FACTORS AFFECTING THE ACCESSIBILITY AND APPEAL OF THE PUBLIC BIKE SHARE SYSTEM OF MEDELLIN, COLOMBIA

An Ethnographic Audit of EnCicla in El Poblado

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An Ethnographic Audit of EnCicla in El Poblado

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EXECUTIVE SUMMARY

EnCicla, the docked public bike share system of Medellín, has important operational and accessibility challenges in the commune of El Poblado that make the system less suitable and appealing to potential users, hindering the city's ability to leverage its public bike share system to reach important mode shift goals.

This report reviews significant factors and variables affecting the appeal and accessibility of EnCicla in El Poblado from a user's perspective; and analyzes stated barriers for bike sharing in the commune. These findings are contrasted to a comprehensive literature review about significant factors that affect the decision to bike share in different regions, including aspects of safety, convenience, infrastructure, individual habits, and costs, among other factors.

The study was based on a three-pronged research approach that incorporated (i) a user-based bike audit of all stations and bikeway corridors in this section of the system; (ii) short-intercept interviews of bike share users and non-users to capture aspects of user satisfaction and non-user perspectives; and (iii) expert feedback from key members of the municipality, the metropolitan authority, and transportation agencies involved with EnCicla.

Research results indicate there are significant factors that undermine EnCicla's usage in this section of the system, albeit important assets that support bike share use in this area. Some of the factors found to support bike sharing in El Poblado include: (i) station proximity to transit, open space areas, and destination nodes; (ii) the presence of a protected bikeway infrastructure adjacent to main roads; and (iii) other supporting amenities like street furniture and landscaping.

Notwithstanding these assets, this study revealed that at critical times bikes and docks are often unavailable at key stations, areas of the neighborhood suitable for cycling are difficult to reach through the bike share system, nearby open space areas are not contiguous, and the protected bikeway infrastructure is incomplete or inadequate in some segments.

This study also revealed a distinct characterization of bike share users in El Poblado through the analysis of user perceptions. Supported users in the commune tend to be male blue-collar workers between twenty and forty years old, while women, students, and users over fifty years old appear to be using the system with less frequency. This has significant implications for this section of the system in terms of equity and accessibility, and for achieving broader city goals

like mode shift and pollution abatement.

In terms of user satisfaction and user perceptions, it was found that constraints that typically affect usage and accessibility to bike sharing, had little effect on current users' positive attitudes towards EnCicla. Some of the EnCicla limitations cited by users included lack of protected bikeways and protected intersections, erratic motorist behavior, and bikeway invasion by pedestrians and motorists. Nevertheless, for the EnCicla members interviewed, the system was considered useful and reliable, and their negative perceptions about the bike sharing experience were mostly overridden by the fact that the system was free of user charges, easy to use, and the bikes were considered accessible to most ages and abilities.

Founded on equity principles based on Medellin's brand of social urbanism, EnCicla is free to all users, but it doesn't support all users equally. EnCicla's emphasis on providing access to low-income residents of the city has helped institutionalize a lengthy and cumbersome pre-registration process that excludes not just higher income individuals or tourists, but also low-income individuals with limited access to information- and limited time to complete the signup process.

For non-users of the system, it was found that lengthy pre-registration is the most significant barrier for signing up to EnCicla, followed by lack of knowledge about EnCicla and bike sharing, and owning a bike: Most non-users stated preference for personally-owned or borrowed bikes for completing occasional commute or leisure trips. Significantly, many non-users reported not to be interested in bike sharing or cycling, preferring other modes of commute, especially driving an automobile.

EnCicla's emphasis on providing accessibility mainly to lower income workers is perpetuating urban cycling paradigms in Medellin: Lower-income individuals cycle for commute as they cannot afford other modes, higher income individuals cycle mostly for leisure using their own bikes, while women and the elderly are safer on sheltered modes.

To break these paradigms and help achieve greater benefits from bike share in El Poblado, this report suggests adopting a more comprehensive approach to social equity by making the system more accessible to a wider range of users, from signup to drop-off.

This report provides recommendations that could help make EnCicla more appealing and accessible to potential users in El Poblado, including: (i) streamlining the signup process and integration to other modes; (ii) further developing connectivity to the Metro and other destinations suitable for bike share in El Poblado; and (iii) promoting cycling corridors within calmer residential pockets, by improving the micro-environmental conditions for cycling

through neighborhood streets. Furthermore, this report recommends reviewing non-supporting auto-centric land-use planning practices in El Poblado, in favor of a user-centered bike and pedestrian connectivity approach for the commune.

PROLOGUE

Twenty-five years ago, Medellín was the epicenter of one of the most infamous urban drug wars in history, and it was considered one of the most dangerous cities in the world.[1] Residents flee to other cities or left the country entirely, and those that decided to stay or could not leave, were barricaded in their workplaces and homes; hoping that a bomb would not hit near them, and that by the end of the day, they will still be alive. These are my distant memories of the city.

Today and looking from afar, Medellín is a city with a booming economy, with abundant inclusive public spaces, and a state-of-the-art public transportation system.[2] This drastic urban transformation cannot be explained solely by the disintegration of the drug cartels. There was a concerted effort by the public administration and the private sector to experiment with urban-social interventions in the poorest areas of the city, that resulted in significant aesthetic changes and much improved public spaces and services.[3] It was the social urbanism that ensued the urban drug war that radically changed Medellín's core.

The term Social Urbanism was coined through the city's planning documents known as Proyectos Integrales Urbanos- PUI ("Integral Urban Projects"), to ascribe social justice objectives to the physical interventions that were taking place in the poorer neighborhoods of the city.[4] The PUI Plans were developed and implemented during the two-term administration of major Sergio Fajardo, a mathematics professor turned politician (2002-2010). Under Sergio Fajardo, Medellin's municipal administration became heavily guided by academia.[5] Most of Medellin's public documents from this time are full of rather complex terminology.[6] Some of

1. Douglas Farah, "Record Murder Waive Overwhelms Medellín," *The New York Times*, March 10, 1991, accessed November 2, 2019, https://www.washingtonpost.com/archive/politics/1991/03/10/record-murder-wave-overwhelms-medellin/5e7f1080-1ea0-46e8-bfef-1ab4df9d53d0/

2. Jason Corburn et al, "The Transformation of Medellín into a City for Life: Insights for Healthy Cities," *Cities and Health*, April 29, 2019.

3. Monica Ines Guerra, "Regulating Neglect: Territory, Planning, and Social Transformation in Medellín," PhD dissertation, University of California, Berkeley, Spring 2014.

4. Ibid.

5. Alcaldía de Medellín, "Plan de Desarrollo 2004-2007," accessed April 22, 2018. https://www.medellin.gov.co/irj/go/km/docs/pccdesign/SubportaldelCiudadano_2/PlandeDesarrollo_0_0_0/Shared%20Content/pdf%20codigo%20buen%20comienzo/Texto%20Completo%20Acuerdo%20Plan.pdf.

6. Alcaldía de Medellín y Empresa de Desarrollo Urbano (EDU), "Proyectos Urbanos Integrales," accessed April 22, 2018, http://proyectosurbanosintegrales.blogspot.com/p/que-es-el-pui.html.

the terms loosely used before, like social urbanism, became mainstream, commonly used by scholars, organizations, and the media.[7] Medellin's urban transformation stem from the PUI Plans, from where Social Urbanism ultimately became a subject of analysis.[8]

The public bike share system of Medellín is a product of social urbanism and cannot be fully understood outside this context. This prologue explores how social urbanism shaped Medellín to become the city it is today.

Social urbanism and the metro culture of Medellín

Medellin is the second largest city in Colombia with a population of about 2.9 million people and an extended metropolitan area totaling close to 3.9 million inhabitants.[9] The city is located in the center of the Aburrá Valley at 4,900 feet above sea level in the Central Andes, with an average year-long temperature of 75.2°F, earning it the nickname of "city of eternal spring."[10]

The extended metropolitan area of Medellin includes ten municipalities, with Medellin at the center core, as shown in Figure 3. The main metropolitan authority is the Area Metropolitana del Valle de Aburrá, hereafter Metropol, which is in charge of all land use, transportation, and environmental planning for the entire region.[11]

Medellin's Metro is the backbone of the city's mass transit system, and arguably the maximum expression of social urbanism. The Metro Company was established in 1979, but it wasn't until 1995 that the first Metro line was inaugurated. By 2004, the system already included one of the first famous gondola lines that connected the marginalized poor to the city's main transport hubs.[12]

7. Jared Green, "Medellín is Healing Itself with Social Urbanism," *The Dirt*, November 28, 2018, accessed November 2, 2019,https://dirt.asla.org/2018/11/28/medellin-is-healing-itself-with-social-urbanism/

8. Monica Ines Guerra, "Regulating Neglect: Territory, Planning, and Social Transformation in Medellín," PhD dissertation, University of California, Berkeley, Spring 2014.

9. Alcaldía de Medellín, "Documento técnico de soporte POT. Medellín y su población," accessed May 17, 2018, https://www.medellin.gov.co/irj/go/km/docs/wpccontent/Sites/Subportal%20del%20Ciudadano/Plan%20de%20Desarrollo/Secciones/Información%20General/Documentos/POT/medellinPoblacion.pdf

10. Medellín Como Vamos, "La Ciudad," accessed May 18, 2018. https://www.medellincomovamos.org/la-ciudad-2/

11. Área Metropolitana, "Objetivos y Funciones," accessed September 9, 2018, http://www.metropol.gov.co/institucional/Paginas/objetivosyfunciones.aspx.

12. Empresa de Transporte Masivo del Valle de Aburrá, "Historia," accessed September 9, 2018, https://www.metrodemedellin.gov.co/quiénessomos/historia.

Figure 1. Medellín

One of the main features of Medellin's mass transit system is what has become widely known as the "Metro Culture." From its inception, the Metro Company and the city heavily invested in community-centered initiatives to promote the Metro as a reference point for Medellin; a place from where the city's "culture" could be reset. This evolved into a massive, multi-sector strategic effort to reinvent and rebrand Medellin after years of being perceived as the most dangerous city in the world. Under the Metro Culture, the system became an "instrument of civic transformation,"[13] a reference point for good behavior and civic engagement. According to architect/urbanist Peter Brand, the Metro and its surrounding urban projects were not just about improving infrastructure with better architecture to inspire communities, but about leveraging these projects as spaces of citizenship and democracy.[14] The Metro Culture has

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13. Mauricio Bejarano et al., "A user-centered assessment of a new bicycle sharing system in Medellin," *Transportation Research Part F: Traffic Psychology* 44 (2017): 145-158.

14. Peter Brand, "Governing inequality in the south through the Barcelona model: Social urbanism in Medellin, Colombia," Paper presented at the conference Interrogating Urban Crisis, De Montfort University, Leicester, UK,

expanded to the entire transportation system of Medellín, and represents the core of the city's values.
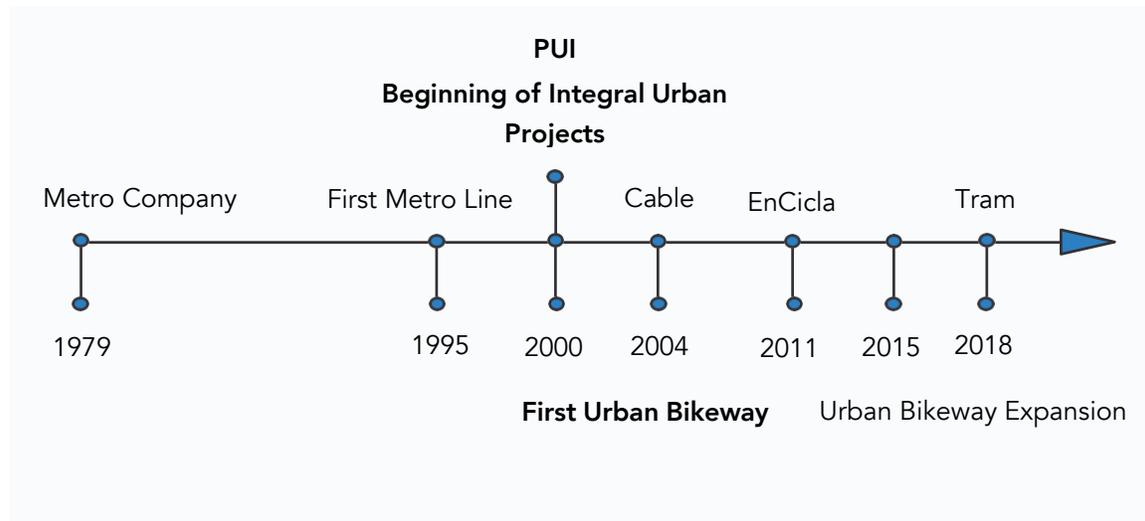
Figure 2. Transportation projects founded on social urbanism in Medellin

The roots of the equity-based transportation planning of Medellín

Medellin boasts a stable economy in the Latin American context, as it was the center of the Colombian coffee trade from the early 20th century, and the most important industrial center in the country from the 1950s.[15] Most recently, Medellin has swiftly shifted from being an industrial powerhouse to a tech powerhouse under a globally integrated knowledge/service economy.[16] However, Medellin's relative economic success in the region has been obscured by the city's brief but spectacular narco-terrorism past in the age of Pablo Escobar (the decade between 1983 and 1993 that ended with Escobar's death in a cinematic rooftop manhunt).

Medellin's epoch of narco-terrorism coincided with the displacement of entire rural communities due to the century-old guerilla conflict, which by then had expanded to the countryside of Colombia's major urban centers. These rural communities settled in the outskirts of Medellin and other major cities, forming large irregular settlements without access to basic

September 2013, accessed September 9, 2018, http://www.dmu.ac.uk/documents/business-and-law-documents/research/lgru/peterbrand.pdf.

15. Andres Sanchez, "The Reinvention of Medellin," Universidad de Antioquia, accessed May 18, 2018, http://aprendeenlinea.udea.edu.co/revistas/index.php/lecturasdeeconomia/article/view/15768/17867.

16. Dario Amar Florez, "International case studies of smart cities: Medellin, Colombia," Inter-American Development Bank, June 2016, accessed May 16, 2018, https://publications.iadb.org/handle/11319/7716.

municipal services or public transportation.[17] Pablo Escobar, having grown up in a city with abysmal income disparities, was arguably sensitive to the growing problem of the slums of Medellin, and made it his personal goal to improve the living conditions of the marginalized poor of the city.[18]

Figure 3. Medellín Metropolitan Area
Source: Adapted from Área Metropolitana del Valle de Aburrá, https://www.metropol.gov.co/

An argument to be made in this study is that Escobar's legacy as a community benefactor has a lot to do with Medellin's most recent urban transformation. The precursor of social urbanism in Medellín was probably Pablo Escobar's pet project "Medellin without slums," though this is

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17. The Economist (Eds.), "Medellin's Comeback: The Trouble with Miracles," *The Economist*, accessed May 18, 2018, https://www.economist.com/the-americas/2014/06/07/the-trouble-with-miracles.

18. Escobar's efforts were not entirely altruistic, as he relied on an expansive network of grateful residents to successfully hide him from authorities for years in the streets of Medellin (Pascual Gaviria 2012).

never highlighted in the city's official discourse.[19] Several revolutionizing attempts to "normalize" and improve the urban living conditions of marginalized neighborhoods in Medellín and other major urban centers in Colombia can be traced to the two decades between the 1960s and 1980s (the golden years of the Colombian guerrilla groups),[20] but Escobar's approach was perhaps the most effective and the one that remained in peoples' minds.[21] Escobar provided free homes to poor families by building an entire neighborhood with the population size of a small US city (called today "Pablo Escobar" in his honor). He also made significant improvements in existing slums including parks (mostly around soccer fields), lighting, and other community infrastructure projects.[22]

After Escobar's death, Medellin continued to suffer extreme violence for a decade as a result of the disintegration of the Medellin cartel. Beset by the remnants of drug violence, Medellin's residents have been supportive of a now official discourse of public investment in the marginalized poor areas of the city, as a way to tackle the roots of violence, crime, inequality, and socio-economic distress.[23]

Notwithstanding this turbulent past, Medellin's pattern of socioeconomic development has been determinant in the city's most recent re-invention as one of the most important innovation hubs in Latin America.[24] Today, the network of gondolas is one of Medellin's most iconic projects developed by the city to improve the living conditions of the poorest neighborhoods, including the one built by Pablo Escobar. These projects were conceived as socio-economic initiatives to address crime and inequality under the official umbrella of Proyectos Urbanos Integrales- PUI *(Integral Urban Projects,* the main metropolitan planning documents). Other iconic projects under the PUI include urban escalators, libraries, schools,

19. Alex Warnock-Smith, "Medellin's urban success story, two decades after Pablo Escobar," *The World Weekly*, May 19, 2016, accessed May 18, 2018, https://www.theworldweekly.com/reader/view/2780/medellins-urban-success-story-two-decades-after-pablo-escobar.

20. Lissete Martínez Zapata, "Tugurio de Dios: El barrio Lenin," *Estudios Políticos* 44 (2014): 221-241.

21. This endeavor seems to have served the multiple purpose of exculpating Escobar's sins; cultivating a political audience; and building up an army of forever grateful citizens that would hide and protect Escobar for years in the midst of an international manhunt that took place in the streets of Medellin (Warnock-Smith 2016).

22. Pascual Gaviria, "Medellín con Tugurios," *Centro Universo,* 32 (2012), accessed May 17, 2018, https://www.universocentro.com/NUMERO32/Medellincontugurios.aspx.

23. Alcaldía de Medellín y Empresa de Desarrollo Urbano (EDU), "Proyectos Urbanos Integrales," accessed April 22, 2018, http://proyectosurbanosintegrales.blogspot.com/p/que-es-el-pui.html; Alcaldía de Medellín, "Plan de Desarrollo 2004-2007," accessed April 22, 2018. https://www.medellin.gov.co/irj/go/km/docs/pccdesign/SubportaldelCiudadano_2/PlandeDesarrollo_0_0_0/Shared%20Content/pdf%20codigo%20buen%20comienzo/Texto%20Completo%20Acuerdo%20Plan.pdf.

24. Association Québécoise des Transport (AQTR): "Medellín on the road to becoming a knowledge economy," accessed May 18, 2018, https://aqtr.com/association/actualites/medellin-road-becoming-knowledge-economy.

shared streets, parks, and museums; all of them in or around marginalized areas of the city.[25]

Figure 4. Medellín's Metro Cable
Source: Image by Brodzinski 2014, The Guardian.

The government's mainstream discourse of social urbanism has evolved with the marked shift of Medellin's economic context from industrial to tech hub over the last fifteen years. As a result, from 2012 Medellin's urban public policies have been centered on developing smart city projects related to Information and Communication Technologies (ICT) and innovation centers, all under the Science, Technology and Innovation Master Plan known as *Ruta^n*.[26] Many projects that were planned during the PUI years were delayed because funding priorities shifted to the most recent tech-based plan (*Ruta^n*). Additionally, Medellin's Tram system, which was the most emblematic PUI project after 2012, was actually the most expensive public transit project planned under the PUI, draining the city's budget for "social infrastructure." Operated by Medellin's Metro company (*Metro de Medellin*), the Tram started circulating in 2015 with only one line and nine stops connecting underserved neighborhoods with the City center (about

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25. Alcaldía de Medellín y Empresa de Desarrollo Urbano (EDU). "Proyectos Urbanos Integrales," accessed April 22, 2018, http://proyectosurbanosintegrales.blogspot.com/p/que-es-el-pui.html; Alcadia de Medellín, Plan de Desarrollo 2004-2007, accessed April 22, 2018, https://www.medellin.gov.co/irj/go/km/docs/pccdesign/SubportaldelCiudadano_2/PlandeDesarrollo_0_0_0/Shared%20Content/pdf%20codigo%20buen%20comienzo/Texto%20Completo%20Acuerdo%20Plan.pdf.

26. Alcaldía de Medellín. Plan de Ciencia, Tecnología e Innovación de Medellín 2010-2021, prepared by Universidad del Rosario and EGADE, accessed April 22, 2018, https://www.rutanmedellin.org/images/programas/plan_cti/Documentos/Plan-de-CTi-de-Medellin.pdf.

9,000 people daily).[27]

Figure 5. Medellín's Tram
Source: Image by Eduardo Sánchez, *El Tiempo.*

Even though Medellin's current plans do not contemplate the type of public investments in marginalized areas of the city developed through the PUI years, the city has managed to continue to develop "integral urban projects" via civic engagement. One of the best examples of civic engagement for the advancement of social urbanism is the development of Medellin's public-private partnership agency in 2015 (right after the PUI plans were concluded), Agencia Para Las Alianzas Público-Privadas, APP. With the initiative and financial support of Medellin's private sector, this agency designs financial mechanisms and develops community-led urban improvement projects in marginalized through middle class neighborhoods in the city.

Additionally, the APP also develops projects prioritized through the city's land use planning instruments that otherwise have no secured funding. Currently, Medellin's APP is attached to the mayor's office, and has completed landscape projects, parks, schools, public restrooms, inter-modal public transit stations, green corridors, landmark restoration projects, and entire neighborhood plans for improving the public urban landscape of Medellin.[28]

27. Metro de Medellín, "Plan Maestro 2006-2030," accessed May 18, 2018, https://www.metrodemedellin.gov.co/portals/1/archivos_metro/proyectos/plan_maestro_metro_2006-2030.pdf.

