

## Potential for Increasing Physical Activity through an e-Bike Pilot Program to Reduce Greenhouse Gas Emissions

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### Abstract

Active transportation such as walking, bicycling, scootering, or using a wheelchair has direct physical and mental health benefits. Electric bicycles (e-bikes) have great potential as a form of active transportation. The Massachusetts Clean Energy Center partnered with the Massachusetts Bicycle Coalition (MassBike) to develop and pilot test a program to provide free pedal assist e-bikes with implementation support for income-eligible residents in Worcester, MA as a strategy to reduce greenhouse gas emissions that contribute to climate change. MassBike received program funding over two years to provide 100 free e-bicycles to income-eligible individuals who live or work in Worcester utilizing a community-engaged approach. The e-bike pilot program took place from August 2022-May 2024. Overall, 64% of the 96 participants regularly reported their e-bike usage during the first 13 months of deployment. Per month, participants who reported their usage on average made 17 trips, rode 65 miles, and were physically active for 20 minutes per trip using their e-bike. Program results demonstrated high aggregate levels as well as strong start-up levels with a return to similar results when weather became milder after winter dips. Lessons learned include the time needed for behavior shifts and retention and reporting challenges. These preliminary results offer a glimpse of the opportunities for increased physical activity possible with a climate change mitigation strategy of active transportation.

**Keywords:** Bicycling, Physical activity, Pilot project

Active transportation such as walking, bicycling, scootering, or using a wheelchair has direct health benefits via increased physical activity and mental health benefits (White et al., 2017). Transportation is recognized as a social determinant of health as well as one of the seven vital conditions that influence health and well-being (Rippel Foundation, n.d.; World Health Organization, 2011). Additional co-benefits of built environments that promote active transportation include greater social connectedness, economic opportunities, reduced injury risk, and decreased traffic congestion (Office of the Surgeon General (OSG), 2023; Sallis et al., 2015; Stoker et al., 2015; Frank et al., 2006).

Electric bicycles, also called e-bikes, have great potential as a form of active transportation. Demand for e-bikes has increased in the U.S. in recent years, growing nearly 300% from 2019 to 2022 (Coren, 2023). E-bikes have been shown to require lower energy output than conventional bicycles but higher energy output than walking and output is sufficient to qualify as moderate intensity or vigorous intensity (Cooper et al., 2018; Langford et al., 2017a; McVicar, Keske, et al., 2022; Riiser et al., 2022; Alessio et al., 2021; Jenkins et al., 2022; La Salle et al., 2017). Even short-term e-bike riding improves glucose regulation and arterial stiffness (Alessio et al., 2024). Just one week of e-bike use was demonstrated to have a positive effect on cognition and wellbeing (Leyland et al., 2019). In addition, e-bikes have the potential to address some of the perceived challenges of conventional bicycles, such as terrain, distance, and transportation of children and goods (Fishman & Cherry, 2016). As the transportation sector is the largest contributor of direct greenhouse gas emissions (GHGs) that are driving climate change, e-bikes also have the potential to reduce GHGs and help mitigate climate change (U.S. Environmental Protection Agency, n.d.; Cherry et al., 2009).

States and cities around the United States, as well as the world, have created programs to incentivize the purchase of e-bikes (*People for Bikes*, n.d.). These programs primarily offer rebates or vouchers for individual purchases that cover part of the cost of an e-bike. Potential limitations of this approach include less access for individuals with lower income and absence of non-monetary support such as community building events or an advisor or coach, who could provide theory-based behavioral support for long-term behavioral change that addresses physical and psychological capability, physical and social opportunity, and motivation (McVicar, Nourse, et al., 2022). Such support may be important for some population groups, including those who are overweight or obese and physically inactive (Jenkins et al., 2022; McVicar, Nourse, et al., 2022).

