Health benefits of Open Streets programmes in Latin America: a quantitative health impact assessment

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Summary

Background To improve physical activity in Latin American cities, several interventions have been promoted, such as Open Streets programmes. Our study aims to quantify the health and economic effects of Open Streets-related physical activity in 15 Latin American cities.

Methods We used a quantitative health impact assessment approach to estimate annual premature deaths and disease incidence (ischaemic heart disease, ischaemic stroke, type 2 diabetes, colon cancer, breast cancer, and dementia) avoided, the disability-adjusted life-years (DALYs) gained, and the cost saving (from reduced premature mortality) related to increased physical activity from Open Streets programmes in 15 Latin American cities. Input data were obtained from scientific publications, reports, and open street city surveys spanning 2017 to 2019. Physical activity data were converted to metabolic equivalent of the task. Exposure–response relationship functions were applied to estimate relative risk and population-attributable fraction, enabling the assessment of premature deaths and disease incidence.

Findings The percentage of male users of the Open Streets programmes ranged from 55% (27 500 of 50 000 in Guatemala) to 75% (2250 of 3000 in El Alto, Bolivia), and female users ranged from 25% (750; El Alto) to 45% (22 500; Guatemala). We estimated that the current Open Streets programmes in the 15 Latin American cities studied could prevent 363 (95% CI 271–494) annual premature deaths due to increased physical activity, with an annual economic impact of US$194·1 million (144·9 million–263·9 million) saved and an annual reduction of 1036·7 DALYs (346·7–1778·3). If one Open Streets event is added per week in each of those cities, the potential benefit could increase to 496 (370 to 677) premature deaths prevented each year.

Interpretation Open Streets programmes in Latin America can provide health and economic benefits related to increased physical activity and can be used as a health promotion and disease prevention tool.

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Introduction

Urbanisation is one of the leading global trends of the 21st century, and the UN predicts that seven in ten people will live in urban areas by 2050.[1] With increased global urbanisation, the importance of understanding relationships between the environment, human health, and wellbeing in cities is increasingly recognised.[1] A growing body of evidence supports the beneficial effect of physical activity on numerous health outcomes, including premature mortality and reduction of chronic medical conditions.[2] WHO recommends that people aged 18–64 years should perform 150–300 min of moderate-intensity aerobic physical activity per week; or at least 75–150 min of vigorous-intensity aerobic physical activity per week.[3] In 2016, the reported global prevalence of insufficient physical activity was 23%, and Latin America had the highest prevalence of insufficient physical activity (39%).[4]

To ameliorate the global challenge of physical inactivity, several interventions to improve physical activity in Latin American cities have been promoted,[5] such as Open Streets programmes. Open Streets (also called Ciclovías Recreativas or Ciclopaseos in Spanish; and Ruas de Lazer or Ciclofaixas de Lazer in Portuguese) are programmes in which at least 1 km of city streets is temporarily repurposed into car-free spaces for several hours a day to create a space that is adapted to allow free and safe access for pedestrians, runners, skaters, and cyclists, promoting leisure activities.[6–8] Open Streets are complemented with activities to encourage physical activity, civic engagement, local economic development, community development, recovery and revitalisation of public spaces, and changing transport behaviour through walking and cycling advocacy.[9,10] Open Streets origins go back to 1957 in Rio de Janeiro, Brazil,[8] but the most well known Open Streets programme in Latin America originated in Bogota, Colombia, in 1974 with a short route; today the route covers more than 120 km of Bogota.[9] Open Streets had a quick expansion in Latin America, covering 77 Latin American cities in 2019.[6,11] Open Streets generally happens once per week, and some cities also add some Open Streets events on holidays in their programmes.[9] These programmes have been supported as a tool

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Research in context

Evidence before this study

Previous studies suggested that Open Streets programmes can provide health co-benefits such as increasing physical activity and social cohesion, reducing noise, and improving air quality in Latin American cities. We searched PubMed and EBSCO for research articles in English published between Jan 1, 2013, and Dec 1, 2019, using the terms "open streets", "bicycling" (or "bike", "cycling"), "exercise" (or "physical activity"), "health impact", "community participation", "social inclusion", and "Latin America". Some studies focused on physical activity levels or perceptions of neighbourhood characteristics and social inclusive programmes. No studies have included health impacts such as morbidity outcomes or disability-adjusted life-years in multiple Open Streets programmes in Latin America.

Added value of this study

This is the first study assessing the health impacts of Open Streets on morbidity and mortality in 15 Latin American cities. Our study found that Open Street programmes in Latin American cities probably provide population health benefits related to physical activity. Cycling is the most common physical activity performed in Open Streets programmes in Latin America and was estimated to provide the largest health benefits among different physical activity types.

