April 12, 2021

AGENDA ITEM # 2

TO: Environmental Commission

FROM: Emiko Ancheta, Staff Liaison

SUBJECT: Climate Action and Adaptation Plan Update Status Report

RECOMMENDATION:

Receive update on Climate Action and Adaptation Plan (CAAP) progress

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BACKGROUND

In 2013 the City of Los Altos adopted the Climate Action Plan in accordance with the State Assembly Bill 32 which required public agencies in California to implement measures to reduce greenhouse gas (GHG) emissions to year 1990 levels by 2020. Cities needed to adopt a plan to addresses carbon emissions and establish an implementation plan for programs and facilities. A Climate Action Plan (CAP) is the policy document that provides the framework to achieve those goals. Since the adoption of the 2013 CAP, two annual report updates were done in 2015 and 2016. The City Council continues to make the environment a priority and directed staff to update the CAP. In December 2020, the City entered into contract with EcoShift Consulting to prepare a Climate Action and Adaptation Plan (CAAP) for the City of Los Altos.

In January 2021, staff began working with the consultant and the Environmental Commission Subcommittee to develop the Los Altos CAAP. The following summarizes the scope of services.

Task I: Project Management: Consultant Project Team will develop a project management plan in conjunction with City staff. The consultant will use best practices in project management methodologies to ensure the project remains on-task and on schedule. **Task Deliverables** include Kick-Off meeting with City staff, ongoing Bi-Weekly conference call meetings with City staff, attendance at meetings and public hearings for the Environmental Commission and City Council, presentation materials and summaries for meetings and public hearings and Ad hoc communication.
Task II: Data Inventory, GHG Forecast and Vulnerability Assessment: Consultant Project Team will use ICLEI protocols for this project and ClearPath portal to conduct the inventories and forecasting. **Task Deliverables** include update of baseline GHG inventory workbooks, summary GHG Report detailing results of inventory and documenting any methodological changes, forecast municipal and community GHG emissions, update GHG emissions reduction targets, vulnerability Assessment assessing the threats of climate risks.
Task III: Review and Assess Relevant City Plans, Policies, Programs and Codes: Consultant Project Team will conduct a review of current City measures, followed by a systematic process to compile the City's current, relevant goals, strategies, actions, tactics, and recommendations. **Task Deliverables** include collection of all relevant existing GHG reduction efforts, quantify efforts using

agreed-upon emission factors, develop matrix detailing the City's current emissions reduction efforts, and explaining the relevance of existing policies to each other and to future CAAP measures, and policy framework matrix.

Task IV: Develop and Evaluate GHG Reduction and Climate Adaptation Measures: Consultant Project Team's roadmap process will identify critical pathways to achieving the City's climate goals, help identify issues and barriers to each pathway, and recommend mitigation strategies to overcome barriers. **Task Deliverables** include list of proposed CAAP measures, summary of transportation scenarios and list of VMT and GHG reduction policies for possible inclusion in the CAAP, adaptation strategies, list of measures and actions to attain City goals, threat matrix detailing types and degree of threats from the effects of climate change and reporting template for reporting on adaptation measures.

Task V: Prepare Draft Climate Action and Adaptation Plan: Consultant Project Team will deliver a comprehensive and robust CAAP that will be designed to be complementary to existing policies for reducing waste and energy use, reducing single occupancy- vehicle trips, and encourage healthy lifestyles. **Task Deliverables** include draft CAAP that includes Executive Summary summarizing report's purpose, methodology, findings, and recommendations, and materials for ongoing outreach and education.

Task VI: Finalize Climate Action and Adaptation Plan: Consultant Project Team will compile all feedback from the draft CAAP review and integrate comments into the final CAAP document. **Task Deliverables** include finalized CAAP, meeting with City to discuss how input and comments were integrated info final CAAP, attendance at 3 public meetings (1 EC meeting and 2 CC meetings).

Task VII: CEQA Compliance: Consultant will prepare an Administrative Draft IS/MND with the following components:

- Project Description
- CEQA Environmental Checklist Form
- Mandatory Findings of Significance
- Contacts and Bibliography
- Mitigated Negative Declaration or Negative Declaration
- Notice of Determination

DISCUSSION

The Environmental Commission CAAP sub-committee members, Bruno Delagneau, Raashina Humayun and Don Weiden attend CAAP meetings and provide support and input with staff and the consultant to develop the CAAP. Receive update on CAAP development progress and status.

Attachments:

A. CAAP Meetings Summary
B. CAAP Schedule Timeline
C. CAAP Outreach and Engagement Schedule
D. PNAS Provisional COVID-19 infrastructure induces large, rapid increases in cycling

Climate Action & Adaptation Plan Meetings Summary

CAAP Kick-Off (January 14, 2021):

- Introduction of lead City staff, Environmental Commission subcommittee and consultant team
- Input for the CAAP development included:
    - Two focus areas should be existing buildings and reducing water use (the City is considering an energy audit of existing buildings).
    - Tie aspirational goals to concrete actions with specific reasons for the recommendations provided.
    - HR has some alternative commute benefits in place, including alternative work schedules and a public transit pre-tax benefit.
    - Important to present the value proposition of the plan to residents and businesses (explain the costs & benefits) to gain buy-in.
    - Two important focus areas will be tracking & measurement of actions and defining the City's GHG reduction target(s).
    - Community outreach will be important to engage the community and obtain input.
    - Action items and measures should be simple and conveyable to create a consistent repeatable message.
    - Important to identify the key drivers and goals of the plan (regulatory, leadership, etc.), as well as identifying where and how to best invest resources to achieve the plan's goals.
    - An updatable GHG model would be preferable, as well as an investigation of land use-related mitigation measures, and an investigation of future and retroactive actions (ex.: building codes to influence energy intensity).
    - A focus should be on creating a bold plan that incorporates technological advances, as well as raising the visibility of the plan in the eyes of the public and decision-makers.
    - The Reach Codes will have a big impact on future energy use in the City.
    - Per-capita residential PV and EV charging adoption are high within the City - there is interest in going off-grid among some residents.
    - The collection of data and using it in an effective reporting format will be important in demonstrating the plan's ongoing success, as well as communicating local and regional benefits.
- A brief presentation was given by the consultant team on the phases of the plan and the role Fehr & Peers' TrendLab+ tool.

CAAP Bi-weekly Meeting (January 29, 2021):

- Definition of an innovative plan was discussed: A valuable starting point will be for the City and consultant team to exchange lists of plans they find interesting/important to this project and discuss (see attachment D). This could result in a menu of innovative plans, policies, etc. for consideration for this project.
    - National and international plans and measures should be considered, not just limited to local efforts.
- Potential areas of interest for innovations include:
    - Learning and building on the Open Streets events over the summer.

  - Community microgrids (potentially utilizing new Community Center).
  - Utilizing carbon sinks and carbon capture to become Carbon Negative.
- Guidelines for private owners as well as enforceable policies for City-owned land and buildings should be looked at when considering innovative measures.
- Important to identify when to bring different stakeholder groups into the planning process. Bringing in different stakeholders at the right time will result in a more inclusive plan and help with the plan's adoption and implementation (ex.: downtown businesses will be impacted by changes to parking policies).
- The team discussed options for the timeframe for the Vulnerability Assessment (Mid Century vs End of Century). This should be determined by types of City infrastructure relevant to climate change. The original input from the City was that a Mid Century timeframe would be most appropriate.
- Alignment between the CAAP and the City's Emergency Preparedness Plan was discussed. Alignment between the CAAP and other City plans (current and future) in general will be an important consideration.
- The consultant team gave a brief intro to ClearPath. This will be the central GHG reduction planning tool, and also offers monitoring & reporting modules for ongoing use.
- An initial list of climate threats was reviewed (Flooding from creeks, Extreme Heat, Urban Heat Island effect, Wildfires, Air Pollution, and Drought). The consultant team will send this list to the City along with a framework for capturing stakeholder feedback on each threat. This is an important step in the Vulnerability Assessment.

