Chapter 14
The Impacts of an Urban Cable Car System on Liveability: A Mixed Methods Study in Bogotá, Colombia

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Abstract Cable cars represent an integral element of urban transport systems designed to connect underserved communities in Latin America. However, evaluations of the liveability impacts of cable cars are scarce. The TransMiCable cable car in Colombia connects the peripheral neighbourhoods of Ciudad Bolívar with the integrated public transport system of Bogotá. This study assessed the effect of TransMiCable on domains of liveability, including transport, public open space, social cohesion, local democracy, and security. *Urban Transformations and Health: The Case of TransMiCable in Bogotá* was a natural experiment involving participatory

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mixed methods. Household surveys, the Our Voice citizen science research method, and the Ripple Effects Mapping technique were applied to capture baseline measurements before TransMiCable's inauguration and follow-up measurements afterwards in both intervention and control areas. Following a simultaneous bidirectional approach, quantitative and qualitative data were collected and analysed separately, then merged for interpretation. The mixed methods approach revealed concordance and complementarity among the multiple effects of the TransMiCable intervention across domains of liveability. These impacts included shorter travel times, increased satisfaction with public transport, increased access to parks, perceived reduction in the neighbourhood's social stigma, increased pride in community, and decreased perceived insecurity. The participatory process facilitated dialogue between community leaders and public sector decision-makers on the ways transportation interventions can improve liveability. This multisectoral engagement enabled a broad understanding of the ongoing transformation of the Ciudad Bolívar area after the implementation of TransMiCable, providing lessons for effectively engaging with local stakeholders to support the sustainability of urban transformations.

Keywords Transport intervention · Urban transformation · Liveability · Mixed methods · Natural experiment · Community engagement · Latin America

14.1 Introduction

Cities play an important role in improving population health (Ramirez-Rubio et al., 2019) and designing "liveable" cities that reduce health inequities and promote wellbeing has been declared a global priority (Crane et al., 2021; World Health Organization, 2016). Liveable cities provide residents with opportunities for healthy living, including accessible public transport and walking and cycling infrastructure, public open spaces, health and community services, and cultural opportunities within socially cohesive, safe, affordable, and inclusive urban settings (Badland et al., 2014). Just as the "urban liveability" approach reflects the social determinants of health, the emerging field of liveability research proposes evidence-based, policy-relevant tools that analyse the distribution of urban liveability within cities (Higgs et al., 2019). To-date, this approach has been primarily applied in high-income

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countries, and limited evidence exists regarding the impacts of urban policies on health and well-being across less-affluent regions such as Latin America (Pineo et al., 2018). Within the context of rapid urbanization, inequality, violence, and informality, Latin America has implemented innovative transportation policies and urban development projects that have the potential to deliver health benefits to large populations living in ever-growing informal settlements (Giles-Corti et al., 2016; Sarmiento et al., 2020). The integration of cable cars within the public transport system represents an innovative intervention that has been applied in Latin America in response to urban development patterns (World Bank, 2017). However, evidence of these interventions' impacts on underserved population is limited, and previous studies have not applied a liveability framework to the evaluation of cable car systems (Sarmiento et al., 2020).

New urban models such as the Superblocks in Barcelona, the 15-min city in Paris, low-traffic neighbourhoods in London, and car-free neighbourhoods in Germany have been touted as "visionary urban models" that might increase liveability in dense cities (Nieuwenhuijsen, 2021). However, it is unclear whether these new urban models could be effectively implemented in dense cities outside Europe (Nieuwenhuijsen, 2021; Ramirez-Rubio et al., 2019). Indeed, the meaning of liveability might vary between Europe and other regions, as different regions have different priorities (Asian Development Bank, 2019). Latin America has urbanized more rapidly than any other region and cable cars may be one of the few viable solutions to inadequate urban transportation infrastructure. Evidence from Medellín, Colombia suggests that the implementation of a cable car system can help reduce crime as part of a wider urban intervention (Cerdá et al., 2012). Evidence from La Paz, Bolivia suggests that a cable car system can reduce travel time (Garsous et al., 2019). However, evidence of cable car systems' broader effects and potential role in creating health-supporting neighbourhoods remains limited (Sarmiento et al., 2020).

One of the newest cable car systems in Latin America is TransMiCable in Colombia, which connects the poor and segregated neighbourhoods of Ciudad Bolívar with TransMilenio, Bogotá's bus rapid transit (BRT) system. TransMiCable can carry 3600 passengers per hour in each direction. The TransMiCable urban transformation was inspired by similar interventions in Medellín and includes parks, playgrounds, and other facilities intended to reduce social inequities and segregation (Guevara-Aladino et al., 2022). TransMiCable was inaugurated in December 2018, with the hope that the cable car and associated interventions would help transform Ciudad Bolívar and improve the area's liveability (Sarmiento et al., 2020).

Urban Transformations and Health: The Case of TransMiCable in Bogotá (or TrUST, for the project's initials in Spanish) is a natural experiment designed to evaluate the impacts of the cable car project on various measures of liveability (Sarmiento et al., 2020). TrUST applied mixed methods, integrating quantitative measurements with two participatory approaches: the Our Voice citizen science method (King et al., 2016) and Ripple Effects Mapping (REM) (Chazdon et al., 2017). This methodological approach allows for the evaluation of context-specific social and built environment characteristics. More importantly, this approach leverages ongoing dialogue between multidisciplinary researchers and intersectoral

stakeholders to address the challenges inherent to evaluating the impacts of urban transformations on liveability. Our Voice is a theory-driven citizen science method that seeks to empower communities to drive change across multiple levels of influence that impact health-related behaviours (King et al., 2019). Our Voice is increasingly being accompanied by REM, a participatory evaluation methodology where community members and other stakeholders work together in a researcher-facilitated group session to map the diverse "ripples" of a given intervention's intended and unintended impacts (Rubio et al., 2022). The aim of the present analysis was to integrate qualitative and quantitative data to understand the effect of the cable car project on multiple domains of liveability, including transport, public open space, social cohesion and local democracy, and security.

14.2 Methods

14.2.1 Study Setting

The TrUST study was conducted in the city of Bogotá, Colombia. The intervention area encompasses the Ciudad Bolívar neighbourhoods, and the control area includes the San Cristóbal neighbourhoods where another cable car is scheduled to be implemented in 2024. In 2018, Bogotá's overall Multidimensional Poverty Index was 4.1; this value rose to 7.1 in 2020 (DANE, 2020) with some neighbourhoods experiencing more extreme conditions than others. The marginalised neighbourhoods of Ciudad Bolívar and San Cristóbal are characterized by precarious planning and dense populations illustrating the effects of accelerated urbanization driven in part by internal, conflict-related displacement. The past five decades has resulted in self-built neighbourhoods located in areas along the outskirts of the city built on extreme slopes land facing severe economic, employment, health, and mobility challenges. The intervention and control areas are difficult to reach from the centre of Bogotá. These areas were selected for this study because they have similar geospatial and sociocultural conditions and crime levels yet are separated by geographical barriers that should limit contamination (Sarmiento et al., 2020).