Implications of all the available evidence

Increasing the number of Open Streets events, the street space available for these events, their frequency, and duration could result in more users and physical activity, with the opportunity to improve population health. Open Streets programmes can be used as a tool for health promotion and disease prevention.

to encourage urban residents to use public spaces, promote leisure physical activity, and to promote active transportation.[7]

Several studies have suggested that Open Streets increases physical activity and social cohesion, reduces noise, and improves air quality.[10–12] A previous study estimated a reduction in premature mortality in Open Streets users due to increased physical activity in three Latin American cities.[13] To our knowledge, no studies have included other health impacts such as morbidity outcomes or disability-adjusted life-years (DALYs) in multiple Open Streets in Latin American cities. Therefore, this study aimed to quantify the health impacts (including disease incidence, premature mortality, and DALYs) of Open Streets-related physical activity in 15 Latin American cities.

See Online for appendix

Methods

Study design and framework

This study focused on quantifying Open Streets programmes' health benefits related to physical activity in multiple Latin American cities. This study was initiated at the request of a group of civil society organisations in Quito, Ecuador (Fundación CicloPolis, CER Promotora de Movilidad Activa y la Unión de Ciclistas BiciUnión) as part of a Science Shop approach. A Science Shop is a participatory research approach whereby non-profit civil society organisations propose a scientific question to academic institutions.[14] Such institutions provide independent (free of charge) research support to respond to the concerns.[14] The Science Shop structure in this study was under the umbrella of the InSPIRES Project from the Barcelona Institute for Global Health (ISGlobal), Spain.[15] For the analysis, we applied a quantitative health impact assessment approach, using an available quantitative risk assessment tool (Blue Active Tool, available from the authors upon request), estimating annual deaths, disease incidence, DALYs, and economic values (of mortality) related to physical activity (figure 1).[16] The study used input data sourced from scientific publications, reports, and open street city surveys spanning 2017 to 2019 (appendix pp 4–9). The Blue Active Tool executes the risk characterisation of a comparative risk assessment, integrating hazard identification, exposure, and exposure–response function assessment (appendix pp 4–8). The tool estimates the health impacts and economic evaluation related to different physical activities by sex and age group, providing a central estimate with 95% CIs.[16]

For more on the **InSPIRES Project** see https://inspiresproject.com/

The Blue Active Tool: physical activity and health outcomes modelling

We applied a quantitative spreadsheet model, the Blue Active Tool, using Excel 2007.[17] The Blue Active Tool models exposure–response relationship between physical activity and all-cause mortality in a non-linear function.[17] For morbidity outcomes, the non-linear exposure–response function was also applied using the same function for mortality (appendix p 4).[17,18] Levels of physical activity performed in the Open Streets were considered additional to basal levels and estimated in metabolic equivalent of task (MET), using the Open Streets user data provided by each city. The physical activity exposure assessment of each Open Street was based on a survey designed explicitly for this study (appendix p 9), which was distributed through the Americas Open Street network (Red de Ciclovías Recreativas de las Américas) to multiple Open Streets city authorities in Latin-America.[6] Exposure assessment data collection included a description of the number of Open Streets users, user characteristics (age and sex), type of physical activity

(walking and cycling, among others), physical activity duration, and frequency (table 1; appendix p 11). Sex was self-reported (options provided were male or female) and collected through a survey deployed from each city local authority. Age-specific and sex-specific exposure–response functions were used from physical activity and all-cause mortality or disease incidence for ischaemic heart disease, ischaemic stroke, type 2 diabetes, colon cancer, breast cancer, and dementia from previous meta-analyses and prospective cohort studies (appendix p 7).[17,18] These exposure–response functions were used to calculate the relative risk and the population-attributable fraction for each health outcome, stratified by age for female and male individuals combined, for different scenarios and Open Streets. The annual prevented deaths and disease cases by city were estimated (appendix pp 22–29).[19,20] The analysis used country-specific and age-specific mortality and incidence rates in male and female individuals combined, derived from the Global Burden of Disease Study metrics (appendix p 5).[21] To estimate the corresponding DALYs for each city and scenario, we multiplied the disease-specific, age-specific, and sex-specific attributable fraction to the corresponding DALYs estimation from each country, scaled to the study population size, derived from the Global Burden of Disease Study report (appendix p 6).[21] Finally, the health economic estimation was based on mortality, using the value of statistical life (VSL), reported for each country in US$ (appendix p 5), multiplying the estimated deaths in each city and scenario by the corresponding VSL.[22,23]

