities for walking in London and to coordinate action.

Cycling infrastructure

London's strategic cycle network has more than quadrupled from 90km in 2016 to over 400km in 2024. Investments are guided by data and analysis, including from a dedicated cycling demand model. Over a quarter of Londoners now live within 400m of a high-quality route. New routes must meet quality standards for protecting cyclists from motorised traffic based on the local context. Cycle routes use the unified "Cycleway" brand with consistent signage across the city. Initially focused on servicing the city center, the network has expanded to cover all inner London boroughs and continues to grow to reach outer London boroughs and connect more town centers.

Cycleways on Lea Bridge Road (top) and Westminster Bridge (bottom)
Photo credit: Dan Bowditch

The Cycleway network is complemented by Low Traffic Neighbourhoods (sometimes called Quieter Neighbourhoods) which reduce through traffic in residential areas and have been linked to a significant increase in cycling, including among children. This approach builds on the success of "Mini Hollands" boroughs (2013) which saw £100m allocated to three outer London boroughs to transform their streets through Dutch-like walking and cycling infrastructure. As part of Vision Zero—a policy that aims to eliminate traffic deaths and serious collisions by 2041—Transport for London and London boroughs have also been rolling out lower speed limits and more stringent safety standards for heavy goods vehicles.

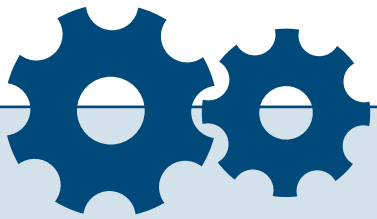
Transport for London's bikeshare scheme began in 2010, and now has over 12,000 bicycles with almost 11 million trips per year. E-bikes are part of the fleet and other privately operated cycle hire schemes have launched in the city.

Bicycle planning

The city's second Cycle Action Plan, launched in 2023 as a follow up to the 2018 plan, aims to increase cycling by 33% by 2030. The primary barrier to cycling is road danger, which the plan aims to tackle. The main initiative to achieve this is to expand the city's strategic cycle network, with a target for 40% of Londoners to live within 400m of the network by 2030, rising to 70% by 2041. The plan also emphasizes diversity—inclusive infrastructure, training, community grants, and promotional campaigns to broaden the appeal of cycling to a wider range of Londoners.

Bicycle parking

Similar to other cities, London is expanding its parking infrastructure and aiming to address bicycle theft. For example, the city saw a 400% increase in the number of cycle hangars between 2017 and 2023. Cycle hangars provide a secure, self-contained space to store cycles which can be accessed by residents using a key or app. They usually replace half a car parking space, include stands for six cycles to be locked to, and can also be adapted to other types of bicycles such as cargo or adapted bicycles. A cycle parking implementation plan was published in 2019.



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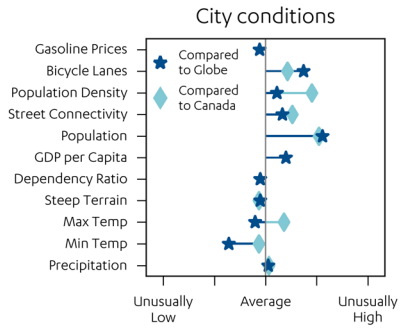
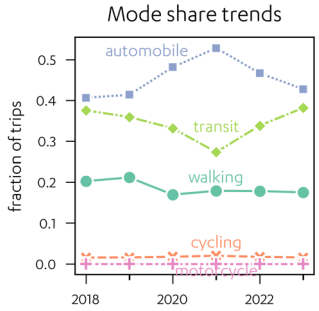
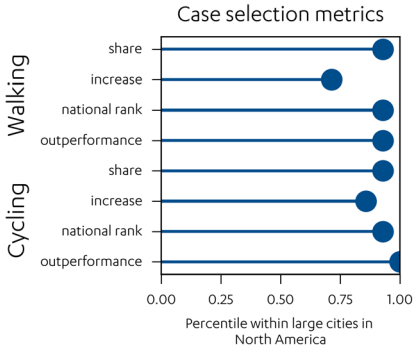
Montreal, Canada

Population: 1,945,563
Walk share: 18% of trips
Cycling share: 2% of trips
Google estimates

As in many cities, removal of on-street parking to create protected bicycle lanes has often been controversial. However, support for walking, bicycling, and public transport has been a key plank of the platform of the progressive Projet Montréal party, whose leader Valérie Plante was elected mayor in 2017. Furthermore, the city's 10-year budget provides a consistent and predictable allocation for cycling, which makes long-term planning easier.







