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CicLAvia: Evaluation of participation, physical activity and cost of an open streets event in Los Angeles

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ABSTRACT

Physical activity is beneficial for health, but there are limited opportunities in urban areas to safely access public streets for traffic-free cycling, skating or walking. Ciclovías are open streets programs that close major roads to motor vehicles so they can be exclusively used by bicyclists and pedestrians. We estimated participation in one Los Angeles Ciclovía event (CicLAvia) using intercept surveys and 14 surveillance cameras which were placed along the 6-mile route in April 2014. We also applied estimates of the distance and speed traveled from the use of GPS data acquired from subsequent CicLAvia events.

CicLAvia attracted between 37,700 and 53,950 active participants generating 176,500 to 263,000 MET-hours of energy expenditure, at an estimated cost borne by tax dollars of $1.29 to $1.91 per MET-hour. Among participants, 37% had never previously participated in CicLAvia, but 40% of individuals said that if they were not at CicLAvia they would have been physically active elsewhere and 45% would have been sedentary.

Given its large reach, it makes sense to increase the frequency of Ciclovías to occur more than a few times a year to promote population health.

1. Introduction

The benefits of physical activity in staving off multiple chronic diseases like heart disease, hypertension, and Type 2 diabetes are undeniable (Lee et al., 2012), yet only a minority of Americans achieve the national guidelines of 150 min per week of moderate-to-vigorous physical activity (USDHHS, 2008). Work has become largely sedentary and transportation is largely motorized, so much of physical activity must occur during leisure time. Cities play an important role in physical activity promotion through the physical infrastructure they develop, as well as through their support of programming and special events. Given that leisure bicycling (<10 miles/h) constitutes moderate physical activity, requiring the expenditure of between 3.5 and 4 METS per hour (Ainsworth et al., 2000), cycling for about 2.5 h per week would allow cyclists to meet the national physical activity (PA) guidelines. A person walking typically expends 2–4 METS per hour and even higher, depending on speed and how much weight is being carried (Ainsworth et al., 2000). Although urban areas are increasingly adding bicycle lanes, few cities have built lanes that fully separate cyclists from motor vehicular traffic. The fear of a collision and the unpleasantness of car exhaust, noise and traffic may limit the frequency and amount of time many urban dwellers spend biking and walking (Pikora et al., 2003).

The Ciclovía movement, which began in Bogotá, Colombia in the 1970s to afford opportunities for traffic-free cycling, walking, and play, closes major roads to automobiles so they can be used exclusively by cyclists, pedestrians and other non-motorized users (Hipp et al., 2014; Sarmiento et al., 2010). In Bogotá, the weekly Ciclovía along 75 miles of designated streets helps hundreds of thousands achieve routine moderate-to-vigorous physical activity without exposure to the usual congestion and pollution of city streets. Ciclovías, or open streets, are now conducted in cities across the globe. These events are often jammed with participants, indicating a demand for such opportunities. However, formal evaluations of the effectiveness and the impact of the Ciclovía events are limited (Sarmiento et al., 2010; Hipp et al., 2012; Montes et al., 2012; Murcia et al., 2014).

In Los Angeles, a city known for its car culture, a non-profit group, CicLAvia, implements a car-free open streets program under its mission to catalyze vibrant public spaces and active transportation, making streets safer for people to walk, skate, play and ride a bike. In collaboration with

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the City of Los Angeles, CicLAvia creates what is tantamount to a new temporary park, simply by removing cars from several linear miles of city streets. Although CicLAvias are currently conducted 4 times per year, usually from 9 am to 4 pm, the aspiration is to schedule them on a monthly basis across expanding neighborhood geographies, and perhaps even more frequently. Ciclovía advocates hope that its events will increase interest in active transport like walking and bicycling and thus develop a demand for more bicycle- and pedestrian friendly infrastructure that would be available on a daily basis.

The Los Angeles CicLAvia was first initiated in 2010, and has received continuous and increasing support over time. Prior to the April 2014 event, there were eight previous day-long CicLAvias. The event is promoted through social media, newspapers, and radio, with local banners and posters, and by sponsors and advocacy groups. Along the route there are also performances, displays, food trucks and interactive exhibits for participants to enjoy.

This study was designed to estimate participation and the level of physical activity facilitated by the April 2014 CicLAvia along a 6-mile route from Downtown Los Angeles to the west along iconic Wilshire Boulevard. Based on these estimates, we also calculated the cost per unit of physical activity measures in MET-hours, where 1 MET-hour is the amount of energy a person expends at rest for one hour.