As a first step to creating a scalable model for promoting e-bike usage among income-eligible individuals who do not ride a bicycle regularly, the Massachusetts Clean Energy Center (MassCEC) funded the development and pilot testing of a program to provide free pedal assist e-bikes with implementation support for income-eligible

residents in Worcester, MA (*Massachusetts Clean Energy Center*, n.d.). This program was one of four e-bike pilots funded as part of MassCEC's *Accelerating Clean Transportation for All (Act4All)*, which is piloting a variety of equity-focused transportation programs to increase clean transportation access and decrease existing transportation burdens for communities that are underserved and overburdened across Massachusetts. The purpose of this manuscript is to describe the program in Worcester, MA and selected pilot evaluation results to illustrate the potential for increasing physical activity.

## Methods

### Setting

The pilot program took place in Worcester, Massachusetts. Worcester is the second largest city in New England and is among the most diverse cities in the U.S. A former industrial city that experienced population decline in the mid-twentieth century, Worcester is now growing, with a population of approximately 207,000; it grew 14% between 2010-2020 (U.S. Census Bureau, n.d.). It is one of 26 "Gateway Cities"; as defined in Massachusetts state law, these are midsize urban centers that anchor their regional economy and face social and economic challenges. Worcester has hilly terrain and limited bicycle infrastructure and culture. The City of Worcester is working to remedy this lack of infrastructure and related policy such as speed limit and bicycling on sidewalks with the first comprehensive plan since 1987, the first ever Mobility Action Plan, and a Vision Zero plan funded through a federal Safe Streets and Roads for All planning grant. Vision Zero is the concept that all deaths and serious injuries on roadways can be prevented (Kim et al., 2017). These plans express the community's vision for safe, multimodal travel and include priority strategies and projects that will be implemented over time.

### Program

The e-bike pilot program took place from August 2022 to May 2024. The program utilized a community-engaged approach. MassCEC partnered with the Massachusetts Bicycle Coalition (MassBike), a statewide bicycling advocacy organization founded in 1947 that boasts a 9000-member list. MassBike received program funding over two years to provide 100 free e-bicycles to income-eligible individuals who live or work in Worcester and create a community to support on-bike training, repair clinics, and group rides. Beginning during proposal development, MassBike recruited a variety of Worcester-based and other partner organizations to conceptualize and then help conduct activities. A local bicycle shop procured the e-bikes, led deployment, and provided maintenance while the participant was in the program. A community bicycle program and a recreational bicycle club assisted with outreach to priority populations and helped organize and lead group rides. The regional planning agency assisted with data analysis. A consulting firm helped with evaluation, including question development and data presentation. A grassroots walk/bike group helped the local

coordinator make connections to municipal staff and helped to engage her and participants in advocacy efforts about policy and infrastructure change. A business group assisted with outreach to priority populations. MassBike held monthly partner meetings and worked one on one with partners in their respective roles. Community partners were invited to the quarterly meetings held by Mass CEC with all funded programs across the state. Only MassBike and the consulting firm were involved with evaluation.

The program was designed with replicability in mind and entailed:

#### *Participant Recruitment*

Applicants had to be aged 18+ and live or work in Worcester, MA. Populations of special interest included college students, older adults, parents with young children, and low-income workers in need of transportation to jobs that fall out of the hours serviced by public transit. The application, designed by MassBike with input from the consulting firm, queried demographics including gender, age, race/ethnicity and language, as well as participation in federal anti-poverty programs, employment, housing, travel habits, bicycling experience, secure bicycle storage options, health, and physical activity. It was translated into the seven languages most commonly spoken in Worcester (Akan kasa/Twi, Albanian, Arabic, Nepali, Brazilian Portuguese, Spanish, Vietnamese) and widely distributed via community-based organizations and flyers at local businesses.