<u>CAAP Bi-weekly Meeting (February 12, 2021):</u>

- Options for stakeholder engagement were discussed. Stakeholders identified are listed below.
  - The City has a Youth Commission that could be a good group to engage with.
  - The High School has a Green Team that engages regularly with the City Council.
  - Businesses will be important stakeholders (Anthony Carnesecca, Economic Development Coordinator).
  - Engage with groups that may be resistant to the measures in the final plan are important to engage with. Their concerns should be listened to and addressed.
  - Important Brown Act requirements to be strictly adhered to when considering meeting with commissions and committees as we plan outreach & engagement activities.
  - Engage the City Council in the process to implement their feedback on goals, and development throughout.

    <u>Stakeholder Groups:</u>
    - Los Altos Property Owners Downtown
    - Los Altos Village Association
    - Los Altos Chamber of Commerce
    - Los Altos History Museum
    - GreenTown Los Altos
    - LAYCAT (Los Altos Youth Climate Action Team)
    - Los Altos High School (Green Team Student Club)
    - LAUSD Outdoor Educator
    - Orchard Commons Committee

- Grass Roots Ecology
- Block Action Teams (BATs)
- Los Altos Community Foundation
- Los Altos Rotary Club
- Environmental Commission
- Parks & Recreation Commission
- Youth Commission
- Complete Streets Commission
- City Council

- An overview of the Vulnerability Assessment survey was given.
- An overview of the example CAPs and case study was given.
- There was a discussion of the Nature Communication article, and the reply by ICLEI. ICLEI's methods are still relevant for this project, but the issues the article raises should be considered in the CAAP (making sure all emissions are captured, including considerations of consumption patterns, flights by municipal and community members, and the way VMT is calculated).

CAAP Bi-weekly Meeting (February 26, 2021):

- Outreach & Engagement options were briefly discussed. Tabling for Farmers' Market will begin in April or May. Several stakeholder groups were identified that could be good channels for sharing information and gathering feedback.
- The results of the Vulnerability Assessment Survey were shared. Climate hazards associated with temperature change were of highest concern, and flooding related to precipitation changes were also a concern.

Table 1: Average Scores and Ranking for Primary Climate Hazards

Primary Climate Hazards	Score
Temperature Increase	2.3
Precipitation Changes	1.7
Sea Level Rise	1.3

Table 2: Average Scores and Ranking for Secondary Climate Hazards

Secondary Climate Hazards	Score
Drought	2.7
Extreme Heat/Heat Waves	2.3
Wildfire	2.3
Air Pollution	2.3
Flooding (Riverine, Areal)	2.3
Urban Heat Island	1.8
Flooding (Coastal)	1.4
Landslide	1.2

- FEMA has flood maps for Los Altos - these will be included in document requests. The Stormwater Master Plan will also be included.
- An overview of asset & population categories for the Vulnerability Assessment was given. A survey will be distributed to gather feedback on the importance of each category.
- A table of local and regional GHG emission reduction targets was shared (see below). As the City considers different target options, it will be valuable to know what targets other municipalities have set. The updated GHG inventory, costs & benefits of different targets, type of target (% based vs absolute), and feedback from different stakeholder groups will also be important.

Climate Targets Table

Municipality/Source	Year	1st Target	2nd Target
IPCC	2018	45% below 2010 levels by 2030	Net Zero around 2050
EO-S-3-05/AB 32	2005/2006	1990 levels (or 15% below 2005 levels) by 2020	80% below 1990 levels by 2050
SB 32	2016	40% below 1990 levels by 2030	
Carlsbad CAP	2015	15% below 2005 levels by 2020	49% below 2005 levels by 2035
Mountain View CPR	2015	80% reduction by 2050	
Encinitas CAP	2018	13% below 2012 levels by 2020	41% below 2012 levels by 2030
Sunnyvale CAP	2019	56% reduction by 2030	80% reduction by 2050
Santa Monica CAAP	2019	80% below 1990 levels by 2030	Carbon Neutral by 2050
City of Alameda CARP	2019	50% below 2005 levels by 2030	Net Zero Emissions as soon as possible
Albany CAAP	2019	70% below 2004 levels by 2035	Carbon Neutral by 2045
San Francisco CAP	2019	Net Zero emissions by 2050	
San Rafael CCAP	2019	40% below 1990 levels by 2030	80% below 1990 levels by 2050
Menlo Park CAP	2020	Zero Carbon by 2030 (90% reduction, 10% removal)	
San Jose GHG Reduction Strategy	2020	40% below 1990 levels by 2030	
Oakland Equitable CAP	2020	56% below 2005 levels by 2030	

San Mateo CAP	2020	Reduce emissions to 4.3 MTCO2e per-capita by 2030	Reduce emissions to 1.2 MTCO2e per-capita by 2050
San Anselmo 2030 CAP	2019	45% below 2010 levels by 2030	80% below 1990 levels by 2050
Santa Clara CAP	updating now		

CAAP Bi-weekly Meeting (March 12, 2021):

- Introduction of the City's PIO (Public Information Officer) team-Trevor and Sonia - they will be assisting with community outreach and engagement efforts.
- Manny in Muncipal Services will provide refrigerant data (buildings and fleet).
- The results of the internal Community Sectors Survey was reviewed - open-ended questions should be pared down for future surveys to improve the user experience.
- The group provided additional comment on the survey results, including sources of air quality effects, specific City resources, and at-risk populations related to climate change.
- A separate meeting will be set up to discuss next steps for outreach & engagement.
- Landfill reduction measures, specifically vinyl banners used for City events, looking for ways to address in the plan.
- Future land use decisions will be important (balancing City character, different types of businesses, etc.) related to climate mitigation and adaptation.
- The City implements green infrastructure (rain gardens, bioswales, etc.) guidelines and details to be provided to consultant.

CAAP Bi-weekly Progress Report (March 26, 2021):

- Vulnerability Assessment: Cal-Adapt provides a view of how climate change might affect California, and its development is a key recommendation of the 2009 California Climate Adaptation Strategy. Using the Cal-Adapt tool, future conditions around precipitation, heat days, and fire hazards can be modeled using a suite of approved climate models.

  Using Cal-Adapt, the findings indicate that the location of Los Altos relatively near the Pacific Ocean and on the eastern edge of the Santa Cruz mountains has defined the area's climate and will somewhat temper future climate hazards compared to other areas in California.

  - Temperature & Drought
    - Average temperatures and the number of extreme heat days are projected to increase throughout the century, according to Cal-Adapt. The number of extreme heat days are projected to be almost 300% more in a high emissions scenario than in a medium scenario.
    - Whether droughts get worse depends on the definition of drought. One definition is a prolonged period with below-average or no precipitation. The length of dry

spells is not expected to change nor is average annual precipitation. However, higher temperatures combined with less consistent rain will impact both water supply and outdoor water demand.

- Precipitation
    - o Los Altos has experienced numerous severe winter storms that have caused flooding and multiple climate models predict at least one severe storm a year under high emissions scenarios by the end of the century. Interestingly, while severe storms will happen more frequently, they won't be much more intense. Similarly, the average annual precipitation is not expected to change
- Wildfires & Air Pollution
    - o Despite increased temperatures, wildfires are not projected to be a significantly worse threat in the future. The average area burned by wildfires is projected to decrease. Regionally, Los Altos and the surrounding area is not high risk, though the relative risk for natural areas is projected to increase slightly. Long term summer air quality will be defined by counteracting forces from increased temperatures and increased vehicle electrification.