2. Methods

2.1. Data

Three sources of data were collected to estimate participation. First, we placed video cameras in 14 locations, half east bound and half westbound at 1-mile intervals along the CicLAvia route, which was approximately a straight-line street segment with no branches (See Fig. 1). Because of the limits on the camera angle, only street areas were viewed, excluding people on the sidewalks. There were no videotapes taken of the pedestrian-only areas at either end of the route (approximately 0.75 miles of linear route divided equally at either end). The video images were processed by National Data and Surveying Services (NDS) who counted all persons passing by the cameras in 5 min intervals from 9 am to 4 pm, categorizing each person as a cyclist, pedestrian, or "other," which included skaters or people in wheelchairs and children in strollers. Quality control procedures include spot reliability checks and recounts.

Second, volunteers at each of 5 information hubs invited CicLAvia participants over 18 years of age to complete a self-administered paper survey. In the survey, we asked how long respondents were going to stay at the event, which served as a key data point for estimating the total participation in CicLAvia. We also collected information on gender, age group, race/ethnicity, zip code of residence, how participants traveled to the CicLAvia route, frequency of previous participation, the number of people they came with, whether they came with children, what they would have done if they were not at CicLAvia, and the frequency and duration of physical activity in which they usually engaged per week. A final question asked about the type of transportation they usually relied on to get around the city.

Although we initially thought we could calculate speed from the cameras, this was only a measure of instantaneous speed, rather than reflecting the overall speed across the entire duration a participant was at the event. Therefore, at subsequent CicLAvia events, we added another measurement mode using GPS devices to get an estimate of the speed of participants riding bicycles. We asked 33 volunteers attending a similar CicLAvia event (May 2015 in Pasadena, CA) to wear GPS devices and follow the flow of participants. The GPS devices recorded the speed, duration, and distances

Fig. 1. CicLAvia Route, Los Angeles, April 2014.

traveled. We repeated the same measures with 19 volunteers at a second event (August 2015 at Culver City, CA). Although the length of the Pasadena route was shorter than the Downtown Wilshire route, our findings at the August 2015 event with comparable route length had exactly the same results.

The RAND IRB ruled the observation of public activities exempt from human subjects protections committee review and approved the surveys of participants as well as the GPS component added subsequently, both of which followed informed consent guidelines.

2.2. Statistical method

To estimate the number of CicLAvia participants, we adapted a method originally used to estimate the size of a political protest in the social statistics literature (Yip et al., 2010; Watson and Yip, 2011; Cariveau, 2014) in which the basic relationship is, $K = \sum_{i=1}^{N} n_i = N\bar{n}$, where K is the total count of people passing through at all check points (i.e., cameras), N is the total number of participants, and $\bar{n}$ is the average times a participant passed any check point. Following this rationale, we applied the following two estimators for the total participation, denoted by N and $\tilde{N}$

$$N = \frac{Kd}{\bar{s}}, \text{and} \tilde{N} = \frac{Kd}{\bar{v}\bar{t}},$$

where $\bar{s}$, $\bar{v}$, and $\bar{t}$ are the average distance, speed, and duration of a participant in CicLAvia respectively, and d is the (approximately one mile) distance between two adjacent cameras. The average distance and speed were estimated from the GPS data, and the average duration was provided by the survey data. More technical details for these two estimators are included in the Appendix.

When people ride a bike, a typical comfortable leisure speed is perhaps between 5 and 10 miles/h. Riding more slowly, for example, at the speed of a walk, makes it difficult for bike riders to maintain balance. We assumed that the average biking speed is 6 miles/h on a relatively busy street requiring the intensity of 3.0 METS per hour, a conservative estimate of energy expenditure for biking relatively slowly (Ainsworth et al., 2000). We used the GPS data to estimate the proportion of time that would have been spent in moderate physical activity by subtracting