28. Agencia Para Las Alianzas Público-Privadas, "Historia," accessed October 1, 2018, http://www.app.gov.co/

Left: Image developed by APP to elicit public input for the urban/economic improvement plan of the neighborhood El Prado. Below: Recently inaugurated Aures School in Comuna 7, a favela neighborhood at the periphery of the city.

Figure 6. PUI-like projects in Medellín developed through Private-Public Partnerships
Source: http://www.app.gov.co

Academia has also played a critical role to continue to advance PUI-like projects in Medellin. Through continued support of local universities, the city's urban development company, Empresa de Desarrollo Urbano (EDU), has developed a sustainable neighborhood program known as Barrios Sostenibles, to control urban growth and improve the living conditions of settlements and newly formed neighborhoods at the periphery of the city.[29] This academia-led program is deeply grounded on community participation and sectorial-institutional coordination to ensure the fulfillment of the program's objectives in terms of sustainability (e.g. stream rehabilitation), infrastructure (e.g. legalization or re-location of properties, and building

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29. Empresa de Desarrollo Urbano, "Jardín Circunvalar de Medellín," accessed October 1, 2018, https://cinturonverde.wordpress.com/tag/medellin/page/5/

sanitary infrastructure), and social objectives (e.g. introducing public health services and facilitating access to jobs and transport).[30]
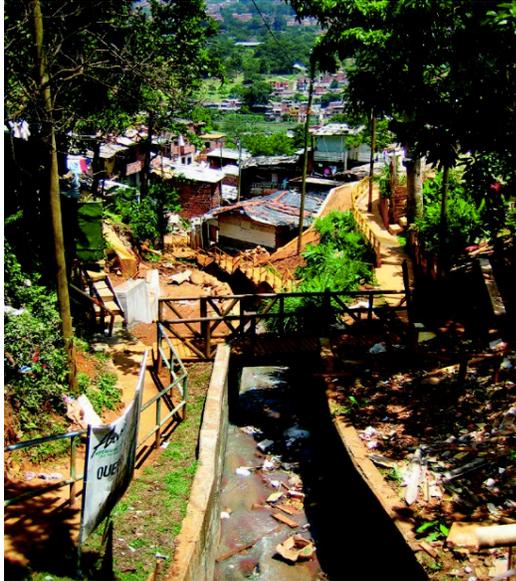
Before (left) and after (below) images of the sustainable neighborhood project Jardín Circunvalar in the favela-like commune, Comuna 8
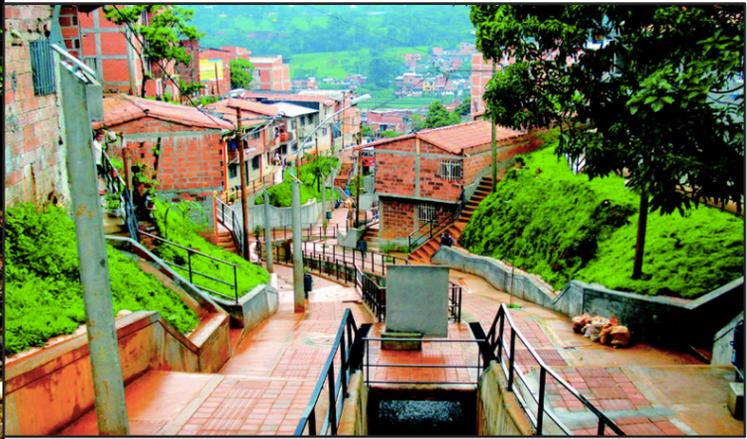
Figure 7. Sustainable neighborhood project
Project based on stream restoration
Source: https://cinturonverde.wordpress.com/about/

Medellin's Public Bike Share System is another example of a PUI-like project that was developed through civic engagement from academia. As it will be explored later in this report, this project was initially intended to provide affordable transportation to university students, but it was quickly elevated as a city project, and eventually as a metropolitan mobility strategy.

Aside from these coordinated efforts, companies, non-profit organizations, and universities are successfully pioneering solutions in Medellín to help address issues of equity and sustainability, and the city is adopting many of these initiatives. Most notable are the solutions created around public transit that take advantage of newly accessible connectivity investments throughout the city, as in the case of the "green re-charge" program, known as Recarga Verde, which allows Metro riders to exchange their PET (Polyethylene Terephthalate), glass, and aluminum containers for Metro credit. The program relies on private investment by the local company Enka, for collecting and processing recyclables, and on the city of Medellin and the Metro company for its expansion.

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30. Empresa de Desarrollo Urbano, "Jardín Circunvalar de Medellín," accessed October 1, 2018, https://cinturonverde.wordpress.com.

The program Recarga Verde allows metro riders to exchange their PET, glass, and aluminum recyclables for metro tickets or metro credit. The prototype of the conversion machine was developed from an engineering master's thesis at a local university, with an approximate investment by Medellin's Metro Company of USD $20,000.
(Metro de Medellin, https://www.metrodemedellin. gov.co)

Figure 8. Recarga Verde

The social equity goals of EnCicla

EnCicla is the first public bike share system in Colombia, and it has become so emblematic, it has transformed the existing bike share market in the country. Bike share systems in Colombia predating EnCicla were mostly privately financed and operated, carefully located around parks, hotels, and restaurant districts, attracting little attention from most commuters. The main characteristic of EnCicla that sets it apart from other systems is that it is focused on servicing lower income communities, and it is cost-free to all users.

After EnCicla started operating with the goal of providing free transport to the residents of Medellín, other cities in Colombia that perhaps were already contemplating the introduction of public bike share followed suit, and drafted plans to develop similar bike share systems. After EnCicla, most metropolitan cities in Colombia have developed cost-free or very low-cost bike share models, fully integrated to their transport systems. The task is not simple, so many municipalities like Bogota with over eight million people, have not been able to launch their public bike share programs, as they struggle with securing institutional support, funding, and

long-term financing.[31]

At the very least, EnCicla triggered a countrywide notion that bike share systems should be fully integrated to transport systems, and free of charge to users to help promote sustainable transportation, alleviate congested systems, and secure an affordable transport mode to many commuters. Nevertheless, EnCicla was not the only precursor for the mobilization of public bike share in Colombia. It was also critical that people in Colombia absolutely love cycling.

Cycling culture and the bike sharing boom in Colombia

The literature explored for this study examining motivators and barriers to cycling indicates that fostering a positive attitude towards cycling can positively affect bike share ridership among different communities.[32] Cycling is the second most important national sport in Colombia after soccer, with Colombian professional cyclists routinely winning important international competitions like the Tour de France and Giro d'Italia. Additionally, there is a large crowd of amateur cyclists that foster several cycling organizations that help advance policies and legislations that protect cyclists.[33] Most importantly, cycling is the main transportation mode in most rural Colombia since the late XIX century, replacing the mule and the cattle car until this day in spite of the impossible geography of the Andean region. [34] It is not uncommon to spot in rural Colombia elderly adults conducting their shopping by bike, farmers carrying crops by bike, and people of all ages biking for daily commute.

31. Felipe García Altamar, "Un año mas sin sistema de bicicletas públicas en Bogotá," *El Espectador*, June 21, 2018, accessed December 1, 2018, https://www.elespectador.com/noticias/bogota/un-ano-mas-sin-sistema-de-bicicletas-publicas-articulo-795787.

32. See the studies by Bejarano et al 2017 in Medellín, Heinen et al 2011 in The Netherlands, and Shaheen & Guzman 2018 in France and Canada, on Chapter 2: Literature Review.

33. Njord Pattiasina et al., "Cycling in Colombia. Report of a fact finding mission by the Dutch Cycling Embassy," May 15, 2015, accessed November 27, 2018, https://english.rvo.nl/sites/default/files/2015/05/Biking%20in%20Colombia%20-%20report%20of%20DCE%20fact%20finding%20mission%20-%20may2015%20(3).pdf.

34. Ana Puentes, "La historia de más de cien anos de pedaleo en la capital," *El Tiempo*, June 8 2018, accessed October 27, 2018, https://www.eltiempo.com/bogota/historia-de-la-bicicleta-en-bogota-desde-su-aparicion-228330.

Professional cyclists training for the upcoming Tour de Colombia, a fifteen-day yearly cycling competition across the country, reaching altitudes of 10,000 feet (2,000 feet above the highest climb for the Tour de France) (Aaron Gulley 2017).

Figure 9. La Vuelta Colombia
Source: Federación Colombiana de Ciclismo, "La Vuelta a Colombia," November 17, 2018,
https://www.colombia.com/deportes/ciclismo/la-vuelta-a-colombia-cambia-sus-fechas-para-2019-211239

The bicycle is also the most important transport mode for thousands of children in Colombia that live in distant townships or remote hilltops without road access to reach local schools.[35] These children typically need to travel several miles each way over fields and dirt roads to reach schools, a feat that would be impossible to achieve in a relatively timely fashion without a bike. One of the country's national hero cyclists, *Nairo Quintana*, was "trained" in his childhood to become a world-class cyclist as he had to bike ten miles each way to go to school in the Andean rural area of Boyacá, on a heavy iron-framed bicycle without gears.[36]

The cycling culture of Colombia resides in a combination of sportsmanship, considering most people need to bike in high altitudes, very steep roads, and adverse climate conditions; and dependency, as cycling has become a reliable and affordable transport mode for millions of people since childhood.

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35. Caras (ed.), "Niños que van a la escuela, gracias a un par de zapatos y una bicicleta," *Revista Caras*, 2016, accessed November 25, 2018, http://caras.com.co/2016/10/10/ninos-que-van-a-la-escuela-gracias-a-un-par-de-zapatos-y-una-bicicleta/

36. Chris Bell, "The untold story behind Colombia's obsession with cycling," *Culture Trip*, March 24, 2018, accessed November 23, 2018, https://theculturetrip.com/south-america/colombia/articles/the-untold-story-behind-colombias-obsession-with-cycling/

A first grader in Boyacá has to walk seven miles each way through fields and highways to reach school (2015). Most of the bicycles that reach children in rural areas of Colombia are donated by local governments and private organizations.

Figure 10. Walking to school
Source: Luisa Fernanda García, "Niños de Boyacá ya no tendrán que caminar dos horas para ir a estudiar," *El Tiempo,* September 18, 2018.

In the rural region of Antioquia, the government addresses school desertion via bicycle programs like "Mi Bici," delivering over 2,000 bicycles per year and providing traffic/cycling training to young students.

Figure 11. Biking to school
Source: Proantioquia, "Estudiantes de Antioquia beneficiados con Mi Bici," August 23, 2017,
https://www.proantioquia.org.co/mas-ninos-de-antioquia-beneficiados-con-mi-bici/

Most of the daily trips in the municipalities of La Ceja and Amalfi in Antioquia (twenty-seven miles away from Medellin) are done by bike (Ospina 2013).

Amalfi holds a yearly one-week-long ciclovía event limiting the use of motor vehicles. Over 60% of households in these townships own bicycles (Ortiz 2017).

Figure 12. Biking as the main transport mode
Source: Gustavo Ospina, "Amalfi, el pueblo de las bicicletas, multa por montar en el parque," *El Colombiano*, March 1, 2013.

In 2016 the city of Cali, with approximately two and a half million inhabitants (DAP Cali 2014), approved 128 miles of new bike lanes, to be completed by 2020 (Viviendo Cali 2016). Since then, eight bike share systems have flourished in the City (Otero 2015).

Figure 13. Bike share in Cali
Source: Viviendo Cali (Ed.), "Cali apuesta por la Bici," April 25, 2016, https://www.viviendocali.com/cali-apuesta-bici/

Before EnCicla, Medellin had some of the lowest levels of bicycle ridership in the country.[37] This is perhaps due to the fact that Medellin has one of the most accessible transit systems in the Americas. Additionally, the city's topography is not precisely cycle-friendly, as Medellín is located on a hill valley with street inclinations parallel to the City of San Francisco. The quick uptake of EnCicla thus far is probably a result, in part, of many people switching from transit and walking to cycling, especially considering that the city has been gaining inhabitants from the municipalities with the highest rates of cycling and bike ownership in Colombia, like Amalfi and La Ceja (see Figure 12 above).[38] The real challenge for EnCicla is to expand the system in a way that it can promote ridership for individuals of more diverse socio-economic backgrounds, gaining users that shift from other motorized modes.

EnCicla users riding along Medellin's tram.

Medellín has carefully integrated EnCicla corridors and stations to its transport system.

Figure 14. Biking along the Tram
Source: Juan Cano, *Revista Semana*, October 27, 2017.

This study focuses in part on this last aspect of mode-shift. However, EnCicla was conceived in the midst of social urbanism, and as such, it is in most aspects an equity project. This is the case not just for Medellín. As it will be explored later in this report, bike share policy and bike share infrastructure in Colombia is solidly grounded on broader socio-economic equity policies.

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37. Área Metropolitana, "PMB 2030," accessed November 30, 2018, http://www.encicla.gov.co/wp-content/uploads/5PMB2030.pdf.

38. Alcaldia de Medellin, "Medellin y su población," Departamento Administrativo de Planeación, accessed November 30, 2018, https://www.medellin.gov.co/irj/go/km/docs/wpccontent/Sites/Subportal%20del%20Ciudadano/Plan%20de%20Desarrollo/Secciones/Información%20General/Documentos/POT/medellinPoblacion.pdf.

The city of Monteria in the Caribbean region of Colombia (approximately 500,000 inhabitants according to the latest census data) received the 2014 Earth Hour Capital prize by the World Wildlife Fund (WWF) in part for promoting bicycle mobility (Semana 2014).

Not long ago, Monteria was the epicenter of the peace process between the Colombian Army and the country's paramilitary groups, but in the last fifteen years the city has gone through a major transformation of the urban landscape. Today, more than twelve percent of trips in Monteria are done by bike over the city's twenty-two miles of urban linear parks and bikeways. In this image, the main road to the right remains unpaved (Alcaldía de Montería 2018).

Figure 15. Prioritizing bikeway infrastructure
Source: Camilo Gómez Ruiz, "Montería," http://monterialamashermosa.blogspot.com/2015/10/la-ciudad-de-san-jeronimo-de-monteria.html.

The city of Bogotá has recently taken the most aggressive approach to make space for urban bikeways: turning driving lanes into bicycle lanes overnight, even on roads with very high occupancy rates.

Figure 16. Creating a protected bikeway in Bogotá

Source: Alcaldía Mayor de Bogotá, "Transformación de la Carrera 7 traerá nuevos kilómetros de ciclorutas," October 20, 2017, http://www.bogota.gov.co/temas-de-ciudad/movilidad/transformacion-de-la-carrera-7-traera-nuevos-kilometros-de-cicloruta

Bogota's Ciclovía started in 1974 as a people's movement. By 1976, the local government released a decree ruling the closure of major avenues from 7:00 am until 2:00 pm every Sunday and every public holiday (IDRD 2017).

Figure 17. The origin of The Ciclovía

Source: Secretaría General Alcaldía Mayor de Bogotá, "Bogotá en Bici," http://internacional.secretariageneral.gov.co/content/bogot%C3%A1-bici

Bogota has continued to "innovate" in the realm of ciclovías, with road closures (more than 70 miles) now averaging about seventy-five days per year, as the city holds additional weekday and late-night seasonal ciclovías.

Figure 18. Ciclovía Nocturna in Bogotá

The Christmas Ciclovia takes advantage of the night illumination during this time of the year. These ciclovias take place on selected weekdays of December from 5:00 pm until mid-night. Source: Wilson Machuk, "Ciclovía Nocturna en Bogotá," Flicker, November 12, 2014, https://www.flickr.com/photos/160513669@N03/40564223671/in/photostream/

An argument to be made in this report is that the political goal of increasing bicycle use through bike share schemes is difficult to achieve without carefully cultivating a strong and inclusive cycling culture. Colombia's ciclovías have helped build that culture over the last four decades, paving the road for public bike share programs. The following chapters explore how Medellín's equity-based urban transportation planning has taken advantage of a rooted cycling culture to popularize a sustainable transportation mode, and analyses deterrents for bike share use in areas of the city planned for the automobile.

CHAPTER 1
INTRODUCTION

The main purpose of this study is to explore the conditions that can make EnCicla a viable transportation option for a wide range of individuals, in an area of Medellin where automobile use is very accessible and convenient in terms of affordability, parking, and right of way.

This report reviews critical aspects of accessibility for bike sharing in El Poblado that inequitably affect potential users. EnCicla's expansion in El Poblado has been focused on the industrial areas of the commune, providing access primarily to workers and employees that live outside of El Poblado, de facto excluding potential local users that could be completing short neighborhood trips with the public bike share system.

Deterrents to bike sharing found in this area include lack of adequate infrastructure and bikeway-transit connectivity, a complex and lengthy pre-registration process, and the predominance of auto-centric land-use planning policies that adversely affect safety conditions for cyclists.

Metropol's expansion plans for EnCicla are focused on improvements to the bikeway infrastructure and the implementation of design standards,[39] which should support users of varied ages and abilities. Nevertheless, Metropol is not carefully considering aspects of location/allocation of bike share stations to support more varied trips and users, and it doesn't seem to be successfully integrating to all of the other modes through its expansion.

This report examines potential interventions and policies that may help boost EnCicla's usage and accessibility to support the city's bike share strategy, promote cycling, and discourage driving for short trips in El Poblado.

1.1 Overview of EnCicla in El Poblado

EnCicla has eight stations in El Poblado hosting at least 206 bicycles distributed among them.[40]

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39. Metropol, "Plan Maestro Metropolitano de la Bicicleta del Valle de Aburrá 2030," http://www.encicla.gov.co/plan-maestro-metropolitano-la-bicicleta-del-valle-aburra/, accessed September 9, 2018.

40. Metropol, "EnCicla," www.encicla.gov.co, accessed October 6, 2019.

Stations are located approximately every 500 to 1,000 feet from each other, covering an approximate distance of two miles over flat topography. [41] This section of EnCicla represents approximately ten percent of the entire system, which consists of sixty-seven stations hosting about 1,700 bikes over a total distance of twenty miles.[42]

EnCicla stations in El Poblado are concentrated in the industrial part of the commune.

Most residential areas in El Poblado are not suitable for cycling because of the difficult topography and the absence of bikeway infrastructure.

Figure 19. Stations and Bikeways

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41. Rough estimation made through google maps measurement instrument.

42. Rough estimation made through google maps measurement instrument.

All of the EnCicla stations in this section of the system are automatic stations, except for the station Primavera, which is a manual station (i.e. a host facilitates the bike rental through a wireless device). Bikes are easily rented with the integrated public transportation card, known as the Tarjeta Cívica or *Civica Card*, which helps unlock bikes at electronic booths located at each station. All stations are similarly equipped, and furnished with a seating area, ornamental and functional vegetation, trash cans, and public phones.

Figure 20. Bike share station MAMM

The eight stations surveyed in this area of the system are strategically positioned at high visibility corners across major destinations and near transit stations. Nevertheless, the coverage area of EnCicla in El Poblado is mostly limited to the light industrial area of the neighborhood, as bikes can only be rented for a maximum of one hour and extending the rental period is not possible without a station's unlocking infrastructure.

EnCicla stations are carefully positioned at or near main destinations like the Museum of Modern Art of Medellín (MAMM Station), Orbis Group, a conglomerate of four major multinational companies (Av. 19 Station) and Telemedellín, the headquarters of the local television channel, facilitating access to large centers of employment. There is also a growing high-density residential area nestled between Avenida Regional (Carrera 48) and the linear park Parque del Río, with three stations directly serving this residential neighborhood pocket, namely MAMM, Villa Carlota, and Ciudad del Río.
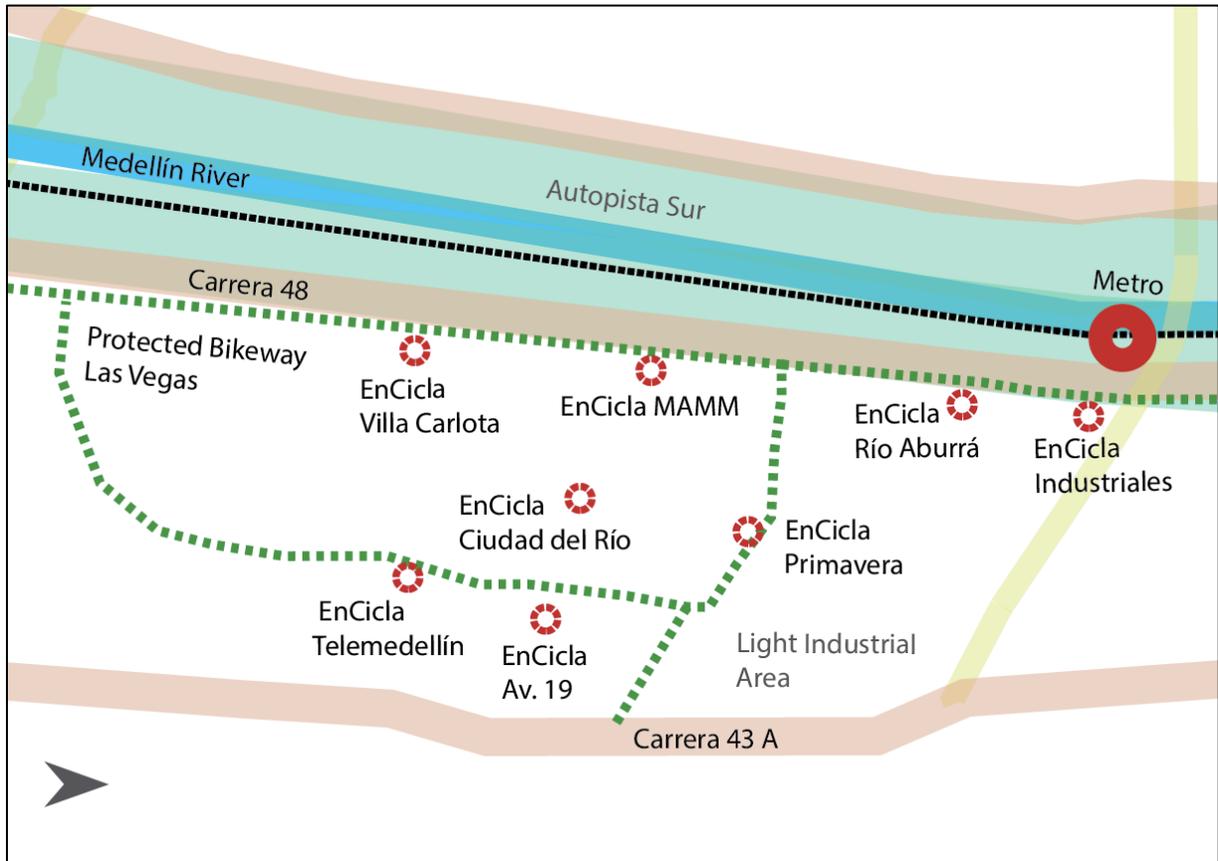
Figure 21. EnCicla stations and bikeways audited in El Poblado

Figure 22. Neighborhood Villa Carlota in El Poblado

This part of El Poblado is characterized by a large and varied concentration of commercial and light industrial businesses, most notably retail, auto shops, banking, government services, medical centers, hotels, restaurants, and places of entertainment.