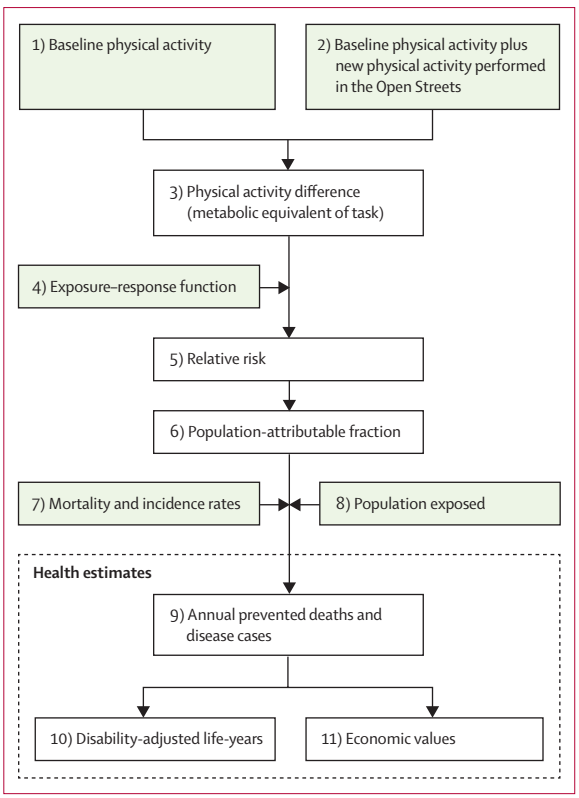

Figure 1: **Methodological approach of the Blue Active Tool**
The input data used in this study to estimate the health and health-related economic impacts of the physical activity related to Open Streets are shown in green.

City selection and input data

The city selection was based on two criteria: (1) those Latin American cities listed inside the Americas Open Street Network (Red de Ciclovías Recreativas de las Américas),[6] the largest Open Streets organisation in the American continent, which lists the active Open Streets programmes that are managed or supported by city authorities; and (2) those cities that provided survey data. The input data used for this analysis are in table 1 and the appendix (pp 5–8). The data included a description of the Open Streets infrastructure and management (Open Streets distance and number of days open per year, etc) and Open Streets users' characteristics (number of users per day, age and sex distribution, type of physical activity performed in the Open Streets, etc). Information regarding race or ethnicity was not collected in our survey format and the available Open Streets reports do not include this information. Health and demographic data from each city and country were collected from official records and scientific publications.[21,24] As mentioned before, to obtain the city data, direct contact with city authorities was made through the Americas Open Street Network (Red de Ciclovías Recreativas de las Américas; appendix p 9).[6] The study population was classified according to the type of physical activity performed in the Open Streets such as cycling, walking, running, and skating. We subsequently divided each of these groups by age (aged 18–64 years and aged ≥65 years) and by sex (male and female) to assign appropriate age-specific and sex-specific incidence rates (appendix p 11).[21] Energy expenditures associated with each type of physical activity were defined in METs as reported by the Ainsworth physical activity compendium (cyclist 7·5 METs, roller skating 7·0 METs, running 7·0 METs, skateboarding 4·0 METs, and walking for leisure 3·5 METs).[25] Physical activity basal levels were obtained from health records reported in each country.[26–28] This study focused only on Open Streets users aged 18 years or older because most of the available exposure–response functions between physical activity and health outcomes are derived from cohort studies on adults.[18,29]

Scenarios

We modelled the health impacts of four scenarios (appendix p 10) based on the total number of Open Streets users and the expected new physical activity related to the Open Streets programmes (represented by the percentage of Open Streets users that reported replacing sedentary time with Open Streets physical activity). The current situation scenario (scenario 1) estimated the health impacts of Open Streets-related physical activity, assuming that only 15% of the Open Streets users replace