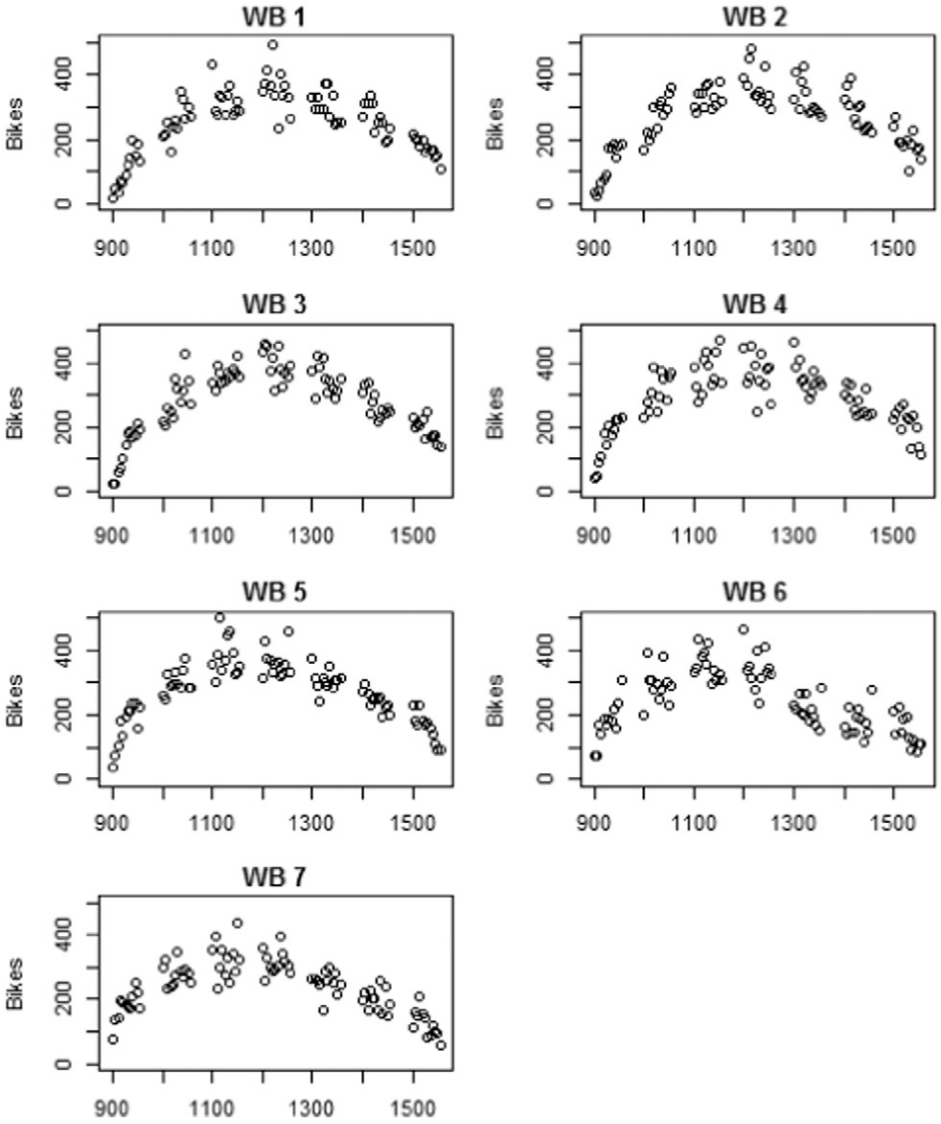

Fig. 2. Number of participants passing by each West-bound (WB) facing camera per hour Plots of numbers of bikers passing a check point versus time (west bound). Each circle represents the count of people passing at a check point in a 5-min interval.

the time it would take to travel the average distance logged from the total time spent at the event.

To estimate the cost to the government of METs generated at CicLAvia, we divided the net costs subsidized by tax dollars by the aggregate METS generated. Net cost was the sum of expenses minus income from sponsorships, donations and sales. CicLAvia provided the financial figures from their accounting system.

3. Results

3.1. Total participation

The total number that passed by and were counted independently by all the cameras included 303,070 cyclists and 8988 non-cyclists (pedestrians, skaters, and other modes of active transport). The 33 volunteer bicyclists at the Pasadena event had an average speed of 1.89 miles/h (SD = 0.78 miles/h), and traveled an average distance of 8.68 miles along the event route (SD = 6.28 miles). The relatively low average speed was due to various breaks of cyclists (e.g., traffic stop, drinking and eating, rest, and attending other activities during the event). The average duration of participation reported by survey respondents was 3.2 h (SD = 1.2 h), we estimated the total number of cyclists as $N \approx$ 34,900 (SE = 4100) and $\tilde{N} \approx$ 50,200 (SE = 2600). We did not have GPS data for non-cyclist participants because all volunteers were cyclists. Theoretically their average speed should be lower than cyclists'. If the average speed for pedestrians were between 0.75 and 1 mile/h, there would have been between 2800 and 3800 pedestrian participants.

Fig. 2 shows the plots of counts of people passing each check point versus time and shows a clear trend with a gradual increase of bikers between 9 am and 12 pm and then gradual decrease until 3 pm. These plots suggest that a more sparse temporal sampling scheme (e.g., counting every other 5 min or even sparser) is likely to be sufficient. On the other hand, since there were relatively few cameras (only 7 in each direction), it is difficult to estimate the spatial distribution of the participants across the entire route at any given time.