14.2.2 The TransMiCable Cable Car Project

TransMiCable is 3.43 kilometres long, includes four stations, and runs on clean energy. There are 163 cabins with a capacity of 10 passengers per cabin. During its first year of operation, approximately 7.5 million people used TransMiCable. Currently, approximately 21,000 people use TransMiCable on workdays and around 17,500 on Sundays and public holidays. TransMiCable is deemed to be a sustainable

and healthy transportation system. TransMiCable cabins have better air quality within the cabins compared to any other public transportation systems in Bogotá (Morales-Betancourt et al., 2023). Additionally, TransMiCable fosters or maintains active travel within combined transport modal shares. More information about TransMiCable and the rest of Bogotá's public transport system can be found online (Transmilenio, 2022). The TransMiCable cable car system is the main component of a wider intervention that also includes a library, a tourism office, a local history museum, a citizen service office, two trails, two sport and recreation centres, three local markets, three community centres, and 11 parks. The TransMiCable project also includes a program to support improvements to local homes and a project to reduce landslides and other local environmental hazards (Sarmiento et al., 2020).

14.2.3 Study Design

The TrUST study is a natural experiment using mixed methods with a simultaneous, bidirectional integration approach (Moseholm & Fetters, 2017) including dimensions of the urban liveability framework (Badland et al., 2014). To assess the effect of the urban transformation in Ciudad Bolívar, we used an array of methodologies to capture the interplay of changes in different liveability domains. The quantitative component focused on measuring the impact of the intervention on liveability, while the qualitative component was intended to document the residents' experience of the urban transformation.

The study design is described in detail elsewhere (Sarmiento et al., 2020). Overall, the intervention area in Ciudad Bolívar included households located within an 800-metre radius (or buffer) of each of the four TransMiCable stations. The area of influence in the control neighbourhood of San Cristóbal included households located within an 800-metre buffer of the potential locations of the planned stations. An 800-metre buffer is greater than the walking buffer normally used in transport studies, based on the hypothesis that people with lower incomes would be willing to walk long distances to take advantage of public transport (Sarmiento et al., 2020). Participants were recruited from 225 blocks within the intervention area and 228 blocks within the control area. Blocks were selected with a probability proportional to the density of parcels. Every third household was systematically selected and one adult that fulfilled the inclusion criteria was selected per household (Sarmiento et al., 2020). For the quantitative study, we included cohort data. 'Citizen science' data was obtained from convenience samples in the intervention and control areas, while REM data was obtained from a convenience sample from the intervention area. For the qualitative study, the overall sample differed in baseline and follow-up periods. Figure 14.1 shows the timeline of quantitative and qualitative data collection; Table 14.1 describes the various data sources.

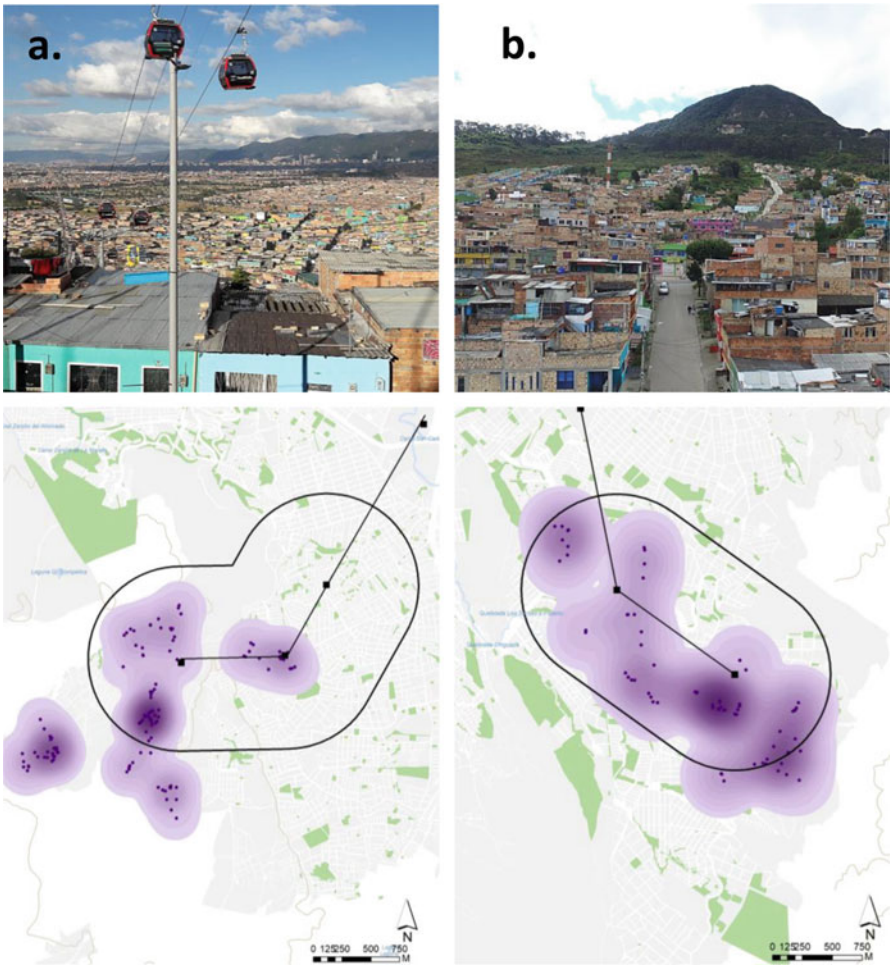

Fig. 14.1 Photos and sampling of buffer areas from the intervention (**a**) and control (**b**) areas. Purple dots correspond to the areas where pictures were taken by citizen scientists. Figures of the TrUST study 2017–2021

14.2.4 Quantitative Component

14.2.4.1 Household Survey and Built Environment Characteristics

Trained interviewers surveyed participants in their households using a structured questionnaire. Baseline surveys were conducted from January 2018 to December 2018 and included 1031 adults in the intervention area and 1021 in the control area. Follow-up surveys were conducted after the inauguration of TransMiCable from July 2019 to March 2020 and included 825 adults in the intervention area and 854 adults in the control area (Table 14.2).

Table 14.1 Data sources for the TrUST study (2017–2021)

		Ciudad Bolivar (intervention group)		San Cristobal (control group)	
Data sources	Dates	Method	Participants	Method	Participants
Quantitative data					
Household survey	2018–2020	Face-to-face questionnaires	Baseline: n = 1031 follow-up: n = 825	Face-to-face questionnaires	Baseline: n = 1021 follow-up: n = 854
Qualitative data					
Semi-structured interviews	2017	Face-to-face interviews	12	NA[a]	NA[a]
Group model building	2018	1 session	31[b]	NA[a]	NA[a]
Our voice community walks[c]	2018–2020	Discovery tool app[c]	Baseline:11	Discovery tool app	Baseline: 13
			Follow-up:14		Follow-up:16
Community meetings with citizen scientists	2018–2020	Baseline: 1 in-person community meetings	3 citizen scientists	Baseline: 1 in-person community meeting	4 citizen scientists
		Follow-up: 1 in-person meeting	7 citizen scientists	Follow-up: 1 virtual community meeting	9 citizen scientists
Community meeting with citizen scientists and other stakeholders[d]	2020	Follow-up: 1 virtual meeting	3 community leaders, 13 stakeholders	Follow-up:1 virtual meeting	2 community leaders, 13 stakeholders
Interviews with policymakers[e]	2020–2021	Follow-up semi structure interviews	2 policy makers	NA[a]	NA[a]
Ripple effects mapping	2020	Follow-up: 1 in-person community meeting	9 citizen scientists	NA[a]	NA[a]

[a]Not applicable because this methodology was only applied for participants in the intervention area or policy makers who were involved in implementing TransMiCable

[b]Stakeholders represented nine institutions from the following sectors: academia, government (Sports and Recreation, Mobility, Health, Habitat, Women's, and Social Secretariats), and community leaders from the intervention area

[c]Stanford Healthy Neighborhood Discovery Tool

[d]Stakeholders belonged to the Ministry of Health, TransMilenio, TransMiCable, the District Institute of Recreation and Sports, and the Urban Development Institute

[e]Policy makers from TransMilenio SA and the Urban Development Institute

Sociodemographic and Transport Characteristics

Sociodemographic characteristics included sex, age, educational attainment, occupation, and monthly household income. Transport accessibility included mode choice, travel time, and distance to the nearest bus-rapid transit station based on the shortest path from the household to the BRT station through the street network.