- Outreach & Engagement: The Outreach & Engagement subcommittee met on March 25th to discuss initial goals, strategies, and timeline for conducing community-facing engagement for the CAAP. Engaging diverse stakeholder groups will be important for soliciting feedback on community makeup, attitudes on climate change, and community priorities, as well as gathering input on proposed mitigation and adaptation measures. Although there are no prescriptive rules, stakeholder engagement is recommended for the climate change mitigation and adaptation work involved in the plan, and will ultimately help streamline its implementation.

  Action items coming out of that meeting include:
    1. The City has a number of tools at its disposal, including existing communication channels, community partners, and internal staff capacity.
    2. EcoShift will provide support in the form of resources, tools, guidance, and advice as needed.
    3. The City will consider a series of focus groups with City stakeholders (program directors, etc.) to gather their feedback on critical issues, as well as reformatting the bi-weekly meetings to more of a working meeting. City directors currently attending bi-weekly meetings could attend these workshops instead, with occasional touch points with the entire group.
    4. EcoShift will work with staff to develop a schedule of engagements (see attachment C).

- Data Collection: Most data has been received and is in the process of being uploaded into ClearPath. The tables below contain the current status of data collection for the Community and Municipal inventories. Since the last update, streetlight, traffic signal, and additional energy data have been received. EcoShift will continue to provide updates as the data is processed.

Community Data

DATA	RECEIVED?
Energy data (electricity & natural gas)	Yes
Municipal Solid Waste	Yes
Water usage	Yes
Wastewater	RWQCP is carbon neutral
Off-Road (construction and lawn & garden equipment, calculated using housing and population data)	No, awaiting housing data from County
Transportation	Developing methodology with Fehr & Peers

Municipal Data

DATA	RECEIVED?
Building Energy use (electricity & natural gas)	Yes
Lighting (street lights & traffic signals)	Yes
Water usage	Yes
Fleet vehicle fuel use (gas & diesel)	Yes
Employee commute	Yes
Municipal Solid Waste	Yes
High Global Warming Potential gas leakage (refrigerants and AC systems)	No
Wastewater	RWQCP is carbon neutral

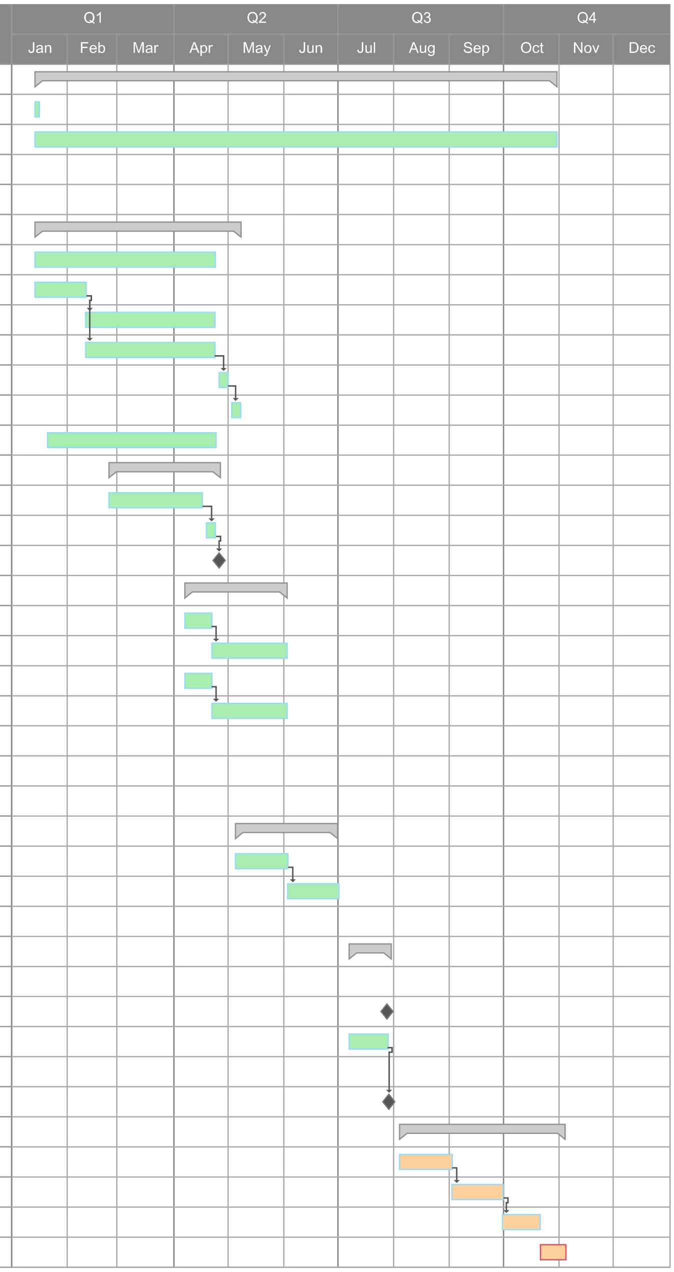
Other Notes:

- The Parks & Rec Dept. is interested in having a representative attend future bi-weekly team meetings and outreach events. The representative will begin attending meetings starting at the next bi-weekly meeting on April 9th.

Attachment B

Los Altos CAAP

Task Name
Task I: Project Management & Meetings
Project Kick-Off meeting
Ongoing project management
Public meeting attendance
Public meeting agendas, presentation materials and summaries
Task II: Data Inventory & Forecast
Gather necessary data
Review and update existing inventories
Revised or additional GHG reduction measures
Quantify baseline GHG emissions
Forecast emission projections
Set new emission reduction targets
Vulnerability assessment
Task III: Review & Assess City Plans, Policies, Programs and Codes
Audit of City's policy framework
Quantify existing efforts
Matrix explaining relevance of existing policies to CAAP
Task IV: Develop & Evaluate GHG Reduction Measures
Identify GHG reduction measures
Quantify and assess GHG reduction measures
Identify adaptation measures
Quantify and assess adaptation measures
TrendLab+ scenario testing study session
TrendLab+ Customization
Reporting template for adaptation reporting
Task V: Prepare Draft CAAP
Prepare administrative CAAP draft
Prepare final CAAP
Attend 2 public meetings each with EC and CC
Task VI: Prepare CAAP
Prepare CAAP
Debrief session with City staff to explain how comments have been addressed
Attend 3 public meetings for final CAAP adoption (1 EC and 2 CC)
PowerPoint presentation for meetings
Certification of CAAP
Task VII: CEQA Compliance
Administrative draft IS/MND
Screencheck draft IS/MND
Public review draft IS/MND
Mitigation Monitoring & Reporting Program



CAAP Outreach and Engagement Schedule

Estimated Schedule for Community and Stakeholder Outreach and Engagement:

Date	Task Description
23-Apr	Focus Group #1: A Review of the Vulnerability Assessment
26-Apr	Survey Community #1: Informational
11-May	City Council Meeting; Poll #1 on Survey #1
23-May	Focus Group #2: A Review of the Gap Analysis
25-May	City Council Meeting; Poll #2 on Survey #1
8-Jun	City Council Meeting; Poll #3 on Survey #1
11-Jun	Survey Community #1 Ends
18-Jun	Community Workshop #1: Potential Strategies and Tactics
25-Jun	Survey Community #2: Strategies
13-Jul	City Council Meeting; Poll #1 on Survey #2
16-Jul	Focus Group #3: Final implementation strategies
31-Jul	Survey Community #2 Ends