3.2. Other results from the survey

A total of 1085 individuals responded to the surveys. Fewer than 2% of the surveys were completed in Spanish. 45% of respondents were female. Compared to the population in the City of Los Angeles CicLAvia participants comprised a higher proportion of Asians (16% at CicLAvia vs. 11% in the city; a lower proportion of African Americans (8% vs. 10%) and a lower proportion of whites (42% vs. 50%). Hispanic ethnicity was reported by 31% vs. 49% in the city. However 27% declined to report race and 62% did not report ethnicity (See Table 1).

Travel to CicLAvia was reported as by car for 38%, bicycle 29% and mass transit 22%. Over 81% said they planned to bike around CicLAvia and 14% planned to walk. Arrival modes to CicLAvia were notably distinct from how respondents reported normally traveling around Los Angeles, with the majority (68%) listing by car, 8.5% by bicycle, and 9% by mass transit. First-time participation in CicLAvia occurred for 37% of respondents. <12% came alone, and 26% came with one other person but 20% said they came with 5 or more persons. 26% brought children — a median of 2 children.

Fig. 3a and b are maps of the zip codes from which participants reported living. In addition to coming from Southern California, participants surveyed also reported 15 zip codes from out of state (Fig. 3b). These included: Oregon, Texas, Pennsylvania, Massachusetts, Missouri, Montana, Iowa, Arkansas, Idaho, Virginia, Georgia and Florida.

3.3. Physical activity of CicLAvia participants

The GPS data from the subsequent CicLavia event showed an average traveling distance of 8.68 miles. At a speed of 6 miles/h it would take 1.45 h to traverse this distance. Since the average duration of stay was roughly 3 h, about half would have been spent biking. Therefore, we developed further estimates on MET-hours expended assuming that about

Table 1
Survey responses from a convenience sample of CicLAvia Participants, Los Angeles, April 2014.

Number of respondents	1085
% Female	45.3%
Age group	
18–29	27.9%
30–39	16.8%
40–49	20.7%
50–59	23.6%
60–69	8.4%
70–79	2.1%
80 or over	0.4%
Estimated Mean age of respondent*	44.0
Race	
White	41.9%
African American	7.8%
Asian	15.9%
Other	5.4%
Marked more than one race	1.6%
Declined to report Race	27.3%
Ethnicity	
Latino/Hispanic	30.9%
Non-Hispanic	7.2%
Declined to report Ethnicity	61.9%
How did you arrive at CicLAvia?	
Car	37.9%
Train/bus (mass transit)	22.1%
Bicycle	29.0%
Walk/skate	5.6%
Other or marked more than one	5.4%
Primary plan to travel around the CicLAvia route	
Bicycle	81.8%
Walk/jog	13.8%
Skate	1.1%
Other or marked more than one	3.3%
Number of times participating in CicLAvia prior to April 2014 Event (not including April event) (mean)	1.8
Number of people accompanied by at CicLAvia (mean)	2.4
How many people did you come with today?	
Came alone	11.7%
1 person	26.0%
2 people	18.5%
3 people	15.2%
4 people	8.6%
5 or more	20.0%
Median number of children accompanying those who brought children	2.0
How many people did you come with today & are any children under age 18?	
Came alone	11.7%
Came with children	25.9%
Came without children	62.4%
How long are you staying at CicLAvia? (estimated mean in minutes, top coded at 5 h)	187.55
What you would be doing if not at CicLAvia?	
At home, sitting indoors	27.1%
Other sedentary reactional activity	17.9%
Other active recreation activity	39.7%
Marked more than one	8.4%
Other	6.9%
Number of times per week engaged in physical activity? (mean, top coded at 7)	4.1
Usual length of physical activity (estimated mean in minutes, top coded at 45 min)	36.5
How do you usually travel around Los Angeles?	
Car	68.4%
Train/bus (mass transit)	9.0%
Bicycle	8.5%
Walk/skate	2.1%
Other or marked more than one	12.0%

* Responses for 80 or over were coded as 80 years of age. All others were coded at the interval mean.

half the duration of the time spent at CicLAvia event was likely spent in moderate physical activity.

Given the estimated participation in CicLAvia (between 34,000 and 51,000 cyclists and between 2800 and 3750 pedestrians), we estimate a total of 163,000 to 245,000 MET hours was expended by cyclists and a total of 13,500 to 18,000 MET hours was expended by pedestrians.