Table 14.2 Sociodemographic, transport and built environment characteristics of the participants of the household survey in follow up period in intervention and control groups, TrUST study 2017–2021

	Ciudad Bolivar Intervention					San Cristobal Control			
	Baseline (N = 1031)		Follow-up (N = 825)		*p*	Baseline (N = 1021)		Follow-up (N = 854)	
	N	%	N	%		N	%	N	%
Population	733,859					394,358			
Sociodemographics[a]									
Sex									
Male	363	35.2	285	34.5	0.372	400	39.2	330	38.6
Female	668	64.8	540	65.5		621	60.8	524	61.4
Age									
Mean (SD)	1031	44.3(18.1)	825	45.8 (18.1)	0.073	1021	42.8(17.3)	854	44.4 (17.4)
Median (IQR)	1031	43(28–59)	825	46 (29–61)		1021	40(28–56)	854	42 (30–58)
Education level									
≤ elementary	399	38.7	335	40.6	0.523	256	24.9	228	26.7
High school	466	45.2	359	43.5		514	49.9	425	49.8
Technical/college/graduate	165	16.0	131	15.9		251	24.4	201	23.5
Monthly household income									
≤ 1 minimal wage ($280 USD)	556	54.0	439	53.2	0.824	350	34.0	292	34.2
> 1- ≤ 2 minimal wages ($281–$1120USD)	386	37.5	322	39.0		485	47.1	414	48.5
> 2 minimal wages (>$1120 USD)	81	7.9	60	7.3		149	14.5	120	14.1
Occupation									
Working	496	48.2	394	47.8	0.631	528	51.8	477	55.9
Studying	42	4.1	18	2.2		71	7.0	44	5.2
Household activities	322	31.3	303	36.8		294	28.9	266	31.1
Not working	169	16.4	109	13.2		126	12.4	67	7.8
Marital status									

Single	214	20.8	169	20.5	0.834	331	32.4	269	31.5
Married	551	53.4	436	52.8		510	50.0	419	49.1
Divorced	266	25.8	220	26.7		180	17.6	166	19.4
Transport behaviours									
Main transport mode – mandatory trips (work or education)									
Public	493	61.4	372	46.7	<0.001	554	67.3	523	62.8
Public-active	174	21.7	189	23.7		168	20.4	189	22.7
Public-private	34	4.2	30	3.8		21	2.6	22	2.6
TransMicable	NA		95	11.9		NA			
Public-informal	52	6.5	45	5.6		12	1.5	14	1.7
Private	50	6.2	66	8.3		68	8.3	85	10.2
TransMiCable ever used since inauguration	NA		617	75.8					
Travel time mandatory trips – one way (minutes)	375	110.0(67.3)	398	90.2(53.9)	<0.001	396	89.9(54.1)	468	85.9(64.8)
Distance to the nearest BRT station (mean km, (SD))			3.2 (1.1)					2.6 (0.8)	
Built environment characteristics (mean, (SD))									
Slope %		9.9 (3.6)		10.0 (3.6)	0.491		6.4 (1.8)		6.3 (1.8)
Intersection density (number/km^2)		578.2(128.7)		579.5 (130)	0.622		415.6(121.6)		417.6 (122)
Parks density		0.06 (0.043)		0.06 (0.045)	0.611		0.05 (0.031)		0.05 (0.034)

[a]Sample sizes may not sum to total N due to missing data
BRT: Bus rapid transit
SD: Standard deviation
Chi-square tests were used for differences in categorical variables and t-test for differences in continuous variables
NA: Not applicable for measurement of TransMiCable

Built Environment Characteristics

Built environment characteristics included slope, intersection density (i.e., crossroads density), and parks density, measured using secondary official data (IDECA & Gobierno de Colombia, 2022). We created a 500-m street network buffer around each georeferenced household, computing slope using the triangulated irregular network that represents terrain surfaces irregularly distributed to accommodate areas of high variability in the surface every five meters. Intersection density was calculated as the number of intersections per square kilometre. Park density was calculated as the area (in square metres) of parks within each buffer area. All analyses were conducted using ArcGIS® software (Esri Inc, n.d.).

Liveability Outcomes

Liveability outcome indicators included measures for transport, neighbourhood public open space, social cohesion, local democracy, and security domains. Satisfaction with public transport was measured on a scale of 1–10 (where 1 is extremely unsatisfied and 10 is extremely satisfied). Potential barriers to better liveability in the neighbourhood included issues surrounding the obstruction or lack of parks and sports centres, disruption of sidewalks and streets, improper disposal of waste, the presence of rodents and insects, bad odours, and air pollution. Social cohesion and local democracy indicators included participation in community organizations and trust in public institutions. Security indicators included perceived security and reports of being a victim of robbery in the last 12 months.

14.2.4.2 Quantitative Data Analysis

First, we described the sociodemographic, transport, and built environment characteristics of the intervention and control groups. Next, we investigated the impact of TransMiCable on liveability outcome indicators by conducting multilevel regression models (linear and non-linear) with random intercepts for individuals. Models included main effects of time (T0/T1) and urban area (intervention/control), as well as a time by urban area interaction. The time by area interaction term was used to assess the effect of the intervention. The models were adjusted for sociodemographic characteristics (age, sex, occupation, marital status, and education), distance to the BRT station, and slope.

14.2.5 Qualitative Component

The qualitative component of our evaluation was intended to capture in-depth insights regarding the implementation of TransMiCable on liveability and the ongoing transformation of Ciudad Bolívar (Sarmiento et al., 2020). Our participatory

approach acknowledged the longstanding relationship between community leaders, policymakers, and other stakeholders (Sarmiento et al., 2020) who since 2007 have been mobilizing and advocating for a cable car system in this area.

14.2.5.1 The Our Voice Citizen Science Method

The Our Voice citizen science method involved four stages, each implemented at baseline and again at follow-up (King et al., 2019). In the first stage, residents walked around their community and used the Our Voice mobile phone app to capture what they deemed to be relevant information (24 citizen scientists participated at baseline and 30 at follow-up) (Fig. 14.2). In the second stage, we facilitated community meetings to discuss residents' findings and to establish local priorities (7 citizen scientists at baseline and 16 at follow-up). In the third stage, we held discussions between residents, policymakers, and other stakeholders to facilitate their engagement in the definition of potential actions (discussions included 16 volunteers from the intervention group and 15 from the control group). Finally, local changes were implemented and evaluated (two volunteers took part in comprehensive interviews and three expert panels were convened). Participating policymakers and stakeholders included representatives of the Secretariats for Mobility, for Women and for Urban Planning, the District Institute of Recreation and Sports, the Ministry of Health TransMilenio, and TransMiCable.