Notwithstanding the proximity to EnCicla stations, residential developments in this area are not catering to bicycle users. Instead, most high-density residential developments being constructed in this area are centered on car use, boasting extensive parking lots for up to three vehicles per unit, and multiple parking services.[43]

The first four levels of this massive project in Villa Carlota are dedicated to vehicle parking.

Vehicular and pedestrian accessibility to this project is misleading. There is no access between the linear park behind the buildings and the parallel street depicted in the back of this model (Carrera 43F), which leads to other important nodes of activity in El Poblado.

Figure 23. Residential project Bosque del Río

Most importantly, these developments are exacerbating issues of pedestrian and bike accessibility in this area of El Poblado, as otherwise highly permeable streets and pathways are converted into super blocks of apartment buildings.

43. Observations made during site visits to some of these projects.

The first advertisement banner of the residential project depicted above is the "Car Lobby" service.

The salesperson at this showroom offered no details about bike parking spaces but commented about other potential perks that may be offered, like electrical vehicle charging stations.

Figure 24. Street View of residential project Bosque del Río

1.1.1 About El Poblado

Medellín's Metropolitan Area is politically divided into sixteen communes that could be considered neighborhood districts with distinct characteristics. El Poblado is the 14th commune of the municipality and it is comprised of twenty-two neighborhoods.[44] In El Poblado, EnCicla is located mostly in the neighborhood Villa Carlota near the Medellín River (see Figure 25 below).

El Poblado is one of the most affluent communes of Medellín according to the municipality, boasting higher levels of education and employment compared to other communes.[45]

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44. Alcaldía de Medellín, "Comuna 14 El Poblado, Perfíl Socio-Demográfico 2005-2015," accessed November 27, 2019,
https://www.medellin.gov.co/irj/go/km/docs/wpccontent/Sites/Subportal%20del%20Ciudadano/Planeaci%C3%B3n%20Municipal/Secciones/Indicadores%20y%20Estad%C3%ADsticas/Documentos/Proyecciones%20de%20poblaci%C3%B3n%202005%20-%202015/Resumen%20perfil%20Barrios%20por%20Comuna/Perfil%20Demografico%20Barrios_Comuna_14final.pdf.
45. Ibid.

Figure 25. EnCicla's coverage area (Stations) in El Poblado
Source: Adapted from Alcaldía de Medellín, Plan de Desarrollo Comuna 14- El Poblado

El Poblado is also one of the districts with the highest car ownership rates in Medellin, and most residents commute by car.[46] EnCicla's expansion in this area could be instrumental for addressing increasing impacts of car ownership/ridership trends in this section of the commune.

46. Alcaldía de Medellín, "Plan de Desarrollo Comuna 14- El Poblado," accessed November 27, 2019, https://www.medellin.gov.co/irj/go/km/docs/wpccontent/Sites/Subportal%20del%20Ciudadano/Planeaci%C3%B3n%20Municipal/Secciones/Plantillas%20Gen%C3%A9ricas/Documentos/Plan%20Desarrollo%20Local/Documento%20Plan%20de%20Desarrollo%20de%20El%20Poblado.pdf.
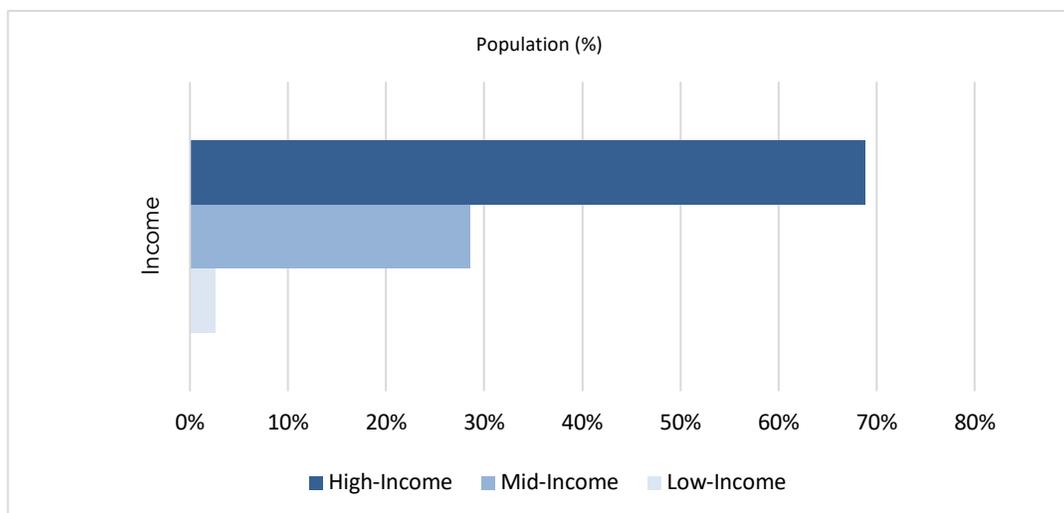
Figure 26. Population distribution by income in El Poblado
Source: Data from Alcaldía de Medellín, Plan de Desarrollo Comuna 14- El Poblado

The number of car trips in El Poblado triples the average car trips in Medellín. By contrast, the number of pedestrian trips in the commune are only a fraction of the average pedestrian trips for the entire city: approximately 2.5% percent of trips in El Poblado are completed by foot, compared to 38% of total pedestrian trips for the entire municipality.
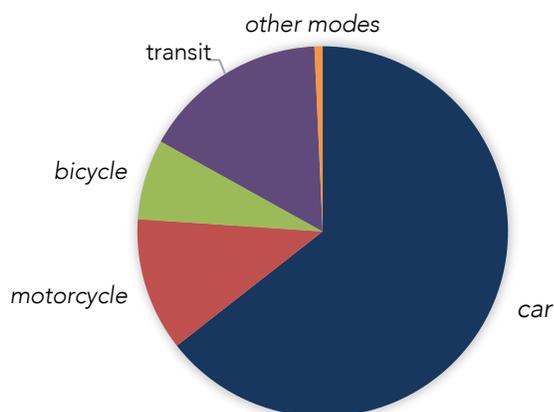
Figure 27. Trip mode distribution in El Poblado
Source: Alcaldía de Medellín, Plan de Desarrollo Comuna 14- El Poblado, 2010

1.2 Study goals and research questions

Bike share as a transportation mode is a rather recent phenomenon worldwide,[47] and there is still limited understanding about what makes bike share mobility successful, given the variability under which these systems are operating (e.g. docked vs. dock-less, or privately

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47. Alex Baca, "What Cities need to Understand about Bike share Now," Citylab, April 24, 2018, accessed September 11, 2018, https://www.citylab.com/transportation/2018/04/a-complete-taxonomy-of-bike share-so-far/558560/

funded vs. publicly funded systems, just to name two factors).[48] Understanding some of the cultural, socio-economic, and technical challenges for Medellín's public bike share system can provide important insights about the difficulties of implementing bike share solutions in the Latin American context. Similarly, identifying the factors that make EnCicla a successful system in Medellín could inform other docked-based bike share initiatives. This study is expected to contribute to the body of knowledge of bike share and micro-mobility, especially for under researched regions like Colombia.

To identify the supporting and deterring conditions to bike share in El Poblado, this study examines two main questions:

1. What are the factors that affect the accessibility and appeal of EnCicla for a wide range of users in El Poblado?
2. What type of interventions and supportive land-use policies can make this section of the system more appealing and accessible to potential users, and facilitate bike share adoption?

The investigation of these questions led to a comprehensive analysis of individual perceptions, barriers, and facilitators for cycling and bike share uptake across different regions of the world. Furthermore, this report compares the causes behind failures and successes of the systems studied, including the administrative arrangements and socio-economic and cultural aspects that have had an impact on local bike share implementation.

A careful examination of Medellín's public bike share system vis-à-vis the researched user experience in El Poblado, helped assessed the ability of EnCicla to have an effect on important social-equity and cycling rate goals. This analysis contributed to the drafting of recommendations intended to further leverage EnCicla for attracting diverse users, supporting different trip purposes, and reducing car trips in El Poblado.

To identify the factors that affect the accessibility and appeal of EnCicla in El Poblado, this study focuses on the following aspects:

▪ Local user perceptions that may have an impact on the decision to bike share
▪ Micro environmental factors of the bike share and cycling infrastructure that affect peoples' choice to sign-up to bike share

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48. Adam Cohen and Susan Shaheen, "Planning for Shared Mobility," APA PAS Report 583 (2016), accessed September 9, 2018, https://escholarship.org/uc/item/0dk3h89p.

- The user experience, including usability, accessibility, and amenability of the bike share system in this section of El Poblado
- Land-use form and policies that may have an impact on bicycle use and mode choice among different individuals
- Administrative and institutional arrangements that may have an impact on operational aspects of the bike share system affecting users' perceptions or accessibility

The literature reviewed for this study facilitated the analysis of factors that affect bike share use in El Poblado, and that may be thwarting the city's ability to reach important bike share-related goals, including aspects of equity, mode-shift, car dependency, and pollution abatement.

Making EnCicla appealing to a broader range of users is critical to position bike share mobility as an alternative to driving. In wealthier areas of the city like El Poblado where trips tend to be shorter,[49] bike share could become an appealing alternative to driving an automobile.

According to a recent study based on Metropol's most recent origin-destination survey data, as the wealth of individuals increases in Medellín (and their ability to purchase a car), movements of people become more localized in the afternoon hours.[50] Paradoxically, preliminary research for this study indicates that in El Poblado, the system is most underutilized during the afternoon hours, up until the rush hour at 6:00 pm. Bike share seems to be appealing across the board when it supports localized, short-distance trips.[51] One may argue that some of the conditions that can foster bike share adoption, including specific mobility patterns, may already be in place in El Poblado.

Medellín is a segregated city by income level and socio-economic status, where the "poor" live among the poor, and the "rich" live among the rich. However, Medellín's transport system is one of the most important places where rich and poor encounters can happen. Furthermore, Medellín has one of the very few public transportation systems in the Americas that integrate

49. Alcaldía de Medellín, "Comuna 14 El Poblado, Perfíl Socio-Demográfico 2005-2015," accessed November 27, 2019,
https://www.medellin.gov.co/irj/go/km/docs/wpccontent/Sites/Subportal%20del%20Ciudadano/Planeaci%C3%B3n%20Municipal/Secciones/Indicadores%20y%20Estad%C3%ADsticas/Documentos/Proyecciones%20de%20poblaci%C3%B3n%202005%20-%202015/Resumen%20perfil%20Barrios%20por%20Comuna/Perfil%20Demografico%20Barrios_Comuna_14final.pdf.

50. Laura Lotero et.al, "Rich do not rise early: Spatio-temporal patterns in the mobility networks of different socio-economic classes," The Royal Society Publishing, October 12, 2016, accessed September 27, 2018, http://rsos.royalsocietypublishing.org/content/3/10/150654#sec-3.

51. Angy Schmit, "If you want bike share to succeed, put stations close together," NACTO, accessed September 27, 2018, https://usa.streetsblog.org/2015/04/29/nacto-if-you-want-bike-share-to-succeed-put-stations-close-together/

so many modes of transport that people actually love.[52] This system is largely viewed as a reference to Medellin's citizenry, and a place of cultural connection. This study ultimately explores ways to expand EnCicla's connectivity to Medellín's inclusive and highly regarded public transportation system.

1.3 Methodology overview

To identify the factors that affect cycling and the use of EnCicla in the commune of El Poblado the author developed a methodological framework based on a user experience audit. Through a prepared audit checklist form that included a short intercept questionnaire (see Appendix A), the author was able to collect information while using the system over a period of six days, including:

- The user experience of EnCicla from beginning to end in El Poblado
- User perceptions
- Non-user perceptions
- The quality of the bike share infrastructure and its supporting urban environment

The user experience audit resulted in a characterization of EnCicla and its users in this area of the city. Forty-eight individuals that were intercepted during the audit provided valuable information about user and non-user perceptions that are affecting bike share use in the commune.

To develop this methodological framework, the author relied on comprehensive literature review about bike share systems worldwide; and about the methods best suited to address aspects of user and non-user perspectives in bike share research. Additionally, various bicycle audits targeting different aspects of the cycling environment including safety, health outcomes, and performance were analyzed to develop the specific audit checklist form used in this study.

The findings and questions that arose from the user experience audit were contrasted with expert interviews collected ante and post research fieldwork.

Outside of the official planning agencies like Metropol, there seems to be no other major study up to date analyzing interventions that could support a wider range of users of EnCicla, or that

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52. Medellín Como Vamos, "Encuesta de Percepción Ciudadana, 2017," accessed September 25, 2018, https://www.medellincomovamos.org/informe-de-la-encuesta-de-percepcion-ciudadana-medellin-2017/.

could support current policies intended to achieve ambitious bicycling rates for Medellín.[53] This study focuses on aspects of accessibility and uptake of bike share mobility in Medellin that have not been closely analyzed, since the initial user-centered study performed during EnCicla's pilot phase, which only considered university student users.[54]

This research will explore a combination of frequently used methodological frameworks in planning (e.g. bicycle audits, ethnographic approaches, and interviews), to try to understand how both user and non-user opinions differ about EnCicla in El Poblado. The methodological approach designed for this study is expected to provide a significant contribution to other researchers interested in both user and non-user perceptions related to bike share.

1.4 Report overview

This report is divided into seven chapters. Chapter 2 provides and overview of the entire EnCicla bike share system. Chapter 3 provides a comparative analysis of cycling barriers and motivators; studies different bike share systems worldwide; and analyses methods for conducting bike share research related to mode choice. Chapter 4 summarizes the research model developed and the methodology implemented, incorporating aspects of user experience and user/non-user perceptions. Chapter 5 summarizes and analyzes research findings, including the author's user experience, and user and non-user perceptions collected through intercept interviews. This chapter provides a general description of EnCicla's main assets and barriers and identifies the typical EnCicla user in the neighborhood El Poblado. Chapter 6 analyzes overarching findings and discusses research limitations. Supported by literature review and expert input, this chapter discusses potential policies that could affect car dependency and mode-choice in El Poblado. Finally, Chapter 7 explores recommendations to support equitable bike share and bicycle use in El Poblado.

53. Yanyong Guo et.al, "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," *PLOS* (2017), accessed September 12, 2018, https://doi.org/10.1371/journal.pone.0185100.

54. Mauricio Bejarano et al., "A user-centered assessment of a new bicycle sharing system in Medellin," *Transportation Research Part F: Traffic Psychology* 44 (2017): 145-158.

CHAPTER 2
OVERVIEW OF ENCICLA

2.1 Antecedents

The EnCicla pilot was originally designed to serve primarily university students in Medellin and connect them to the Metro.[55] As the system grew from a graduate project to a municipal strategy, it had to adapt fairly quickly to support a much more diverse pool of potential users in an expanded geographic area. The preliminary research for this study revealed that there is a mismatch between EnCicla's expansion goals, and the ability of the system to develop high-serviced routes and stations that would appeal to new users, in areas further away from the city's Metro core.[56] A close observation of a specific area served by EnCicla would provide a better understanding about the challenges and opportunities for the current operation and continuing expansion of the bike share system. Some of these challenges may be greater in areas of the system like the corridor of El Poblado, where cycling rates are extremely low, and car use remains very high, and growing.[57]

2.1.1 From academic exercise to metropolitan strategy

As Medellín started its urban-social transformation through the PUI years, miles of bikeways were built in the city, especially around linear parks and university campuses. However, these bikeways were largely underutilized. One may speculate that one reason for this phenomenon is related to risk perception, as Medellín's urbanites were still adjusting to safer street conditions. Another plausible explanation is that the vast majority of residents at the time did not consider cycling as a viable or competitive transport mode.[58]

To solve this problem, engineering product design students from the local university Escuela de Administración, Finanzas e Instituto Tecnológico (EAFIT), designed a public bike share

55. Mauricio Bejarano et al., "A user-centered assessment of a new bicycle sharing system in Medellin" Transportation Research Part F: Traffic Psychology 44 (2017): 145-158.

56. Jaime Perez, "Fallas en el sistema de bicicletas publicas EnCicla," El Colombiano, October 3, 2017, http://www.elcolombiano.com/antioquia/alta-demanda-desgasta-las-bicis-de-encicla-FF7421315, accessed September 26, 2018.

57. Metropol, "Encuesta Origen-Destino," https://www.metropol.gov.co/encuesta_od2017_v2/index.html#/, accessed October 6, 2019.

58. See Annex X, Interview with Lina Lopez, co-founder of EnCicla.

system around three major university campuses, taking advantage of the existing bikeways. With a high-quality bicycle prototype and the enthusiasm of early adapters consisting mainly of university students, the project was picked up by Medellin's City Council. A project pilot called *Area EnCicla* was set in 2011 in agreement between EAFIT and Metropol, but the pilot never stopped;[59] EnCicla was adopted in 2012 as Medellín's public bike share system, and it has continued to grow and expand to the entire metropolitan area.

Today the system has expanded to three municipalities with 65 stations connected to transit; a fleet of 1,700 bicycles; and 15,500 loans per day.[60] An ambitious expansion plan established via the Master Metropolitan Biking Plan 2030[61] is set to grow the rate of bike mobility from one percent of total trips (roughly two percent today) to ten percent of total trips for the entire metropolitan area by 2030. This expansion does not contemplate funding via user fees; the system will continue to be entirely free for residents to promote "inclusive biking mobility" and help the city achieve important sustainability goals.[62]

Dynamic information map showing real-time bike availability of EnCicla stations- Tuesday, October 1, 2018 at 6:51 pm PT (8:51 pm in Colombia). Stations in red indicate there are no bicycles available. Stations in orange indicate limited availability. Stations in light/dark blue have more than ten units available.

Figure 28. EnCicla dynamic information map
Source: http://www.encicla.gov.co/estaciones/

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59. Interview with co-founder of EnCicla, October 2, 2019.

60. Throughout this research the system has been expanding. From December 2018 to October 2019, seven new stations have been built, and ridership reportedly grew from 10,000 loans to 15,500 loans per day. Area Metropolitana, "EnCicla," accessed October 6, 2019, www.encicla.gov.co.

61. Área Metropolitana, "Plan Maestro Metropolitano de la Bicicleta del Valle de Aburrá 2030," accessed September 9, 2018, http://www.encicla.gov.co/plan-maestro-metropolitano-la-bicicleta-del-valle-aburra/

62. Ibid.

A user-centered assessment of the pilot *Area EnCicla* showed that the system was a success in terms of feelings of pride, belonging, and civic culture amongst its initial users (mostly university students), albeit important infrastructure and operational voids (e.g. missing appropriate street and trail signs, and unavailability of bike units).[63] Researchers explained that these results were related to: (1) the fact that the system was presented as publicly funded (free of charge to any user); (2) the system was directly related to the needs of the users; and, most important, (3) It was perceived as an extension of the metro culture, meaning the system could *"transcend its functional value and become a vehicle for* [cultural] *change."*[64]

2.2 EnCicla's objectives

In 2012 it was estimated that only one percent of trips in Medellin were done by bike, so Metropol developed the *Bicycle Plan 2030* ("Plan Maestro Metropolitano de la Bicicleta (PMB) 2030") with the objective to increase the rate of cycling for transport to five percent of trips in the short-term, to eight percent of trips mid-term, and finally, to ten percent of trips by 2030.[65]

EnCicla is considered to be one of the most critical strategies to reach the goals established in the Bicycle Plan 2030, so a significant expansion of the current system is taking place. In 2016 Metropol took over EnCicla's operation to complete the ambitious expansion project that would multiply the number of stations from fifty to one hundred,[66] and the extension of bikeways from about forty miles, to over one hundred miles.[67] The main objectives of EnCicla's expansion are (1) to consolidate a last mile solution to transit, and (2) to expand the offer of sustainable single trips for the entire metropolitan area.[68]

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63. Mauricio Bejarano et al., "A user-centered assessment of a new bicycle sharing system in Medellin" Transportation Research Part F: Traffic Psychology 44 (2017): 145-158.