Nearly 27% said they if they had not been at CicLAvia, they would have stayed home while another 18% said they would have been sedentary. About 40% of individuals said that if they were not at CicLAvia they would have been physically active elsewhere. The remaining either marked more than one response (7%) or checked "Other" (8%). On average, respondents said they engaged in physical activity 4 times per week, just over half an hour each time. But 50% of respondents did not meet the national guidelines of 150 min per week.

3.4. Differences among population subgroups

Female respondents reported that they had participated in fewer previous CicLAvias than males (1.5 events vs. 2.0 events; $p < 0.0001$), as did respondents younger than 40 vs. those over age 40 (1.6 events vs. 2.0 events; $p < 0.002$). First time participants planned to stay a shorter amount of time than those who had participated previously (176 min vs. 194 min, $p < 0.0001$) and came with fewer people than those who had previously participated at CicLAvia. Hispanic respondents were younger than non-Hispanics (38.4 vs. 43.2 years; $p < 0.0001$), came with more people (2.8 vs. 2.3, $p < 0.0001$), and, on average, brought more children (2.1 vs. 1.7; $p < 0.0001$). Males were much more likely than females to report that they used bicycles to get around Los Angeles (12% vs. 4%; $p < 0.0001$).

3.5. Cost of CicLAvia and costs per MET

CicLAvia's net cost (after receiving income from private sources and deducting expenses, including government law enforcement costs) was approximately $339,700. Income included a total of about $176,760 in donations and grants and $33,580 from selling CicLAvia merchandise and fees collected from food trucks. Expenses included nearly $19,750 for supplies and materials, about $35,900 for development, $253,700 for programming, $53,730 for administration, and $37,960 for marketing. The City of LA spent approximately $149,000 to cover the costs for safety, security and management.

The cost per MET hour was between $1.29 and $1.92. The actual cost per MET hour are likely to be much lower than these numbers since the estimates do not include physical activity by pedestrians on the sidewalk and the active transportation going to the event and back.

4. Discussion

Compared to other published evaluations of Ciclovía events, attendance at the Los Angeles CicLAvia was substantially higher than in other American cities, except possibly New York City (Sarmiento et al., 2010; Kuhlberg et al., 2013). Compared to the giant Ciclovía events