Analysis of the Our Voice Citizen Science Data

Five researchers with backgrounds in social sciences and public health analysed citizen scientist data from the mobile phone app. First, citizen scientists presented their data during the facilitated community meetings. Second, researchers reviewed notes from community meetings and prepared a list of potential themes to consider across the baseline and follow-up periods. Third, all entries were coded in Excel matrices according to consolidated themes. Fourth, entries were analysed using a content analysis approach to characterise themes (Elo & Kyngäs, 2008). Fifth, following a grounded theory approach, themes were ranked by frequency (Carlin & Kim, 2017). Finally, all themes were discussed and consolidated during five separate meetings with research team specialists as part of the integration strategy described in Sect. 14.2.6. The research team included specialists in transport, air quality, crime, quality of life, and physical activity.

14.2.5.2 Ripple Effects Mapping Methodology

Ripple Effects Mapping was applied to further capture and map the diverse 'ripples' of the TransMiCable intervention (Chazdon et al., 2017). We conducted a Ripple Effects Mapping session in February 2020 with nine citizen scientists, including

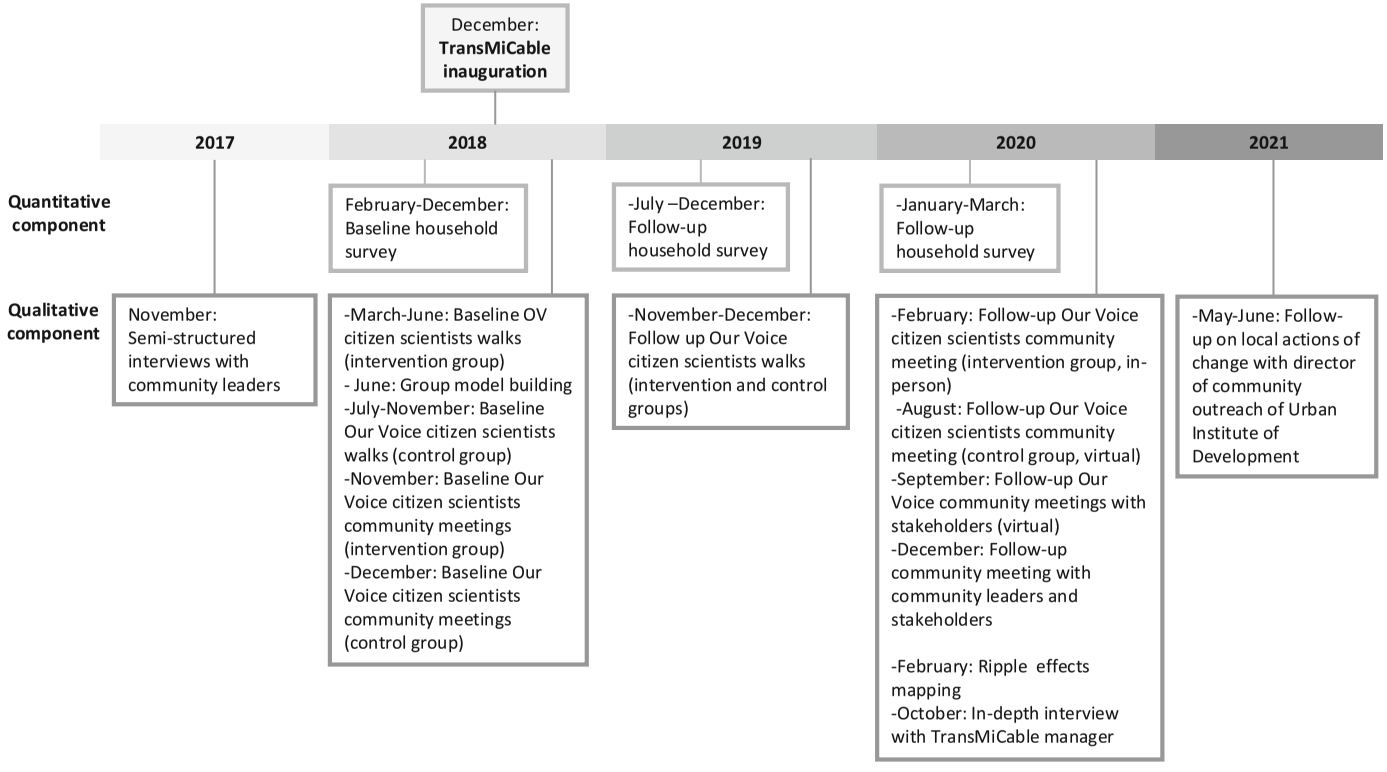

Fig. 14.2 Mixed methods approach: timeline of quantitative and qualitative data collection for the TrUST study 2017–2021

community leaders, who had already taken part in the citizen science data collection in the intervention area. First, participants were divided into groups of two and interviewed each other using a questionnaire reflecting the interview component of Ripple Effects Mapping. Next, each participant reported the insights expressed during their interviews to the larger group. One researcher asked questions to deepen the reports, and a recorder took note of each account using the XMind mind mapping tool (XMind, n.d.). Participants collectively organised their insights by themes, giving form to the mind map. The session was recorded and transcribed verbatim. Following the session, two researchers independently streamlined the map in XMind, regrouping the Ripple Effects Mapping themes using the Our Voice themes using a grounded theory and content analysis approach. The map was exported to Excel to obtain a final count of frequencies for each subtheme.

14.2.6 Integration of Quantitative and Qualitative Data

We used a simultaneous, bidirectional approach to integrate the various quantitative and qualitative data collected regarding effects per each assessed liveability domain (Moseholm & Fetters, 2017). Thus, quantitative and qualitative data were analysed separately and then merged for interpretation according to the liveability framework (Badland et al., 2014). First, researchers organized results in Excel, with liveability domains providing the framework for analysis. Second, through the comparison of liveability outcomes in Excel, we assessed the convergence, divergence, and complementarity of quantitative and qualitative data. Third, results were discussed and consolidated by the research team to drive final interpretation.

14.3 Results

Household survey results are summarised in Sect. 14.3.1. In Sect. 14.3.2, we describe the quantitative results of TransMiCable implementation on liveability outcomes. We present findings from the Our Voice citizen science process in Sect. 14.3.3, then summarize what the Ripple Effects Mapping exercise revealed in Sect. 14.3.4. The bidirectional integration of the quantitative and qualitative data is described in Sect. 14.3.5. Finally, outcomes from the participatory processes implemented throughout this study are presented in Sect. 14.3.6.

14.3.1 Household Survey Results

Overall, we had an 81.8% participant retention rate (1679/2052) (Table 14.2). Close to two thirds of participants were female, and their average age was 44. Most

participants had received at least a high school education. The monthly income in most households was less than two times the minimum wage in Colombia. Most participants were employed or homemakers, and approximately half of participants were married. Participants in the intervention and control areas reported spending on average 110 min and 89.9 min per commuting trip, respectively. Approximately 12% of residents reported using TransMiCable for mandatory trips, and 75% reported having used the cable car system at least once. On average, the intervention group had greater distances to travel to reach the BRT system. Both geographic areas of the study were characterized by hilly terrains, with high intersection density and low park density.

14.3.2 Effect of TransMiCable Implementation on Liveability Outcomes

When analysing levels of transport satisfaction, we observed a greater increase in the intervention group compared to the control group, though the increase continues to be low (5.4/10). Nevertheless, average satisfaction levels with TransMiCable was significantly higher (8.7/10).