Key Takeaways

- Montreal ensures that cycling is accessible during all seasons, including harsh winters
- Pedestrian-only streets are expanding across the city
- Community engagement helps to secure support for bicycle lanes, even where they remove on-street parking

All-year cycle network

Given the often harsh winter conditions, cycling in Montreal has historically been seasonal. However the city is coming up with innovative solutions to address this. Two-thirds of the bicycle network is made accessible in winter through snow clearing and salting. On protected bicycle lanes, this entails dedicated winter maintenance operations, carried out with machines distinct from those used on roads and sidewalks. The city offers online guidance on how to adapt a bicycle for winter and one of the boroughs even provides discounted studded bicycle tires to its residents.

Express Bicycle Network

Montreal was one of the first cities in North America to implement protected bicycle lanes. New protected lanes are being built and existing ones are being upgraded to create a 191 km *Réseau express vélo* ("Express Bicycle Network") composed of wide, high-capacity lanes that allow cyclists to pass each other. The network aims to create the most direct routes to key destinations.

Winter cycling on the Express Bicycle Network
Photo credit: Ville de Montréal

Bicycle sharing

Montreal was the first city in North America to introduce bikeshare at a large scale. Its scheme—BIXI—has grown in size and popularity to over 10,0000 bicycles (a fifth of which are e-assisted) and 900 stations. As of 2023, it is keeping a subset of stations open through the winter and outfitting part of the fleet of bicycles with studded tires for winter use. To reduce congestion and the carbon footprint of package deliveries, the city has financed a project called Colibri, which has set up two sites where packages are transferred from trucks to standard and electric cargo bicycles.

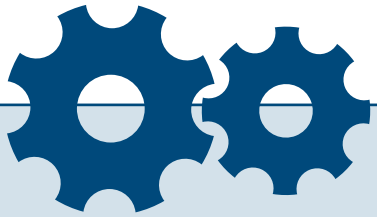
Pedestrian streets

Pedestrianization has increasingly become a priority. The city has three different classifications for streets: (i) pedestrian streets, which are fully pedestrian, (ii) pedestrian streets with slow zones, which are shared with non-motorized modes of transit, and (iii) shared streets, on which pedestrians may walk on the entire width. In Summer 2023, the city launched 10 temporary pedestrian-only streets to encourage economic activity around commercial hubs and highlight the city's investment in pedestrian infrastructure. In addition, there are plans to pedestrianize the city's historic core, Old Montreal.

Community engagement

Social acceptance of biking and walking infrastructure is very important to the success of active transport infrastructure. Engaging early and consistently to ensure buy in from key stakeholders and the wider community is key. Where bicycle lanes require on-street parking removal, for example, the planners aim for transparency— developing alternative options and providing data on parking availability on other streets. The city also highlights the financial benefits of pedestrian and bicycle infrastructure for businesses along those routes and engages with business owners during the planning stage. The city also publishes its evaluations of the impact of active travel infrastructure, providing a foundation for future infrastructure development of a similar nature. On Rue Saint-Denis, for example, retail vacancies fell from 30% to less than 15% following implementation of the Express Bicycle Network lanes.

Pedestrian Street Rue St. Paul
Photo credit: Caribb via Flickr, CC BY-NC-ND 2.0



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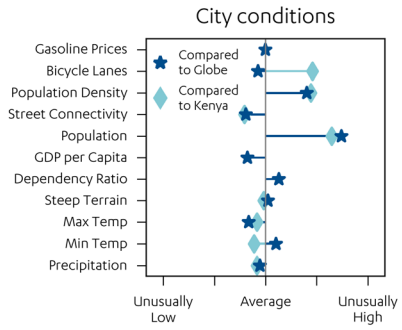
Nairobi, Kenya

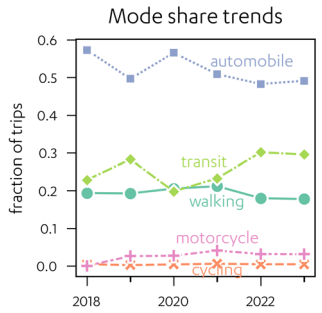
Population: 4.4 million
Walk share: 18% of trips
Cycling share: 0.4% of trips
Google estimates

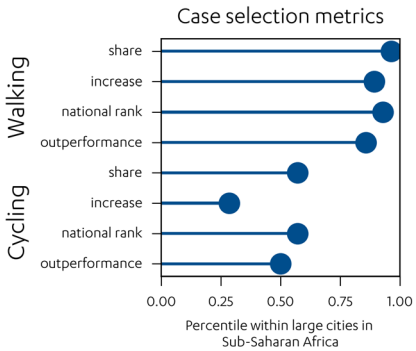
Nairobi—one of Africa's main hubs—has been strengthening walking and biking across the city. A survey by the Climate & Development Knowledge network estimates that 55,000 trips are made per day on bicycles. The majority of trips were taken by low-income earners for commuting purposes rather than leisure. A stark finding from a survey of 703 cyclists was that over 99% of respondents were men.