Focus Group	Focus Groups with Leads and specific stakeholders to gather input
Community Work	Public workshop open to residents to answer questions and gather input
Survey Communit	An open survey for residents to take
City Council Poll	Small polls about how well we are messaging the surveys; measuring our engagement; advertise survey

Attachment D

Provisional COVID-19 infrastructure induces large, rapid increases in cycling

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Edited by Susan Hanson, Clark University, Worcester, MA, and approved February 18, 2021 (received for review November 26, 2020)

The bicycle is a low-cost means of transport linked to low risk of transmission of infectious disease. During the COVID-19 crisis, governments have therefore incentivized cycling by provisionally redistributing street space. We evaluate the impact of this new bicycle infrastructure on cycling traffic using a generalized difference in differences design. We scrape daily bicycle counts from 736 bicycle counters in 106 European cities. We combine these with data on announced and completed pop-up bike lane road work projects. Within 4 mo, an average of 11.5 km of provisional pop-up bike lanes have been built per city and the policy has increased cycling between 11 and 48% on average. We calculate that the new infrastructure will generate between $1 and $7 billion in health benefits per year if cycling habits are sticky.

urban planning | active travel | generalized difference in differences

The COVID-19 crisis has led to important changes in transport behavior in 2020 (1). Early evidence points to shifts from public transport to car use as users have reacted to the pandemic (2). Governments have incentivized cycling as a low-cost, sustainable, equitable, and space-saving mode of transport that reduces the risk of COVID-19 transmission. A key measure has been the redistribution of street space in cities to create provisional bike infrastructure typically marked and protected by materials readily available from road construction companies. As of July 8, 2020, 2,000 km of these infrastructure changes had been announced in European cities (3).

Transport mode choices are influenced by a variety of behavioral effects that make people stick to their habits, such as status quo bias, default effects, and time-inconsistent preferences (4). This complicates the task of policymakers to encourage people to cycle, particularly in the short run. However, major disruptions to public transport, such as strikes, cause people to reconsider their habits (5) and the provision of dedicated infrastructure has been identified as an important means to increase cycling (6). Thus, the fast provision of new bike infrastructure during the COVID-19 pandemic is a suitable policy experiment to investigate the responsiveness of cycling under conducive conditions.

Here, we estimate the causal effect of the post-COVID-19 lockdown rollout of provisional ("pop-up") bike lanes in European cities. We compile new data on daily bike counts in 106 cities. We connect to the open data application programming interfaces (APIs) of these cities to download bike counts from a total of 736 counters. We combine these data with information on day-to-day kilometer changes in pop-up cycling infrastructure (Fig. 1).

The spatial placement of pop-up bike lanes has mainly been driven by the availability of street space that could be redistributed without restricting car traffic to one direction and the existence of "shovel-ready" construction plans. The exact timing of pop-up bike lane construction is driven by administrative idiosyncrasies and the availability and schedules of construction firms. Therefore, the timing of the pop-up bike lane rollout has been as good as random. This quasi-experimental setting allows us to address the important concerns that bike lanes could be built as a reaction to increased cycling traffic (reverse causality) or that both the implementation of bike lanes and bicycle counts could be driven by a third factor, such as local "green" preferences, that cannot be measured (omitted variable bias).

Results

We use panel regressions to compare bike traffic in treated cities before and after they get treated with control cities. We find that pop-up bike lanes have led to substantial increases in cycling. This effect is robustly visible in comparisons over both a longer and a shorter time span. First, in Fig. 2 we show the effect comparing treated and control cities over several months before and after treatment. Second, in Fig. 3 we provide estimates from a range of more conservative specifications identifying the effect based on daily variation within a narrow time window in the same city.

The outcome in all our regressions is modeled as the natural logarithm of the cycling count. We use daily variation in this variable either at the counter or at the city level. Our coefficients can be interpreted as the average change in cycling caused by the pop-up bike lane program.

Standard Difference in Differences. Fig. 2 shows the dynamic treatment effect of the pop-up bike lane program. For the analysis shown here, we define March 2020 as the time of treatment and plot the estimated differences between treated and control cities over time. Since we expect cycling to increase in both treated and

Significance

Active travel makes people healthier and creates a wide range of additional social and environmental benefits. The provision of dedicated infrastructure is considered a crucial policy to increase cycling. However, evaluating the impact of this type of intervention is difficult because infrastructure changes are typically slow. The rollout of so-called pop-up bike lanes during the COVID-19 pandemic is a unique empirical context to estimate the pull effect of new cycling infrastructure. We show that the policy has worked. We find large increases in cycling. This result is robust for a variety of empirical counterfactuals. Further research is needed to investigate whether this change is persistent and whether similar results can be achieved in situations outside the context of a pandemic.

Author contributions: S.K. and N.K. designed research; S.K. analyzed data; and S.K. and N.K. wrote the paper.

The authors declare no competing interest.

This article is a PNAS Direct Submission.

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This article contains supporting information online at https://www.pnas.org/lookup/suppl/doi:10.1073/pnas.2024399118/-/DCSupplemental.

Published March 29, 2021.

SUSTAINABILITY SCIENCE

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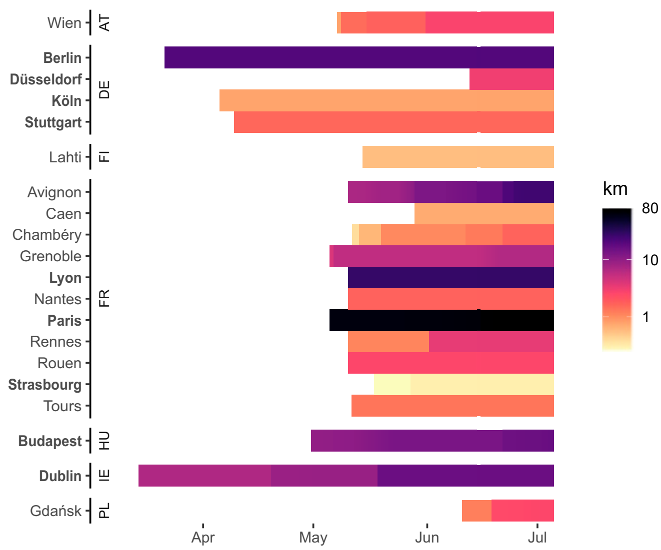

Fig. 1. Treated cities and their treatment intensities in terms of implemented kilometers of public bike lanes in service (cumulative) on a given day between March and July 2020. Cities used in the estimation sample for Fig. 3 are marked in boldface type. Control cities are plotted in *SI Appendix*, Fig. S2. London, Milan, Rome, and Lisbon are missing from the sample due to a lack of daily bicycle counter data. Data are from the European Cyclists' Federation (3).

control cities as a reaction to COVID-19, we take the difference between the cycling increase in treated and in control cities as our estimate of the average effect of the program. This difference in differences approach suggests an increase in cycling of 41.6% induced on average by the policy. A crucial assumption for this research design is that cycling would have evolved on a parallel trend in the treatment and control group in the absence of treatment. This is called the common trends assumption. Since we model the outcome as the natural logarithm of cycling counts, we make the assumption that cycling would have grown at the same rate in the treatment and in the control group.

Fig. 2 allows us to verify this assumption. The treatment effect becomes apparent after the treatment sets in. Before, treatment and control groups have been on the same trend. There is a slight, albeit statistically insignificant downward trend before treatment, hinting at the possibility of stronger mobility reductions due to COVID-19 in cities that have decided to build pop-up bike lanes. This could for instance be the case because local and national governments are more likely to take wide-ranging action if their country is hit by a more intense outbreak. It could also be due to governments acting upon stronger risk aversion of their local populations toward cycling in the context of emptier roads and increased speeding during the lockdown. We mitigate some of these potential selection into treatment effects by controlling for COVID-19–related dynamics with fixed effects at the country–day level. This removes the effect of daily national-level policy changes, such as lockdowns.