After the implementation of TransMiCable, a greater decrease in neighbourhood barriers (lack of parks and sports centres, obstruction of squares, parks, sidewalks, and streets) in the intervention group was observed, as compared to the control group. However, improvements in perceptions of improper generation and handling of waste was higher in the control group as compared to the intervention group. Trust in public institutions increased in the intervention group as compared to the control group, but participation in community organizations decreased in the intervention group compared to the control group. A reduction in the percent change of perceived insecurity and victimization was higher in the intervention as compared to the control group (Table 14.3).

14.3.3 Our Voice Citizen Science Results

A total of 54 citizen scientists with an average age of 50.1 (SD = 14.6) took part in the citizen science method. Fifty five percent were women and 40% were community leaders. The citizen scientists collected a total of 600 photographs and 920 audio narratives, recording both barriers and facilitators to liveability. After the implementation of TransMiCable, the main liveability indicators that emerged as facilitators were neighbourhood aesthetics, TransMiCable transport system, community pride and travel time (Table 14.4). The main liveability indicators reported as barriers after the urban intervention were road and sidewalk quality, neighbourhood aesthetics, travel time, and management of garbage and debris. Regarding the feasible action

Table 14.3 Effect of the implementation of TransMiCable on liveability indicators including neighbourhood characteristics, crime, and satisfaction with transport. TrUST study 2017–2021

	Ciudad Bolivar Intervention (N = 825)						San Cristobal Control (N = 854)						Crude DID	AdjustedDID	95%CI	p[a]
	Baseline		Follow-up		Change	p	Baseline		Follow-up		Change	p				
Transport and neighbourhood satisfaction[b]	**Mean (SD)**		**Mean (SD)**				**Mean (SD)**		**Mean (SD)**				**Beta**	**Beta^**	**95%CI**	**p[a]**
Public transport satisfaction	4.36 (2.55)		5.38 (2.59)		1.02	<0.001	4.15 (2.51)		4.39 (2.48)		0.24	0.041	0.78	0.79	(0.52;1.06)	<0.001
TransMiCable satisfaction	NA		8.72 (1.73)		NA		NA									
Neighbourhood satisfaction	7.04 (2.28)		7.31 (2.08)		0.27	0.049	7.30 (2.08)		7.46 (2.11)		0.16	0.065	0.11	0.12	(−0.09;0.33)	0.278
Neighbourhood characteristics[c]	**N**	**%**	**N**	**%**	**%**		**N**	**%**	**N**	**%**	**%**		**OR**	**Or^**		
Lack of parks and/or sports centres	632	76.61	531	64.36	−12.25	<0.001	533	62.41	528	61.83	−0.58	0.803	0.46	0.46	(0.33;0.65)	<0.001
Obstruction of squares and parks	227	27.52	218	26.42	−1.10	0.618	143	16.74	185	21.66	4.92	0.01	0.63	0.62	(0.43;0.90)	0.011
Obstruction of sidewalks and streets	339	41.09	330	40.00	−1.09	0.652	240	28.10	267	31.26	3.16	0.153	0.75	0.76	(0.54;1.07)	0.115
Improper waste management	657	79.64	640	77.58	−2.06	0.307	664	77.75	563	65.93	−11.82	<0.001	1.85	1.84	(1.28;2.65)	0.001
Presence of insects, rodents	592	71.76	525	63.64	−8.12	<0.001	449	52.58	413	48.36	−4.22	0.081	0.76	0.76	(0.55;1.06)	0.112
Bad doors	627	76.00	593	71.88	−4.12	0.057	473	55.39	422	49.41	−5.98	0.013	1.05	1.05	(0.74;1.49)	0.774
Air pollution	561	68.00	565	68.48	0.48	0.832	489	57.26	460	53.86	−3.40	0.158	1.27	1.28	(0.90;1.80)	0.165

(continued)

Table 14.3 (continued)

	Ciudad Bolivar Intervention (N = 825)						San Cristobal Control (N = 854)						Crude DID	AdjustedDID	95%CI	p[a]
	Baseline		Follow-up		Change	p	Baseline		Follow-up		Change	p				
Social cohesion and local democracy																
Participation in organizations advocating for transport	54	6.55	29	3.52	−3.03	0.005	35	4.10	51	5.97	1.87	0.077	0.29	0.30	(0.15;0.60)	0.001
Participation in other community organizations	72	8.73	53	6.42	−2.31	0.077	37	4.33	66	7.73	3.40	0.003	0.32	0.32	(0.17;0.60)	<0.001
Trust towards public institutions	107	12.97	138	16.73	3.76	0.032	182	21.31	133	15.57	−5.74	0.002	2.33	2.34	(1.55;3.54)	<0.001
Security																
Victimization[d]	313	37.94	173	20.97	−16.97	<0.001	229	26.81	187	21.90	−4.91	0.018	0.48	0.48	(0.34;0.69)	<0.001
Perceived insecurity[c]	718	87.03	671	81.33	−5.70	0.002	733	85.71	712	83.37	−2.34	0.181	0.72	0.72	(0.46;1.10)	0.135

[a]p value of the Difference-in-difference (DID) method adjusting for age, sex, occupation, marital status, and distance to bus rapid transit
[b]1–10 satisfaction scales, (1 = Extremely unsatisfied, 10 = Extremely satisfied)
[c] Participants were asked whether they identified (yes/no) these neighbourhood characteristics as barriers
[d]The question for victimization was: have you or any member of your household been a victim of robbery in the last 12 months?
Satisfaction levels with transport, with TransMiCable, and with neighbourhood were measure on 1–10 scale
SD: Standard deviation
NA: Satisfaction with TransMiCable only applies to follow-up period for the intervention group

Table 14.4 Our Voice results on neighbourhood liveability indicators identified by citizen scientists ranked by total frequency comparing baseline and follow up, intervention and control group. TrUST study 2017–2021

	Ranking of prioritized themes	Liveability facilitators	Liveability barriers	Exemplar photograph	Exemplar commentary
Ciudad Bolivar Intervention					
T0	1	Community networks	Perceived security	Perceived security, prioritized liveability barrier (Intervention, T0) 	"The police station is far away, so we are under- protected in our neighbourhood. (...) If there were an incident on these streets, like a fight or robbery, the police would arrive an hour or two later." – Male citizen scientist
	2	Quality and use of public parks	Use of psychoactive drugs		
	3	Educational institutions	Garbage and debris management		
	4	Use of public space	Quality and use of public parks		
	5	Community centres	Road and sidewalk quality		
T1	1	Neighbourhood aesthetics	Road and sidewalk quality	Neighbourhood aesthetics, prioritized liveability facilitator (Intervention, T1) 	"I took the photo because this is a very beautiful landscape, [the neighbourhood] looks big and the TransMiCable is very nice. In addition, the houses are painted very nicely and inside the cabins it is also very nice, [it is a] more relaxed and secure [environment]". – Female citizen scientist
	2	TransMiCable	Neighbourhood aesthetics		
	3	Community pride on their neighbourhood	Travel time		
	4	Travel time	Garbage and debris management		
	5	Access to public services	Housing quality		

(continued)

Table 14.4 (continued)

	Ranking of prioritized themes	Liveability facilitators	Liveability barriers	Exemplar photograph	Exemplar commentary
San Cristobal Control					
T0	1	Public transport availability	Road and sidewalk quality	Road and sidewalk quality, prioritized liveability barrier (Control, T0) 	"As you may see [in this photograph], the pavement, and streets are very deteriorated. Nobody cares about us (...) a year ago we, as neighbours, submitted a request [to the government] to fix the roads, so far nobody has answered." – Female citizen scientist
	2	Churches and parishes	Garbage and debris management		
	3	Community pride on their neighbourhood	Frequency of public transport buses		
	4	Educational institutions	Street damage due to vehicular traffic		
	5	Physical activity	Perceived security		
T1	1	Quality and use of parks	Road and sidewalk quality	Quality and use of parks, prioritized liveability facilitator (Control, T1) 	"I am happy for my neighbourhood, seeing how the main park has changed. Before it was a bit abandoned, now we have equipment in good condition, we can see that the [soccer] field is painted very nicely. I am happy to see progress in my neighbourhood and that the government is truly contributing with works that benefit all the inhabitants of this sector." – Male citizen scientist
	2	Road and sidewalk quality	Garbage and debris management		
	3	Community pride on their neighbourhood	Perceived security		
	4	Educational institutions	Use of public space		
	5	Local businesses	Perception of state presence		

Liveability indicators identified by citizen scientists using Our Voice mobile phone app ranked by total frequency. Exemplar photographs of the prioritized themes with their commentary associated

steps proposed by citizen scientists and policymakers to continue improving liveability, were discussed placemaking strategies fostered by community-based physical activity promotion in public spaces.