#### *Application and selection*

MassBike fielded a total of 2,684 inquiries about the program and received 1,181 completed applications. Of this pool, 732 individuals met program qualifications, from which 100 applicants were selected via a multi-step process that included program criteria, telephone interviews, and prioritization of low-income status and a balance of demographic characteristics. Preference was given to those living in identified environmental justice areas as well as individuals from communities of color. MassBike staff began selection with this group of 100. If a potential applicant did not respond to three contact attempts, staff pulled another name from the list of qualified applicants. Given concerns about theft, applicants were screened to ensure they had a secure spot to store their vehicle and provided with a robust lock and each bike's serial number was recorded to help with identification by the local police department. All selected participants were required to provide identification and proof of income. Participants who dropped out of the program for various reasons (relocation, storage constraints, family issues, etc.) were expected to return the e-bike to be redeployed to a new participant.

#### *E-bikes*

The heart of the program was a free pedal-assist e-bike that the participant would own following completion of the program in exchange for agreeing to provide data for at

least 18 months. Models included several types of commuter e-bikes and one type of cargo e-bike, as pandemic-related supply chain issues limited numbers available for any one model. The application included a question about preference for commuter or cargo model. Participants also received a helmet, lock, lights, bike floor pump, reflective vest, gloves, maintenance lube and a cover for storage. All participants received two-year maintenance and accidental damage insurance coverage along with the e-bike and accessories at the time of deployment.

#### *Deployment and training*

Participants were required to attend three educational workshops. The first one was online in two parts: the first was a video with tips for riding legally and safely, and the second was a video about e-bike battery care. The second was a personalized hands-on safety training that occurred the day the participant received their e-bike and accessories at the bicycle shop (referred to as deployment) and included a test ride. The third one was an in-person workshop at the bicycle shop with the same content on two dates in January 2023, in which participants learned how to fix a flat tire and do basic bike maintenance. Participants were encouraged to attend two additional webinars, one on winter riding and one on the new Massachusetts Vulnerable Users Law. On the day they received their e-bike, participants received individual instruction on how to record their e-bike usage data.

#### *Group activities*

To help support the e-bike cohort and build community among program participants, other bicycle riders in Worcester, and potential riders, the program organized 35 community events, including 6 tabling events at local farmers markets, 3 bike-related movie screenings 12 community rides, 3 repair clinics, and Bike Month activities such as a breakfast, a swap where attendees could give away, trade, or sell their unwanted bicycle parts and gear and acquire from others, and a bicycle art event. A final celebration was held at the program's conclusion, which was attended by 41 people and included a group ride that proceeded despite pouring rain.

#### *Local coordinator*

As a statewide organization, MassBike did not have deep ties in Worcester, so a key program component was to hire a local coordinator. The coordinator was recruited for Spanish-language ability and experience in operations for a nonprofit organization. The individual hired for the position was a native Spanish speaker and Worcester resident with no prior experience with bicycle programs or bicycle advocacy but who had an extensive community network. The local coordinator strengthened relationships with partners, provided individual consultations for program participants and solicited their data, and organized most of the group activities. MassBike received a follow-on grant from the Boston-based Barr Foundation to build the bicycle culture in Worcester, and the coordinator integrated that work with the e-bike pilot program.

### *Data collection, management, and analysis*

The initiative described here was a pilot program, not a research study. The coordinator worked with the consulting firm partner to design all application questions and survey questions and compile descriptive statistics for quarterly reporting to MassCEC over the course of the program. Only participant characteristics, e-bike deployment, usage reporting frequency, and usage data are presented here. All data were compiled and provided by MassBike.

All data reporting was voluntary and started as soon as the first group of e-bikes was distributed to participants in August of 2022. To further encourage compliance with the reporting that participants agreed to in exchange for the free e-bike, participants who reported their data received \$30 gift cards every quarter from March through November 2023. Participants were asked to record their e-bike usage (trip date, mileage, purpose, and minutes plus trip mode replaced, e.g. vehicle) as well as any maintenance required or performed on hard copy template sheets provided by Mass CEC and to report the data weekly to the coordinator via email, text, or telephone. Trip minutes were self-reported riding time (i.e. not automated collection) and did not distinguish time pedaling from time waiting at traffic lights or similar delays. Participants were instructed to record and report all weeks, including those with zero e-bike trips. The coordinator entered data into a spreadsheet template customized for the program. Participants who did not submit data for two consecutive months were asked to return their e-bike.