	Starting year	Open Street schedule; number of events per year	Overall distance of Open Street in the city	Mean participants per day	Percentage of Open Street users from the city population	Mean proportion of cyclists*	Mean proportion of pedestrians*	Mean proportion of runners*	Mean proportion of roller skaters*	Mean proportion of skateboarders*	Number of Open Street events per year	Mean number of visits per person per year to Open Street	Mean minutes spent doing physical activity during each visit
Argentina													
Rosario	2010	Sunday 0830–1230 h; 52	28 km	43 000	2·89%	14 620 (34%)	21 500 (50%)	0	6450 (15%)	0	52	27	88
Bolivia													
El Alto	2016	Sunday 0900–1300 h; 52	6 km	3000	0·17%	1500 (50%)	570 (19%)	150 (5%)	300 (10%)	240 (8%)	52	40	19
Brazil													
São Paulo	2009	Sunday and holidays 0800–1700 h; 69	22 km	120 000	0·55%	60 434 (50%)	29 612 (25%)	7025 (6%)	6000 (5%)	4006 (3%)	69	36	76
Chile													
Santiago de Chile	2006	Sunday 0900–1300 h; 52	36 km	35 000	0·52%	24 500 (70%)	2800 (8%)	3850 (11%)	3150 (9%)	350 (1%)	52	25	113
Colombia													
Bogota	1974	Sunday and holidays 0700–1400 h; 70	120 km	600 000	13·24%	480 000 (80%)	72 000 (12%)	0	30 000 (5%)	0	70	37	29
Cali	1982	Sunday 0830–1300 h; 52	36 km	26 000	0·95%	11 440 (44%)	10 400 (40%)	0	3640 (14%)	0	52	27	14
Medellin	1984	Sunday 0700–1300 h, and Tuesday and Thursday 2000–2200 h; 164	61 km	50 000	1·27%	28 650 (57%)	20 050 (40%)	0	0	1300 (3%)	164	86	11
Ecuador													
Cuenca	2014	Sunday 0800–1300 h; 52	13 km	500	0·15%	230 (46%)	210 (42%)	60 (12%)	0	0	52	27	30

(Table 1 continues on next page)

	Starting year	Open Street schedule; number of events per year	Overall distance of Open Street in the city	Mean participants per day	Percentage of Open Street users from the city population	Mean proportion of cyclists*	Mean proportion of pedestrians*	Mean proportion of runners*	Mean proportion of roller skaters*	Mean proportion of skateboarders*	Number of Open Street events per year	Mean number of visits per person per year to Open Street	Mean minutes spent doing physical activity during each visit
(Continued from previous page)													
Quito	2003	Sunday every 2 weeks 0900–1300 h; 26	29 km	12 000	0·66%	6043 (50%)	2961 (25%)	702 (6%)	600 (5%)	401 (3%)	26	14	91
Guatemala													
Guatemala City	2007	Sunday 1000–1400 h; 52	7 km	50 000	1·75%	11 500 (23%)	32 500 (65%)	2500 (5%)	500 (1%)	2500 (5%)	52	27	20
Mexico													
Guadalajara	2004	Sunday 0800–1400 h; 52	22 km	116 000	2·31%	61 480 (53%)	34 800 (30%)	11600 (10%)	1160 (1%)	3480 (3%)	52	28	68
Mexico City	2007	Sunday 0700–1400 h; 52	10 km	83 000	0·38%	55 610 (67%)	7470 (9%)	12 450 (15%)	4980 (6%)	2490 (3%)	52	20	31
Puebla	2012	Sunday 0800–1230 h; 52	4 km	1500	0·05%	1125 (75%)	300 (20%)	0	45 (3%)	0	52	27	13
Panama													
Panama City	2014	Sunday 0600–1200 h; 52	21 km	16 000	0·90%	7200 (45%)	1600 (10%)	1600 (10%)	1600 (10%)	800 (5%)	52	27	66
Peru													
Lima	2003	Sunday 0700–1300 h; 48	6 km	7141	0·07%	4142 (58%)	1571 (22%)	928 (13%)	0	500 (7%)	48	20	19

Data are n (%) unless stated otherwise. The data presented are as reported, not estimated. *This proportion is out of all Open Street users, per day.

Table 1: **Open Streets included in the study**

Figure 2: **Map of the cities and countries included in the study**

sedentary behaviours with physical activity performed during the Open Streets (similar to the levels reported in Bogota, Colombia). In scenario 2, we created a hypothetical What If scenario supposing that all the Open Streets programmes add one event per week during a year. In scenario 3, we modelled a more conservative What If scenario assuming only 5% of the Open Streets users replace sedentary behaviours with physical activity performed during the Open Streets. In scenario 4, we created an ambitious hypothetical What If scenario assuming that 50% of the Open Streets users replace sedentary behaviours with physical activity performed during the Open Streets.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

15 cities with Open Streets from ten different Latin American countries were included in the analysis (Rosario [Argentina]; El Alto [Bolivia]; São Paulo [Brazil]; Santiago de Chile [Chile]; Bogota, Cali, and Medellin [Colombia]; Cuenca and Quito [Ecuador]; Guatemala City [Guatemala]; Guadalajara, Mexico City, and Puebla [Mexico]; Panama City [Panama]; and Lima [Peru]; table 1; figure 2). The Open Streets year of implementation among the 15 cities ranged from 1974 (Bogota) to 2016 (El Alto). The Open Streets users ranged from 500 (Cuenca) to 1 400 000 (Bogota), representing 0·05% to 13·24% of the corresponding city population, respectively. The percentage of male users ranged from 55% (27 500 of 50 000 in Guatemala) to 75% (2250 of 3000 in El Alto), and the female users ranged from 25% (750; El Alto) to 45% (22 500; Guatemala; appendix p 11). The number of Open Streets events per year ranged from 26 in Quito to 164 in Medellin (overall mean 52 events per year), with an Open Streets length from 6 km in El Alto to 120 km in Bogota (overall mean 22 km). The most common physical activity performed was cycling (from 11 500 [23%] to 480 000 [80%]), followed by walking (7470 [9%] to 21 500 [50%]), running (zero to 12 450 [15%]), roller skating (zero to 6450 [15%]), and skateboarding (zero to 240 [8%]). The mean physical activity duration in each visit ranged from 11 min (Medellin) to 113 min (Santiago de Chile).