64. Ibid.

65. Área Metropolitana, "PMB 2030," Pp. 59, accessed November 30, 2018, http://www.encicla.gov.co/wp-content/uploads/5PMB2030.pdf.

66. Other city documents cite different numbers, up to four hundred and fifty additional stations. Here it will be used the number of stations established in the PMB 2030.

67. Área Metropolitana, "PMB 2030," accessed November 30, 2018, http://www.encicla.gov.co/wp-content/uploads/5PMB2030.pdf.

68. Ibid.

2.3 EnCicla's range of service

EnCicla is not suitable for the entire metropolitan area because of the topography limitations of the Aburrá Valley. According to Midgley 2014, most people are less likely to cycle when slopes exceed a four percent inclination.[69] EnCicla has established a range of service that is limited to the areas of the city that have a slope inclination below six percent, as described in Figure 29 below.

Other criteria established for delimiting the system's range of service could be defined here as (1) land use, (2) journeys, and (3) mobility.[70] In terms of land use, EnCicla is focused on urbanized areas with higher densities of population. In terms of journeys, stations and supporting services are limited to areas with higher volumes of activity and are determined by average distances (including distances between destinations and between municipalities).

Finally, in terms of mobility, the system is focused on providing a last mile solution, and a transportation alternative for short trips (ensuring coverage in areas that typically generate trips of less than three to five kilometers). As previously argued, it is perhaps the last mile solution criterion the one that is weighing the most for the current system's expansion. Figure 29 portrays a recreated map developed by Metropol overlapping the previous three criteria per the latest data obtained by the city's most recent origin-destination survey.[71] This map represents EnCicla's most desirable implementation area.

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69. Peter Midgley, "Bicycle sharing schemes: Enhancing sustainable mobility in urban areas." Commission on Sustainable Development report, United Nations, New York, May 2011, accessed November 14, 2018, https://sustainabledevelopment.un.org/content/dsd/resources/res_pdfs/csd-19/Background-Paper8-P.Midgley-Bicycle.pdf.

70. Área Metropolitana, "Sistema de bicicletas públicas EnCicla. Planeación, implementación y operación," accessed November 26, 2018, http://www.emov.gob.ec/sites/default/files/Andr%C3%A9s%20Alvarez%20-%20Sistema%20de%20Bicicletas%20P%C3%BAblicas%20ENCICLA%20SIM_0.pdf.

71. Área Metropolitana, "PMB 2030," accessed November 30, 2018, http://www.encicla.gov.co/wp-content/uploads/5PMB2030.pdf.
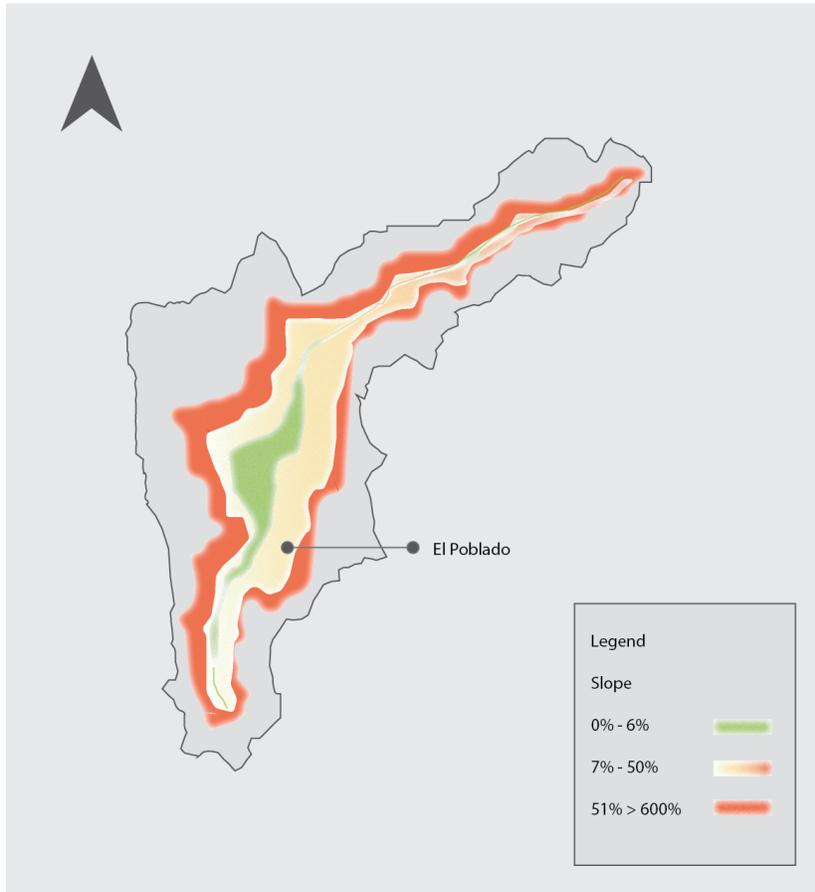
The green areas in the map indicate the areas where the system is more likely to succeed because of optimal topographic conditions, population density, nodes of activity, proximity to transit, and prevalence of short distance trips. This is the target area for EnCicla's expansion. Most of the yellow area is not suitable for cycling (in terms of topography, land use, journeys, and mobility). The red area represents adverse conditions because of extreme slopes.

Figure 29. Suitable areas for EnCicla's expansion

Source: Adapted from Metropol, "Sistema de bicicletas públicas EnCicla. Planeación, implementación y operación," http://www.emov.gob.ec/sites/default/files/Andr%C3%A9s%20Alvarez%20-%20Sistema%20de%20Bicicletas%20P%C3%BAblicas%20ENCICLA%20SIM_0.pdf

2.4 EnCicla's expansion, station density, and distribution

At the city center and around universities (the area from where the system developed), stations are approximately 315 feet to 900 feet apart,[72] with denser clusters of stations located near important nodes of activity (e.g. city hall, banks, public offices, among others). However, as the system expands from this initial core, station density decreases significantly (even within equally important nodes of activity), with distances between stations varying from 900 feet to 2,000 feet from each other, twice the distance between stations recommended by the National Association of City of Transportation Officials (NACTO),[73] and researchers like Fishman et al.

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72. Distance estimated via gross measurements from google maps.

73. NACTO, "Walkable station spacing is key to successful, equitable, bike share," accessed September 20, 2018. https://nacto.org/wp-content/uploads/2015/09/NACTO_Walkable-Station-Spacing-Is-Key-For-Bike-Share_Sc.pdf.

2014,[74] Garcia-Palomares 2012,[75] and Guo et al. 2017.[76] In fact, the Metropolitan Bicycle Pan 2030 also recommends distance between stations should not exceed 1,000 feet in areas with high volumes of activity to promote ridership and ensure equitable access to the bike share system, but the document does not provide a clear strategy about how to address this issue as the system expands.

Instead, as EnCicla expands to the metropolitan area, island clusters of stations are surfacing with a greater distance between stations. This is the case for example of the recently inaugurated stations of *Sabaneta*, a municipality about ten miles away from Medellín's city center that was absorbed by Medellín's metropolitan area. Even though there are twelve EnCicla stations planned for Sabaneta, Metropol has only developed two stations, located approximately 1,500 feet away from each other[77] (one station is located at the main plaza, and the other one at the Metro station). These stations are intended to be used as last mile solutions to transit, as the nearest EnCicla station would be at least five miles away across an inter-municipal bridge.[78]

The way EnCicla is expanding (developing first stations next to the Metro) indicates that Metropol is giving priority to transit connectivity, positioning EnCicla, for the moment, as a last mile solution, although this is not clearly spelled out in any government document researched here. It is likely that EnCicla will continue to grow in a similar way throughout the ten municipalities of the Aburrá Valley (building stations close to the metro first, developing bikeway infrastructure and station density later).

EnCicla's expansion also contemplates: (1) the construction of three hundred parking areas along bikeways, (2) the intervention of intersections to protect cyclists, and (3) the expansion of sidewalks into "active mobility corridors" to encourage walking and cycling. These interventions are accompanied by frequent community engagement events and workshops to help citizens adopt sustainable mobility lifestyles, and to help organizations implement sustainable mobility policies and strategies.[79]

74. E., Fishman et al., "Bike share's impact on car use: evidence from the United States, Great Britain, and Australia," *Transportation Research Part D: Transport and Environment* 31 (2014): 13–20.

75. Garcia-Palomares et al., "Optimizing the location of stations in bike-sharing programs: A GIS approach," *Applied Geography* 35 (2012): 235-246.

76. Guo et al., "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," *PLoS One* 12 (2017).

77. Distance estimated via gross measurements from google maps.

78. Distance estimated via gross measurements from google maps.

79. Metropol, "Sistema de bicicletas públicas EnCicla. Planeación, implementación y operación," accessed November 26, 2018,

2.5 Accessibility

One example of EnCicla's citizen engagement programs is the *bike school for adults* ("Biciescuela para Adultos"), which takes place every Sunday at selected EnCicla stations, to help non-cyclers through novice riders gain cycling skills and confidence on the road. Additionally, other cycling organizations participate in these events, helping EnCicla with promotion activities, and facilitating bike lessons.[80]

Another example of a community engagement program established through EnCicla, is the workshop program for the development of Enterprise Sustainable Mobility Plans ("Planes de Movilidad Empresarial Sostenible"), known as MES plans. In Medellín MES plans are mandated by the law 1379 of 2017 for companies with two hundred employees or more.[81] Through this workshop program, Metropol provides assistance to private companies to: (1) help them identify environmental impacts caused by their employees' travel, (2) help them develop strategies that would mitigate those impacts, and (3) help them identify the most cost-effective ways to implement those strategies. With the expansion of EnCicla, Metropol has been conducting free workshops to help private organizations diagnose, formulate, implement, and monitor their MES plans, while emphasizing bicycle mobility.[82]

http://www.emov.gob.ec/sites/default/files/Andr%C3%A9s%20Alvarez%20-%20Sistema%20de%20Bicicletas%20P%C3%BAblicas%20ENCICLA%20SIM_0.pdf.

80. Área Metropolitana, "Tatiana aprende a montar bicicleta con la Biciescuela EnCicla," promotional video, youtube, April 19, 2018, accessed December 1, 2018, https://www.youtube.com/watch?v=kNQ-PEv0wTs.

81. Resolución Metropolitana 1379 de 2017, accessed December 2, 2018, https://www.medellin.gov.co/normograma/docs/r_amva_1379_2017.htm.

82. Metropol 2017, "Muévete, Movilidad Sostenible," accessed December 3, 2018, https://ecf.com/sites/ecf.com/files/Tobon_V._muevete_Movilidad_Sostenible.pdf.

Figure 30. EnCicla's pop-up bike school
Two novice riders getting cycling instruction on a Sunday morning through
EnCicla's "Biciescuela." Source: EnCicla Twitter feed, https://twitter.com/encicla/status/999661496912277504

Additionally, Metropol has been implementing important tactical urbanism interventions in anticipation of permanent projected changes in the urban landscape. Moreover, from an institutional point of view, Metropol has adopted a new lexicon around EnCicla that reflects the expectation of higher standards for it its cycling infrastructure, with active corridors now evaluated in terms of "cycle-walk-amenability" (*ciclocaminabilidad)*, which basically measures how *amenable* integrated bikeways and walking paths are to the surrounding community. The level of amenability of a biking corridor would increase with the presence (and quality) of supporting infrastructure like pocket parks, exercise equipment, playgrounds, water fountains, street furniture, bicycle repair stations, bicycle parking spaces, among other supporting amenities.[83]

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83. Área Metropolitana, "Corredor verde quebrada La Picacha, accessed December 3, 2018, https://www.metropol.gov.co/Paginas/Noticias/obras-metropolitanas/ciclocaminabilidad/medellin/corredor-de-Ciclocaminabilidad-Quebrada-La-Picacha.aspx.

Figure 31. Active mobility corridor "La Picacha"

Image simulation of the active mobility corridor La Picacha in the neighborhood Los Almendros, currently under construction. This corridor comprehends four neighborhoods and approximately 2.3 miles of bikeways. According to the Metropol, one of the purposes of this project is to intervene important intersections that are not safe for cyclists, and to integrate the existing green corridor (La Picacha is an urban stream) to the newly built walking and cycling infrastructure (and accompanying amenities), without interrupting vehicular access.[84]

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84. Área Metropolitana, "Corredor verde quebrada La Picacha," accessed December 3, 2018, https://www.metropol.gov.co/Paginas/Noticias/obras-metropolitanas/ciclocaminabilidad/medellin/corredor-de-Ciclocaminabilidad-Quebrada-La-Picacha.aspx.

Figure 32. Bike parking areas in El Poblado

Bicycle parking areas developed through EnCicla's expansion plan. Source: Metropol, "Sistema de   bicicletas públicas EnCicla. Planeación, implementación y operación," http://www.emov.gob.ec

Protected intersection intervention under EnCicla's expansion. Source: Boxer-Macomber 2017.

Figure 33: Protected intersections

Figure 34: Tactical urbanism in Medellín

Through EnCicla's expansion, tactical urbanism interventions in Medellin involve approximately 24,000 square feet. Source: Alcaldía de Medellín, "Con entrega de cruces seguros para peatones, comenzó la semana de movilidad," October 22, 2017, https://www.medellin.gov.co/movilidad/de-interes/con-entrega-de-cruces-seguros-para-peatones-comenzo-la-semana-de-movilidad.

In spite of all of these efforts, Medellin still has very low levels of cycling ridership compared to other cities in Colombia.[85] However, there is a growing demand for EnCicla. According to a report by Metropol, in average EnCicla reports between six and eight daily trips per bike. This is more than the number of trips per day per bike reported for very successful systems (for stations with a similar number of bikes) like the one of Barcelona (reporting between five and seven trips per bike per day), Lyon (reporting four to seven trips per bike per day), or New York City (reporting six to seven trips per bike per day) (data from 2013).[86] This average however is not such a precise indicator for EnCicla, as the number of bicycles per station is far from uniform, with some areas of the system having much lower demand, and others greater.

In terms of accessibility, under the current expansion phase of EnCicla's network, there has

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85. Área Metropolitana, "PMB 2030," accessed November 30, 2018, http://www.encicla.gov.co/wp-content/uploads/5PMB2030.pdf.

86. Metropol, "Sistema de bicicletas públicas EnCicla. Planeación, implementación y operación," http://www.emov.gob.ec/sites/default/files/Andr%C3%A9s%20Alvarez%20-%20Sistema%20de%20Bicicletas%20P%C3%BAblicas%20ENCICLA%20SIM_0.pdf, accessed November 26, 2018.

been a lot of emphasis on connectivity to the mass transit system (bus and Metro), but new bike share stations are located further apart from each other,[87] making the system seemingly inconvenient to many potential users residing in these areas. Metropol, the agency responsible for EnCicla's planning and operation, has invested substantially in marketing campaigns and community engagement strategies to attract diverse users.[88] These campaigns seem to have had a very positive impact on ridership of EnCicla, but no public analysis has been found so far characterizing these riders in detail.[89] What is clear thus far is that Metropol has been able to make modest investments to make established routes more accessible, but not in all areas of the system.[90] This study will examine feasible supportive infrastructure that could help make EnCicla more appealing to diverse groups of people.

2.6 EnCicla's administration and operational costs

The main components of EnCicla's operations are rebalancing, maintenance, personnel, and customer service.[91] According to a comparative cost analysis developed by Metropol for other bike share systems around the world, one of the largest operational costs for most cities is related to rebalancing, as bicycles need to be re-distributed in trucks, requiring vehicle purchases, insurance, maintenance and personnel.[92] According to Metropol, bike share systems of cities surveyed (including systems like Bicing in Barcelona and Ecobici in Mexico City), in average spend fifty-two percent of operational costs in rebalancing, and thirteen percent in customer service.[93] EnCicla has different levels of services and objectives, so its main operational costs are not related to rebalancing but to personnel.[94] Considering all the "host"

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87. Área Metropolitana, "Plan Maestro Metropolitano de la Bicicleta del Valle de Aburrá 2030," accessed September 9, 2018, http://www.encicla.gov.co/plan-maestro-metropolitano-la-bicicleta-del-valle-aburra/

88. Julián Rodrigo Quintero, "Bicicletas compartidas como sistema de transporte publico urbano: Análisis de políticas publicas en Colombia (1989-2017)," Revista Ciudades, Estados y Política 4, issue 3 (2017): 17-35, accessed September 15, 2018, https://revistas.unal.edu.co/index.php/revcep/article/view/66296.

89. A request was sent to Metropol to ascertain if they have this information, but to the date of publication the author received no response.

90. Julián Quintero, "Bicicletas compartidas como sistema de transporte publico urbano," Revista Ciudades, Estados y Política 4, issue 3 (2017): 17-35.

91. Área Metropolitana, "Sistema de bicicletas públicas EnCicla. Planeación, implementación y operación," accessed November 26, 2018, http://www.emov.gob.ec/sites/default/files/Andr%C3%A9s%20Alvarez%20-%20Sistema%20de%20Bicicletas%20P%C3%BAblicas%20ENCICLA%20SIM_0.pdf.

92. Ibid.

93. Ibid.

94. Ibid.

activities and "manual" stations, it is no surprise that fifty two percent of EnCicla's operational costs are related to personnel, while only fifteen percent of operational costs are related to rebalancing (it must be noted EnCicla's hosts oftentimes carry on some basic re-balancing operations by biking themselves between stations). Other costs related to maintenance, and customer service (e.g. communications) are more similar to other systems.[95]

EnCicla is a professional organization. Its administration resides in Metropol, with four metropolitan-level departments overseeing EnCicla departments, including Metropol's communications, social development, economic development, and legal departments. The five main EnCicla departments within Metropol are: Personnel, operations, expansion, technology, and maintenance, which oversee the daily operations of EnCicla involving customer service, communications, maintenance, and costs.[96]

2.7 EnCicla's financing mechanism

EnCicla's funding source comes from an environmental protection tax known as Sobretasa Ambiental, collected by the city through property tax assessment.[97] This tax is not an additional tariff over property. Instead, a percentage of the property tax collected is transferred to Metropol for investment in environmental protection.[98] Municipalities set their own tariffs according to the limitations of the Law regulating the environmental tax (the percentage of the tax dedicated to environmental protection cannot be less than 15% or more than 25.9% of the property tax collected).[99] Because Metropol is in charge of all environmental planning in the urban areas of Medellín's metropolitan area, it receives 98% of this tax, while the environmental authority in charge of environmental protection of rural areas within the metropolitan area, Corantioquia, receives the remaining 2%. According to an EnCicla expert consulted for this study, EnCicla does not have a funding problem, and has been able to

95. Área Metropolitana, "Sistema de bicicletas públicas EnCicla. Planeación, implementación y operación," accessed November 26, 2018, http://www.emov.gob.ec/sites/default/files/Andr%C3%A9s%20Alvarez%20-%20Sistema%20de%20Bicicletas%20P%C3%BAblicas%20ENCICLA%20SIM_0.pdf.

96. Ibid.

97. Interview with co-founder of EnCicla on October 2, 2019.

98. Congreso de Colombia, Ley 99 de 1993, "Artículo 44: Porcentaje Ambiental de los Gravámenes a la Propiedad Inmueble," accessed October 6, 2019, https://www.funcionpublica.gov.co/eva/gestornormativo/norma.php?i=297.

99. Presidencia de la República, Decreto 141 de 2011, "Artículo 10: Modifíquese el artículo 44 de la Ley 99 de 1993," accessed October 6, 2019, https://www.funcionpublica.gov.co/eva/gestornormativo/norma.php?i=41361#10.

sustainably secure financial resources through this tax.[100]

It is important to note that Medellin's financial capacity to advance social urbanism like projects without major borrowing is in part because it receives funding from the publicly owned utilities company, Empresas Públicas de Medellin (EPM). EPM has become one of the most profitable utility companies in Latin America and transfers a large percentage of its operating profits (over 30%) to the municipality to advance its social-urban agenda.[101]

2.7.1 Is EnCicla sustainable without user fees?

Bejarano et al 2017 found that one of the most critical factors for individuals to use or try EnCicla is that the system is free.[102] What started as a bonus to university students to take advantage of underutilized bikeways, has become a major transportation mode for many working-class residents that seize the opportunity of free transit.

At its initial smaller scale, EnCicla seemed to be easily sustainable without user fees, but as the system expands, it is questionable that EnCicla will be able to sustain higher levels of service with its current funding stream. To secure long-term sustainability, EnCicla could consider alternative sources of revenue by introducing escalated user fees for non-residents, or by expanding current public-private partnerships to fund additional programs.

The following chapter reviews the main characteristics of public bike share systems in different regions, and analyses barriers and motivators to bike share that are applicable to Medellín's socio-economic and cultural conditions. Furthermore, the literature reviewed in the following chapter examines methods commonly used for researching individual habits and perceptions that affect the choice to bike share. A combination of some of these methods were applied to this study.

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100. Interview with cofounder of EnCicla on October 2, 2019.

101. Peter Brand, "Governing inequality in the south through the Barcelona model: Social Urbanism in Medellin, Colombia," Interrogating Urban Crisis, De Montfort University, September 9-11, accessed September 9, 2018, http://www.dmu.ac.uk/documents/business-and-law-documents/research/lgru/peterbrand.pdf.