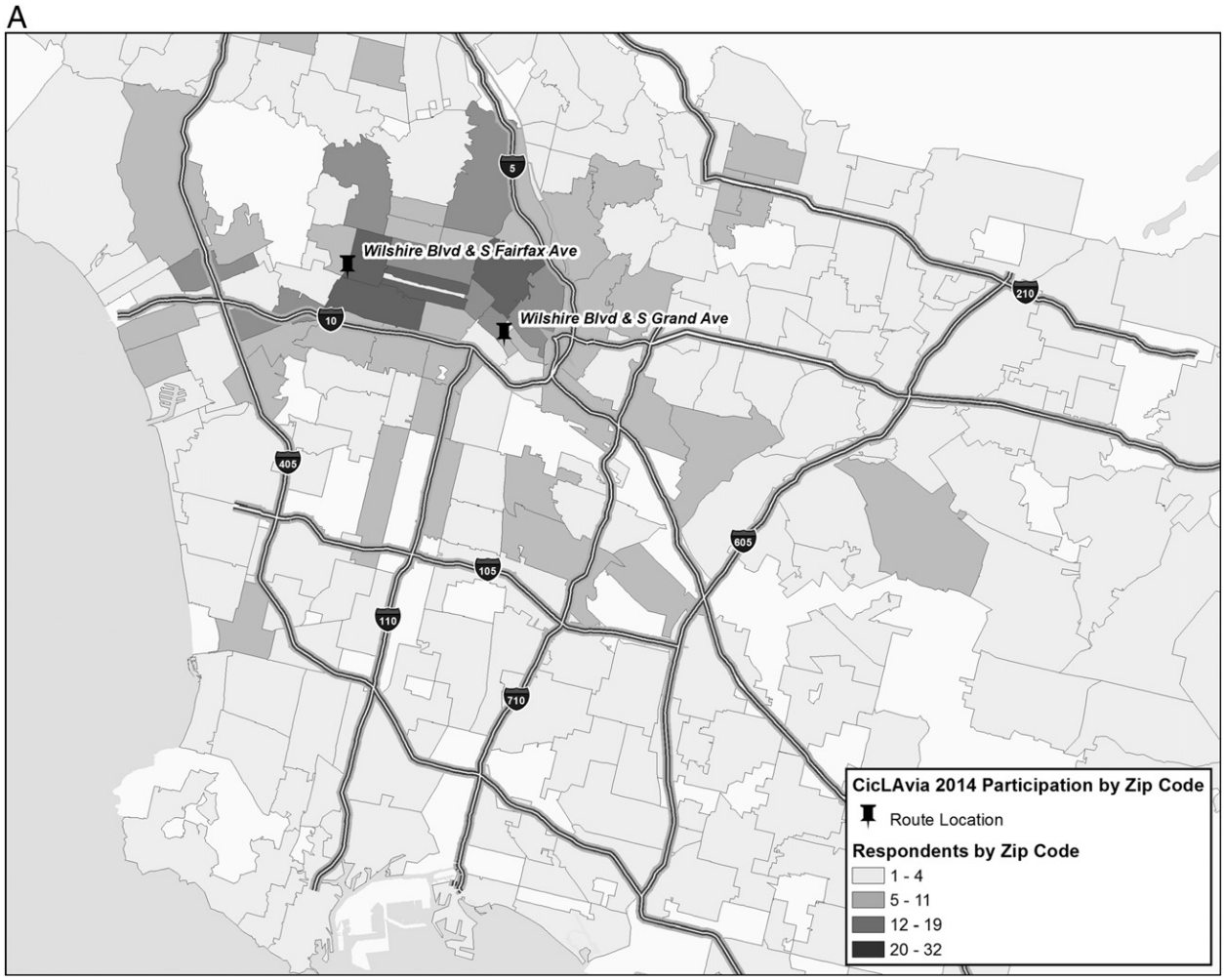

Fig. 3. a. Maps of respondent zip codes, locally and b. nationally.