14.3.4 The Ripple Effects Mapping Results

Nine community leaders in different neighbourhoods in the TransMiCable area of influence mapped-out outcomes of the intervention into three main themes: social capital, mobility, and security (Fig. 14.3). Among the social capital outcomes, participants emphasized that much of Ciudad Bolívar is no longer isolated and no longer so stigmatized. Residents also expressed that the TransMiCable project had encouraged the sense of pride in their neighbourhood, has motivated other people to visit the area, and has changed people's perceptions of the neighbourhoods and helped expand community networks. Among mobility outcomes, residents particularly welcomed a decrease in travel time and an increase in free time. Participants were conscious of an improvement in civic culture among users of TransMiCable, but complained of high fares, overcrowding, and poor signage. Among the security outcomes, residents recognised that another hospital, another police station, and another public services office were needed as part of the ongoing urban transformation to improve state presence and liveability.

14.3.5 Integration of Quantitative and Qualitative Data

The integration of the various quantitative and qualitative data allowed us to understand the variety and the depth of the impacts of TransMiCable on liveability. Table 14.5 presents complementary findings across liveability domains, including: transport; public open space; social cohesion and local democracy; and security; indicating whether the various data were convergent, divergent, or complementary.

14.3.5.1 Transport

The reduction in travel time was the main positive impact of the TransMiCable intervention in the transport liveability domain, and the various travel time data were convergent: the household survey, the Our Voice citizen science component, and the Ripple Effects Mapping all suggested that travel time had improved (Table 14.5). In addition, regarding satisfaction with public transport we observed complimentary findings: when interpreting the survey results in the light of the qualitative reports, we observed that although satisfaction with the TransMiCable contributed to increase the satisfaction with the transport system, disconformity with transport affordability was expressed.

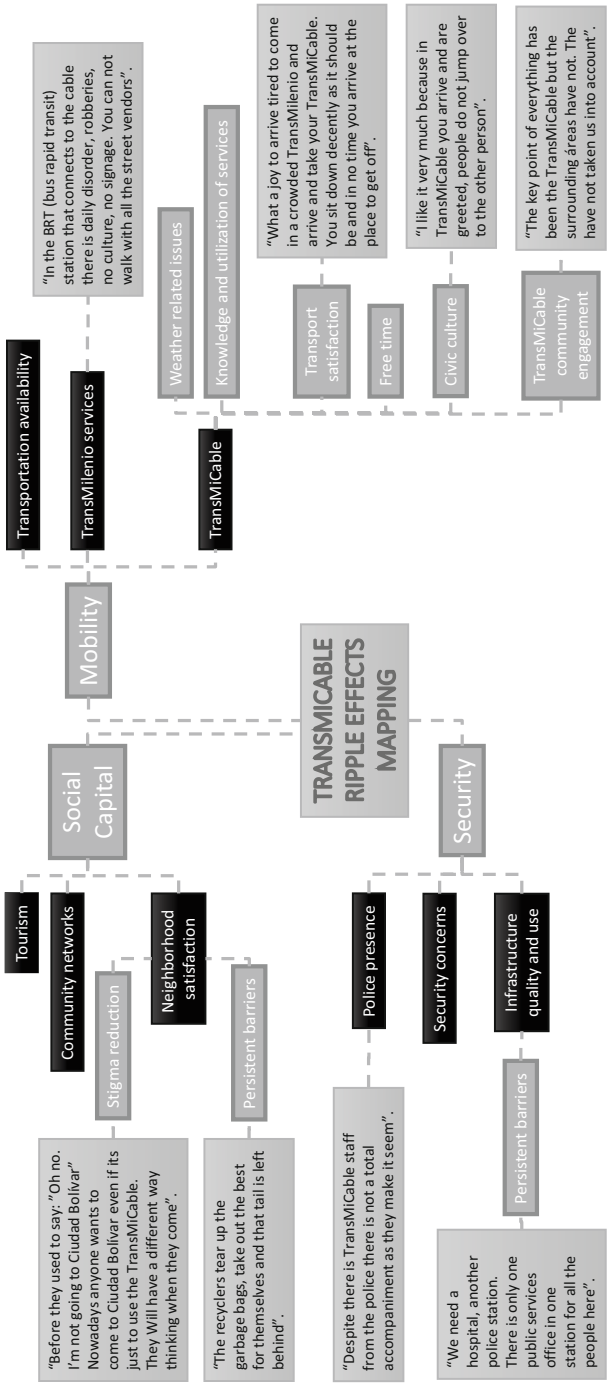

Fig. 14.3 Neighbourhood liveability outcomes identified by citizen scientists from the intervention area with Ripple Effects Mapping technique. The TrUST study 2017–2021

Table 14.5 Integration of quantitative and qualitative results according to liveability domains for the TrUST study (2017–2021)

	Quantitative component		Qualitative component				Integration of findings	
	Household survey		Our Voice citizen science method		Ripple Effects Mapping		Convergence; divergence; complementarity	
Liveability domain	Indicator	Ciudad Bolivar Intervention outcomes	Theme	Description	Theme	Description	Type	Conclusions
Transport	Travel time (min)	Reduced travel time in mandatory trips (T0 = 110 min; T1 = 90 min; P < 0.001)	Travel time	Reports of time savings after the intervention: *"My wife saves time in going from the station up to here. She saves 50 minutes compared to the bus that she took before the cable. That is the best, where she has time left to share with the family and me. Being together, do what you do at home, that is priceless"*	Travel time	Reports of time savings after the implementation of TransMiCable	Convergent	Results show improvements in objective and perceived travel time

(continued)

Table 14.5 (continued)