102. Mauricio Bejarano et al., "A user-centered assessment of a new bicycle sharing system in Medellin," Transportation Research Part F: Traffic Psychology 44 (2017): 145-158.

CHAPTER 3
LITERATURE REVIEW

Research published up to date about bike share systems in Latin America is very limited. This is in part because the majority of these systems are fairly new. Additionally, there is limited data readily available for bike share research in Latin American countries because most of the systems developed there are a combination of second, and third generation systems that may not have the capability to collect user data (docked bikes with limited information technology capabilities, like integrated smart cards and availability of real time information).[103] However, bike share research available across the globe can provide an adequate framework to identify the factors affecting aspects of ridership and user satisfaction that are most likely to be relevant for the Latin American context and Medellín. This literature review focuses on analyzing these factors to identify commonalities and differences, and to recognize the specific characteristics of the public bike share system of Medellin.

Additionally, part of this literature review is focused on identifying the most adequate methodological approaches for researching aspects of bike share user satisfaction, as well as non-user perspectives about bike share and cycling. The main objective of this part of the review is to inform the methodological framework developed for this study.

3.1 Overview

The first section of this literature review, "Bike share Mobility Around the World," explores the characteristics of researched programs globally, comparing various systems and contrasting varied outcomes in different regions. The following section, "Bike share Mobility in Colombia," considers the findings of the previous chapter to identify challenges and opportunities for bike share development in Latin America and Medellín. The third section of this review, "Understanding User Perceptions in Bike share Research," identifies the most adequate methodological approaches for researching the factors that affect peoples' choice to bike share, which informed the methodological approach adopted for this study.

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103. Shaheen et al, "Bikesharing in Europe, the Americas, and Asia. Past, Present, and Future," Transportation Research Record 2143 (2010):1-20.

3.2 Bike share mobility around the world

A comparative analysis of bike share systems helped identify the most significant factors that affect bike share use and satisfaction in different geographies, and the barriers and motivators that affect individuals' choice to bike share.

3.2.1 Barriers for implementing public bike share systems

To identify potential barriers for bike share use in Medellín, part of this literature review focuses on analyzing common and differentiated characteristics of successful bike share programs worldwide to assess if these characteristics are transferable/applicable to Medellin's context. Similarly, remarkably unsuccessful cases are analyzed to try to determine the factors that contributed to bike share systems' demise.

Most of the research reviewed here identified a set of key motivators and barriers to bike share that are grounded on specific socio-economic, institutional, or cultural aspects that characterize the communities and locales where bike share systems developed. The following table summarizes key motivators to bike share found in the literature at different locales.

Table 1. Factors that support bike share ridership and attract members

Factors	Study	Geographic Area
Attitudes about cycling and bike share		
Sense of pride	Bejarano et al 2017	Medellin, Colombia
Positive attitudes about cycling	Bejarano et al 2017	Medellin, Colombia
	Heinen et al 2011	Various cities in the Netherlands
	Shahen & Guzman 2018	France and Canada
Respect for city services	Bejarano et al 2017	Medellin, Colombia
Bike share system as civic builder	Bejarano et al 2017	Medellin, Colombia
High satisfaction with bike share system	Chen et al 2017	Hangzhou, China
	Guo et al 2018	Ningbo, China.
	Shahen & Guzman 2011	France and Canada
Costs		
Money savings	Bejarano et al 2017	Medellin, Colombia
	Fishman et al 2013	Worldwide

	Guo et al 2018	Ningbo, China
	Heinen et al 2011	Various cities in the Netherlands
Trip Distance		
Short trip distance	Guo et al 2018	Ningbo, China.
Long trip distance	Heinen et al 2011	Various cities in the Netherlands
Health and environmental benefits		
Health benefits	Heinen et al 2011	Various cities in the Netherlands
Environmental concerns	Guo et al 2018	Ningbo, China.
	Heinen et al 2011	Various cities in the Netherlands
CO_2 emission reductions	Shahen & Guzman 2011	Paris, France Montreal, Canada
Time savings		
Short time travel	Bejarano et al 2017	Medellin, Colombia
	Guo et al 2018	Ningbo, China.
Convenience		
Spontaneity	Fishman et al 2013	Worldwide
Flexibility of routes	Guo et al 2018	Ningbo, China.
Easy sign up	Guo et al 2018	Ningbo, China
Income		
Lower income	Gámez-Pérez et al 2017	Leon, Mexico
Higher income	Guo et al 2018	Ningbo, China
	McNeil et al 2018	Philadelphia, Chicago, and Brooklyn, US
Infrastructure		
Adequate infrastructure	Gámez-Pérez et al 2017	Leon, Mexico
	Bejarano et al 2017	Medellin, Colombia
	Shahen & Guzman 2011	Paris and Lyon, France
	Zhang et al 2014	Hangzhou, Wuhan, and Zhuzhou, China
Station proximity to transit	Chen et al 2017	Hangzhou, China
	Gámez-Pérez et al 2017	Leon, Mexico

	Guo et al 2018	Ningbo, China
	Shahen & Guzman 2011	Paris and Lyon, France Montreal, Canada Hangzhou, China
Gender		
Male	Guo et al 2018	Ningbo, China.
Female (at peak hours)	Campbell et al 2017	Beijing, China
Station density and proximity		
Proximity to residential addresses (300 to 500 meters)	Fishman et al 2013	Worldwide
	Guo et al 2018	Ningbo, China.
	Garcia Palomares et al 2012	Madrid, Spain
High density of stations	Garcia Palomares et al 2012	Madrid, Spain
	Zhang et al 2014	Hangzhou and Zhuzhou, China
Transport and bike use		
Owning a bike	Guo et al 2018	Ningbo, China.
Frequent public transport use	Guo et al 2018	Ningbo, China.
Knowledge about bike share		
Familiarity with bike share	Guo et al 2018	Ningbo, China.
	Zhang et al 2014	Hangzhou and Zhuzhou, China
Marketing and promotion	Guo et al 2018	Ningbo, China.
Quality of cycling experience		
Speed, movement, and momentum	Muhs & Clifton 2016	Worldwide
Micro-environmental factors (infrastructure and bikeway/network characteristics)	Mertens, Lieze 2018	Flanders, Belgium
	Muhs & Clifton 2016	Worldwide

Considering the variables that motivate individuals to bike share, it is possible to identify in the literature common effects for certain variables across regions, and contradictory effects for others.

A. Common variables that positively affect ridership with varying effects

Contradictory effects of explanatory variables that support bike share ridership exemplify significantly different results among different communities that hold different values. This was the case for the variables *income* and *travel distance* found in the literature.

According to a very comprehensive study about equity issues of bike share in the US by McNeil et al 2018, individuals in higher income brackets are more likely to bike share. [104] Similar results were found by Guo et al 2018 on a study of user perceptions in Ningbo, China, but the explanatory factors varied.[105] In the case of the US, the study by McNeil et al 2018 indicates that higher income individuals are more likely to bike share mostly because bike share stations are typically located around more affluent areas and important centers of economic activity.[106] By contrast, in the case of China, Guo et al 2018 suggest that higher income individuals are more likely to bike share because they are more familiar with the concept of bike share, and therefore are more likely to successfully use the bike share system.[107] Even though authors in these two studies considered both explanations applicable, they placed the emphasis on the aspects that better characterized their communities.

Contrasting the two previous studies, the research by Gámez-Pérez et al 2017 about attitudes towards bike share by potential users in Leon, Mexico, indicates that lower income individuals are actually more likely to bike share than higher income individuals.[108] The difference in the effect of *income* in the likelihood to bike share is directly related to the cultural and socio-economic arrangements of the locales. According to Gámez-Pérez et al 2017, more than 30% of transport trips in León are conducted by foot or bike, and most people that commute by foot or bike are individuals with lower incomes.[109] These results are consistent with the study by Fay et al 2017 over the state of the transportation sector in Latin America, where the authors found people use pedestrian and biking infrastructure in larger numbers when compared to

104. N. McNeil et al, "Breaking Barriers to Bike Share: Lessons on Bike Share Equity," *Institute of Transportation Engineers. ITE Journal* 88, issue 2 (2018): 31-35.

105. Yanyong Guo, et al, "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," *PLOS* (2017), accessed September, 12 2018, https://doi.org/10.1371/journal.pone.0185100.

106. N. McNeil et al, "Breaking Barriers to Bike Share: Lessons on Bike Share Equity," *Institute of Transportation Engineers. ITE Journal* 88, issue 2 (2018): 31-35.

107. Yanyong Guo, et al, "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," *PLOS* (2017), accessed September, 12 2018, https://doi.org/10.1371/journal.pone.0185100.

108. Karla Gámez-Pérez, et al, "Defining a primary Market for bikesharing programs. A study of habits and usage intentions in León, México," *Transportation Research Record* 2634 (2017): 50-56.

109. Ibid.

North America, and in larger proportion related to transit when compared to Asia/Pacific.[110] In light of this information, it makes more sense that lower income individuals in Latin America would be the most attracted to bike share.

Two studies found contradictory results for the variable *travel distance.* According to Guo et al 2018, bike share users of the very successful system of Ningbo, China, are more likely to bike share shorter distances to complete trips in half an hour or less.[111] By contrast, according to a study by Heinen et al 2011 focusing on commuters in various regions in the Netherlands, individuals are more likely to cycle for longer distance trips that would take more than half an hour to complete.[112] The significant difference in the effect of *travel distance* in the Netherlands is directly related to the local cultural context, as commute biking for longer distances is much more popular in the Netherlands than in China or the US. Furthermore, according to Heinen et al 2011, long distance bike travel is preferred for people that commute to work by bike, regardless of the safety and convenience of the biking environment.[113]

Another variable that was found to have a somewhat contradictory effect within in the same region is *gender.* According to Guo et al 2018, most bike share riders in Ningbo and in China in general, are males.[114] However, according to a study on user perceptions in Beijing by Campbell et al 2017, women are more likely to bike share during the rush hours in Beijing to avoid congestion in sheltered modes.[115] This observation was only found by Campbell et al 2017, but it is plausible that the gender gap in bike share use may be shrinking as a response to congested transit. A meta-literature review of bike share systems worldwide by Fishman et al 2013 indicates that bike share is helping reduce overcrowding in sheltered modes during peak hours.[116] More recently, a study about the state of the art of bike share systems worldwide by Shaheen and Guzman 2011 suggests that successful bike share systems like the ones in

110. Marianne Fay et al, "Rethinking infrastructure in Latin America and the Caribbean. Spending better to achieve more." The World Bank, 2017, accessed November 8, 2018, https://openknowledge.worldbank.org/bitstream/handle/10986/26390/114110-REVISED-PUBLIC-RethinkingInfrastructureFull.pdf.

111. Yanyong Guo, et al, "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," *PLOS* (2017), accessed September, 12 2018, https://doi.org/10.1371/journal.pone.0185100.

112. Eva Heinen et al, "The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances." *Transportation Research 16*, issue 2 (2011): 102-109.

113. Ibid.

114. Yanyong Guo, et al, "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," *PLOS* (2017), accessed September, 12 2018, https://doi.org/10.1371/journal.pone.0185100.

115. Andrew Campbell et al, "Factors Influencing the Choice of Shared Bicycles and Shared Electric Bikes in Beijing," *Transportation Research: Part C* 67 (2016):399-414.

116. Elliot Fishman et al, "Bike Share: A Synthesis of the Literature," *Transport Reviews* 33 (2013): 148-65.

Hangzhou and Mexico City have been experiencing exponential demand during peak hours in response to congested traffic and transit.[117] Moreover, this trend has extended to unsuspected locales like Montreal, and Shaheen and Guzman argue that this will eventually become a trend in all of North America.[118] Considering that according to Fay et al 2017 a staggering sixty to ninety percent of woman report sexual harassment or assault in public transport any given year in Bogota, Lima, Mexico City, and Santiago,[119] it is plausible that more women will become increasingly attracted to bike share in Latin America, especially during the rush hours when buses and trains are packed.

B. Common variables that positively affect ridership with similar effects in different regions

Some variables were found to have a very similar effect among very different communities. This is the case for variables that are summarized here as: (1) quality of the cycling experience, (2) station density and proximity, (3) adequate infrastructure, (4) convenience, (5) money savings, (6) health and environmental benefits, and (7) positive attitudes towards cycling.

Quality of the cycling experience

The quality of the cycling experience largely depends on the quality of the cycling infrastructure and the bikeway network characteristics. According to a study of cycling perceptions in older adults by Mertens 2018 in Belgium, physical and aesthetic microenvironmental factors (e.g. vegetation, upkeep, evenness of path, lower speed limits, lanes separated from traffic, etc.) can improve the cycling experience and encourage people to cycle.[120] This was also found by Muhs & Clifton 2016 in their worldwide study about the impact of the built environment on cycling.[121] According to Mertens 2018, physical and aesthetic changes alone do not encourage cycling in older adults when safety microenvironmental

117. Susan Shaheen and Stacy Guzman, "Worldwide Bike-sharing, Access Magazine of UCTC 39 (2011), accessed September, 9 2018, https://web.archive.org/web/20120719042742/http://uctc.net/access/39/access39_bikesharing.shtml.

118. Ibid.

119. Marianne Fay et al, "Rethinking infrastructure in Latin America and the Caribbean. Spending better to achieve more." The World Bank, 2017, accessed November 8, 2018, https://openknowledge.worldbank.org/bitstream/handle/10986/26390/114110-REVISED-PUBLIC-RethinkingInfrastructureFull.pdf.

120. Lieze Mertens, "Cycling for transport: The role of the physical environment," PhD dissertation presented to Universiteit Gent, 2016, accessed September 27, 2018, https://ecf.com/sites/ecf.com/files/Doctoraat%20Lieze%20Mertens_%20Cycling%20for%20transport_FINAAL.pdf.

121. Christopher Muhs and Kelly Clifton, "Do characteristics of walkable environments support bicycling? Toward a definition of bicycle-supported development," *Journal of Transport and Land Use* 9, issue 2 (2016): 147-188.

conditions are not addressed (e.g. separated lanes from traffic).[122] Muhs & Clifton 2016 found similar results considering younger age groups. They found that even travel time, which is almost consistently found to have a negative effect on cycling, seems to be mitigated by separated cycling facilities that provide comfort and safety.[123] These two studies found very similar effects for this variable, even though they looked at very different types of cyclists that interact differently with the built environment in very specific cultural contexts.

Station density and proximity

Station location is very important to bike share systems because it is directly related with aspects of accessibility and demand. According to a location-allocation study by Garcia Palomares 2012 in Madrid, Spain, it is more important to develop dense clusters of stations than to evenly distribute them throughout the bike share network.[124] To Garcia Palomares, denser clusters of stations "maximize coverage" and better address bike share demand in areas of high volume of activity.[125] Furthermore, according to this author, applying this approach to residential areas can also support bike share demand. This type of approach has worked very well for the bike share systems of Hangzhou, Zhuzhou, and Ningbo, which are by far the most successful models in China (Hangzhou's bike share system is praised as one of the most successful in the world). According to Zhang et al 2014, what Hangzhou's and Zhuzhou's bike share systems have in common, among other socio-demographic factors like population size, is that they have a higher number of stations in relation to population and users, in areas of higher volume of activity.[126] Additionally, Guo et al 2018 attributes part of the success of the Ningbo's bike share system to the availability of dense clusters of stations near residential addresses.[127] This is also supported by the meta literature review of bike share systems worldwide by Fishman et al 2013, who found that proximity to residential addresses may influence the choice to use bike share.[128] In this last study, the authors found that most bike

122. Lieze Mertens, "Cycling for transport: The role of the physical environment," PhD dissertation presented to Universiteit Gent, 2016, accessed September 27, 2018,
https://ecf.com/sites/ecf.com/files/Doctoraat%20Lieze%20Mertens_%20Cycling%20for%20transport_FINAAL.pdf.

123. Christopher Muhs and Kelly Clifton, "Do characteristics of walkable environments support bicycling? Toward a definition of bicycle-supported development," Journal of Transport and Land Use 9, issue 2 (2016): 147-188.

124. J. García Palomares, "Optimizing the location of stations in bike-sharing programs: A GIS approach," Applied Geography, 35 (2012): 235-246.

125. Ibid.

126. L. Zhang et al, "Sustainable bike-sharing systems: Characteristics and commonalities across cases in urban China," Journal of Cleaner Production 97 (2015):124-133.

127. Yanyong Guo, et al, "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," *PLOS* (2017), accessed September, 12 2018, https://doi.org/10.1371/journal.pone.0185100.

128. Elliot Fishman et al, "Bike Share: A Synthesis of the Literature." Transport Reviews 33 (2013): 148-65.

share users identified having a bike share station near home or work (within 500 meters).[129]

Adequate infrastructure

In relation to infrastructure, there is quite a lot of variation about what is considered "adequate," most of it related to the quality of the cycling environment and the cycling experience. For bike share systems in developing countries, a critical aspect of "adequacy" is the actual existence of a bikeway system, and connectivity to transit. Because many people that are likely to bike share in Latin America are already cycling, walking, or taking transit, it is very important for these bike share systems to develop a cycling network fully integrated to the transit system. This was found by Bejarano et al 2017 in their pilot study of Medellin's bike share system,[130] and by Gámez-Pérez et al 2017 in their intention study in Leon, Mexico.[131] Furthermore, Gámez-Pérez et al 2017 found that even though Leon's bike share system was intended for residential areas, most respondents were more interested in having access to bike share next to transit stations.[132] These studies are consistent with the report by Fay et al 2017 about transportation in Latin America, which indicates individuals across the region heavily use bike lanes and sidewalks to complete trips, or for last mile solutions to reach public transit.[133]

Connectivity to transit is also very important in China. According to Zhang et al 2014 and Chen et al 2017, successful models like the ones of Hangzhou and Zhuzhou are fully integrated to the transit systems and comprehend vast networks of bikeways.[134] According to Shaheen and Guzman 2011, these "adequate" infrastructure characteristics (docking stations close to transit and vast network of bikeways) is common to other very successful bike share systems, like the

129. Ibid.

130. Mauricio Bejarano et al, "A user-centered assessment of a new bicycle sharing system in Medellin," *Transportation Research Part F: Traffic Psychology* 44 (2017):145-158.

131. Karla Gámez-Pérez, et al, "Defining a primary Market for bikesharing programs. A study of habits and usage intentions in León, México," *Transportation Research Record* 2634 (2017): 50-56.

132. Ibid.

133. Marianne Fay et al, "Rethinking infrastructure in Latin America and the Caribbean. Spending better to achieve more." The World Bank, 2017, accessed November 8, 2018, https://openknowledge.worldbank.org/bitstream/handle/10986/26390/114110-REVISED-PUBLIC-RethinkingInfrastructureFull.pdf.

134. Mengwei Chen et al, "Service Evaluation of Public Bicycle Scheme from a User Perspective. A case Study in Hangzhou, China," *Transportation Research Record* 2634 (2017): 28-34; and L. Zhang et al, "Sustainable bike-sharing systems: Characteristics and commonalities across cases in urban China," *Journal of Cleaner Production* 97 (2015):124-133.

ones in Paris (Velib') and Lyon (Velo'v) in France.[135] Moreover, according to Guo et al 2018, an adequate bike share infrastructure is closely related to higher levels of user satisfaction, which the authors found, increases the likelihood to bike share.[136]

Convenience

Convenience is in great part a factor of trip purpose. It has significantly different meanings among different communities, but in general it refers to the ability to swiftly use a bike share system.

Fishman et al 2013 considers *convenience* in terms of spontaneity, so a bike share system should minimize barriers like lengthy signup process or mandatory helmet requirements so potential users can access the bike share system with serendipity.[137] This makes sense for countries like Australia and North America because according to Fishman et al 2013, the most common bike share trip purpose in these countries is commuting to work.[138]

To Guo et al 2018 *convenience* is understood in terms of accessibility, so a bike share system should have a straightforward sign up process and comprehend flexible routes to accommodate different types of users.[139] This makes sense for China because as Shaheen and Guzman 2011 noted, bike share trips in China have a much wider range of purposes and a much wider range of users.[140]

Money savings

Bike share has become an affordable transportation solution for many people around the world, and money savings are frequently found in the literature as one of the main reasons to bike share. However, this is not the case for all regions, most notably for the US, as it will be discussed in more detail in the next section.

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135. Susan Shaheen and Stacy Guzman, "Worldwide Bike-sharing," *Access Magazine of UCTC* 39 (2011), accessed September 9, 2018, https://web.archive.org/web/20120719042742/http://uctc.net/access/39/access39_bikesharing.shtml.

136. Yanyong Guo, et al, "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," *PLOS* (2017), accessed September, 12 2018, https://doi.org/10.1371/journal.pone.0185100.

137. Elliot Fishman et al, "Bike Share: A Synthesis of the Literature." *Transport Reviews* 33 (2013): 148-65.

138. Ibid.

139. Yanyong Guo, et al, "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," *PLOS* (2017), accessed September, 12 2018, https://doi.org/10.1371/journal.pone.0185100.

140. Susan Shaheen and Stacy Guzman, "Worldwide Bike-sharing," *Access Magazine of UCTC* 39 (2011), accessed September, 9, 2018, https://web.archive.org/web/20120719042742/http://uctc.net/access/39/access39_bikesharing.shtml.