In the current situation (scenario 1), we estimated that among the 15 Open Streets cities combined in Latin America, 363 (95% CI 271–494) annual premature deaths could be prevented each year, corresponding to an economic value of US$194·1 million (144·9 million–263·9 million; table 2). The estimated benefits in terms of mortality ranged from 0·41 in Lima to 4·58 annual deaths avoided in Bogota per 10 000 Open Streets users (appendix p 21). Among morbidity outcomes, dementia had the greatest number of annual cases avoided, with 50·1 (21·1–85·5) cases avoided in the 15 cities combined, followed by ischaemic heart disease with 35·9 (13·3–60·4), type 2 diabetes with 15·4 (3·0–25·8), stroke with 6·1 (0·0–12·8), colon cancer with 1·5 (1·0–4·2), and breast cancer with 0·7 (0·2–1·5; table 2). Regarding DALYs, the annual estimated reduction for the 15 Open Streets cities was 1036·7 (346·7–1778·3). In terms of impacts related to the type of physical activity performed in the 15 Open Streets cities, the greatest benefit estimated was related to cycling, with 643·4 (215·8–1105·0) DALYs avoided each year followed by walking (203·0 [67·9–347·2]), running (120·3 [40·4–206·4]), roller skating (44·1 [14·2–75·5]), and skateboarding (25·8 [8·3–44·1]; table 3).

In scenario 2 (what if one Open Streets event per week is added), we estimated that among the 15 Open Streets cities combined in Latin America 496·3 (95% CI 369·6–676·9) annual premature deaths would be avoided, corresponding to an economic value of US$263·2 million (195·9 million–359·4 million) per year (table 2). Regarding DALYs, the annual estimated reduction for the 15 Open Streets cities was 1327·5 (441·9–2288·8; table 2). The estimated benefits in terms of mortality ranged from 0·64 in Lima to 4·14 annual deaths avoided in Mexico City per 10 000 Open Streets users (appendix p 19). Among morbidity outcomes, dementia had the greatest number of annual cases avoided, with 68·7 (28·6–118·1) cases avoided in the 15 cities combined, followed by ischaemic heart disease with 48·6 (17·9–82·1), type 2 diabetes with 20·9 (4·1–35·1), stroke with 8·3 (0·0–17·5), colon cancer with 2·0 (1·4–5·6), and breast cancer with 0·9 (0·2–2·0; table 2). In terms of impacts related to the

	Scenario description	Annual deaths avoided	Ischaemic heart disease cases avoided	Stroke cases avoided	Type 2 diabetes cases avoided	Colon cancer cases avoided	Breast cancer cases avoided	Dementia cases avoided	DALYs avoided	Economic value related to mortality in million US$
Scenario 1	Current situation*	363·4 (271·5–493·8)	35·9 (13·3–60·4)	6·1 (0·0–12·8)	15·4 (3·0–25·8)	1·5 (1·0–4·2)	0·6 (0·2–1·5)	50·1 (21·1–85·5)	1036·7 (346·7–1778·3)	194·1 (144·9–263·9)
Scenario 2	What if all the Open Streets programmes added one event per week	496·3 (369·6–676·9)	48·6 (17·9–82·1)	8·3 (0·0 to17·5)	20·9 (4·1–35·1)	2·0 (1·4–5·6)	0·9 (0·2–2·0)	68·7 (28·6–118·1)	1327·5 (441·9–2288·8)	263·2 (195·9–359·3)
Scenario 3	What if only 5% of users replaced sedentary behaviour with the physical activity performed in the Open Streets	37·1 (27·7–50·5)	3·4 (1·3–5·8)	0·7 (0·0–1·5)	1·8 (0·4–3·1)	0·2 (0·1–0·5)	0·1 (0·0–0·2)	4·8 (2·0–8·2)	99·3 (32·6–170·7)	25·1 (18·7–34·2)
Scenario 4	What if 50% of users replaced sedentary behaviour for the physical activity performed in the Open Streets	575·9 (429·8–783·4)	56·0 (20·6–94·3)	10·3 (0·0–21·6)	26·0 (5·1–43·6)	2·4 (1·6–6·8)	1·1 (0·2–2·4)	76·4 (32·0–130·6)	1560·3 (517·0–2681·8)	794·8 (593·1–1081·3)

Data are n (95% CI). DALYs=disability-adjusted life-year. *Assuming 15% of the Open Street users substitute sedentary behaviour with Open Street physical activity, as reported in Bogota, Colombia.