Key Takeaways

- Increased attention on cycling and walking as a way to combat congestion in the city
- Bicycle paths and footbridges developed along major roads in the city
- At least 45% of road fatalities involve pedestrians, making walking high risk





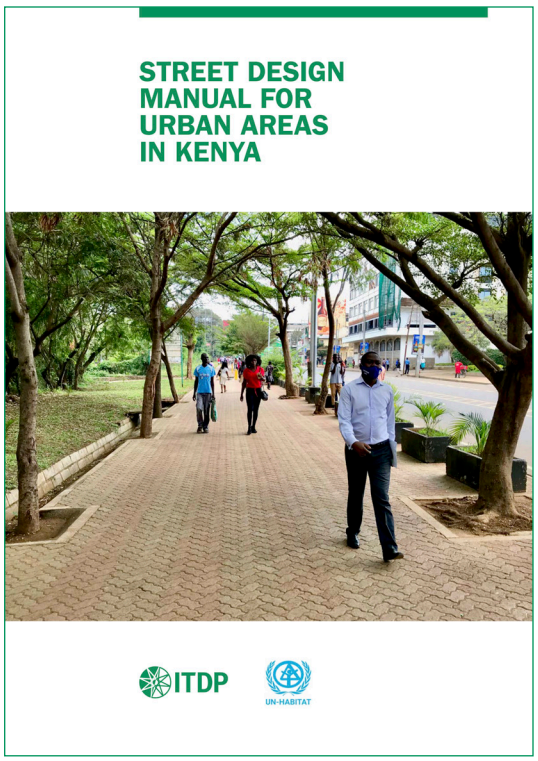


Policy and planning

A 2017 policy commits at least 20% of the transportation budget to non-motorized transportation (NMT). In practice, the share of the budget devoted to NMT has been more than 30%. The city is currently developing an NMT master plan, and collaborations with international organizations such as UN Habitat, the UN Environment Programme, and the Institute for Transport and Development Policy have helped to build local political support for bicycling and walking.

Cycle infrastructure

The development of bike lanes started in the 1990s along Waiyaki Way, a major arterial. More recently, the Thika Superhighway and Missing Links roads gained protected bicycle lanes which run alongside the busy highway and are separated by a curb. To expand these efforts, the Institute for Transport and Development Policy (ITDP), an international nonprofit, together with the government of Kenya and UN-Habitat, has developed a street design manual for key urban areas in Kenya, including Nairobi, that includes design concepts for bike lanes. However, this design manual has not yet been officially adopted.



Street Design Manual
Image: ITDP, CC BY 4.0

Advocacy

Advocacy organizations like Critical Mass are working towards enhancing awareness for cycling across the city through group rides and advocating for enhanced bicycle infrastructure to make cycling safer. For example, in August 2023 the group organized a 10 km ride for children.

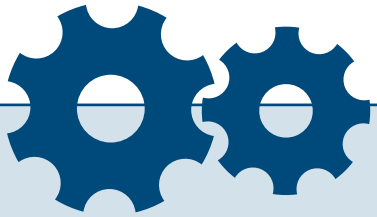
Pedestrian infrastructure

40% of trips in Nairobi are made on foot. Recent projects in the city center—on Luthuli Avenue, Kenyatta Avenue, Mama Ngina Street, Tom Mboya Street, Kenneth Matiba, Latema, River Road and Aga Khan Walk, for example—have pedestrianized streets, widened walkways, and installed bollards, guardrails, or raised curbs to prevent cars from parking on walkways. Involving informal traders and other stakeholders in the planning process has helped reduce encroachment into pedestrian space, for example through designating space for traders that does not obstruct the walkway, and fostering local leadership that provides informal enforcement against encroachment. A citywide audit of the pedestrian infrastructure is currently underway, and plans for the mass rapid transit system include investment in walking infrastructure to link to public transit. Similar to cycling, however, walking in most of Nairobi is still not a choice for most people, but a necessity driven by low incomes and congested traffic.