A remaining concern is that bike lanes could have been built as a reaction to locally increased cycling traffic (reverse causality) or that both the implementation of bike lanes and bicycle counts could be driven by an unaccounted third factor (omitted variable bias). We address these potential biases with regressions focusing on changes over a shorter time span as discussed in the next section.

Generalized Difference in Differences. In our second set of specifications (Fig. 3) we investigate more focused comparisons using both variation in the timing of treatment between cities and variation in the treatment dose, i.e., the number of kilometers of pop-up bike lane in service on a given day. With these specifications we robustify the more simple difference in differences design by using additional fixed effects and by including control variables for the weather, for changes in overall mobility and public transport, and for the number of active bike counters in a city. Crucially, we look at the effects of pop-up bike lanes in a shorter time span to investigate potential reverse causality between cycling and the implementation of pop-up bike lanes. Although pop-up bike lanes tend to be based on preexisting plans by city planners or civil society organizations and could therefore be implemented comparatively quickly, the erection of a bike lane needs at least a few days' notice and the exact timing of these road works depends on the availability and the schedule of construction firms. This has been confirmed in our conversations with local policymakers in Berlin and Paris. Our preferred specifications (Eq. **1**) are therefore based on comparisons of cycling counts on the days before and after a change in the treatment intensity (marked in blue). These comparisons are created by the

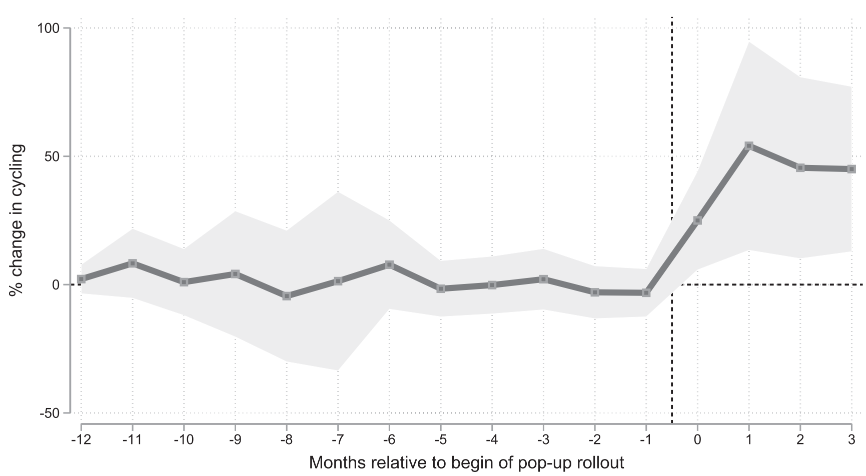

Fig. 2. Treatment effect (difference between treated and control cities) in months before and after the beginning of the pop-up bike lane policy. Observations are binned into months. Treatment for this plot is hard coded to March 2020 and the baseline category and the beginning of the sample are set to February 2019. Estimates are from Poisson regressions that include city and country–day fixed effects (*SI Appendix*, Eq. **S1**). The shaded area shows the 95% confidence interval. Data for the outcome variable are from the European Cyclists' Federation (3) and data for the treatment variable are from municipal bike counters (*Materials and Methods*).

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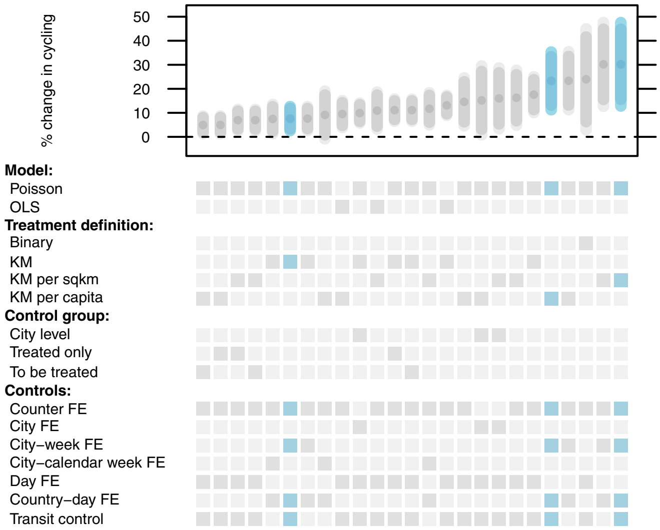

Fig. 3. Estimates of the average effect of pop-up bike lanes on cycling. Dose–response regressions (in kilometers, kilometers per capita, or kilometers per square kilometer in service on a given day) are multiplied by the average treatment dose. The 90 and 95% confidence intervals are shown in darker and lighter color. The unit of observation is the bike counter except for regressions at the city level. Preferred specifications are marked in blue (Eq. **1**) and are reported in more detail in *SI Appendix*, Table S5. Gray (and blue) indicators (*Bottom*) indicate the type of specification. Three estimates are from OLS specifications and therefore use the natural logarithm of the bicycle count as the outcome. All other specifications are Poisson regressions using the level of the count. Data for the outcome are from the European Cyclists' Federation (3) and data for the treatment are from municipal bike counters (*Materials and Methods*). All regressions include controls for the number of active counters in a city on a given day and for the weather (temperature, sunshine, wind, precipitation) (7). All regressions, except those that rely on observations before 2020, include a control for overall mobility (8). The transit control is from Apple routing requests (2020 only) (1). Code is from ref. 9.

inclusion of city–week fixed effect. This fixed effect ensures that our estimates are based on variation within the same city within the same week. If the exact (i.e., day-level) timing of the rollout of pop-up bike lanes has been as good as random, estimates from these specification are not driven by reverse causality.

Our unit of observation in most regressions is the cycling counter. This allows us to control for within-city differences despite doing a cross-city study. We do this by including a counter fixed effect that flexibly controls for any local confounders that are time invariant within the time frame of the variation used in the analysis. We thereby control for the density of public transport stops, population density, and topography, but also for additional, unobservable dimensions, such as social capital and local preferences for green lifestyles, at a high spatial resolution within the city. With the counter fixed effect we also rule out that our result is driven by new counters that get placed next to pop-up bike lanes. We assign treatment to each counter based on its city, since we measure daily changes in the pop-up bike lane network at that level. We investigate the effect of this source of measurement error by defining the treatment dose either as a binary variable or in terms of kilometers, kilometers per capita, and kilometers per square kilometer of city area. We find that measuring the dose–response in terms of kilometers attenuates the effect (7.6%). This indicates that the effect is not exclusively driven by the announcement effect of new infrastructure in a city, but by the de facto availability of new infrastructure in the neighborhood surrounding a counter, which is better approximated by a measure in per capita or per area terms (estimates of 23.3 and 30.2%, respectively). Remaining measurement error due to some counters being closer to or farther from new infrastructure than the rest of the sample is unlikely to be systematic conditional on fixed effects and control variables (detailed discussion of measurement error in *SI Appendix*). We also run specifications for which we take the mean of all counters in a city (marked as city level in Fig. 3) to show that the effect is not driven by our use of the counter as the unit of observation.

We use a variable capturing transit routing searches on Apple maps (1) to control for omitted variable bias that could be present if changes in public transport affect both pop-up bike lane construction and cycling. In our preferred specification this could still be the case, if daily changes in the provision or in the use of public transport in a city led to new pop-up infrastructure within the same week. Public officials may for instance have tried to schedule the erection of pop-up bike lanes for the same day as planned public transport disruptions. The transit control removes this potential remaining bias. Since the Apple data are available only for a subset of larger cities in our sample (marked in boldface type in Fig. 1), we run our main regressions (Fig. 3) on this smaller sample. *SI Appendix*, Table S4 shows robustness to lifting this sample restriction and to excluding Paris, which has had the strongest treatment, from the analysis.