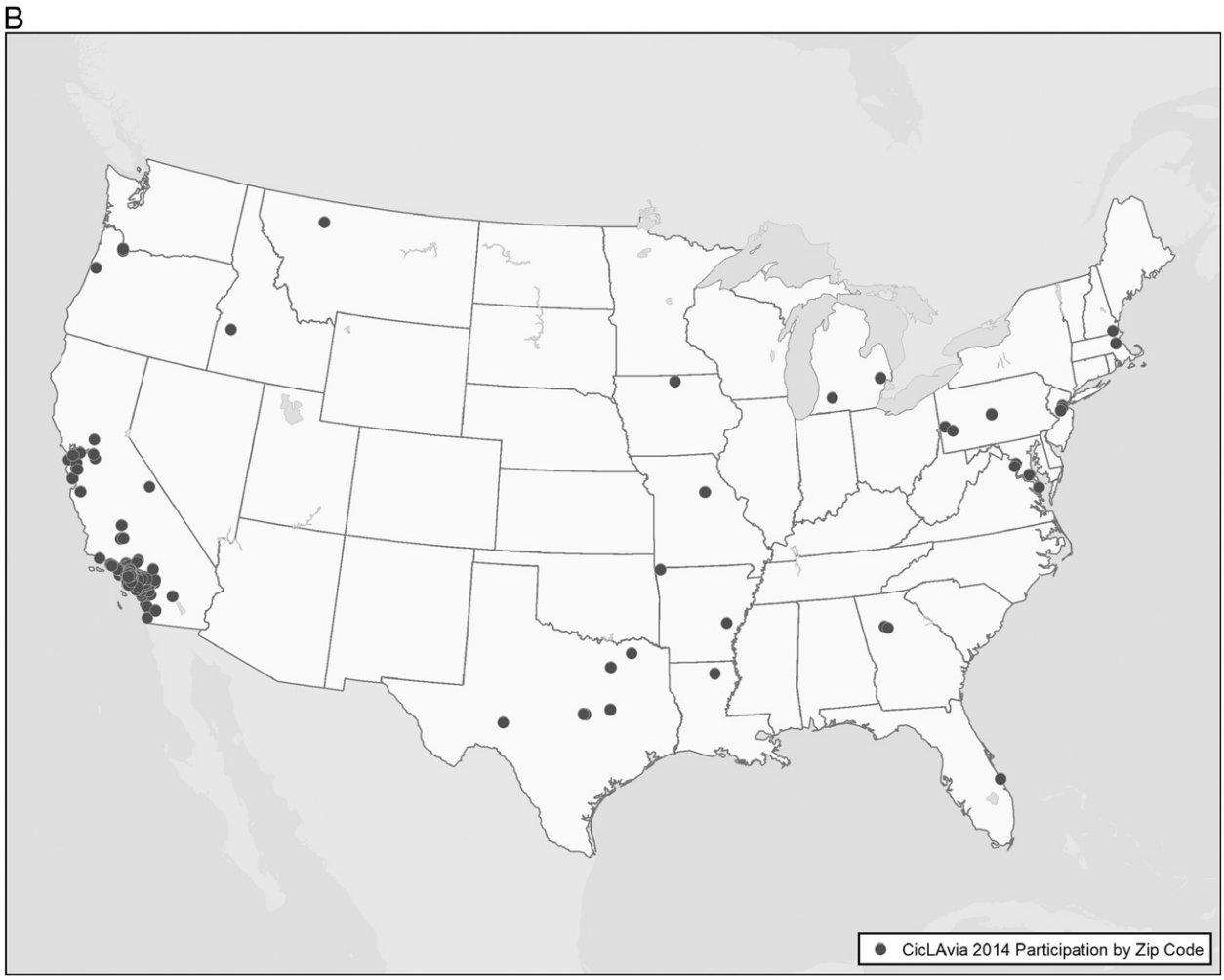

Fig. 3 (*continued*).

estimated for Bogota and Cali, with 3–10 times more miles of roadway available, attendance at CicLAvia was somewhat lower per mile (Sarmiento et al., 2010; Murcia et al., 2014). However, estimates for attendance at other Ciclovías, except for New Brunswick, have primarily relied on manual counts and qualitative interviews, were not aided by the use of surveillance cameras as well as GPS or survey data, and are possibly inflated (Murcia et al., 2014; Zieff et al., 2014). Counts using video cameras allow slowing or stopping images for greater accuracy, and may be superior to other evaluations which rely on real-time human observation or methods that count participants at fewer points along the route (Engelberg et al., 2014).

CicLAvia participants come from miles away and from across the country. The large turnout from local and non-local residents is a sign that this is a unique opportunity, worthy of significant effort to attend. It also demonstrates demand for such opportunities. The experience of a CicLAvia, of riding or walking on wide paved streets otherwise occupied by cars, cannot be replicated by existing parks, since none have the kinds of scenery and views of city streets that can be experienced in downtown settings. Except for narrow paths along the beach or river, linear bike paths that are exclusive for bikes or pedestrians are not available in Los Angeles.

Costs of Ciclovías vary widely across localities. Reports from other cities show expenditures between $31,395 per event for San Francisco (Montes et al., 2012) and the $70,000 range for New Brunswick (Brown and Martin, 2013) and Portland (Portland Sunday Parkways 2010 Report, 2010). However, each of these events drew considerably fewer attendees than in Los Angeles, and their reported per capita costs ranged from $2 to $17, vs. between $6 and $10 for CicLAvia. This difference in attendance may be partly explained by population density, but is also likely a function of the extensive marketing.

Duration of stay also differed across events. San Francisco's open streets event had attendees staying between 70 and 90 min (Zieff et al., 2014), while attendees at Atlanta events in 2010 and 2012 (Torres, 2015) stayed an average of 142 min vs. 180 min for CicLAvia. The differences are likely explained by multiple performances, special events and displays along the route in Los Angeles.

Our cost-effectiveness analysis focused on the cost to the taxpayer for a city-sponsored event. Many localities financially support leisure activities (e.g. fireworks, motor parades, holiday extravaganzas, etc., ranging in cost from the tens of thousands to multi-millions of dollars)* where most participants are no more than spectators and the event has no benefit to physical health. Physical inactivity is responsible for 10% of all deaths (Lee et al., 2012), yet local governments devote limited resources to address it. It makes sense for future municipal discretionary funds for entertainment to be preferentially directed toward activities

* Annual U.S. revenues for display fireworks are $332 million (http://www.huffingtonpost.com/gobankingrates/4th-of-july-fireworks-the_b_7697388.html). Boston spent $2.5 million on fireworks, while Seattle spent $500,000. (http://www.dailyfinance.com/2010/07/04/the-most-extravagant-fireworks-displays-on-july-4th/).

that yield health benefits beyond the short-term. Just as Colombia recognized the potential return on investment for health and incorporated the Ciclovía program into their National Public Health Plan in 2007 and 2 years later institutionalized it as part of national obesity-prevention law (Pratt et al., 2014), the hope is that the frequency of Open Streets events will grow, so they can be integrated into the routine lifestyle of Americans. One study in Bogota found that adults ≥60 years who lived near the Ciclovia route were more likely to achieve 150 min of walking each week (Gomez et al., 2010).