Pedestrian safety

Despite Nairobi's efforts, safety is still a challenge. The majority of people that walk are lower income and male. Infrastructure is generally poor, with pedestrians often forced to share the road with cars due to a lack of sidewalks. In other instances, roads do have sidewalks, but pedestrians are forced into the street because of encroachment by informal traders, parked cars, or the high volume of people walking. The dangers of walking on the road are evidenced by the fact that over 45% of road fatalities are linked with pedestrians. The lack of planning for pedestrians is also highlighted by examples such as the 8-lane Thika Superhighway, which was originally constructed without any pedestrian crossings. Due to increasing pedestrian fatalities on this road, speed bumps, pedestrian bridges and other crossings have been retroactively added.

Pedestrian Infrastructure on Mama Ngina Street
Photo credit: Ben Welle via Flickr, CC BY 2.0



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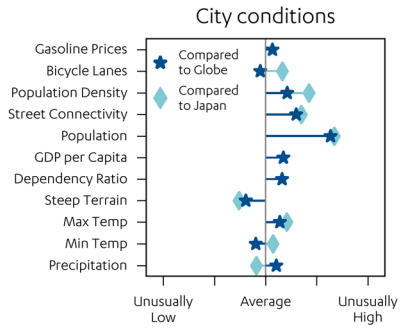
Osaka, Japan

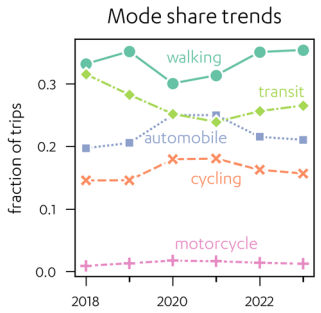
Population: 2,680,233
Walk share: 35% of trips
Cycling share: 16% of trips
Google estimates

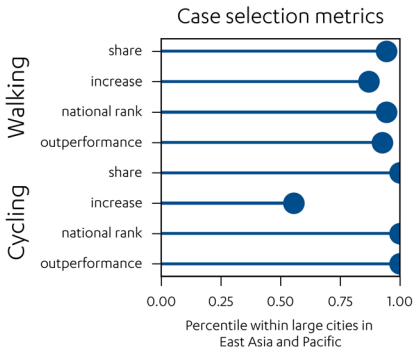
Both the central city of Osaka and smaller cities in the metropolitan region have high levels of walking and cycling, even by Japanese standards. Within the region, the most urbanized areas have a higher percentage of walking trips than the least urbanized areas.

Key Takeaways

- Japan has high levels of walking and cycling compared to most Asian cities
- Wide roads are being redesigned with more pedestrian/cycling space and infrastructure
- While past practice was for cyclists to share the sidewalk with pedestrians, current efforts prioritize on-street bicycle lanes







Street design

While Osaka city has bicycle lanes and sidewalks on major streets, most minor streets, as in many Japanese cities, are characterized by a shared space (*see photos*). Sidewalks are frequently demarcated only by a painted line. However, low car traffic volumes and speeds on these minor streets generally make it comfortable for all road users to share the space.

Bicycle infrastructure

As in other cities in Japan, the 1970 Road Traffic Act allowed bicycles to use sidewalks for safety reasons. However, this practice makes cycling trips slow, and in recent years, conflicts have increased. Osaka city saw a 13-fold increase in collisions between pedestrians and cyclists from 1999 to 2014, to a total of 155 per year. Therefore, the city now aims to create bicycle lanes on the roadway. Where sidewalk-level bicycle facilities exist, the policy is to separate bicycles from pedestrians using colored surfaces.

Shared streets in Osaka
Photo credit: Shane Phillips

The pandemic saw an increase in cycling trips with the development of pop-up bicycle lanes and other interventions to encourage active travel. In the long run, the city aims to provide bicycle lanes spaced 0.5km apart on major roads in the city center, with wider spacing in the suburbs. Expo 2025 will take place in Osaka, and more bicycle lanes are planned in conjunction with that event along with educational programs around transportation emissions and active travel.