According to Bejarano et al 2017, the initial success of the bike share system EnCicla in Medellin precisely relied on the fact that it was huge money saver for university students- it cannot be cheaper than free. This system became very popular very quickly as it was opened to all residents of the city, in great part because of money savings.

High quality transport in Medellin might be free for individuals that are unemployed or under the line of poverty, but lower middle-class families have to put up with the cost of transport, which is not always cheap considering average wages. According to Fay et al 2017, in Bogota, Buenos Aires, and Sao Paulo, commuting by public transport can add up to twenty or thirty percent of a family's income.[141] In these cases, the possibility of walking or cycling to work becomes extremely important.

Money savings was also found to be a factor in the decision to bike share in Ningbo,[142] and for most of the European bike share systems according to the reviews by Fishman et al 2013 and Shaheen and Guzman 2011.[143] Heinen et al 2011 also found that money savings was a major factor in the decision to cycle for commuting in the Netherlands.[144] According to Shaheen and Guzman 2011, the only places in North America where users cited money savings as a reason to bike share were Montreal, New York City, and Washington DC.[145]

Health and environmental benefits

According to the comparative study by Fishman et al 2014 of the bike share systems in Melbourne (AU) Brisbane (AU), Washington DC (US), Minnesota (US) and London (UK), the benefits of bike share are exaggerated, especially the perceived environmental benefits.[146] This

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141. Marianne Fay et al, "Rethinking infrastructure in Latin America and the Caribbean. Spending better to achieve more." The World Bank, 2017, accessed November 8, 2018, https://openknowledge.worldbank.org/bitstream/handle/10986/26390/114110-REVISED-PUBLIC-RethinkingInfrastructureFull.pdf.

142. Yanyong Guo, et al, "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," *PLOS* (2017), accessed September, 12 2018, https://doi.org/10.1371/journal.pone.0185100.

143. Elliot Fishman et al, "Bike share's impact on car use: evidence from the United States, Great Britain, and Australia." *Transportation Research Part D: Transport and Environment* 31 (2014): 13–20; and Susan Shaheen and Stacy Guzman, "Worldwide Bike-sharing," *Access Magazine of UCTC* 39 (2011).

144. Susan Shaheen and Stacy Guzman 2011.

145. Susan Shaheen and Stacy Guzman, "Worldwide Bike-sharing," Access Magazine of UCTC 39 (2011), accessed September, 9, 2018, https://web.archive.org/web/20120719042742/http://uctc.net/access/39/access39_bikesharing.shtml.

146. Elliot Fishman et al, "Bike share's impact on car use: evidence from the United States, Great Britain, and Australia." Transportation Research Part D: Transport and Environment 31 (2014): 13–20.

was also highlighted by the report on bike share to the United Nations by Midgley 2011,[147] and the literature review by Ricci 2015 analyzing aspects of implementation and operation of bike share systems.[148]

According to these authors, since car substitution rate is low, the positive impacts of bike share in terms of CO_2 emissions reductions are also very small, more likely insignificant.[149] Additionally, Fishman et al 2014 argued that potential emissions reductions can be easily overridden by the use of diesel-fueled trucks to re-distribute bicycles across the bike share network.[150] However, according to Shahen and Guzman 2018, a recent shift to electric and fuel-efficient vehicles for rebalancing purposes allowed the bike share systems SmartBike (deployed in different cities in Europe), Velib' (Paris), and BIXI (Montreal) to actually report CO_2 emission reductions after discounting for rebalancing activities.[151]

As bike share picks up steam, Shahen and Guzman 2018 have also found that some programs today actually report important modal shifts from cars to bikes, including Barcelona (Bicing), Paris (Velib'), Lyon (Velo'v, 7% of trips replaced by car trips), and Washington DC (SmartBike, 16% of trips replaced car trips).[152]

No study found in the literature assessed whether or not bike share can provide specific health benefits. Nevertheless, users and bike share operators often cite potential health benefits from more frequent cycling, as evidenced by Bejarano et al 2017 in Medellin,[153] and Fishman et al 2014 in Australia, the US, and the UK.[154]

Heinen et al 2011 noted that environmental concerns about climate change as well as health

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147. Peter Midgley, "Bicycle sharing schemes: Enhancing sustainable mobility in urban areas." Commission on Sustainable Development report, United Nations, New York, May 2011, accessed November 14, 2018, https://sustainabledevelopment.un.org/content/dsd/resources/res_pdfs/csd-19/Background-Paper8-P.Midgley-Bicycle.pdf.

148. M. Ricci, "Bike sharing: A review of evidence on impacts and processes of implementation and operation." *Research in Transportation Business & Management* 15 (2015): 28-38.

149. Elliot Fishman et al 2014; and M. Ricci 2015.

150. Elliot Fishman et al, (2014): 13–20.

151. Susan Shaheen and Stacy Guzman 2011.

152. Ibid.

153. Mauricio Bejarano et al, "A user-centered assessment of a new bicycle sharing system in Medellin" *Transportation Research Part F: Traffic Psychology* 44 (2017):145-158.

154. Elliot Fishman et al, "Bike share's impact on car use: evidence from the United States, Great Britain, and Australia." *Transportation Research Part D*: Transport and Environment 31 (2014): 13–20.

concerns motivate people to cycle in the Netherlands.[155] Similarly, Guo et al 2018 found that most users in Ningbo consider bike share use positive for their health and the environment.[156]

Positive attitudes towards cycling

Six of the eighteen studies discussed in this section reported that a prevalent cycling culture coupled with positive attitudes towards public transportation services are key factors that motivate people to bike share. These studies focused in Colombia (Bejarano et al 2017), the Netherlands (Heinen et al 2011), France (Shaheen and Guzman 2011) and China (Chen et al 2017, and Guo et al 2018), indeed countries with a rich history of cycling.

According to Chen et al 2017 and Guo et al 2018, the bike share systems of Hangzhou and Ningbo are highly regarded among users, boasting very high levels of satisfaction (over 95%).[157] Both of these systems are publicly run, heavily subsidized, and are very low cost to users,[158] but these are not the only factors these systems have in common. According to Zhang et al 2014, bike share systems in China tend to be more successful in smaller cities (three million people or less), where there is still a very strong cycling culture enabled by more traditional urban forms, and where air pollution is not so severe.[159] Compared to Beijing for example, with over twenty-one million people, severe pollution issues, and a declining cycling culture due to changing urban form, bike share is considerably less popular and in fact, has failed in several attempts.[160]

Furthermore, according to Guo et al 2018 and Chen et al 2017, people that bike share in Ningbo and Hangzhou are more likely to own a bicycle, and their choice to bike share is not affected by whether or not they own a car.[161] Since the bike share systems in these two cities

155. Eva Heinen et al, "The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances." Transportation Research 16, issue 2 (2011): 102-109.

156. Yanyong Guo, et al, "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," *PLOS* (2017), accessed September, 12 2018, https://doi.org/10.1371/journal.pone.0185100.

157. Mengwei Chen et al, "Service Evaluation of Public Bicycle Scheme from a User Perspective. A Case Study in Hangzhou, China," *Transportation Research Record* 2634 (2017): 28-34; and L. Zhang et al, "Sustainable bike-sharing systems: Characteristics and commonalities across cases in urban China," *Journal of Cleaner Production* 97 (2015):124-133.

158. Ibid.

159. L. Zhang et al, "Sustainable bike-sharing systems: Characteristics and commonalities across cases in urban China," *Journal of Cleaner Production* 97 (2015):124-133.

160. Ibid.

161. Mengwei Chen et al, "Service Evaluation of Public Bicycle Scheme from a User Perspective. A Case Study in Hangzhou, China," *Transportation Research Record* 2634 (2017): 28-34; and L. Zhang et al, "Sustainable bike-

reportedly boast incredible infrastructure at very low cost to users, it is no wonder people are happy with their bike share service.

Shaheen and Guzman 2011 found similar user satisfaction results for the systems of Paris and Lyon in France, and the bike share system of Montreal.[162] These systems are also publicly owned and enabled by traditional urban forms and very low costs. According to these authors, considering the costs of transport in these cities, cycling in good weather has become a preferred transport mode among individuals of all ages.[163]

Bejarano et al 2017 found that the cycling culture in Medellin is so positive, and the perceived benefits of the EnCicla system as a city service are so magnified, that users tended to override rational perceptions about the system's problems (e.g. unprotected intersections, erratic motorist behavior, lack of signaling, etc.).[164] The case of Medellin is somewhat unique, as users perceive the bike share system as a civic builder, but it also exemplifies the effect of a positive cycling culture in the choice to bike share.

C. Common variables that adversely affect bike share ridership

The following table summarizes key barriers to bike share found in the literature among different communities.

Table 2. Factors that adversely affect bike share membership and ridership

Factors	Study	Geographic Area
Attitudes towards cyclists		
Entitled motorist behavior	Bejarano et al 2017	Medellin, Colombia
	Fishman et al 2013	Worldwide
	Fishman et al 2012	Brisbane, Australia
Infrastructure		
Poor infrastructure	Bejarano et al 2017	Medellin, Colombia

sharing systems: Characteristics and commonalities across cases in urban China," Journal of Cleaner Production 97 (2015):124-133.

162. Susan Shaheen and Stacy Guzman, "Worldwide Bike-sharing," *Access Magazine of UCTC* 39 (2011), accessed September 9, 2018,
https://web.archive.org/web/20120719042742/http://uctc.net/access/39/access39_bikesharing.shtml.

163. Ibid.

164. Mauricio Bejarano et al, "A user-centered assessment of a new bicycle sharing system in Medellin" *Transportation Research Part F: Traffic Psychology* 44 (2017):145-158.

	Gámez-Pérez et al 2017	Leon, Mexico
	Taylor 2018	China
	Zhang 2014	Beijing and Shanghai, China
Safety in the roadway		
Risk perception	Fishman et al 2013	Worldwide
Traffic safety	Mertens 2018	Flanders, Belgium
Time and distance		
Long trip distance/travel time	Campbell et al 2016	Beijing, China
	Fishman et al 2013	Worldwide
	Muhs & Clifton 2016	Worldwide
Environmental conditions		
Low temperature	Campbell et al 2016	Beijing, China
Snow conditions	Heinen et al 2011	Various cities in the Netherlands
Precipitation	Campbell et al 2016	Beijing, China
Air quality	Campbell et al 2016	Beijing, China
Individual habits		
Travel purpose	Chen et al 2017	Hangzhou, China
Familiarity with bikesharing and knowledge of BSS	Chen et al 2017	Hangzhou, China
	Gámez-Pérez et al 2017	Leon, Mexico
	McNeil et al 2018	Philadelphia, Chicago, and Brooklyn, US
	Zhang et al 2014	Beijing, Shanghai, and Wuhan, China
Convenience		
Lengthy pre-registration	Fishman et al 2013	Australia
	Fishman et al 2012	Brisbane, Australia
Lack of spontaneity	Fishman et al 2012	Brisbane, Australia

Mandatory helmet policy	Fishman et al 2013	Melbourne, Australia
	Fishman et al 2012	Brisbane, Australia
Access to internet/Smartphone	McNeil et al 2018	Philadelphia, Chicago, and Brooklyn, US
Costs		
High costs	McNeil et al 2018	Philadelphia, Chicago, and Brooklyn, US
Limited payment options	McNeil et al 2018	Philadelphia, Chicago, and Brooklyn, US
Cost perception (liability)	McNeil et al 2018	Philadelphia, Chicago, and Brooklyn, US

Some of the factors that affect bike share ridership or the decision to bike share in most communities are very straightforward, like adverse environmental conditions (e.g. snow, rain and poor air quality), time and distance (e.g. people prefer shorter trips, except apparently in some communities in the Netherlands), and convenience (bike share systems should be easy to use to all types of cyclists and not pose too many barriers). There are, however, barriers that are more complex and should be examined carefully: safety, costs, and individual habits.

Safety

The study of infrastructure for cycling by Mertens 2018 in Belgium indicates that traffic safety issues (e.g. speed limits and car densities) are determinant in the decision to cycle in older adults,[165] and Fishman et al 2013 found similar results for other age groups in other countries.[166] But according to Mertens 2018 and Heinen et al 2011, safety concerns are not as important for middle-aged adults in Europe, who (in the absence of bikeways) can perceive "safer" environments as barriers for cycling.[167] Among this type of cyclists, traffic calming measures (e.g. speed bumps, trails, among others) can increase time travel and adversely

165. Eva Heinen et al, "The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances," *Transportation Research* 16, issue 2 (2011): 102-109; and Lieze Mertens, "Cycling for transport: The role of the physical environment." PhD dissertation presented to Universiteit Gent, 2016, accessed September 27, 2018, https://ecf.com/sites/ecf.com/files/Doctoraat%20Lieze%20Mertens_%20Cycling%20for%20transport_FINAAL.pdf.

166. Elliot Fishman et al, "Bike Share: A Synthesis of the Literature." *Transport Reviews* 33 (2013): 148-65.

167. Lieze Mertens 2016.

disrupt momentum in the act of cycling, which becomes very problematic under adverse climate conditions.[168] Fishman et al 2013 indicated that issues of risk perception in the roadway probably affect different types of cyclists in different ways, and that this effect should be analyzed in more detail to better understand mode choice and improve planning for bike share infrastructure.[169]

Costs

Cost concerns are probably not as relevant in the case of Medellin and other systems in China and Europe where public bike share systems are either free, very low cost, or do not require a hefty deposit. But in the US the situation is more complex, as most bike share systems do not rely as heavily on subsidies, and critical mass is difficult to reach to compensate with user fees (by contrast, according to Midgley 2011, Vélib' in Paris makes about thirty million Euros in revenues per year in user fees, as all operational expenses are covered through advertisement earnings.)[170]

McNeil et al 2018 found that cost is one of the main barriers to bike share in the US, especially among lower income communities and minorities.[171] Even when actual cost is not a major factor, McNeil et al 2018 found that cost perception is also a barrier, and many people choose not to bike share in fear of liability in case of theft or vandalism of the rented bike, or potentially undisclosed additional charges.[172]

According to McNeil et al 2018, payment options are also barriers for individuals without a credit card, as most bike share systems (especially fourth generation systems highly enabled by information technology) require a credit card to sign up, and most operators offer no alternative payment method. According to the authors, this not only excludes people without credit cards, it also affects overall ridership. [173] This situation may help explain why bike share tends to attract higher income individuals in the US.

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168. Ibid.

169. Elliot Fishman et al 2013.

170. Peter Midgley, "Bicycle sharing schemes: Enhancing sustainable mobility in urban areas," Commission on Sustainable Development report, United Nations, New York, May 2011, accessed November 14, 2018, https://sustainabledevelopment.un.org/content/dsd/resources/res_pdfs/csd-19/Background-Paper8-P.Midgley-Bicycle.pdf.

171. N. McNeil et al, "Breaking Barriers to Bike Share: Lessons on Bike Share Equity," *Institute of Transportation Engineers, ITE Journal* 88, issue 2 (2018): 31-35.

172. Ibid.

173. Ibid.

Individual Habits

Wang et al 2018 analyzed bike share user data from New York City and found clear differences in bike share use among different age cohorts, with older millennials (27-38 years old) conforming the majority of riders in New York City.[174] To Wang et al 2018, this result can be explained by the generational differences that shape the individual habits of different age cohorts, so younger cohorts for example would be attracted by more technology-dependent shared modes of transport than older cohorts.[175] Only this single study was found in the literature that researched aspects of individual habits that ultimately affect the decision to bike share, even though this has been identified as an important factor by Fishman et al 2013, Heinen et al 2011, and Campbell et al 2016.[176] However, Campbell et al 2016 suggested a rather simple approach to address aspects of individual habits, which is to locate bike share stations near residential addresses to improve the chances of people with different habits, to be enticed to bike share. [177]

3.2.2 Why Bike share systems fail?

According to the analysis by Zhang et al 2014 comparing successful and failed bike share systems in China, the main reasons why bike share systems fail are: absence of a policy framework, lack of clear financing mechanisms, lack of coordination among governing/management agencies, absence of adequate infrastructure (connectivity to transit and comprehensive bikeways), lack of station density near nodes of activity and residential addresses to build critical mass, poor customer service/unreliable information systems, and high rebalancing requirements, which critically increases costs.[178]

According to Zhang et al 2014, successful models have grown relatively slowly, under higher levels of coordination among different agencies, with clear commitments for financing and

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174. K. Wang et al, "Bike sharing differences among Millennials, Gen Xers, and Baby Boomers: Lessons learnt from New York City's bike share," *Transportation Research Part A: Policy & Practice* 116 (2018):1–14.

175. Ibid.

176. Elliot Fishman et al, "Bike Share: A Synthesis of the Literature." *Transport Reviews* 33 (2013): 148-65; Eva Heinen et al, "The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances," *Transportation Research* 16, issue 2 (2011): 102-109; and Andrew Campbell et al, "Factors Influencing the Choice of Shared Bicycles and Shared Electric Bikes in Beijing," *Transportation Research: Part C* 67 (2016):399-414.

177. Andrew Campbell et al, "Factors Influencing the Choice of Shared Bicycles and Shared Electric Bikes in Beijing," *Transportation Research: Part C* 67 (2016):399-414.

178. L. Zhang et al, "Sustainable bike-sharing systems: Characteristics and commonalities across cases in urban China," *Journal of Cleaner Production* 97 (2015):124-133.

clear future financing mechanisms, like advertisement.[179] These characteristics are shared by other successful systems like the one in Paris as reported by Shaheen and Guzman 2011.[180] Public failed systems in China lacked all of these characteristics, like the public system in Beijing that popped up quickly for the 2008 summer Olympics and vanished as quickly a year after.[181] But privately owned and operated systems have also failed in China for the same reasons.

According to Taylor 2018, many Chinese cities are struggling with piles of hundreds of bikes blocking streets, sidewalks and pathways, abandoned by unsuspected users anywhere everywhere. The issue has become so pressing, China has enormous graveyards of hundreds of thousands of abandoned or decommissioned bikes.[182] The bikes belong mostly to fourth generation bike share operators of dockless devices, enabling flexible pick-ups and drop-offs, but in the absence of adequate infrastructure, rebalancing strategies, or clear policy mechanisms to help organize the booming yet speculative bike share market in China, with disastrous results.[183]

According to a report on bike share worldwide by Midgley 2011, Spain had the fastest booming bike share market in the world between 2005 and 2010, opening even more programs than China during this period of time.[184] Unfortunately, soon after the country experienced the most system closures in the world, as more than half of those schemes (more than forty) failed due to lack of financing, adequate infrastructure, poor coordination among different agencies, and lack of a strong cycling culture (or the political will to foster it).[185]

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179. Ibid.

180. Susan Shaheen and Stacy Guzman, "Worldwide Bike-sharing," *Access Magazine of UCTC* 39 (2011), accessed September 9, 2018, https://web.archive.org/web/20120719042742/http://uctc.net/access/39/access39_bikesharing.shtml.

181. L. Zhang et al, "Sustainable bike-sharing systems: Characteristics and commonalities across cases in urban China," *Journal of Cleaner Production* 97 (2015):124-133.

182. Ann Taylor, "The Bike share oversupply in China: Huge Piles of abandoned and broken bicycles." *The Atlantic,* March 22, 2018, accessed September 30, 2018, https://www.theatlantic.com/photo/2018/03/bike-share-oversupply-in-china-huge-piles-of-abandoned-and-broken-bicycles/556268/

183. L. Zhang et al, "Sustainable bike-sharing systems: Characteristics and commonalities across cases in urban China," *Journal of Cleaner Production* 97 (2015):124-133.

184. Peter Midgley, "Bicycle sharing schemes: Enhancing sustainable mobility in urban areas," Commission on Sustainable Development report, United Nations, New York, May 2011, accessed November 14, 2018, https://sustainabledevelopment.un.org/content/dsd/resources/res_pdfs/csd-19/Background-Paper8-P.Midgley-Bicycle.pdf.

185. Ibid.

3.3 Bike share Mobility in Colombia

Because of the very limited number of studies found in the literature about EnCicla or other bike share systems in Colombia, this section of the literature review focuses on contrasting the bike share experience globally with the known strengths and challenges of EnCicla.

3.3.1 The significance of the bike sharing experience in different regions for Latin America and Colombia

For Latin American countries, the Chinese experience is perhaps the most relevant for two main reasons.

First, main Latin American cities are growing fast, and keeping proportions and cultural differences aside, they share significant growth patterns with emerging Chinese cities.

According to Fay et al 2017, the middle class in Latin America increased by fifty percent in the first decade of the 21st century, along with the consumption of durable consumer goods, like cars.[186] The same phenomenon developed in China in the last two decades, as discussed by Guo et al 2018 and Chen et al 2017.[187] In terms of sustainable planning, large Latin American cities and Chinese cities share very similar urban challenges in the 21st century.

The second reason why the bike share Chinese experience is so relevant to Latin America is that both regions historically have largely depended on informal public transport providers, especially in mid-size cities where bike share could be most effectively deployed. According to Taylor 2017, the reliance on informal private bike share providers became a major issue for Chinese cities that now need to manage bike share waste.[188] To Fay et al 2017, this can become an issue in Latin America. According to these authors, private investment for bike share development in Brazil and Mexico is coming mainly from the same Chinese investors that

186. Marianne Fay et al, "Rethinking infrastructure in Latin America and the Caribbean. Spending better to achieve more." The World Bank, 2017, accessed November 8, 2018, https://openknowledge.worldbank.org/bitstream/handle/10986/26390/114110-REVISED-PUBLIC-RethinkingInfrastructureFull.pdf.