Participants also completed two surveys during their time with the program. A mid-program survey, conducted in December 2022, gathered information about how the program could be improved for participants as well as their ideas on what would encourage them to ride more, such as winter gear and accessories or group rides. An exit survey, conducted in early 2024, contained different items from the mid-program survey and assessed self-reported health

status and quality of life as well as suggestions for program changes. For each survey, the coordinator sent a link to a web-based survey in QuestionPro (*Questionpro*, n.d.) to all participants. The surveys were in English only, and each was open for one month.

## **Results**

### **Participants**

Final program participants included 96 individuals who ranged in age from 19-70 (average: 41). Race/ethnicity data reflected the wider community (48% White, 13% Black, and 27% Hispanic/Latinx). 45% of participants had incomes less than \$20,000/year, and 52% earned \$21,000-\$50,000. In terms of housing, 26% of participants owned their home, 72% rented, and 2% lived in temporary housing. Despite the extensive outreach, only four participants selected a language other than English that they were most comfortable speaking (Spanish, French and Lingala).

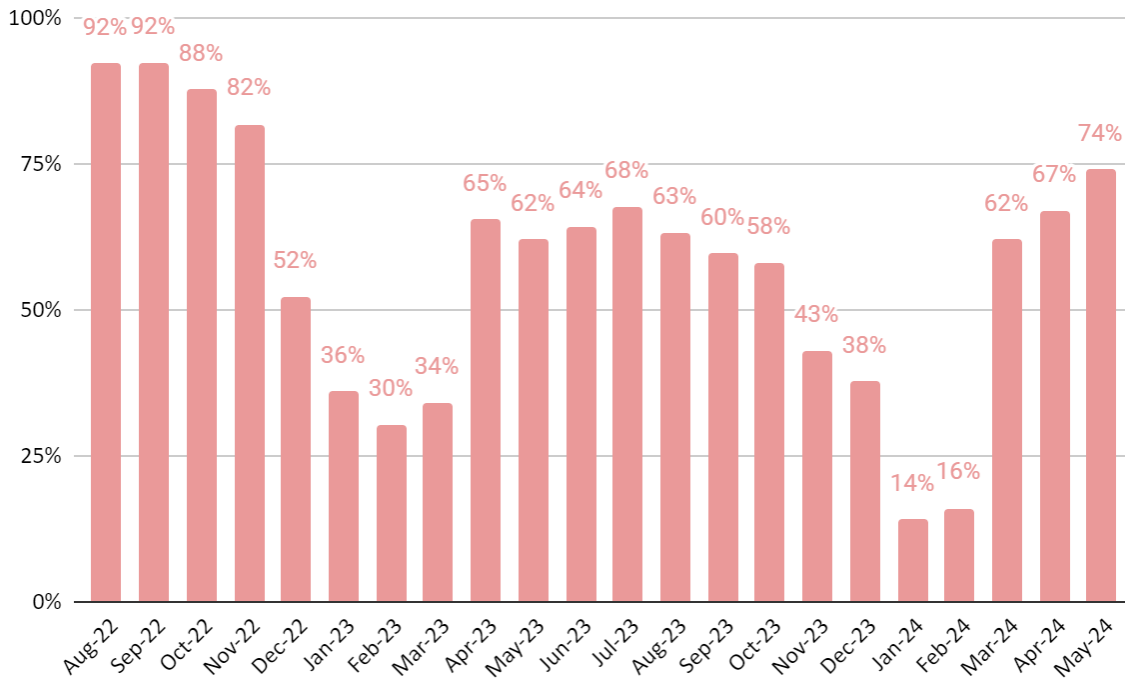
### **Deployment process**

Deployment, or e-bike distribution, took place between August 2022 and June 2023, with the majority (n=85) deployed by December 2022. There were six e-bike redeployments, i.e. a participant voluntarily left the program and returned their e-bike or was asked to return it after not reporting and it was given to a new participant. Each participant received the model of their choice, i.e. cargo or commuter.