Table 2: **Avoided annual deaths, cases of disease, DALYs, and economic values, by scenario among the 15 cities**

type of physical activity performed in the 15 Open Streets cities, the greatest benefit estimated was related to cycling, with 821·8 (247·3–1419·1) DALYs avoided each year followed by walking (265·3 [88·4–456·0]), running (152·3 [50·9–262·8]), roller skating (58·0 [18·6–99·6]), and skateboarding (29·9 [9·6–51·2]; table 3).

In scenario 3 (what if only 5% of Open Streets users replace sedentary behaviour with Open Streets-related physical activity), we estimated that among the 15 Open Streets cities combined in Latin America, 37·1 (95% CI 27·7–50·5) annual premature deaths would be prevented each year, corresponding to an economic value of US$25·1 million (18·7 million–34·2 million; table 2). Regarding DALYs, the annual estimated reduction for the 15 Open Streets cities was 99·3 (32·6–170·7; table 2). The estimated benefits in terms of mortality ranged from 0·14 in Lima to 0·83 annual deaths avoided in Medellin per 10 000 Open Streets users (appendix p 20). Among morbidity outcomes, dementia had the greatest number of annual cases avoided, with 4·8 (2·0–8·2) cases avoided in the 15 cities combined, followed by ischaemic heart disease with 3·4 (1·3–5·8), type 2 diabetes with 1·8 (0·4–3·1), stroke with 0·7 (0·0–1·5), colon cancer with 0·2 (0·1–0·5), and breast cancer with 0·1 (0·0–0·2; table 2). In terms of impacts related to the type of physical activity performed in the 15 Open Streets cities, the greatest benefit estimated was related to cycling, with 55·5 (18·4–95·7) DALYs avoided each year, followed by walking (22·3 [7·3–38·3]), roller skating (4·1 [1·3–7·0]), running (9·2 [3·0–15·7]), and skateboarding (8·2 [2·7–14·0]; table 3).

In scenario 4 (what if as many as 50% of Open Streets users replace sedentary behaviour with Open Streets-related physical activity), we estimated that among the 15 Open Streets cities combined in Latin America 575·9 (95% CI 429·8–783·4) annual premature deaths would be avoided, corresponding to an economic value of US$794·8 million (593·1 million–1·1 billion) per year. Regarding DALYs, the annual estimated reduction for the 15 Open Streets cities was 1560·3 (517·0–2681·8; table 2). The estimated benefits in terms of mortality ranged from 2·4 in Lima to 20·2 annual deaths avoided in Medellin per 10 000 Open Streets users (appendix p 20). Among morbidity outcomes, dementia had the greatest number of annual cases avoided, with 76·4 (32·0–130·6) in the 15 cities combined, followed by ischaemic heart disease with 56·0 (20·6–94·3), type 2 diabetes with 26·0 (5·1–43·6), stroke with 10·3 (0·0–21·6), colon cancer with 2·4 (1·6–6·8), and breast cancer with 1·1 (0·2–2·4; table 2). In terms of impacts related to the type of physical activity performed in the 15 Open Streets cities, the greatest benefit estimated was related to cycling, with 1025·2 (342·9–1761·7) DALYs avoided each year, followed by walking (243·8 [80·2–418·4]), roller skating (87·3 [27·2–150·6]), skateboarding (82·2 [26·5–140·4]), and running (40·9 [13·2–70·5]; table 3).

Discussion

This is the first study assessing the health impacts of Open Streets on morbidity and mortality in mulitple Latin American cities. In collaboration with the Latin American Open Streets Network, we were able to contact those in charge of each programme in the different cities to obtain the data needed. We found that the Open Streets in the 15 Latin American cities included prevented an estimated 363 annual premature deaths due to the increase in physical activity, equivalent to an annual economic impact of US$194·1 million. Assuming that the 15 Open Streets added one event per week, the estimated benefit could rise to prevent 496 annual deaths, with an annual economic impact of US$263·2 million. Regarding the type of physical activity, Open Streets has successfully supported cycling and walking, which is reflected in the estimated health benefits, where the most benefits between the 15 cities were derived from cyclists (643·4 DALYs), followed by pedestrians (203·0 DALYs).