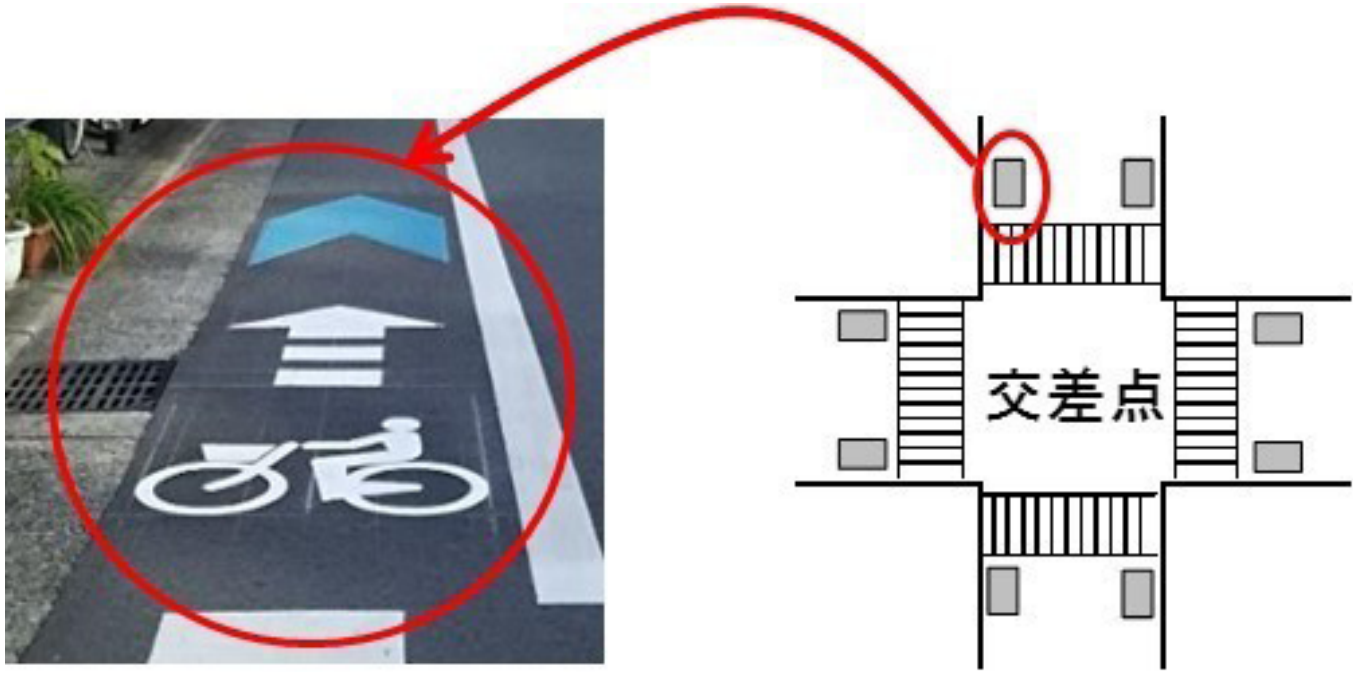
Pedestrianization

Osaka city is turning one of its main streets—Midosuji—into a people-centered, pedestrian street. The street is currently a six-lane, one-way road, but as a first step plans will see some of this road space allocated to pedestrians, cyclists, and restaurants.

In 2022 the city also transformed the area outside Nankai Namba Station, which has been dominated by taxis and buses, to a pedestrian square. Amenities such as a rest area and a tourist information center have been added.

Cycling safety

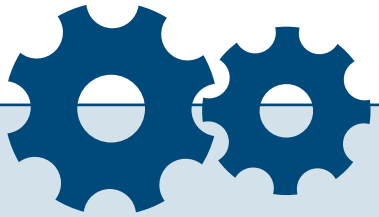
The city has developed the "Osaka City Bicycle Traffic Environment Development Plan" which aims to address cycling accidents on main roads and intersections. Interventions include better signage, dedicated road space and building awareness on traffic regulations so that bicycles and cars are better able to share the road.



Design guidance for bicycle markings at intersections

Image source: Osaka City, City Bicycle Traffic Environment Development Plan 2024.

[大阪市都市整備局.「大阪市自転車ネットワーク計画（概要版）」, 2016年7月. 大阪市]



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Conclusions

Our results demonstrate that mayors, city planners, and other local officials have two important ways to promote walking and cycling.

First, they can **make cities denser**. Higher population densities bring destinations closer together, making it feasible to walk and cycle for many trips that would otherwise require a car or public transport. Density is most important in wealthier countries where travelers often have more travel choices. In lower-income places, walking and cycling are primarily driven by financial constraints. Thus, promoting density can be seen as a long-term strategy to promote active travel as a country grows richer.