### **Participant reporting**

Reporting of e-bike usage varied, with seasonal dips during winter months despite the requirement to report zero-trip weeks. The average monthly percentage of participants who reported usage over the first 13 months was 64%, but this varied substantially, from a high of 92% per month to a low of 14% per month (Figure 1).

**Figure 1. Percentage of e-bike program participants reporting e-bike usage throughout the program (required reporting August 2022 to February 2024)**



**E-bike usage**

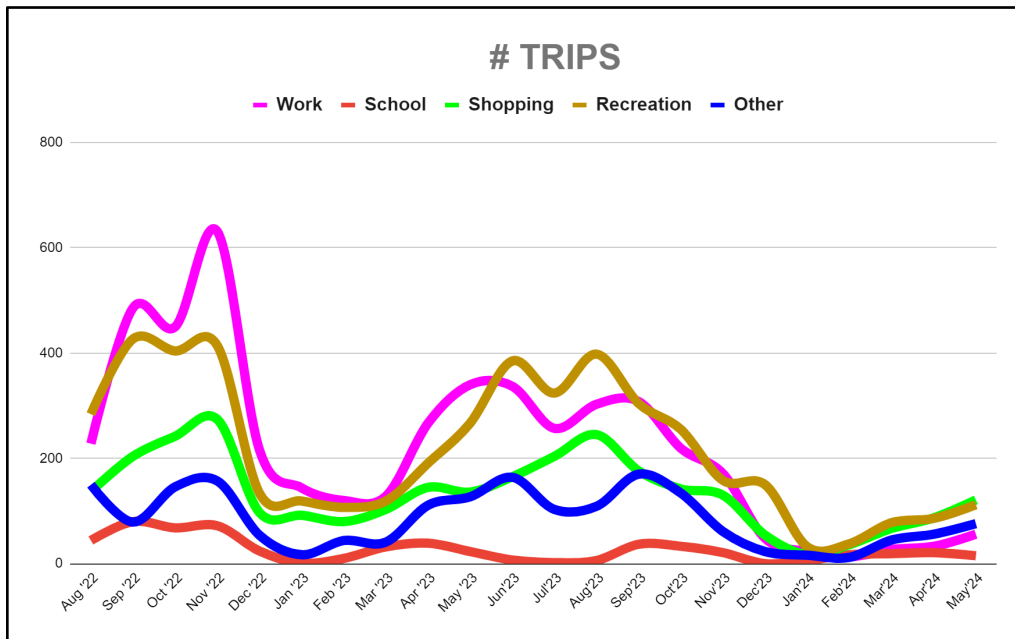
Among participants who reported their e-bike usage, the average monthly number of trips was 17, the average monthly number of miles ridden was 65, and the average monthly time per trip was 20 minutes using their e-bike.

In aggregate, participants traveled 63,993 miles on their e-bikes, including for recreation (24,077 miles), work (17,916 miles), shopping (12,654 miles), other purposes (7,550 miles) and school (1,797 miles). These miles were achieved through 15,017 trips, including for recreation