We control for subnational changes in policies and behaviors related to COVID-19 with a variable that captures overall human mobility based on Facebook user movements. We control for the number of counters active in a city on a given day to account for unusual traffic situations, for instance when a counter gets shut down because of road works. We also include control variables for daily total precipitation and mean wind, temperature, and sunshine to address the concern that both the scheduling of pop-up bike lane construction work and daily variation in cycling could have been driven by weather conditions.

We check the sensitivity of our results to changing the time span of our identifying variation and to reshaping our treatment and control group definitions (additional specifications in Fig. 3). The effect is robust to including days from the same calendar week in previous years in these comparisons rather than days from 2020 only. We also provide estimates for the effects of the policy based on comparisons between 1) treated and untreated cities, 2) treated cities using only their variation in treatment timing, 3) cities that are already treated and those that have announced only pop-up bike lanes, and 4) treated cities only using their variation in treatment dose and treatment timing.

Heterogeneity Analysis. We investigate how the treatment effect of pop-up bike lanes varies depending on relevant features of the cities in our sample (Table 1). These heterogeneous effects should not be interpreted causally, since we cannot control for additional omitted variable bias or reverse causality created by the inclusion of these variables in our model. We find that the effect of pop-up bike lanes is stronger in cities with a higher population density [1] and a higher modal share of public transport in commutes [2], which are correlates of a built environment favoring active travel. The treatment effect is lower for cities with faster average speeds of car commutes [6] and for cities with more road death per capita [7]. It is also lower for cities with more cars per capita [5]. However, this estimate is imprecise. These heterogeneities confirm research that found that US cities with better safety, low car ownership, and more density have more cycling (10, 11).

Our analysis also shows that the baseline length of the bike lane network per capita [3] is correlated with a lower treatment effect. We interpret this as an indication that the pop-up bike lane effect is a phenomenon of catch-up growth in cities with a high cycling potential that was previously impeded by missing infrastructure. The effect of baseline cycling modal shares [4] is, however, statistically unclear.

Further research could also look at the effect of pop-up bike lanes in terms of improvements in bike lane network connectivity

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https://doi.org/10.1073/pnas.2024399118

Table 1. Heterogeneous treatment effects of the pop-up bike lane rollout

	× baseline (natural log) of						
	[1] Population density	[2] PT modal share	[3] Bike lanes per capita	[4] Cycling modal share	[5] Cars per capita	[6] Car commute speeds	[7] Road deaths per capita
Pop-up treatment	0.221*	0.258***	−0.194*	0.093	−0.592	−0.509**	−0.351***
	(0.121)	(0.100)	(0.115)	(0.082)	(0.485)	(0.233)	(0.058)
N	59,521	27,486	24,611	27,486	34,408	26,886	34,922

Estimates are based on the interaction term of the treatment variable (in kilometers per city area) and the natural logarithm of the heterogeneity variables (column names). Coefficients are scaled to the average treatment dose in our sample. They can be interpreted as the unit change in cycling if a heterogeneity variable is one unit higher (when assuming treatment with an average pop-up bike lane program). All regressions include counter, city–week, and country–day fixed effects. They also include weather controls (7), a control for overall mobility (8), and a control for the number of counters active in a city on a given day. Data for the outcome variable are from the European Cyclists' Federation (3) and data for the treatment variable are from municipal bike counters (*Materials and Methods*). All heterogeneity variables except for bike lanes per capita (17) are from the European Urban Audit (18, 19). Standard errors clustered at the city level are reported in parentheses. Significance levels are $^*P < 0.1$, $^{**}P < 0.05$, $^{***}P < 0.01$.

and directness as proposed by ref. 12 and other more complex measures of a bike lane network, such as the level of protection of a bike lane and the treatment of intersections (13). In this context it is important to investigate how underserved communities can be provided with a pop-up bike lane network that is complete and inclusive and how additional political, cultural, and economic barriers to cycling for low-income and minority groups can be removed (14). Bike sharing can support changes in modal choice (15), but important barriers to adoption remain for underrepresented groups (16). We therefore think it would be valuable to investigate interactions between the pop-up bike lane policy and time series data on bike sharing policies including changes in pricing and the availability of bikes and stations.

Discussion

We find robust evidence for substantial short-run increases in cycling in European cities due to new provisional cycling infrastructure. Independent of its potential impacts in reducing COVID-19 transmission, the net benefits of the intervention are likely to be large. The direct cost of cycling infrastructure is low. At the higher end, 1 km of bike lane in Sevilla has previously cost €250,000 (20). However, Berlin's approach of iterative planning with provisional infrastructure during the pandemic has for instance reduced costs to €9,500/km as of July 2020 (21). These costs are small compared to the substantial health benefits from the new infrastructure. Previous research has found that every kilometer of cycling generates health benefits of \$0.45 (22). As a complementary and more stylized analysis, we combine this estimate from the literature with our econometric estimates of policy-induced cycling increases to provide a projection of health benefits generated by pop-up bike lane programs. We calculate baseline values for total cycling in a city based on data on daily kilometers cycled in German cities in 2018 and extrapolate these numbers to the other European cities in our sample based on city-level data on transport and population (*Materials and Methods*). This extrapolation is approximate but sufficient to calculate a range of potential health benefits. Based on our regression-based estimate for the 95% confidence interval of the "treatment dose" in terms of kilometers per square kilometer, we project that the additional cycling induced by the pop-up bike lane treatment during its first months of operation has generated between \$0.5 and \$1.7 billion in health benefits. Thus, the new infrastructure may generate between \$2.2 and \$6.9 billion/y in health benefits if the new bike lanes become permanent and make cycling habits stick. We project this range to be between \$1.2 and \$3.5 in annual health benefits if we use our alternative estimate for the 95% confidence interval of the policy effect based on the "treatment dose" in terms of kilometers per capita.

The magnitude of our estimate is large compared to previous evaluations of new cycling infrastructure improvements that have found statistically unclear or modest effects, typically because of the limited scale of the interventions (23–25). Our estimate implies a higher responsiveness of cycling to new infrastructure than the associations found in cross-sections of US cities (10, 26). However, in cities in Europe (17) and the United Kingdom (27) additional infrastructure is associated with more cycling than in the United States. The case of Sevilla has shown that in a dense city with a high share of narrow, cycling-friendly roads the construction of bike lanes on major roads can create substantial cycling growth: 120 km of new bike lanes have led there to a fivefold increase of cycling between 2006 and 2011 (20). Similarly, pop-up bike lanes have often been placed on main roads. Thereby they have removed important bottlenecks for cyclists and generated important improvements for the overall cycling network. Many of the cities in our sample are fundamentally well suited for cycling. For instance, they are often dense and have a high share of side roads with slow car speeds. Therefore, they can be assumed to have a high potential for catch-up growth, which is one explanation for our larger effect estimate. In addition, the pandemic has led to a reshuffling of otherwise rather inelastic mobility choices and thus created the conditions for new infrastructure to induce shifts to active travel. However, this also means that our results cannot be directly generalized to other settings. Given this limitation in terms of external validity, we caution against an overinterpretation of our estimates as providing a benchmark value for increases in cycling that planners should expect from an additional kilometer of bike infrastructure. It remains to be evaluated whether the new bicycle use is sticky and how similar treatments influence behavior outside of the context of a pandemic.