Second, cities can **redesign streets** to make active travel safer and more comfortable. Our dataset highlights the role of bicycle lanes and paths, but other aspects of street design— sidewalks, safe crossings, and traffic calming measures such as raised intersections—are also important for active travel. The quality of the infrastructure is significant too: our case vignettes highlight how cities such as Konstanz, Germany have constructed dedicated bridges for pedestrians and cyclists, and how Montreal, Canada has designated an Express Bike Network with higher design standards. Bicycle sharing programs were also a near-ubiquitous feature of our case vignettes. In cities in Africa and south Asia, meanwhile, the infrastructure challenges are somewhat different than those in the West. For example, vendors on sidewalks may leave limited space for pedestrians.

The success of cities such as Montreal and London rests on a base of political support and extensive planning for walking and cycling. But policy at the national level also matters. Most significantly, higher **gasoline prices** encourage people to walk and cycle. This finding also suggests that a broader set of price incentives (such as tolls and parking charges) can lead to shifts in travel away from cars and towards walking and cycling. These alternative strategies for raising the cost of driving may become increasingly important as electric vehicles become more common.

Day-to-day fluctuations in the weather undoubtedly affect active travel. But over the course of the year, our results show that **people largely adjust to the prevailing climate**. Rain and snow have no detectable impact on walking and cycling rates, when averaged annually. Cold winters reduce cycling, but have a smaller effect than many other determinants of walking. Meanwhile, some of the highest rates of active travel are found in the snow of Montreal and Copenhagen, and in the heat and humidity of Kolkata and Dhaka. People adapt to their local climate, and planners can promote active travel everywhere.

Danish and Dutch cities are well known for their superb infrastructure that supports active travel, particularly cycling, and their policies and design practices are well documented in news accounts and policy reports. Our results show that their reputation is well deserved, but that cities can also look to a **wider range of role models** for inspiration. Dedicated bicycle infrastructure is one important pathway to a bicycle-friendly city, but our data and case vignettes show an alternative approach, exemplified by Japanese cities such as Osaka. There, bicycling is primarily facilitated by a network of narrow, low-speed, low-traffic streets. High levels of walking and cycling are the product of a city where driving is slow and expensive. While in some places, the combination of high cycling rates and limited bicycle infrastructure might be a recipe for hazardous streets, Japanese cities tend to have low injury and fatality rates.

Moreover, **walking accounts for more than twice as much travel as cycling (and seven times as many trips)**, and cities with the highest rates of walking are found in countries that receive less attention for supporting active travel, such as Ukraine (even prior to the Russian invasion), Spain, and France. Cities such as Buenos Aires may provide the best roadmap for increasing walking—often through restricting private vehicles in the city center, pedestrianization, and designing streets for low-speed traffic.

Cities have **varied motivations** for promoting active travel. In European cities, environmental policy is an important driver, but encouraging physical activity matters too. Elsewhere, congestion reduction and poverty alleviation can be the main policy goals, with environmental motivations of secondary importance.

Given high pedestrian fatality rates, increasing walking and cycling mode share might also be a less immediate policy goal than **ensuring the safety of** those who already use these modes. Conversely, the traffic safety agenda pursued by cities such as Buenos Aires and Hoboken has encouraged more people to walk and cycle.

The wider message for local policy makers is that they have many models from which to seek inspiration. Copenhagen and Amsterdam may resonate with some mayors and city transport planners, but other cities in many parts of the world have pursued similar approaches with less fanfare and at low cost. And cities such as Osaka highlight the potential of an alternative pathway with less extensive walking and cycling infrastructure, but a network of slow streets where different road users coexist.

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Publication coordination by **Claudia Bustamante**

Designed by **Brian Goodman**

Appendix

Data

EIE travel data

The Google Environmental Insights Explorer (EIE) data are aggregated to Google-defined cities for the year 2023, and consist of the distance traveled (person km) and the number of person trips made by each mode. Wheelchair trips are generally classified as walking. For all cities, the data include trips within the city boundary. For about 30% of cities, in- and outbound trips are also reported (i.e., trips that originate within the city but are traveling to a destination outside or vice versa). We include 50% of the distance of these in- and outbound trips in our calculations, in line with established greenhouse gas reporting protocols.

EIE draws on aggregated, anonymized, and differentially private Location History data from opted-in users. One natural question is the validity and representativeness of the data—does it accurately reflect the travel of people in each city, and in a consistent way around the world? Unfortunately, there is no comparison dataset, authoritative or not, with comparable global coverage. Even for individual cities and countries, data are patchy and inconsistently collected. Pedestrian data in particular are subject to recall bias (respondents may not recall all of their trips on foot).