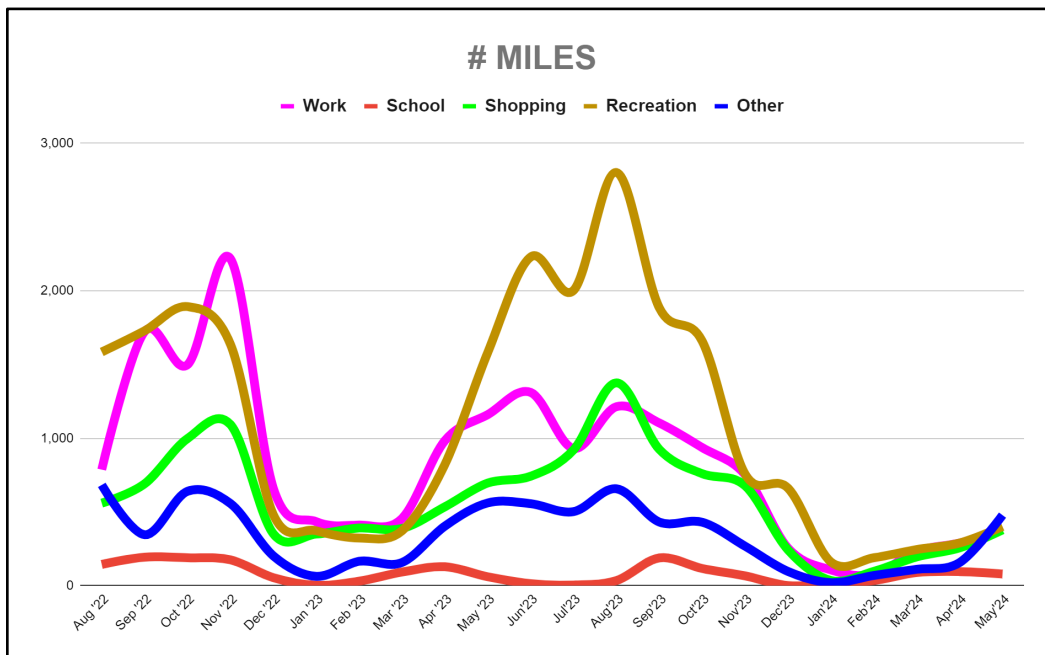
(4,786 miles), work (4,805 trips), shopping (2,954 trips), other purpose (1,895 trips) and school (577 trips). See Figures 2-4 below.

With the exception of work trips, the trips data illustrate a return to start-up levels during summer 2023 after notable winter dips. In addition, the data show mileage during summer 2023 for shopping, other purposes, and especially recreational trips that is comparable to or exceeds the start-up period (trend lines were not applied given the seasonal dips). Work trip mileage did not follow this pattern.