Surveys indicate that separated, protected infrastructure is a key element to incentivize uptake of cycling (28–30). Cities have experimented with different measures to create new spaces for cycling, ranging from painted to provisionally protected bike lanes and from traffic calming with signs to built "modal filters" that prevent the passage of cars. Our data on pop-up infrastructure do not allow us to systematically distinguish between these types of interventions and the quality of their implementation.* Further research should investigate which types of infrastructure have more successfully increased cycling by previously underrepresented groups, such as women, older people, and children.

*In *SI Appendix*, Table S3 we show that the results are robust to specifying treatment in terms of 1) the total length of all types of infrastructure, 2) the total length of measures clearly marked as bike lanes in the data, 3) the number of measures, and 4) a binary indicator for treatment.

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Attachment D

Materials and Methods

Bicycle Counter Data. We connect to municipal Open Data Portals to obtain daily bicycle counts from bike counters in large- and medium-sized cities in 20 European countries. The raw data and code to download counter data are included in our code package (31). The outcome is modeled as the natural logarithm of cycling counts. This means that we investigate percentage changes rather than absolute increases in the number of cyclists. Our outcome varies daily at the counter level (summary statistics and cleaning procedures in *SI Appendix*).

Bike Lane Data. The data on planned and completed pop-up infrastructure projects have been collected and crowdsourced by the European Cyclists' Federation based on technical reports and media announcements. A visualization of the data can be accessed at https://ecf.com/dashboard. We merge these data with city polygons from the European Urban Audit 2020 (32) to generate a cumulative measure for the total number of pop-up bike lanes in service in a city on a given day (summary statistics and cleaning procedures in *SI Appendix*). We generate a range of treatment variables (binary, kilometers built, kilometers per capita, kilometers per square kilometer of city area) and assign this treatment to counters based on their city polygon.

Control Variables. Using fixed effects in our regressions, we remove and therefore control for time-invariant differences between cities and between the locations of the individual counters in our data. Therefore, any additional time-invariant control variables at the city and the counter level would be redundant in our analysis. We also use fixed effects interacting different spatial levels with time dimensions, thereby controlling for many time-varying observable and unobservable factors. We use additional controls to rule out any bias that may be introduced by time-varying factors below our fixed effect levels.

We control for daily changes in public transport supply and demand with the transit variable from the Apple COVID-19 Mobility Trends Reports (1). This variable captures daily variations in the number of requests for public transport directions on Apple Maps. We access these data using the covmobility package (33).

We capture average human mobility throughout the phase of the COVID-19 pandemic starting in March with a human mobility index based on Facebook data (8). The index is from a dataset called "movement range maps" that Facebook shares after aggregating individual user movements for humanitarian and research purposes with a reference to the principles outlined by epidemiologists and public health researchers (34). It measures the number of daily 600-m grid cells visited by Facebook users compared to a baseline in February. For most of our sample the index is aggregated to the state level, where we use the data. On average, in our sample period daily mobility has been below the February baseline.

We use weather data from the ERA5 climate model that generates hourly measures of surface temperature, ultraviolet (UV) radiation, precipitation, and wind at a $0.25^\circ \times 0.25^\circ$ resolution (7). We use the ecwmfr package (35) to aggregate this to the European Union Urban Audit city polygons (32) at the daily level.

Heterogeneity Variables. We analyze heterogeneous treatment effects along seven city-level variables. Bike lanes per capita measures the length of the bike lane network in a city based on Open Street Map data (17, 36). Population density is from the European Urban Audit (19). Public transport (PT) modal share, cycling modal share, cars per capita, car commute speeds, and road deaths per capita are based on city transport statistics from Eurostat (18). We use the natural logarithm of these variables to obtain the unit change in cycling for a unit change in the respective heterogeneity variable.

Empirical Strategy. We estimate a panel regression model at the counter level with daily counts of cyclists as the outcome variable and the number of kilometers (kilometers, kilometers per capita, or kilometers per square kilometer of city area) of pop-up bike lanes in service in a city on a given day as the treatment. This regression analysis forms comparisons between treatment and control groups before and after treatment for each cohort of new bike lanes and for different treatment intensities (generalized difference in differences). This separates the effect of pop-up bike lanes from overall changes in cycling due to COVID-19. We use a set of indicator variables (fixed effects) that remove remaining variation from our estimation sample that would otherwise bias our estimates. Our study design thus allows for systematic differences in the level of bike traffic between treatment and control groups, but relies on a common trends assumption, that bike traffic in treated and control cities would have evolved on a parallel trend in the absence of treatment. We cannot observe treated units in their untreated state after treatment (potential outcome). However, we can investigate pretreatment trends between treated and control cities and check the sensitivity of our estimates to changes in the control group definition, i.e., in the way we construct the empirical counterfactual (Fig. 3).

In our preferred specification we model the relationship between cycling traffic and the pop-up bike lane treatment as

$$\ln \text{Count}_{id} = \beta \text{Bike Lanes}_{cd} + \mathbf{X}_{cd} + \lambda_i + \sigma_{cw} + \varphi_{nd} + \varepsilon_{id} \quad [1]$$

where *i* indexes a counter, *c* a city, *n* a country, *d* a day, and *w* a week.

λ_i is a counter fixed effect that controls for time-invariant factors at a high spatial resolution. σ_{cw} is a city–week fixed effect that controls for week-specific time-varying factors, thereby restricting identifying variation to days before and after treatment within the same week in the same city. φ_{nd} is a country–day fixed effect that captures any daily changes common to all cities in a country.

We cannot include fixed effects for factors that vary at the city level over time, such as local mobility or weather, since this is the geographical level at which our treatment is measured. $\mathbf{X}_{cd}$ is a vector of control variables that account for these factors. It includes an index for public transport use from Apple (1), an index for overall mobility based on Facebook data (8), weather variables (temperature, UV radiation, wind, precipitation) (7), and the number of counters per city active on a given day.

The coefficient of interest is β. It captures the effect of the pop-up bike lane treatment on bicycle counts. Our treatment variable is defined either as a binary indicator for treatment or as the number of kilometers (kilometers, kilometers per capita, or kilometers per square kilometer of city area) of pop-up bike lanes in service on a given day.

Figs. 2 and 3 and Table 1 present the transformed estimate $100 \times (\exp \beta - 1)$.

Since our outcome is a count variable, we use Poisson pseudo–maximum-likelihood (PPML) regressions to estimate this model (37). As a robustness check we also use ordinary least squares (OLS) with the natural logarithm of the bicycle count as the outcome (Fig. 3). We cluster standard errors at the city level, where treatment is assigned (38).

Calculating the Health Benefits. We calculate the health benefits by combining our regression estimates of cycling increases for each kilometer of pop-up bike lane with an estimate of the average health benefits of a kilometer cycled ($0.45 converted from 0.62 Australian dollars), which is lower than typical values from the gray literature (22). Our dose–response regressions give us the percentage increase in cycling per kilometer of bike lane divided by the city size or city population. For each city in our sample we multiply this effect by the size of its pop-up bike lane program. We then convert this result into additional kilometers cycled in a city based on baseline values of kilometers cycled per person from a detailed transport behavior survey in 135 German cities (39). We impute values of kilometers cycled for other European cities based on ordinary least-squares regressions using information on baseline values of a city's modal split (trips) of commutes, its population density, the length of its initial bike lane network, the modal share of public transport, the number of cars per capita, the average speed of car commuting, and road deaths per capita (more detail in *Heterogeneity Variables*).

Data and Code Availability. Raw data and code have been deposited in Zenodo (DOI: 10.5281/zenodo.3973038) (31).