We therefore compare our EIE data to three partial reference sources—the US census, data reported by Buehler and Pucher (2023)[6], and data reported by Lee et al. (2022)[7]. The US census

[6] Buehler, Ralph, and John Pucher. 2023. "Overview of Walking Rates, Walking Safety, and Government Policies to Encourage More and Safer Walking in Europe and North America." *Sustainability* 15 (7): 5719. https://doi.org/10.3390/su15075719.

[7] Lee, Sujin, Jinwoo Lee, Suzanne Hiemstra-van Mastrigt, and Euiyoung Kim. 2022. "What Cities Have Is How People Travel: Conceptualizing a Data-Mining-Driven Modal Split Framework." *Cities* 131: 103902. https://doi.org/10.1016/j.cities.2022.103902.

provides data for commute trips only, but has the advantage of consistency and includes all cities in the country, thus avoiding selection bias. Buehler and Pucher compiled walking mode share for all trips for 36 European and Japanese cities, providing some international coverage, although with a Western bias, and Lee et al. compiled cycling mode-share for all trips for 46 cities across North and South America, Asia, Europe, and Oceania, providing greater international coverage (although still excluding cities within Africa).

Figure A-1 shows the comparison. Overall, the EIE data are highly correlated with these other data sources, although the EIE data generally provide higher estimates of walking and lower estimates of cycling, which is not surprising since walking is generally underreported, creating potential for other modes (including cycling) to be overestimated with regards to mode-share. For the US Census, EIE tends to provide higher estimates, which is not surprising as non-commute trips are more likely to be made on foot or by bicycle. Overall, the strong correlation between EIE and independent data sources gives us confidence in the dataset, and it is not possible to determine which provides the more authoritative values. A key advantage of EIE for our purposes, however, is its global consistency in methods and the definition of a trip.

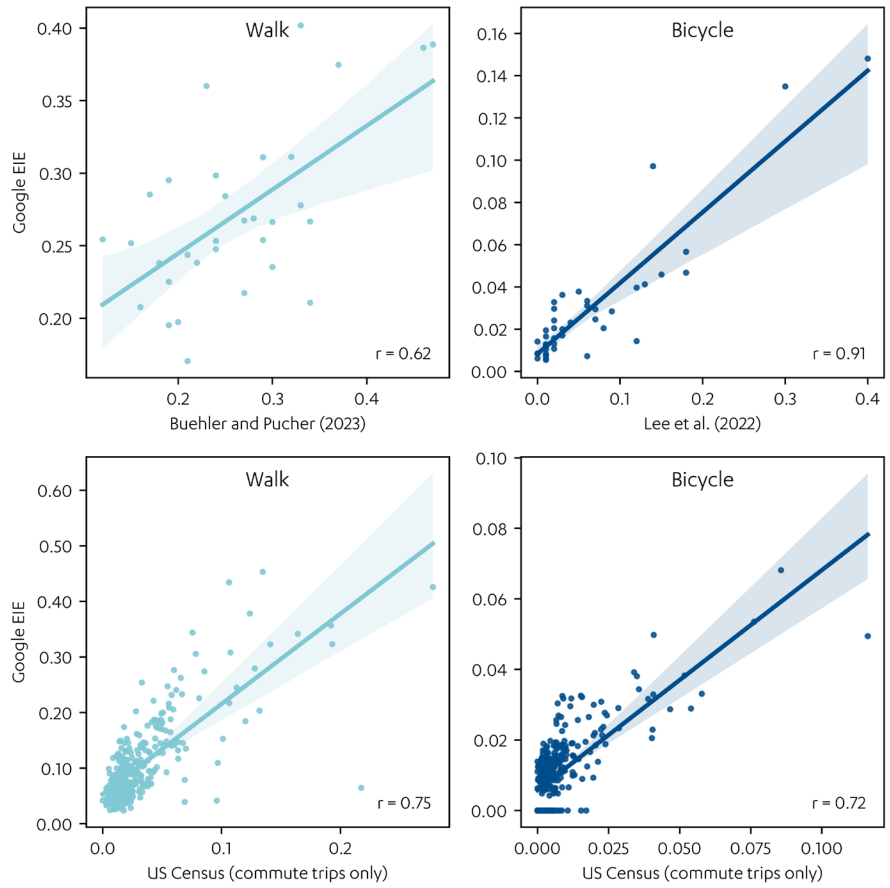

Figure A-1. EIE comparison to other data sources. Left panels: walk trips. Right panels: cycling trips. Upper panels: Cross-national comparisons, for all trips. Lower panels: US comparisons, for commute trips only. Only cities with >=100,000 population are shown. Adapted from Millard-Ball et al. (2025). https://doi.org/10.1073/pnas.2422334122.