187. Mengwei Chen et al, "Service Evaluation of Public Bicycle Scheme from a User Perspective. A case Study in Hangzhou, China," Transportation Research Record 2634 (2017): 28-34; Yanyong Guo, et al, "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," PLOS (2017).

188. Ann Taylor, "The Bike share oversupply in China: Huge Piles of abandoned and broken bicycles." The Atlantic, March 22, 2018, accessed September 30, 2018, https://www.theatlantic.com/photo/2018/03/bike-share-oversupply-in-china-huge-piles-of-abandoned-and-broken-bicycles/556268/

deployed and abandoned failed bike share schemes across China.[189] In the absence of appropriate legislation and infrastructure, bike share in Latin America can easily become a public nuisance at best, and a public hazard at worst, as electric dockless bikes are introduced.

Even though China has a rich cycling history and an important cycling culture, attitudes towards cycling and bike share in larger cities in Colombia resemble more the European experience. Bejarano et al 2017 indicated that cycling is a very important feature of popular culture in Colombia.[190] According to Fay et al 2017, the bikeway infrastructure in Latin America resembles European models, with some cities like Bogota adopting extensive bikeway networks over forty years ago, which allowed citizens to get comfortable cycling across town for a couple of generations.[191] Most importantly, as for many cyclists in Europe (according to Heinen et al 2011 and Mertens 2018), Fay et al 2017 found that people in Colombia will cycle regardless of the weather conditions, or the need to travel long distances.

The Bejarano et al 2017 study about EnCicla's pilot was the only study found about EnCicla in the literature. The gray literature about EnCicla not explored in this section of the report is mostly limited to news reports about the system's sporadic failures (e.g. not enough bikes on important dates) and successes (e.g. inauguration of new stations). No studies were found throughout this literature review about emerging bike share systems in Colombia like the one in Cali, probably because these systems have just begun operations in the last year (2017). Even in the absence of abundant literature, the case of Medellin is so unique for Colombia and so representative, that other cities in Colombia like Cali and Bogota are trying to replicate the model at different scales.

Considering all the factors that may affect bike share use, appeal, and accessibility found in the literature, the following section explores in more detail the relevance of these factors in the case of Medellín.

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189. Marianne Fay et al, "Rethinking infrastructure in Latin America and the Caribbean. Spending better to achieve more." The World Bank, 2017, accessed November 8, 2018, https://openknowledge.worldbank.org/bitstream/handle/10986/26390/114110-REVISED-PUBLIC-RethinkingInfrastructureFull.pdf.

190. Mauricio Bejarano et al, "A user-centered assessment of a new bicycle sharing system in Medellin," *Transportation Research Part F: Traffic Psychology* 44 (2017):145-158.

191. Marianne Fay et al 2017.

3.3.2 The significance of the bike sharing experience in different regions for Medellin

Even though EnCicla is a successful system with increasing demand, cycling rates in Medellin are nowhere near cycling rates in other major cities in Colombia like Bogota. According to Fay et al 2017 only three percent of Medellin's population commutes by bike, compared to seven percent of the population in Bogota.[192] In fact, the authors found that Bogotá has the largest proportion of commute cyclers in Latin America, surpassing in number of trips cities in Mexico and Brazil with larger populations.[193] Considering that many significant deterrents to cycle cited in the literature reviewed here are present in Bogota (e.g. constant rain, high levels of pollution, entitled motorist behavior resulting in an unacceptable rate of cyclist's deaths, among others), cycling is still more popular in Bogota than in any other city in Colombia, and perhaps in Latin America. To Fay et al 2017, this has to do with Bogota's decades old urban cycling experience, and the rather courageous political will of several city administrators over the past two decades, prioritizing bikeway infrastructure over roadway infrastructure, and implementing very ambitious urban cycling promotion programs.

Medellin doesn't have the same cycling culture of Bogota, but as Bejarano et al 2017 noted, it is working diligently to strengthen it.[194] In its favor, EnCicla has many characteristics of successful systems per the literature reviewed here, including factors that facilitate usage such as smart-card use, visibility, and integration to other public transport modes.[195] According to Fishman et al 2012, visibility is also an important factor for roadway safety.[196] According to these authors, bike share users in Australia reported better motorist behavior when using the public bike share system, than when they were cycling in their own bicycles.[197]

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192. Marianne Fay et al, "Rethinking infrastructure in Latin America and the Caribbean. Spending better to achieve more," The World Bank, 2017, accessed November 8, 2018, https://openknowledge.worldbank.org/bitstream/handle/10986/26390/114110-REVISED-PUBLIC-RethinkingInfrastructureFull.pdf.

193. Ibid.

194. Mauricio Bejarano et al, "A user-centered assessment of a new bicycle sharing system in Medellin," Transportation Research Part F: Traffic Psychology 44 (2017):145-158.

195. Peter Midgley, "Bicycle sharing schemes: Enhancing sustainable mobility in urban areas," Commission on Sustainable Development report, United Nations, New York, May 2011, accessed November 14, 2018, https://sustainabledevelopment.un.org/content/dsd/resources/res_pdfs/csd-19/Background-Paper8-P.Midgley-Bicycle.pdf.

196. Elliot Fishman et al, "Barriers and facilitators to public bicycle scheme use: A qualitative approach," Transportation Research. Part F, Traffic Psychology and Behavior 15, issue 6 (2012): 686-698.

197. Ibid.

There are however several factors that may affect EnCicla's appeal and accessibility found in the literature review. These include factors related to the bikeway network characteristics, urban form challenges, and supporting land use policies to encourage cycling mobility. Additionally, as the system expands, EnCicla may be facing increasing challenges related to station density and transit connectivity.

A. Urban form and land use policy challenges

Medellin has important geographic challenges because of its very steep streets, even for walking. According to Midgley 2011, topography is an important factor for cycling, and inclines of more than four percent may deter bike share users.[198] According to Midgley, in Barcelona people use the bike share system going downhill to the city center but prefer taking transit back up to the periphery.[199] This may cause important issues with re-distribution, especially for EnCicla as it expands to the steeper periphery with inclines of up to six percent in viable areas of expansion.

Another challenge for Medellin is that certain parts of the city, especially the most affluent ones, are very car oriented. According to Midgley 2011, successful bike share systems have been accompanied by urban mobility measures that restrict car use,[200] but no evidence was found throughout this literature review that supports this type of urban policy changes in the city. According to the analysis by Ferreiro 2015 about bike share in Latin America, cities that have implemented important policies that restrict vehicle use report better outcomes from bike share.[201] Per Ferreiro's account, Ecobici in Buenos Aires replaced a significant amount of taxi trips, as taxis could no longer park along transit stations, so it became easier for people to reach transit by bike than by car.[202] Similar results are observable for Bogota, where barriers for car use, including large pedestrianized corridors at the city center, often result in increasing rates of biking and walking.

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198. Peter Midgley 2011

199. Ibid.

200. Peter Midgley, "Bicycle sharing schemes: Enhancing sustainable mobility in urban areas," Commission on Sustainable Development report, United Nations, New York, May 2011, accessed November 14, 2018, https://sustainabledevelopment.un.org/content/dsd/resources/res_pdfs/csd-19/Background-Paper8-P.Midgley-Bicycle.pdf.

201. Leticia Ferreiro, "Cycling gains ground on Latin American streets" World Bank Group, accessed November 8, 2018, http://www.worldbank.org/en/news/feature/2015/06/24/el-pedaleo-gana-espacio-en-las-calles-latinoamericanas.

202. Ibid.

A preliminary observation exercise of demand patterns of EnCicla carried out for this research's proposal indicated that while the system expands, the density of stations is reduced, along with the level of services provided when compared to core of the bike share system (see Chapter 3). As a result, these stations seemed to be largely underutilized. This preliminary finding is consistent with the 2018 study by the National Association of City Transportation Officials (NACTO) that concludes that station density has a significant impact on bike share demand. Similar conclusions were drawn by all studies reviewed here that looked at bike share station location and density issues.

As EnCicla expands, it is important to address aspects of station density, which according to NACTO 2018 is a common mistake by bike share system operators that can lead to failure.[203] According to Ricci 2015, lack of density at the periphery of bike share systems can also lead to unequitable systems, as better served portions of the system are typically located near city's commercial and economic centers that are more frequented by better employed individuals with higher incomes.[204]

The literature reviewed here also indicates that decreased station density may have an important impact on accessibility to other modes of transport.[205] As newer EnCicla stations are located further apart, the system becomes less likely to support first-last mile solutions.

3.4 Methods for understanding user and non-user perspectives in bike share research

To address this question, studies selected here met at least one of the following criteria: first, the studies relied on robust research frameworks and conceptual analysis; second, the studies generated significant analysis on aspects of bike share usage, user satisfaction, active mobility attitudes, mode choice, factors affecting bike share systems, and non-user perspectives; third, the studies covered different geographies and approaches to allow for comparative analysis in terms of varying worldviews over public bike share systems, and varying approaches applied to

203. NACTO, "Walkable Station Spacing is Key to Successful, Equitable Bike Share," Nacto Bike Share Equity Practitioner's Paper 2015, accessed September 20, 2018, https://nacto.org/wp-content/uploads/2015/09/NACTO_Walkable-Station-Spacing-Is-Key-For-Bike-Share_Sc.pdf.

204. M. Ricci, "Bike sharing: A review of evidence on impacts and processes of implementation and operation," *Research in Transportation Business & Management* 15 (2015): 28-38.

205. Juan Carlos García-Palomares et al, "Optimizing the location of stations in bike-sharing programs: A GIS approach," *Applied Geography* 35 (2012): 235-246.

active transportation research and planning.

Table 3 summarizes the type of methods used in the studies analyzed in this section of this literature review, highlighting the frequency of use, the topic of study, and the targeted region.

Table 3. Methods applied in bike share research found in the literature

Method	Study
Survey	- Campbell et al 2017: Bike share current use and future demand in Beijing - Chen et al 2017: User perceptions, Bike share system of Hangzhou, China - Gamez-Perez et al 2017: Bike share use intentions in Leon, Mexico - Guo et al.2018: Bike share user perceptions in Ningbo, China - Heinen et al 2011: Attitudes of cycle commute, Netherlands
Survey + other methods	- Fishman et al 2014: Comparative analysis, bike share impact on car use - McNeil et al 2018: Issues of equity of bike share systems in the US - Mertens et al 2018: Comparative analysis, cycling for transport in Europe
Literature review	- Fishman et al 2013: Review of bike share programs worldwide - Moudon and Lee 2013: Evaluation of environmental audit instruments - Mouhs and Clifton 2016: Review of land use impacts on cycling - Ricci 2015: Review of impacts on bike share planning and implementation - Shaheen et al 2011: State of the art of bike share systems around the world
Interviews, focus groups & ethnography	- Bejarano et al 2017: Ethnography, bike share pilot in Medellin, Colombia. - Fishman et al 2012: Focus groups, bike share users and non-users, Brisbane, Australia. - Mertens et al 2018: Interviews, cycling for transport among residents of Flanders, Belgium.
Bike share data enabled analysis	- Wang et al 2018: Differences among bike share users of different age cohorts in New York City. - NACTO 2018: Correlation of ridership data in North America.
GIS	Garcia-Palomares 2012: Bike share station location- allocation models in Madrid, Spain.
Methodology for Product Service System (MPSS)	Zhang et al 2014: Differences in planning, design, and business models of China's most prominent bike share systems: Beijing, Hangzhou, Shanghai, Wuhan, and Zhuzhou.

3.4.1 The use of surveys for understanding individual perceptions and attitudes that affect bike share use and future demand: Issues of skewed data

The most commonly used form of inquiry for understanding bike share users and residents' attitudes found in this literature review is the survey. Eight of the sixteen peer reviewed articles analyzed here applied survey methodology accompanied by some form of statistical validity (see table 3 above). The most critical aspect in the use of surveys to assess individual attitudes and bike share user characteristics is perhaps the ability to capture information for a wide range of users. However, because bike share surveys typically rely on user generated data, oftentimes results are only applicable to a single set of individuals (e.g. mostly older middle-aged adults signed up as members of a bike share system, from where survey respondents were selected). Sometimes this is related to the scope of research, but most often authors are cautioning readers about the shortcomings of skewed data.

Only three of the eight studies based on surveys reviewed here targeted a specific segment of the population or a specific set of bike share users and cyclists. According to a 2018 PhD thesis dissertation by Mertens et al, analyzing the impact of the physical environment for cycling for transport among middle aged individuals resulted in a better understanding of a specific age group that would benefit from cycling promotion.[206] This study was the only one that did not report issues of bias or representativeness due to their focused research target. The other two studies that targeted specific users reported data representation issues. This was the case of a 2017 study by Chen et al that focused only on bike share users in Hangzhou, China, to obtain specific socio-demographic and user perception data not captured by the bike share IT data systems.[207] In this case, authors reported limitations related to potentially skewed data because people surveyed were specifically "current and active users" sourced from the bike share data system, leaving outside of the research less frequent cyclists of different ages and socio-economic backgrounds.[208] Heinen et al found similar limitations in their 2011 survey of Dutch residents that cycle to work, which resulted in limited perceptions from workers of large employers in the area of study.[209] By contrast, a 2018 study by Guo et al that analyzed bike share users in Ningbo, China, avoided issues of bias and data representation by implementing

206. Lieze Mertens, "Cycling for transport: The role of the physical environment," PhD dissertation presented to Universiteit Gent, 2016.
https://ecf.com/sites/ecf.com/files/Doctoraat%20Lieze%20Mertens_%20Cycling%20for%20transport_FINAAL.pdf (accessed September 27, 2018).

207. Mengwei Chen et al, "Service Evaluation of Public Bicycle Scheme from a User Perspective. A Case Study in Hangzhou, China," Transportation Research Record 2634 (2017): 28-34.

208. Ibid.

209. Eva Heinen et al, "The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances." Transportation Research 16, issue 2 (2011): 102-109.

random, intercept-based surveys while people were using the bike share system.[210] This study indicates that sourcing survey participants outside of bike share user-generated systems limits the exposure to issues of data representation/bias exposed above.[211]
Another difficulty found in the survey-based literature reviewed here is that implementation of intercept-based surveys is not always feasible, and authors oftentimes need to rely on low quality bike share user-generated data. This was the case of a 2014 study by Fishman et al that covered users of five different bike share schemes in Melbourne, Brisbane, Washington DC, London, and Minnesota.[212]

While bike share data information systems become more robust, survey-based studies that focus on a specific geographic area, and that considered both bike share users and non-users, have encountered fewer limitations in terms of identifying a wider of range of user perceptions. Four of the eight survey-based studies discussed here considered non-user perspectives, and all of these studies reported obtaining high quality data related to individual attitudes and perceptions.

According to Campbell et al 2017, performing an intercept survey while people are not only cycling, but also using other modes of transport, helped identify critical aspects of mode choice for different types of people that could affect bike share demand.[213] Similarly, a 2017 study by Gámez-Perez et al 2017 that surveyed residents of Leon (Mexico) for the planning of a future public bike share, demonstrated that interest in bike share (and the factors that would encourage/discourage bike share use) differs for different types of users.[214] Similar contrasts among different types of potential users were found by McNeil et al in a 2018 report about issues of equity among bike share schemes in the US.[215] The 2018 study by Mertens et al 2018 also reported high quality of user perception data by surveying both cyclist and non-cyclist

210. Yanyong Guo, et al, "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," PLOS (2017), https://doi.org/10.1371/journal.pone.0185100, accessed September, 12 2018.

211. Ibid.

212. Elliot Fishman et al, "Bike share's impact on car use: evidence from the United States, Great Britain, and Australia," Transportation Research Part D: Transport and Environment 31 (2014): 13–20.

213. Andrew Campbell et al, "Factors Influencing the Choice of Shared Bicycles and Shared Electric Bikes in Beijing," *Transportation Research: Part C* 67 (2016):399-414.

214. Karla Gámez-Pérez et al, "Defining a primary Market for bikesharing programs. A study of habits and usage intentions in León, México," *Transportation Research Record* 2634 (2017): 50-56.

215. N. McNeil et al, "Breaking Barriers to Bike Share: Lessons on Bike Share Equity," *Institute of Transportation Engineers. ITE Journal 88*, issue 2 (2018): 31-35.

groups.[216]

The analysis of the survey methodology applied in these studies to assess aspects of mode choice, individual perceptions, or the intention to bike, indicates that intercept-based surveys provide better quality data for a wider range of groups than internet-based surveys that rely on bike share user data.

3.4.2 Understanding bike share use patterns and user perceptions through participatory methods: focus groups, interviews, and ethnographic approaches

Only a limited number of studies found in the literature relied on purely qualitative methodology, even though several studies reported the need for more in-depth participatory research to better understand a wider range of current and future bike share users, and positively impact bike share demand. This aspect was highlighted by the survey-based study by Campbell et al 2016 and Chen et al 2017.[217] Additionally, this aspect was also highlighted in the 2013 meta-literature review by Fishman et al that analyzed bike share programs worldwide,[218] in the 2016 literature review by Muhs and Clifton that evaluated impacts of the built environment on cycling,[219] and in the 2015 literature review by Ricci that evaluated the aspects of bike share implementation and operation.[220]

Three of the twenty studies reviewed here relied on the analysis of rich qualitative information to assess individual perceptions over bike share and cycling. These studies are quite different, as they are deeply grounded in specific cultural, political, or socio-demographic characteristics of the local bike share systems, the cycling environment, and their current or potential users.

One such study is the 2017 ethnographic research of Medellin's bike share system by Bejarano et al that assesses cultural/psychological perceptions of users related to the introduction of a

216. Lieze Mertens, "Cycling for transport: The role of the physical environment," PhD dissertation presented to Universiteit Gent, 2016, accessed September 27, 2018, https://ecf.com/sites/ecf.com/files/Doctoraat%20Lieze%20Mertens_%20Cycling%20for%20transport_FINAAL.pdf.

217. Andrew Campbell et al, "Factors Influencing the Choice of Shared Bicycles and Shared Electric Bikes in Beijing," *Transportation Research: Part C* 67 (2016):399-414; and Mengwei Chen et al, "Service Evaluation of Public Bicycle Scheme from a User Perspective. A case Study in Hangzhou, China," *Transportation Research Record* 2634 (2017): 28-34.

218. Elliot Fishman et al, "Bike Share: A Synthesis of the Literature," *Transport Reviews* 33 (2013): 148-65.

219. Christopher Muhs and Kelly Clifton., "Do characteristics of walkable environments support bicycling? Toward a definition of bicycle-supported development," *Journal of Transport and Land Use* 9, issue 2 (2016): 147-188.

220. M. Ricci, "Bike sharing: A review of evidence on impacts and processes of implementation and operation," *Research in Transportation Business & Management* 15 (2015): 28-38

public bike share pilot that was initially conceived as research, but quickly became a mainstream planning project in the city.[221] In a different cultural and socio-political context, the 2012 focus group study by Fishman et al, evaluates substantially lower bike share rates in Brisbane compared to the rest of the world due to mandatory helmet policies for bike share in Australia.[222] Finally, in a socio-demographic context, the 2018 study by Mertens et al used a combination of survey and two-step interview methodology to assess changes in user perspectives for a specific age group residing in Flanders, Belgium.[223] This two-pronged approach to the interview process allowed the validation of previous survey results and the identification of the most significant factors that affect bike share use among the targeted group under study.[224] The different cultural, political, or socio-demographic contexts in these studies are directly related to the methods chosen.

Another aspect of qualitative based approaches is that they easily compliment additional methods of inquiry, as in the study about cycling infrastructure responses by Mertens et al 2018, and the 2018 study by McNeil et al analyzing equity issues of bike share schemes in the US. As in the Mertens et al study, Mc Neil et al 2018 contrasted in-person neighborhood interviews with previously conducted surveys of residents, bike share users, and bike share system operators.[225]This approach enabled a rich comparison of equity issues of bike share services with user and non-user patterns and perceptions.

Contrasting different forms of inquiry can be critical for contextualizing rational perceptions of bike share users with the characteristics of the cycling environment. Mertens et al 2018 used a virtual audit tool based on modified photographs to allow the people interviewed to place themselves in a specific cycling environment, and not just rely on memory, recollection, or imagination.[226] According to a 2003 review by Moudon and Lee analyzing almost all available validated audit instruments to evaluate walkable and cycling environments, even planning

221. Mauricio Bejarano et al, "A user-centered assessment of a new bicycle sharing system in Medellin," *Transportation Research Part F: Traffic Psychology* 44 (2017):145-158.

222. Elliot Fishman et al, "Barriers and facilitators to public bicycle scheme use: A qualitative approach" *Transportation Research. Part F, Traffic Psychology and Behavior* 15, issue 6 (2012): 686-698.

223. Lieze Mertens, "Cycling for transport: The role of the physical environment," PhD dissertation presented to Universiteit Gent, 2016, accessed September 27, 2018, https://ecf.com/sites/ecf.com/files/Doctoraat%20Lieze%20Mertens_%20Cycling%20for%20transport_FINAAL.pdf.

224. Ibid.

225. N. McNeil et al, "Breaking Barriers to Bike Share: Lessons on Bike Share Equity," *Institute of Transportation Engineers, ITE Journal* 88, issue 2 (2018): 31-35.