	Scenario description	Cyclist	Pedestrian	Runner	Roller skater	Skateboarder
Scenario 1	Current situation*	643·4 (215·8–1105·0)	203·0 (67·9–347·2)	120·3 (40·4–206·4)	44·1 (14·2–75·5)	25·8 (8·3–44·1)
Scenario 2	What if all the Open Streets programmes added one event per week	821·8 (274·3–1419·1)	265·3 (88·4–456·0)	152·3 (50·9–262·8)	58·0 (18·6–99·6)	29·9 (9·6–51·2)
Scenario 3	What if only 5% of users replaced sedentary behaviour with the physical activity performed in the Open Streets	55·5 (18·4–95·7)	22·3 (7·3–38·3)	9·2 (3·0–15·7)	4·1 (1·3–7·0)	8·2 (2·7–14·0)
Scenario 4	What if 50% of users replaced sedentary behaviour for the physical activity performed in the Open Streets	1025·2 (342·9–1761·7)	243·8 (80·2–418·4)	40·9 (13·2–70·5)	87·3 (27·2–150·6)	82·2 (26·5–140·4)

Data are DALYs (95% CI). DALYs=disability-adjusted life-year. *Assuming 15% of the Open Street users substitute sedentary behaviour with Open Street physical activity, as reported in Bogota, Colombia.

Table 3: **DALYs avoided by physical activity type and scenario among the 15 cities**

This study found that health impacts related to Open Streets varied between Latin American cities. Bogota, Colombia, reported the highest mortality prevention rate (4·58 annual deaths avoided per 10 000 users) versus Lima, Peru, with the lowest mortality prevention rate (0·41 annual deaths avoided per 10 000 users). This finding is because Bogota has the highest number of Open Streets participants (13% of total population), resulting in more Open Streets health benefits. Medellin (Colombia), Guadalajara and Mexico City (Mexico), and Santiago (Chile) were also among the top five cities with regard to annual deaths avoided per 10 000 users. Cities such as Lima (Peru) and Cali (Colombia) showed fewer health benefits in terms of annual deaths per 10 000 Open Streets users due to the fewer Open Streets events held per year and the short duration users spend in those Open Streets.

Latin America has been described as a unique structural, political, cultural, and social environment.[12] According to the UN, Latin America is one of the most urbanised regions in the world (81% of Latin Americans live in cities), which is also correlated with high levels of insufficient physical activity (39% overall population). Moreover, rapid urbanisation is a continuous process in Latin America, particularly in Argentina, Brazil, and Colombia.[4,30] These characteristics mean that the region faces challenges related to rapid changes in population density, such as the need for quality transit systems and safe urban environments to perform physical activity, such as parks, recreation centres, gyms, or trails.[12] For these reasons, implementing and promoting Open Streets events are important tools to increase physical activity in the Latin American context. Open Streets also provides other social benefits, such as social interaction, support of social cohesion, and promotion of active transportation.[7,31] A previous study analysed the cost–benefit ratios of physical activity of Open Streets programmes in three Latin American cities from a public health perspective. The authors found a cost–benefit ratio for health benefits from physical activity of 3·23–4·26 for Bogota, 1·83 for Medellin, and 1·02–1·23 for Guadalajara.[13] These results were similar to those estimated in our study. Open Streets also provides additional co-benefits, such as improving air quality, increasing social capital, and reducing carbon emissions, which might result in even more positive cost–benefit ratios.[13] Thus, Open Streets can be low-cost and cost-effective compared with other physical activity promotion programmes.

Multiple pathways between Open Streets and health benefits have been described.[7,12,32] Our study only measured the health impacts related to physical activity performed in Open Streets (figure 1). Our results are a conservative assessment, and more health benefits from Open Streets could be expected. Additionally, we only included six diseases and all-cause mortality as the main health outcomes related to physical activity. However, more health outcomes have been related to physical activity.[33] We decided to include only these six diseases and all-cause mortality because the epidemiological evidence is more robust on these diseases, there are robust exposure–response functions, and they also provide more conservative estimates than for other diseases. A previous study found that in Bogota, Open Streets users also had improved psychological outcomes and mental health.[32] These are other health outcomes that our study does not quantify and could be added as a potential marginal benefit to those estimated in this study. Unlike a previous study on Open Streets-related physical activity and mortality,[11,12,32] our study provided a more conservative approach, modelling the relationship between physical activity and the health outcomes with a non-linear function, taking into account that individuals who already were physically active would gain fewer benefits compared with those who are more sedentary.[16,20]

This project was part of a Science Shop approach whereby non-profit and community organisations submit research questions to academic institutions (ISGlobal-InSPIRES Science Shop). This specific project was initiated by request of a group of civil society organisations in Quito, Ecuador (Fundación CicloPolis, CER Promotora

de Movilidad Activa y la Unión de Ciclistas BiciUnión) involved in the promotion of active transportation. In addition to the research activities and results described in this Article, the research team provided translational and dissemination activities related to the research project. We provided a policy brief, one-on-one meetings with civil society organisations, oral presentations to Open Streets managers, webinars, and radio interviews (all in Spanish), among those materials and activities.