ACKNOWLEDGMENTS. We thank Ben Thies and Lennard Naumann for their excellent research assistance.

1. Apple, Mobility trends reports (2020) https://www.apple.com/covid19/mobility. Accessed 18 July 2020.
2. H. H. Chang, C. Meyerhoefer, F. A. Yang, Covid-19 prevention and air pollution in the absence of a lockdown. https://www.nber.org/system/files/working_papers/w27604/w27604.pdf. Accessed 23 March 2021.
3. ECF, COVID-19 cycling measures tracker (2020) https://ecf.com/dashboard. Accessed 24 July 2020.
4. L. Mattauch, M. Ridgway, F. Creutzig, Happy or liberal? Making sense of behavior in transport policy design. *Transport. Res. Transport Environ.* **45**, 64–83 (2016).
5. S. Larcom, F. Rauch, T. Willems, The benefits of forced experimentation: Striking evidence from the London underground network. *Q. J. Econ.* **132**, 2019–2055 (2017).
6. J. Pucher, J. Dill, S. Handy, Infrastructure, programs, and policies to increase bicycling: An international review. *Prev. Med.* **50**, S106–S125 (2010).

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7. H. Hersbach *et al*., The era5 global reanalysis. *Q. J. R. Meteorol. Soc.* **146**, 1999–2049 (2020).
8. Facebook, Movement range maps (2020) https://data.humdata.org/dataset/movement-range-maps. Accessed 2 August 2020.
9. A. Ortiz-Bobea, ArielOrtizBobea/spec_chart (2020) https://github.com/ArielOrtizBobea/spec_chart. Accessed 19 November 2020.
10. R. Buehler, J. Pucher, Cycling to work in 90 large American cities: New evidence on the role of bike paths and lanes. *Transportation* **39**, 409–432 (2012).
11. R. Buehler, J. Pucher, A. Bauman, Physical activity from walking and cycling for daily travel in the United States, 2001–2017: Demographic, socioeconomic, and geographic variation. *J. Trans. Health* **16**, 100811 (2020).
12. J. E. Schoner, D. M. Levinson, The missing link: Bicycle infrastructure networks and ridership in 74 US cities. *Transportation* **41**, 1187–1204 (2014).
13. R. Buehler, J. Dill, Bikeway networks: A review of effects on cycling. *Transport Rev.* **36**, 9–27 (2016).
14. J. Agyeman, Poor and black 'invisible cyclists' need to be part of post-pandemic transport planning too (2020) theconversation.com/poor-and-black-invisible-cyclists-need-to-be-part-of-post-pandemic-transport-planning-too-139145. Accessed 30 October 2020.
15. T. L. Hamilton, C. J. Wichman, Bicycle infrastructure and traffic congestion: Evidence from DC's Capital Bikeshare. *J. Environ. Econ. Manag.* **87**, 72–93 (2018).
16. N. McNeil, J. Broach, J. L. Dill, Breaking barriers to bike share: Lessons on bike share equity. *ITE J. Institute Transp. Eng.* **88**, 31–35 (2018).
17. N. Mueller *et al.*, Health impact assessment of cycling network expansions in European cities. *Prev. Med.* **109**, 62–70 (2018).
18. Eurostat, Transport - cities and greater cities (urb_ctran) (2020) https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=urb_ctran&lang=en. Accessed 2 August 2020.
19. Eurostat, Geostat grid (2020) https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/population-distribution-demography/geostat. Accessed 2 August 2020.
20. R. Marqués, V. Hernández-Herrador, M. Calvo-Salazar, J. A. García-Cebrián, How infrastructure can promote cycling in cities: Lessons from Seville. *Res. Transport. Econ.* **53**, 31–44 (2015).
21. B. Friedrichshain-Kreuzberg, Einrichtung von pandemieresilienter Infrastruktur in Form von temporären Radverkehrsanlagen (2020) https://www.berlin.de/ba-friedrichshain-kreuzberg/aktuelles/pressemitteilungen/2020/pressemitteilung.937004.php. Accessed 30 July 2020.
22. B. Zapata-Diomedi, L. Gunn, B. Giles-Corti, A. Shiell, J. Lennert. Veerman, A method for the inclusion of physical activity-related health benefits in cost-benefit analysis of built environment initiatives. *Prev. Med.* **106**, 224–230 (2018).
23. L. Yang, S. Sahlqvist, A. McMinn, S. J. Griffin, D. Ogilvie, Interventions to promote cycling: Systematic review. *BMJ* **341**, c5293 (2010).
24. M. Winters, R. Buehler, T. Götschi, Policies to promote active travel: Evidence from reviews of the literature. *Curr. Environ. Health Rep.* **4**, 278–285 (2017).
25. R. Aldred, Built environment interventions to increase active travel: A critical review and discussion. *Curr. Environ. Health Rep.* **6**, 309–315 (2019).
26. J. Dill, T. Carr, Bicycle commuting and facilities in major U.S. Cities: If you build them, commuters will use them. Transportation research record. *J. Trans. Res. Board* **1828**, 116–123 (2003).
27. J. Parkin, M. Wardman, M. Page, Estimation of the determinants of bicycle mode share for the journey to work using census data. *Transportation* **35**, 93–109 (2007).
28. J. Dill, N. McNeil, Revisiting the four types of cyclists: Findings from a national survey. *Transport. Res. Rec.* **2587**, 90–99 (2020).
29. K. Manaugh, G. Boisjoly, A. El-Geneidy, Overcoming barriers to cycling: Understanding frequency of cycling in a university setting and the factors preventing commuters from cycling on a regular basis. *Transportation* **44**, 871–884 (2017).
30. R. Aldred, B. Elliott, J. Woodcock, A. Goodman, Cycling provision separated from motor traffic: A systematic review exploring whether stated preferences vary by gender and age. *Transport Rev.* **37**, 29–55 (2017).
31. S. Kraus, N. Koch, Effect of pop-up bike lanes on cycling in European cities (code and data). Zenodo. https://zenodo.org/record/3973038. Deposited 5 September 2020.
32. Eurostat, Urban Audit geodata (gisco) (2020) https://gisco-services.ec.europa.eu/distribution/v2/urau/download/ref-urau-2020-100k.geojson.zip. Accessed 2 August 2020.
33. K. Healy, covmobility: Mobility data from apple and google (R package version 0.1.0, 2020) http://kjhealy.github.io/covmobility. Accessed 17 March 2021.
34. C. O. Buckee *et al.*, Aggregated mobility data could help fight COVID-19. *Science* **368**, 145–146 (2020).
35. K. Hufkens, R. Stauffer, E. Campitelli, The ecwmfr package: An interface to ecmwf API endpoints (2019) https://bluegreen-labs.github.io/ecmwfr/. Accessed 2 August 2020.
36. M. Salmon, N. Mueller, masalmon/cycle_infrastructure_modeshare: Zenodo first version (2017) https://zenodo.org/record/322906. Accessed 17 March 2021.
37. S. Correia, P. Guimarães, T. Zylkin, Fast Poisson estimation with high-dimensional fixed effects. *STATA J.* **20**, 95–115 (2020).
38. A. Abadie, S. Athey, G. W. Imbens, J. Wooldridge, When should you adjust standard errors for clustering? https://www.nber.org/papers/w24003. Accessed 23 March 2021.
39. S. Hubrich, F. Ließke, R. Wittwer, S. Wittig, R. Gerike, Methodenbericht zum Forschungsprojekt - Mobilität in Städten–SrV 2018 (Technische Universität Dresden, 2019) https://tu-dresden.de/bu/verkehr/ivs/srv/ressourcen/dateien/SrV2018_Methodenbericht.pdf?lang=en. Accessed 2 August 2020.

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