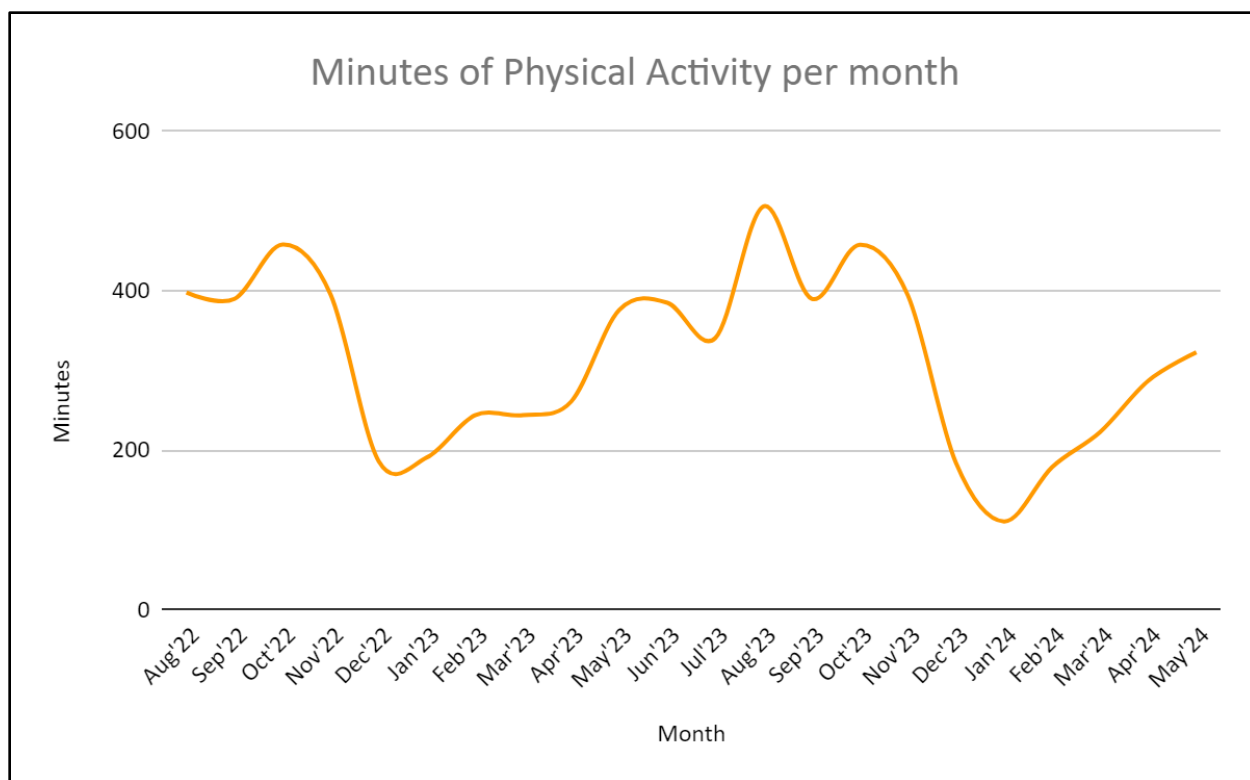
**Figure 2. Total number of trips reported by e-bike program participants by trip type**



**Figure 3. Total number of miles reported by e-bike program participants by trip type**



**Figure 4. Total minutes of physical activity reported by e-bike program participants**



### Discussion

Preliminary results of the Worcester, MA-based MassBike e-bike pilot program offer a glimpse of the opportunities for increased physical activity possible with a climate change mitigation strategy of active transportation. Impressively, participants traveled over 63,000 miles. Program results demonstrated an encouraging return to initial usage levels, when novelty would have been high, during milder weather months. Recreational riding increased notably from the start-up level, as did physical activity as captured in riding time. Mileage for shopping trips also increased. Lessons learned include the time needed for behavior shifts and retention and reporting challenges.

The data revealed large variability in the number of trips, with notable decline in winter months but rebounds in the spring. As a northeast U.S. city, Worcester winter weather conditions make it less comfortable to bicycle then, even on an e-bike. The city's current dearth of dedicated bicycle facilities makes riding in the winter even less safe and appealing. The Community Guide, the evidence-based recommendations and findings of the Community Preventive Services Task Force about effectiveness and economic impact of public health programs, services and other interventions, recommends built environment approaches to increase physical activity that combine land use and transportation interventions (Community Preventive Services Task Force, n.d.;

Community Preventive Services Task Force, 2016). While there has been growth nationwide in bicycle facilities, continued allocation of resources requires strong support from the local community. With encouragement from the leader of the grassroots walk/bike group, the e-bike program coordinator engaged in public input opportunities related to bicycling and pedestrian infrastructure, development of mobility and Vision Zero plans, and proposed policy changes such as lowering the statutory speed limit, i.e. the legal speed limit for vehicle travel. The coordinator in turn shared input opportunities with program participants, several of whom participated in public meetings and spoke with elected officials and transportation department staff. Program organizers and partners believe continuing to engage participants in support of built environment change offers opportunities for individual and collective action.