Liveability domain	Quantitative component		Qualitative component				Integration of findings	
	Household survey		Our Voice citizen science method		Ripple Effects Mapping		Convergence; divergence; complementarity	
	Indicator	Ciudad Bolivar Intervention outcomes	Theme	Description	Theme	Description	Type	Conclusions
	Transport satisfaction score[a]	Increased satisfaction with transport system (T0 = 4.36; T1 = 5.38; P < 0.001)	Satisfaction with TransMiCable transport system	Reports of satisfaction with TransMiCable: *"TransMiCable provides us with an excellent service because in the cabins, everyone can sit comfortably in their own seat without the risk of being robbed"*	Transport satisfaction	Reports of satisfaction with the transport system	Complementary	Although satisfaction with the transport system increased, disconformity with transport affordability was expressed.
					Transport affordability	Reports of disconformity regarding the transport system fares		
		TransMiCable satisfaction (T1 = 8.72)			TransMiCable	Reports of satisfaction with TransMiCable	Convergent	Results indicate satisfaction with TransMiCable
Public open space	Access to parks and/or sports centres	Perception of lack of parks and/or sports centres decreased (T0 = 76.6% to T1 = 64.4%; P < 0.001)	Parks	Reports of how insecurity and drug use limit the use of parks: "*If even these newly installed stair rods are already being stolen...so much work has been put into it, well that makes you sad because that*	Theme did not emerge		Complementary	Results from the survey indicate increased parks' availability however, participants also reported that parks are perceived as unsafe places not being properly used.
	Access to squares and parks	Perceived invasion of squares and parks decreased (T0 = 27.52%						

		to T1 = 26.42%; P = 0.011)		*is for the neighbourhood improvement, so that it looks nice for you, (...) there are several new games for the children, that is great for recreation but on the other hand, there are damaged people who come and steal and damage the [park's] equipment."*			
	Access to sidewalks and streets	Perceived obstruction of sidewalks and streets did not change (T0 = 41.09% to T1 = 40.00%; P = 0.109)	Roads and sidewalks	Reports of bad quality of roads and sidewalks: *"This is the state of the roads, completely impassable, causing accidents and we are realizing it. We would also like you to collaborate with us here with the sewage system because as this road is, all the roads in*	Theme did not emerge	Divergent	Despite the results from the survey indicate decreased obstruction of streets, sidewalks, parks and squares, participants also reported the persistent bad quality of roads and sidewalks.

(continued)

Table 14.5 (continued)

	Quantitative component		Qualitative component				Integration of findings	
	Household survey		Our Voice citizen science method		Ripple Effects Mapping		Convergence; divergence; complementarity	
Liveability domain	Indicator	Ciudad Bolivar Intervention outcomes	Theme	Description	Theme	Description	Type	Conclusions
				our neighbourhood are, which is very harmful to health because the sewage runs over the streets and this terribly affects health and traffic of vehicles. So this is also a big inconvenience and very detrimental to the health of all the inhabitants, bringing us a lot of contamination from retained water, mosquitoes, flu viruses."				

	Improper waste management	Perceived improper management of waste decreased (T0 = 79.64% to T1 = 77.58%; P = 0.001)	Garbage and debris management	Reports of poor garbage management in the neighbourhood: *"Garbage pollution in our neighbourhood is a critical issue, we observe people take out the garbage on the wrong day, when there are no garbage collectors, and because of that we have rodents, we have dogs that break bags, we have recyclers that make more mess. Because of this we have more pollution and health issues every day."*	Theme did not emerge	Divergent	Although the perception of improper waste management decreased, it was still reported as a persistent barrier to liveability.

(continued)

Table 14.5 (continued)

	Quantitative component		Qualitative component				Integration of findings	
	Household survey		Our Voice citizen science method		Ripple Effects Mapping		Convergence; divergence; complementarity	
Liveability domain	Indicator	Ciudad Bolivar Intervention outcomes	Theme	Description	Theme	Description	Type	Conclusions
Social cohesion and local democracy	Neighbourhood satisfaction	Overall Neighbourhood satisfaction did not change	Neighbourhood aesthetics	Reports of satisfaction with the neighbourhood after the TransMiCable urban transformation: *"All these paintings and murals you see are "the route of Hope" which made a beautification in the environment."*	Neighbourhood satisfaction	Reports of satisfaction with the neighbourhood after the intervention	Complementary	Results indicate increased neighbourhood satisfaction and reduced perceived social stigma.
					Neighbourhood stigma reduction	Reports of perceived decrease in segregation and discrimination		
	Participation in community organizations advocating for transport	Participation in community organizations for transportation decreased (T0 = 6.55%; T1 = 3.52%; P = 0.001)	Community networks	Reports of ongoing community networks and organization: *"The social leaders from the beginning participated actively, attended all the meetings, and*	Community networks	Reports of the ongoing community relations and organization	Complementary	Results indicate improvements in citizens' relationships among themselves and with local institutions.
	Institutional trust	Trust towards institutions			Civic culture	Reports of positive		

		increased (T0 = 12.97%; T1 = 16.73%; P = <0.001)		*evaluated and valued what we did. (...) it is theirs, this project is theirs, and it is an example to follow".*		behavioural change and civic culture in TransMiCable		
Security	Crimes against the person	Victimization decreased (T0 = 37.94% to T1 = 20.97%; P < 0.001)	Security perception	Reports of perceived insecurity in public spaces: *"Security has improved. You feel safe in the cable car cabins. But when you go out, it is a different story. So, we have to keep improving"*	Security concerns	Reports of perceived insecurity in public spaces	Complementary	Results indicate improvements in objective and perception-based measures of security. Although perceived insecurity decreased, insecurity is a persistent barrier in the area.
	Perceived security	Perceived insecurity did not change (T0 = 87.03% to T1 = 81.33%; P = 0.118)			Security at TransMiCable	Reports of perceived security within TransMiCable facilities		
					Police presence	Reports of the absence of the police in the neighbourhood		

[a]Satisfaction levels with transport, with TransMiCable, and with neighbourhood were measure on 1–10 scale

It is true happiness to arrive very tired, coming from an uncomfortable TransMilenio, to take the TransMiCable. There you go sitting down, decently, as it should be, and in a blinking, you already reached the place to get off. -Citizen scientist.

14.3.5.2 Public Open Space

Quantitative and qualitative results were complimentary, indicating both increased access to and limited satisfaction with public open space. The household survey showed that parks and recreational facilities had become more accessible, but the Our Voice citizen science component, while not contradicting this, showed that parks were regarded as unsafe places. Similarly, despite the results from the survey indicating decreases on improper waste management and on the obstruction of streets, sidewalks, parks and squares, participants reported poor garbage management and bad quality of roads and sidewalks as persistent barriers to liveability in the neighbourhood.

I like this park, it turned out very nice, but unfortunately people here don't take care of it and I, for example, as a park user, I would like them to put about two guards in the park for more security and surveillance. -Citizen scientist.

14.3.5.3 Social Cohesion and Local Democracy

We observed complementary findings evidencing improvements in citizens' relationships amongst themselves and with local institutions. The most prominent effect on social cohesion and local democracy domain reflected in the qualitative results was the reduced perceived neighbourhood social stigma. Additionally, according to the quantitative results, after the implementation of TransMiCable trust towards institutions increased and participation in community organizations advocating for better transport decreased. However, overall neighbourhood satisfaction did not change (Table 14.5). Complementing these quantitative results, the qualitative assessment revealed ongoing and strong community organization as a perceived key factor enabling and sustaining urban transformation. Positive behavioural change in the transport environment related to the civic culture promoted in the TransMiCable was also highlighted.

We are more united since TransMiCable arrived here. People have been encouraged to buy and come to live here. TransMiCable has been a good boost for people in our neighbourhood to feel happy and proud, and our community grows every day. But why does TransMiCable help people to come more? Because it is faster, people no longer fear coming here, being late at work, or arriving home early. -Citizen scientist.

14.3.5.4 Security

We observed complementary findings indicating improvements in security. Quantitative results showed reductions in victimization following the intervention. Additionally, the Our Voice citizen science and Ripple Effects Mapping included

reports of improved security while using TransMiCable. However, insecurity was highlighted as a persistent barrier to liveability.

Security has improved. You feel safe in the cabins. But when you go out, it is a different story. So, we must keep improving. -Citizen scientist.