As in all quantitative health impact assessments, our study was limited by data availability and the necessity to make assumptions to model probable scenarios. One limitation of the data collection was the scarcity of published data on Open Streets use, user characteristics, and Open Streets-related physical activity. For that reason, we created an Open Streets survey distributed to the Open Streets network managers to collect and harmonise Open Streets-related data (appendix p 9). Although most of the input data used to model the scenarios came from local authorities and scientific publications, we acknowledge that the data collected by local authorities were not aimed to be used in a health impact assessment, and the quality and representativeness might vary between cities. Another limitation was the available evidence between physical activity and health. In this study, we only included those health outcomes (all-cause mortality and six diseases) and populations (adults) for which robust evidence between physical activity and health exists, and we might have excluded many potential health benefits. Those exposure–response functions used in this study were based on previous published meta-analyses and cohort studies, have also been used in previous health impact assessments, and are only for adults.[16,34,35] Thus, other populations, such as children, that are also Open Streets users, were not included in this analysis. Another limitation was the inability to characterise health impacts based on sex and other socioeconomic indicators due to the insufficient amount of disaggregated data from Open Streets users in the included cities. Finally, we only focus our analysis on long-term impacts related to physical activity (disease incidence and mortality) as opposed to shorter-term impacts such as improvements in respiratory function, mental health, blood pressure, and sleep. Open Streets users will need to continue participating in Open Streets events for several years to experience the long-term health benefits.

We found that Open Streets could provide multiple health and economic benefits. Those benefits could be increased if the number of Open Streets events and the duration of each event increased. To attract more users, promote equity, and increase health benefits, Open Streets managers could support the Open Streets expansion among multiple neighbourhoods, prioritising low-income communities, those with little access to parks and public spaces, and those affected by environmental issues (eg, highly polluted areas) and expanding the size of the area dedicated to current Open Streets programmes. To support Open Streets use, Open Streets managers can also improve Open Streets maintenance, increase the number of Open Streets events per year, duration, and geographical coverage, and add user surveys collecting data on Open Streets use (frequency, duration, type of physical activity, and physical activity substitution), user demographics, user perceptions, and needs that will help guide the management and expansion of Open Streets.

The results also support using Open Streets as a tool for health promotion and prevention. Health practitioners should be aware of the Open Streets events in their communities: if an Open Streets programme is available, health professionals could encourage the use of Open Streets; if an Open Streets programme is not available, health practitioners could consider asking local authorities to implement Open Streets projects, or could increase their collaboration with community organisations and non-health sectors to promote Open Streets implementation and use, and support data collection to assess the health impacts related to local Open Streets. Researchers and academics can also support data collection related to Open Streets use, users' characteristics, and Open Streets-related health determinants (eg, physical activity), with particular attention to physical activity substitution (from other types of physical activity and locations); support stakeholders and health practitioners with Open Streets monitoring and evaluation; support research on barriers and opportunities; and support research on physical activity and health outcomes in diverse populations (eg, children, women, and disadvantaged communities). Our results highlight the need for collaboration between health practitioners, community groups, and policy makers to encourage the implementation and expansion of Open Streets in urban settings.

This study found that the Open Streets programme in Latin America probably provides reasonable health and economic benefits related to physical activity, given the low cost of implementation. Open Streets can be used as a tool for health promotion and disease prevention and should be considered in urban settings as a tool to promote physical activity, especially in those areas and countries where physical inactivity is common. In those cities where Open Streets exists, an increase in the number of Open Streets events, length (in km), and duration could result in more users and increased duration of Open Streets-related physical activity with the opportunity to increase health benefits.

Contributors

DR-R conceived, designed, and coordinated the assessment and the study. DV-C oversaw the data collection. DV-C and DR-R accessed and verified the data used in the study and all authors had access to the data. DV-C and DR-R analysed the data and drafted the first manuscript. DV-C, DR-R, MJN, and MJ participated in drafting the manuscript. All authors read and approved the final manuscript and had final responsibility for the decision to submit for publication.

Declaration of interests

We declare no competing interests.

Data sharing

The survey data collected in this study is presented in the tables and appendix. Data used on mortality, disease incidence, value of statistical life, exposure–response functions, and basal levels of physical activity are publicly available and the links to datasets are available in the references and appendix.

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