Other data sources

Our independent variables come from a range of sources (Table A-1). For density, we weight the density of 1 km^2 grid cells by population in order to minimize dependence on arbitrary city boundaries and the presence of water and open space. Most variables were log transformed to address skew in the underlying data.

We aggregate all city-level data to the polygons of the Google-defined cities. While we did not have access to the original polygon boundaries, we approximate them using open-source materials (e.g., OpenStreetMap, national census boundaries, and the Global Administrative Areas dataset at www.gadm.org), and verify with Google that our overlap is greater than 90%. Discrepancies between our boundaries and Google's original polygon boundaries generally occur in uninhabited or sparsely inhabited areas, because there is generally consistency in the inclusion of population centers across open-source materials and Google's boundaries. As a result, discrepancies have a minimal effect on aggregated data, which are driven by areas with more roads and population density.

Variable	Source
City level	
Weighted population density (natural log)	Calculated using GHS-POP from the Global Human Settlements Layer. https://dx.doi.org/10.2760/098587
Population (natural log)	GHS-POP, as above
Street-network sprawl (SNDi) (natural log)	Barrington-Leigh and Millard-Ball (2025)[8]
Street-network connectivity added by bicycle lanes and pedestrian paths	Difference between SNDi calculated for the network including versus excluding these lanes and paths
Bicycle lanes (km per km of road)	OpenStreetMap
Slope (natural log)	Calculated from the US Geological Survey GMTED 2010 dataset
Monthly maximum temperature	European Centre for Medium-Range Weather Forecasts ERA5 (2018 to 2022)
Monthly minimum temperature	European Centre for Medium-Range Weather Forecasts ERA5 (2018 to 2022)
Annual precipitation (natural log)	European Centre for Medium-Range Weather Forecasts ERA5 (2018 to 2022)
Rail (binary variable)	Google Environmental Insights Explorer
Motorways (km per km of road)	OpenStreetMap
Country level	
GDP per capita (natural log)	World Development Indicators
Dependency ratio	World Development Indicators
Gasoline price	GIZ, International Fuel Prices 2018/19. https://transformative-mobility.org/international-fuel-prices/

Table A-1. Data sources

[8] Barrington-Leigh, Christopher, and Adam Millard-Ball. 2025. "A High-Resolution Global Time Series of Street-Network Sprawl." *Environment and Planning B: Urban Analytics and City Science* 23998083241306829. doi: 10.1177/23998083241306829.

Statistical modeling

We used a Bayesian hierarchical model[9] to assess the association between our independent variables and walking and cycling. The hierarchical model allows us to capture the effect of national-level variables (gasoline price, GDP, and dependency ratio) on walking and cycling. But it also allows the effect of city-level variables to vary by country, and to be moderated by national-level variables. For example, bicycle lanes or temperature might have a different impact in low-income countries, or in countries with higher gasoline prices. The model uses a beta distribution and an inverse logit link function in order to constrain the dependent variable to lie between 0 and 1. Such beta regression models are often used to model proportions.

Another advantage of the hierarchical model is partial pooling, sometimes called "shrinkage".[10] In countries with many cities in our dataset, the model provides country-specific estimates of the impacts of our city-level variables. In countries with more sparse data, the model "shrinks" to the global mean, in effect using information from cities in other countries with similar levels of GDP and gasoline prices.

The initial versions of the model included all of the variables in Table A-1, as well as squared terms for minimum and maximum temperature and population density. In the final version, we dropped the variables for SNDi added and motorways, and the squared terms for maximum temperature and density. This made the results easier to interpret, while not changing the conclusions. (We retained the squared term for minimum temperature, as the linear term on its own does not appropriately capture the effects.)

We also included a dummy variable that controls for whether in- and outbound trips (i.e., trips that are coming from or going to somewhere outside the city boundary) are included in our dataset. We included this control because the shares of travel by walking or cycling are generally higher for trips within a city than for trips into or out of a city, given that the former are more likely to be short trips easily accomplished by active modes.

[9] For full details, see Millard-Ball et al. 2025, Global health and climate benefits from walking and cycling infrastructure, *Proceedings of the National Academy of Sciences* 122: e2422334122. https://doi.org/10.1073/pnas.2422334122.

[10] Gelman, Andrew, and Jennifer Hill. 2007. *Data Analysis Using Regression and Multilevel/Hierarchical Models*. Cambridge: Cambridge University Press.

3320 Public Affairs Building
Los Angeles, CA 90095-1656
uclaits@ucla.edu
its.ucla.edu

UCLA Institute of Transportation Studies