14.3.6 Outcomes from the Participatory Process

The participatory process of this study served as an opportunity to contribute to the local advocacy process to improve liveability. Following the actions after community meetings in the Our Voice method, citizen scientists emphasized emerging collaboration and exchange of experiences among community leaders from control and intervention areas. Citizen scientists from the intervention area recommended that leaders from the control group establish effective institutional communication channels for the implementation of the next cable car. Additionally, citizen scientists mapped out ideas with the District Institute of Recreation and Sports representatives to continue promoting physical activity for the children, the elderly, and women, such as dance classes and hiking groups. In fact, community-based physical activity sessions guided by a publicly funded instructor take place every Thursday (7:30 a 9: 30 am) and Saturday (9 a 11 am) morning.

Diverse stakeholders highlighted TransMiCable as an exemplar integral urban transformation based on community engagement and ownership. Policymakers underscored that TransMiCable was possible thanks to the community's active, patient, and persistent participation that allowed them to overcome changes through different administrations, in addition to the continued efforts by local government institutions to develop an intervention based on civic engagement and cross-sectoral working groups. In fact, the project nourished and leveraged the city-level "Policy of social management and service to citizens", which posits the city as a built habitat planned for human enjoyment to guarantee the rights to equity, affirming community inclusion and involvement in urban transformation projects (Instituto de Desarrollo Urbano, 2021).

Stakeholders stressed the importance of this comprehensive study uncovering the multiple dimensions of liveability potentially impacted by the intervention. Stakeholders reported incorporating research in their policy practice, reported that environmental features evaluated by citizen scientists were essential to acknowledging potential effects of urban interventions not previously considered: (1) the TransMiCable manager highlighted the importance of collecting data from a public health perspective; (2) the Secretary of Women found great interest in transport-related data focused on women and the possibility of understanding the gender-based differential experience in public transport; (3) the Secretary of Mobility expressed interest in continuing data collection activities that demonstrate the impact of transport interventions on access to quality employment. Overall, transportation was underlined as a means of promoting inclusive and integral development at the neighbourhood level.

TransMiCable generated an impact on public servants, which is not written anywhere. They now recognize that citizen participation is legitimate and valuable. Undoubtedly, the community-engaged urban development is a victory for both citizens and the institutions. -Policymaker.

Sixteen months following the study, twenty-two stakeholders from the Urban Planning Secretariat participated in a 40-h course facilitated by the research team aimed at building capacities for mixed-methods impact evaluation. The research team also initiated the impact evaluation of the Care Block public program, which was developed in conjunction with TransMiCable. Built next to a TransMiCable station, the Care Block offers caregivers education, psychosocial support, physical activity, and recreation opportunities while providing care for their dependents.

14.4 Discussion

This study sought to evaluate the impacts of the TransMiCable cable car project on liveability in the neighbourhoods of Ciudad Bolívar in Bogotá, Colombia. By engaging community members and stakeholders and applying a mixed methods approach oriented by a liveability framework, this study revealed that TransMiCable contributed to the ongoing transformation of Ciudad Bolívar neighbourhoods and to efforts to increase wellbeing among residents. Positive impacts included shorter travel times, increased satisfaction with public transport, increased access to parks and sports centres, perceived reduction in the neighbourhood's social stigma, and decreased perception of insecurity. In addition, the participatory process allowed residents to identify local priorities and make recommendations to policymakers and community leaders. Policymakers emphasized the importance of evidence generated by this study regarding the impact of transport and urban interventions on liveability and health, and for informing future proposals and interventions to further improve liveability.

To-date, most liveability indicators have been developed and proposed from a 'global north' perspective (Badland et al., 2014). To the best of our knowledge, the present study is the first evaluation of a transport system in Latin America to include a range of liveability indicators identified and selected to ensure relevance to the local community, policymakers, and other stakeholders. Cerdá et al. (2012) explored the impact of a cable car system in Medellín, Colombia, but their investigation was limited to criminal activity and perception of crime. Similarly, Garsous and colleagues (2019) assessed the impact of a cable car system in La Paz, Bolivia, but only focused on travel times. By applying a bidirectional approach to integrate the various quantitative and qualitative results for each liveability domain, our findings highlight the relevance of intersectoral liveability indicators amongst underserved urban areas in Latin America. In particular, the participatory approach shed light on a relevant

yet unexpected liveability outcome: impacts on neighbourhood social stigma. Policymakers again indicated the importance of having evidence of the multiple impacts of a transport intervention, beyond the transport domain of urban liveability.

By employing the Our Voice citizen science method, our study provides real-world understanding of the perceived effects of a community-informed transport intervention. We found the Our Voice method to be valuable for conducting an urban and transport transformation evaluation, because it contributed to collectively discussing local liveability needs, developing locally relevant liveability indicators, and engaging communities to monitor the progress of local urban planning policies from an urban health perspective. Improvements in travel time, access to parks, community pride, and perceived security were acknowledged as health supporting factors by residents and policymakers. Of note, the participatory process enabled additional opportunities for the collaborative placemaking among community leaders, researchers, and policymakers.

The results of the present study have important implications for policy and practice in Latin America. Sarmiento et al. (2021) investigated the urban landscapes of 370 cities in Latin American and found that many were overcrowded, with high street density and high intersection density. Duque et al. (2019) investigated the topography of 919 cites in Latin America and the Caribbean and found that many were located on steep slopes. Within this context, traveling as the crow flies in cables cars is often be the only viable solution to rehousing people and building roads (Guevara-Aladino et al., 2022). Furthermore, this population depends on public transport as their main mode of transport. Our study provides evidence that cable car integral interventions are acceptable to residents in part due to their ripple effects on liveability, beyond their value for transport. Our study also suggests that residents and policy makers can work together to implement and evaluate cable car interventions and to create more liveable neighbourhoods.

The integrated application of quantitative and qualitative methods and the application of a culturally sensitive and interdisciplinary approach represent core strengths of this study. However, the COVID-19 pandemic posed important challenges to the participatory approach and resulted in some amount of attrition. Participant dropout over time from the household survey and Our Voice method presents difficulties. Nevertheless, the household survey had a response rate of over 80%. Despite the attrition observed during the Our Voice phases, participants were able to reach a consensus surrounding central ideas and activities, underscoring that a relatively small number of highly engaged community members can sustain effective inter-institutional and community dialogue and ultimately drive environmental change. In 2020, the COVID-19 pandemic created challenges and delays for both community meetings with stakeholders and for study dissemination. In response, analysis and dissemination of results were implemented virtually as allowed by study phases. Most importantly, intersectoral dialogue was maintained via virtual calls and social media.

14.5 Conclusions

Across this study, the voices of diverse sectors and stakeholders were convened in dialogue and joint workspaces, creating room for knowledge co-creation regarding the health and liveability impacts of an urban cable car system and associated urban transformations. The main impacts of TransMiCable include shorter travel times, increased satisfaction with public transport, increased access to parks and recreational facilities, perceived reduction in the neighbourhood's social stigma, and decreases in perceived insecurity. Lessons from TransMiCable can inform the design of urban interventions to promote more liveable cities, and for the development of participatory evaluation processes that effectively engage with local stakeholders to support successful and sustainable urban transformations.

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Ethics Statement All phases of the study were reviewed and approved by the ethics committee of the Universidad de los Andes (Acta No. 806-2017; Acta No. 977-2019; Acta No. 994-2019). Each of the participants provided written informed consent to participate in this study.

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