It is noteworthy that the e-bike program, which did not target or promote physical activity recommendations, produced results that appear to align with the recommendation that adults get 150 minutes of physical activity per week, or about 20 minutes per day (U.S. Department of Health and Human Services, n.d.). Although we do not know participants' level of physical activity prior to the bike program, they were not regular bicycle riders. Researchers have observed that lower perceived exertion using an e-bike may encourage longer and more frequent trips than conventional bicycles, resulting in potentially equal or greater expenditure of energy over time, as well as

a higher feeling of wellbeing and enjoyment (Alessio et al., 2021; Castro et al., 2019; Hughey et al., 2022; Anderson et al., 2022; Langford et al., 2017b). Evidence also shows e-bikes may have particular utility among specific groups, including making cycling less tiring and enabling return to bicycling habits among cancer patients, helping individuals with Type 2 diabetes over barriers such as hills and enabling older adults who did not bicycle to start and sub-groups at higher risk for inactivity such as women and individuals with higher body mass index to bicycle (Cooper et al., 2018; Way et al., 2023; Cooper et al., 2018; Jenkins et al., 2023; Van Cauwenberg et al., 2018, 2022; Way et al., 2023).

Reporting varied over the pilot period, which reflected both retention and the reporting process itself. While only two e-bikes were lost (presumed stolen) and only six redeployments occurred, the local coordinator had ongoing challenges reaching participants due to disconnected telephone numbers. Exit survey data indicate some participants found the reporting process tedious, and several individuals suggested an electronic format such as a customized app might have been easier to use.

Comments from the exit survey indicated that group activities like the rides were an important feature of the program, with some participants expressing support for a requirement to participate in at least one. Few interventions have assessed behavioral support for participants in e-bike programs (Bourne et al., 2023; McVicar, Keske, et al., 2022). Individuals without prior bicycling experience may benefit from a support structure, at least in the early days of ownership. The cohort approach of the MassBike e-bike program, including the local coordinator, hands-on safety training, additional accessories, and various community events (the majority being group rides) to integrate program participants into the bicycling community, is innovative and worth further exploration.

The local coordinator with dedicated time is a critical feature for reproducibility of the e-bike program. The Worcester coordinator cultivated trusting relationships with participants that fostered engagement. Extensive bicycling experience is not required, but organizational skills and people skills are crucial. Speaking a language other than English that is prevalent in a community may be helpful.

In addition to leading the local grassroots walk/bike group, the corresponding author works for the Prevention Research Center at UMass Chan Medical School (PRC), a network of Prevention Research Centers funded by the U.S. Centers for Disease Control and Prevention. The PRC at UMass Chan and MassBike are currently exploring the potential for research collaborations made possible by their relationship building through the e-bike project. In addition to translating academic research into real world contexts, the PRC is interested in surfacing questions from the community on a range of healthy communities topics that can be investigated systematically.



Based on the results of this first e-bike program, MassBike recently received additional funding from the

MassCEC to distribute an additional 100 e-bikes regionally (Worcester plus ten surrounding towns). The new program will utilize a dual model that includes a free e-bike for income-eligible individuals and a purchase voucher for other applicants. The new program will apply lessons learned to increase usage and improve reporting. Changes include a shortened reporting period (from 18 months to 6 months), more opportunities to engage such as frequent group rides, and the greater responsibility of the voucher component that gives participants “skin in the game”. Health behavior and status questions have been added in the application and reporting, and there will be more details about minutes of activity in reporting. Data from both program phases will inform a planned state rebate program for e-bikes.

In summary, distributing free e-bikes via a program with a local support structure holds promise as an approach for increasing physical activity among income-eligible individuals. In addition, building working relationships between PRCs and local and statewide groups focused on bicycling programming and advocacy can generate exciting future collaboration opportunities.

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#### Author contributions

Conceptualization: K.V.G., A.S.; Data Curation & Visualization: A.S.; Writing – Original Draft: K.V.G., S.L., A.S.; Writing – Review & Editing: G.M.; Funding Acquisition: G.M.

**Conflict of Interest Statement:**

The authors have no conflicts of interest to disclose.

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