The evaluation has several limitations. First, the survey respondents represent a convenience sample, and applying their responses to the estimation of total participation may not be appropriate. Many did not report their race/ethnicity, which may be a sensitive issue, and this makes it more difficult to determine the population representativeness of survey participants. Second, our estimate of speed was derived from a different CicLAvia event using a convenience sample of volunteers who may not be representative of all CicLavia participants. Although these events have similar travel patterns and participant demographics, there may still be systematic differences that cannot be fully ignored. Third, the cameras were in limited locations and could not account for the heterogeneity of travel along the route. At one end of the route where there was a steep hill, for most of the day participants were required to get off their bicycles and walk, so their speeds were likely much slower than the estimates used, resulting in our estimated number likely to be lower than what actually occurred. Fourth, we did not evaluate any physical activity gained traveling to and from the event. We also did not count people on sidewalks. Although it did not appear that there were many participants on the sidewalks along the route, at either end, there were thousands who came to take advantage of entertainment, food, and information booths that were stationed there. Furthermore, at five stations along the route there were multiple food trucks with long lines. We probably underestimated participants who spent larger amounts of time in these locations. Finally, the estimators for total participation are biased downwards, and our final estimates likely underestimated the total participation.

5. Conclusion

The Los Angeles CicLAvia is unique in its draw of attendees, the duration of their participation, as well as the potential for this event to help thousands to meet the weekly recommended levels of physical activity, if its frequency is expanded. The enthusiastic response suggests that there is good reason to expand the event to longer routes, to increase the reach and capacity of the event, as well as to hold them more frequently. Even though the event needs government support and is relatively expensive, it is a civic activity that has health benefits to participants. More frequent events would potentially lower the cost for each event, improving the overall cost-effectiveness (Montes et al., 2012).

Conflict of interest statement

Aaron Paley was employed at CicLAvia during this evaluation. Christina Batteate works at UCLA which received funding to assist with the CicLAvia evaluation. None of the remaining authors have any conflicts of interest to report.

Transparency document

The Transparency document associated with this article can be found, in the online version.

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Appendix A

The basic rationale for our analysis is derived from the social statistics literature (Yip et al., 2010; Watson and Yip, 2011; Cariveau, 2014) $K = \sum_{i=1}^{N} n_i = N\bar{n}$, where K is the total count of people passing through at all check points (i.e., cameras), N is the total number of participants, and $\bar{n}$ is the average times a participant passed any check point. At first glance, this expression simply states that the sample total K is equal to the sample mean $\bar{n}$ multiplied by the sample size N. However, the sample size N is unknown. Both N and $\bar{n}$ were treated as random variables in this paper. The expected value of N given the observed sample total, denoted as $E(N|K)$, represents a plausible quantity of total participation in the event and is our estimation target. By Jensen's inequality (Casella and Berger, 2002), we have

$$\frac{K}{E(n)} = \frac{K}{E(\bar{n})} \leq E\left(\frac{K}{\bar{n}}|K\right) = E(N|K) \tag{A.1}$$

Since K is observed, we only need to estimate $E(n)$, i.e., the expected times a participant passed any check point, to form a conservative estimator for the total participant with a negative estimation bias. Further note that

$$n \approx \frac{s}{d} = \frac{vt}{d} \tag{A.2}$$

where s, v, and t are the distance, average speed, and duration of a participant in CicLAvia respectively, and d is the (approximately one mile) distance between two adjacent cameras. The GPS data provides a small sample of distances and average speed of the volunteers along the event route, denoted by $s_1, s_2, \ldots, s_{33}$ and $v_1, v_2, \ldots v_{33}$, respectively. The survey data provided a large sample of duration, denoted as $t_1, t_2, \ldots t_m$, $m = 1085$. The sample averages $\bar{s} = \sum_{h=1}^{33} \frac{s_h}{33}$, $\bar{v} = \sum_{h=1}^{33} \frac{v_h}{33}$, and $\bar{t} = \sum_{j=1}^{m} \frac{t_j}{m}$ estimate $E(s)$, $E(v)$, and $E(t)$ respectively. Substituting Eq. (A.2) into Eq. (A.1) yields the two estimators $\hat{N}$ and $\tilde{N}$

$$\hat{N} = \frac{Kd}{\bar{s}}, \text{and} \tilde{N} = \frac{Kd}{\bar{v}\bar{t}}, \tag{A.3}$$

where the first method $\hat{N}$ assumed that the volunteers had similar travel distances as regular participants, and the second method $\tilde{N}$ assumed that the volunteers had similar average travel speed as regular participants.

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