226. Lieze Mertens, "Cycling for transport: The role of the physical environment," PhD dissertation presented to Universiteit Gent, 2016, accessed September 27, 2018, https://ecf.com/sites/ecf.com/files/Doctoraat%20Lieze%20Mertens_%20Cycling%20for%20transport_FINAAL.pdf.

instruments designed to objectively measure the environment can rely on arbitrarily selected variables.[227] These two studies reveal that in cases were micro environmental aspects of cycling environments are being assessed, it is better to use a combination of methods to validate results, and assess the significance of the variables used.

3.4.3 Methods enabled via user and open source data: GIS and correlation analysis of bike share user datasets

The growth of open source data and recent improvements in the quality of bike share user information through improved data systems has enabled the study of bike share schemes (and the analysis of user information), without the absolute need for surveys and other more labor intensive and oftentimes time-consuming data collection methodologies. Open source methodological tools can help identify patterns and develop scenarios that facilitate bike share planning and can help improve bike share operational aspects. This was evidenced in the 2012 study by Garcia-Palomares et al, which used GIS open source methodology to model potential location and distribution of bike share stations in Madrid.[228]

Additionally, higher quality of open source data can be correlated to bike share user data to identify bike share use patterns and preferences among differentiated user groups. This was evidenced in the 2018 study by Wang et al that correlated New York City bike share user data with New York City Open Data and the 2010 Census, to identify significant differences among users of different age cohorts.[229]

Most significantly, the growing data age is helping generate new methodological approaches that can guide future bike share research. This is evidenced in the 2018 report by NACTO that determined the optimal distance between bike share stations for North America, according to the number of trips generated in relation to station density and distribution.[230]

In spite of the promising outlook of data enabled research, the 2015 literature review of bike

227. Ann Moudon and Lee Chanam, "Walking and bicycling: An evaluation of environmental audit instruments," *American Journal of Health Promotion* 18, issue 1 (2003): 21-37.

228. Juan Carlos García-Palomares et al, "Optimizing the location of stations in bike-sharing programs: A GIS approach," Applied Geography 35 (2012): 235-246.

229. K Wang, et al, "Bike sharing differences among Millennials, Gen Xers, and Baby Boomers: Lessons learnt from New York City's bike share," Transportation Research Part A: Policy & Practice 116 (2018):1–14.

230. National Association of City Transportation Officials (NACTO), "Walkable Station Spacing is Key to Successful, Equitable Bike Share," Nacto Bike Share Equity Practitioner's Paper, 2015. https://nacto.org/wp-content/uploads/2015/09/NACTO_Walkable-Station-Spacing-Is-Key-For-Bike-Share_Sc.pdf (accessed September 20, 2018).

share systems by Ricci indicates that most data-enabled bike share studies analyzed ignored important perceptions, attitudes, and preferences of communities underrepresented by bike share schemes.[231] Additionally, Ricci suggests that this is directly related to the typical geographic distribution of bike share stations, which is one of the main research topics addressed via data enabled research (e.g. areas near shopping and businesses with high volumes of activity).[232]

3.5 The relevance of the Chinese experience: Methodological lessons from the largest bike share user base in the world

According to a 2011 review of the state-of-the-art of bike share systems globally by Shaheen and Guzman, Hangzhou's bike share system in China is the largest in the world.[233] China is by far the country with the largest base of bike share users and bike share schemes, in some cases boasting very high degrees of user satisfaction. This was evidenced in the 2017 user perception study by Chen et al of the Hangzhou bike share system,[234] and the 2018 user perception study by Guo et al of the bike share system in Ningbo.[235]

A singular interesting study by Zhang et al 2015 surfaced throughout this literature review analyzing the intersection of bike share planning, design, and business models for China's most prominent bike share schemes. The literature reviewed here indicates that some of these aspects are either analyzed individually or can surface as an element of discussion. This is the only study found here that combines these aspects into a methodological framework to evaluate the overall rate of success or failure of bike share systems in Beijing, Hangzhou, Shanghai, Wuhan, and Zhuzhou.[236]

In this last study, the authors contrast user perceptions and use patterns of these bike share

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231. M. Ricci, "Bike sharing: A review of evidence on impacts and processes of implementation and operation," Research in Transportation Business & Management 15 (2015): 28-38

232. Ibid.

233. Susan Shaheen and Stacy Guzman, "Worldwide Bike-sharing," Access Magazine of UCTC 39 (2011), https://web.archive.org/web/20120719042742/http://uctc.net/access/39/access39_bikesharing.shtml, accessed September 9, 2018.

234. Mengwei Chen et al, "Service Evaluation of Public Bicycle Scheme from a User Perspective. A case Study in Hangzhou, China," *Transportation Research Record* 2634 (2017): 28-34.

235. Yanyong Guo, et al, "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," *PLOS* (2017), accessed September, 12 2018, https://doi.org/10.1371/journal.pone.0185100.

236. L. Zhang et al, "Sustainable bike-sharing systems: Characteristics and commonalities across cases in urban China." *Journal of Cleaner Production* 97 (2015):124-133.

systems to a variety of significant factors, including quality of information systems, level of subsidies, expansion and quality of specialized infrastructure, quality of bikes, operational costs, stakeholder engagement and institutional coordination, costs, and the rate of expansion, among other aspects.[237] This was the only study found in the literature that comparatively analyzed several bike share schemes in the same region, facilitating the generation of more generalizable conclusions for the Chinese context.

3.6 Understanding EnCicla through the comparative analyses of other bike share systems

Although studies reviewed here covered a variety of bike share systems in different regions, the present study made a special emphasis on the Chinese experience because of important urban growth similarities with Colombia, and the abundance of research published for Chinese bike share systems. Public bike share systems are fairly new to the Colombian context, and there are very few bike share systems in Latin America compared to the rest of the world. Only two relevant studies were found up to date specifically related to bike share user attitudes in this region. By contrast, China boasts some of the largest bike share systems in the world, and the Chinese experience has been adequately researched.

The review of literature evidenced that there are important similarities between China and Colombia related to the conditions under which bike share schemes are surfacing in big cities. Evident cultural and socio-economic differences aside, there are two main similarities between the Colombian and the Chinese experience that are worth looking at. First, Bicycle use is in decline in major urban centers in both countries because of changing urban form, population growth, pollution, and an explosion of motor vehicle ownership. Second, both countries have an important history of cycling for commuting, and cycling is still the main form of transport in many rural areas. With rapid migration and urbanization in these two countries, a specific rural-like culture and worldview of cycling is migrating to the cities, permeating emerging public bike share schemes from planning objectives through implementation.

From a methodological point of view, the literature reviewed here indicates that there is a specific survey methodology that is most suitable for addressing aspects of user satisfaction and on non-user perceptions related to bike share: the random intercept survey, independent of bike share user generated data. Even though appropriately designed surveys have been found here to be adequate, researchers that have applied this methodology successfully still expressed the need for more participatory-based, quality-rich methods that can provide

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237. L. Zhang et al, "Sustainable bike-sharing systems: Characteristics and commonalities across cases in urban China." *Journal of Cleaner Production* 97 (2015):124-133.

information about social groups that could be easily excluded from bike share schemes, and bike share research.

Qualitative participatory-based methods seem to be more appropriate when potential equity issues related to gender, equity, socio-demographic factors, policy, or cultural issues have been previously identified. These findings validate the choosing of an ethnographic approach for this study to identify the factors that affect the accessibility and appeal of EnCicla in Medellin (especially because this research considers a segment of potential users that seem to be excluded from the bike share system that could replace car trips for bike share trips).

The review of the literature indicates that improved quality and availability of bike share user data enables the applicability of diverse methods like GIS analysis, but it does not necessarily resolve important limitations in terms of obtaining a full range of perceptions from a variety of current or potential users. Most of the literature reviewed here indicates that to fully capture the complexities affecting user/non-user perspectives of bike share systems, it is important to contrast surveys and user data with other rich qualitative forms of inquiry.

The following chapter explores the research design and methodologies applied to better understand EnCicla's challenges, and user, non-user perceptions.

CHAPTER 4
METHODOLOGY

The methodology adopted for studying the factors that may be affecting EnCicla's use in Medellín is based on a three-pronged approach involving: (1) user experience systematic observations, (2) the collection of user and non-user perceptions, and (2) expert feedback.

User Experience Bikeshare Audit Conceptual Model
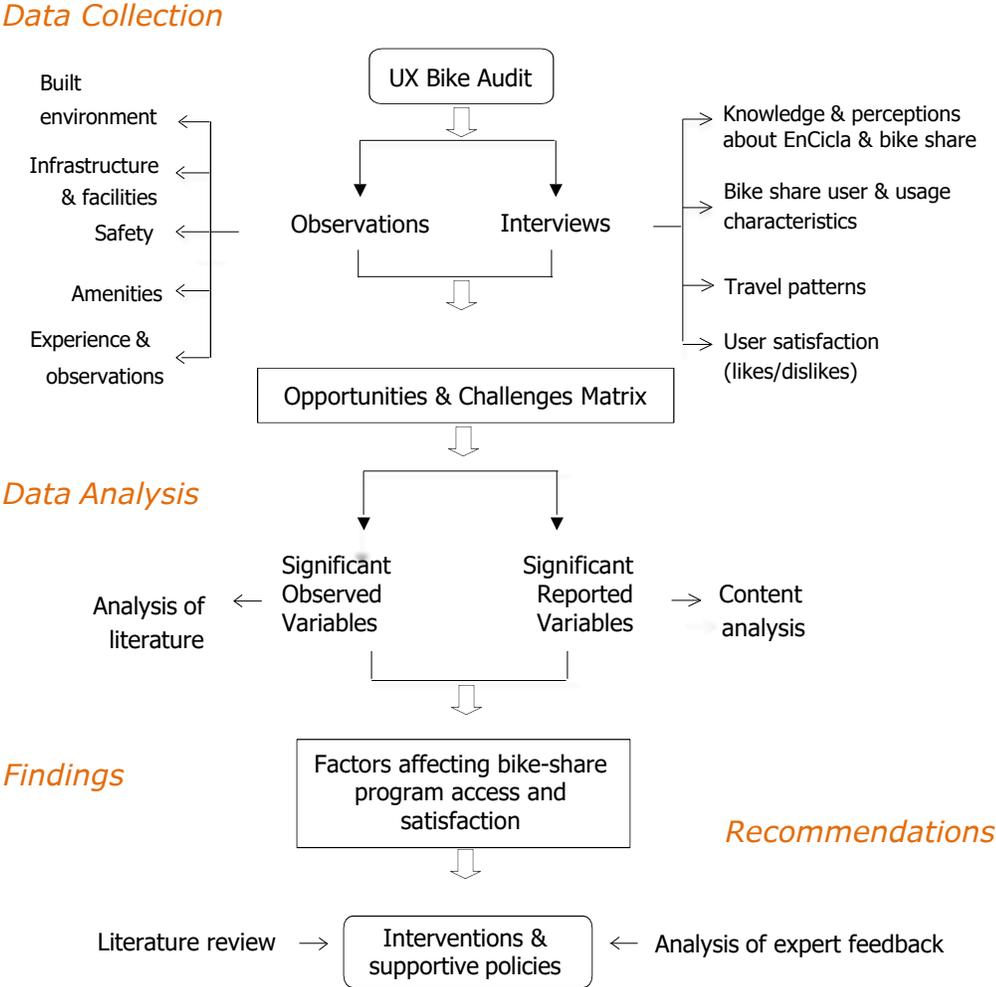
Figure 35. Research design model

4.1 Research Design

Transportation planning methodology explored in the literature review of this report highlights the importance of capturing the experiential and affecting factors (e.g. emotions) that influence transportation mode decisions, and that cannot be fully understood through traditional survey methodology.[238] To address this issue, the methodology proposed for this research incorporates a user experience approach to better understand experiential and affecting factors; direct observations to better understand the urban built and social environments; the inquiry of user and non-user perceptions to try to partially answer why the system may be unappealing or inaccessible to potential users; and the guidance of expert feedback to help contextualize the information gathered through research and literature review. The juxtaposition between the different sources of information sought here helped identify potential recommendations that could help improve the appeal and accessibility of EnCicla in El Poblado.

4.1.1 Data Collection Instruments

The primary objective of this research is to identify and analyze significant factors that may be affecting the uptake and accessibility of the public bike share system EnCicla in a section of Medellín that heavily relies on automobile use.[239] Answering this question requires a methodological approach that allows both systematic and subjective data collection methods to: (i) identify somewhat objectively the main characteristics of EnCicla in El Poblado, including the quality of the built and social environments; and (ii) understand people's perceptions of EnCicla, or lack thereof, and their overall user experience. To approach these questions, the following methods of data collection were selected:

1. A systematic audit of EnCicla's stations and connecting bikeway corridor in El Poblado based on adapted, existing bicycle audit tools, and performed mostly by bike while using the system (see Figure 36).
2. Short intercept-interviews of EnCicla users and non-users, performed at the stations, bikeway corridor and the surrounding area of the bike share system in El Poblado.

238. Peter Nijkamp, "Impact Assessment and Evaluation in Transportation Planning," Dordrecht; Boston: Kluwer Academic Publishers, 1994; Eva Heinen et.al, "The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances," *Transportation Research* 16, issue 2 (2011):102-109; and Yanyong Guo, et.al "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," *PLOS* (2017), accessed September, 12 2018, https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0185100&type=printable.

239. Área Metrpolitana, "Encuesta Origen-Destino 2017," accessed September 25, 2018, http://www.metropol.gov.co/encuesta_od2017_v2/index.html#/

Other aspects considered in this research are the potential interventions and land use policies that could support this section of the bike share system to: (i) make it more appealing to potential users in this neighborhood; and (ii) address some of the sustainability goals outlined for EnCicla, including cycling uptake and mode shift.

To better approach these questions, and to compliment and contrast fieldwork information, eight bike share experts were consulted (see expert interview questions in Appendix B). Experts consulted had a comprehensive knowledge of active mobility theory and methods, and/or had a profound understanding about EnCicla and the challenges of planning public bike share systems. Experts interviewed included staff members of the City of Medellín, Metropol, EnCicla, and Metro de Medellín; members of non-profit organizations dedicated to issues of urban sustainability; and members of the local private sector that have invested and experimented with mode shift policies involving bike sharing.

A. User Experience Audit

Overview

The audit entailed a systematic scan of the stations, bikeway corridor, and the surrounding environment of EnCicla in El Poblado. The area of study is portrayed in Figure 36 below. The purpose of performing the audit was to collect data about the quality of the built environment, the services offered through the bike share system, complimentary amenities, and other important aspects associated with successful bike share systems identified in the literature, like convenience (e.g. proximity to transit), and quality of the cycling experience.

The audit was performed by bike while recording:

- Information about the selected variables
- The researcher's own user experience
- Observations about the surrounding environment; and
- Observations about the experiences of others while using EnCicla.

The purpose of adopting this user-centered approach was to try to assess the overall user experience of EnCicla from the beginning (sign up) until the end of the interaction (destination).

Figure 36. Research Area, Cycling Route, and EnCicla Stations Source: Google Earth

Audit Variables

Audit variables were selected from existing audit tools and guidelines, considering transportation planning variables typically used to objectively measure the bike share environment; and variables that can help measure aspects that affect usage, like risk perception, or the costumer experience. The following audit tools and guidelines were considered to develop a specific user-experience audit checklist form for this research.

Table 4. Audit tools and guidelines researched

Bicycle Audit Tool/Guidelines	Purpose and Scope	Author and Organization
Bicycle Road Safety Audit Guidelines and Prompt Lists[240]	Considers cyclist-specific road safety aspects including: - Characteristics of the cycling network - Bikeway guidelines and best practices - Bikeway physical and environmental conditions - Cyclist vulnerability - Human and behavioral factors - Traffic conditions and safety data	Dan Nabors et al 2002, US Federal High-Way Administration

240. Dan Nabors et.al, "Bicycle road safety audit guidelines and prompt lists," US FHWA, accessed December 4, 2018, https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa12018/

Survey of the Physical Environment in Local Neighborhoods, SPACES Instrument Observer's Manual,[241] and SPACES form[242]	Provides guidelines for measuring the physical and environmental aspects that may affect biking and cycling, including: - Land use patterns - The condition of bikeway and pedestrian facilities - Local transportation options and facilities - Roadway, bikeway, and pedestrian infrastructure safety - Aesthetic factors - User characteristics	Terri Pikora et al 2000, University of Western Australia
Bike share Planning Guide[243]	A comprehensive bike share planning and policy guide that provides recommendations for evaluating and supporting bike share systems, including the following aspects: - Planning best practices and supporting regulatory framework - Equity and education - Implementation strategies and operational constraints - Financial mechanisms to support the sustainability and expansion of bike share systems	Institute for Transportation and Development Policy (ITDP)
Walking and Biking Audit Guide[244]	A practical guide that summarizes the general steps that need to be considered for conducting bike audits, considering specific research objectives.	Go Human

241. Terri Pikora et.al, "Spaces Instrument: Observer's manual," University of Western Australia, accessed December 4, 2018, Wehttps://activelivingresearch.org/sites/activelivingresearch.org/files/SPACES_Observation_Manual.pdf.

242. Terri Pikora et.al, "Spaces Instrument Checklist," accessed December 4, 2018, https://activelivingresearch.org/sites/activelivingresearch.org/files/SPACES_Audit_Instrument_0.pdf.

243. Institute for Transportation and Development Policy, "The bike-share planning guide," accessed December 4, 2018, https://www.eenews.net/assets/2013/12/06/document_cw_01.pdf.

244. Go Human, "How to conduct walking and biking audits," accessed June 17, 2019, http://gohumansocal.org/Documents/Tools/ToolBox_Audit.pdf.

Analytical Bike Audit Tool[245]	This audit checklist was designed to collect information about the urban infrastructure and environmental characteristics that may influence cycling and have an impact on physical activity. Variables considered in this audit tool included: - Land use and transportation environment - Facilities - Aesthetics - Signage - Social Environment	Ross Branson et al 2003, St. Louis University Public School of Health

To avoid a compilation of a large array of arbitrary variables frequently used to try to objectively measure the bike share environment,[246] two main criteria were established for variable selection: relevance and cultural appropriateness.

In terms of relevance, the variables selected for this audit checklist corresponded to the literature reviewed about the aspects that may affect the decision to bike share and that may be applicable to Medellin, including: bikeway characteristics, station characteristics and supporting services, area characteristics, characteristics of the transportation environment, characteristics of the land-use environment, safety, bike adequacy, and cycling comfort.

In terms of cultural appropriateness, variables selected were reviewed for their adequacy to relate to the local socio-cultural arrangements. For instance, a variable commonly used like the suitability of a bikeway relative to roadway function, was not considered. Urban bikeways in Colombia are rarely unprotected and tend to be heavily used regardless of roadway function. Instead, the audit focuses on measuring the micro-environmental aspects of the bikeway (e.g. vegetated amenities, comfort, and other aesthetic factors), that would make the cycling experience more comfortable to local users.

The variables selected and assessed through the audit included specific aspects of the built

245. Ross Brownson et.al, "Audit Tool, Analytic Version," accessed June 10, 2019, https://activelivingresearch.org/sites/activelivingresearch.org/files/audit_tool_analytic.pdf.

246. Ann Moudon and Lee Chanam, "Walking and bicycling: An evaluation of environmental audit instruments," *American Journal of Health Promotion* 18, issue 1 (2003): 21-37.

environment of EnCicla, but also aspects related to the surrounding urban form, land use, and the conditions and characteristics of cycling in this area of the city (e.g. perceived level of pollution, and steepness of slopes). The purpose of analyzing these variables was to better understand the relationship between them, which is determinant for planning and designing more supportive cycling environments.[247]

The following table lists the main variables recorded during the audit. A sample of the checklist audit form can be found in Appendix A.

Table 5. Variables selected for the audit checklist form

Properties Assessed	Audit Variables Selected	Targeted Observations
Built Environment	Area characteristics	- Aesthetics - Marketing and promotion - Perceived environmental characteristics - Social environment
	Land use environment	- Type of buildings and businesses - Area/segment land use characteristics
EnCicla's Infrastructure and Facilities	Bikeway characteristics	- Type of bike lane - Slope - Proximity to drive lanes and pedestrian facilities - Evenness of path - Wayfinding - Barriers - Supporting services - Safety concerns
	Station characteristics and supporting amenities	- Proximity to other stations (Density) - Accessibility - Proximity to residential areas - Signage and instructions - Supporting infrastructure and services - Usability and convenience
	Bike adequacy and cycling comfort	- Comfort of bicycles - Amenability of ride
Transportation environment	Traffic, parking, and transport options	- Traffic volume - Parking - Alternative transportation options - Connectivity to other modes

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247. Christopher Muhs and Kelly Clifton, "Do characteristics of walkable environments support bicycling? Toward a definition of bicycle-supported development," *Journal of Transport and Land Use*, 9, issue 2 (2016):147-188.

		- Observed speed limit
		- Observed motorist behavior
Safety	Traffic safety, safety amenities, and perceived safety concerns	- Conflict of legal traffic movements
		- Crossings and intersections
		- Night illumination
		- Police presence
		- Suspicious activity
		- Other safety concerns

The variables proposed for the audit checklist form helped assessed the following aspects about EnCicla in El Poblado:

- Built environment: The area's main characteristics and land use patterns.
- EnCicla's infrastructure and facilities: Bikeway and station characteristics, bike adequacy, supporting amenities, and cycling comfort.
- Transportation environment: Traffic patterns, availability of parking, and connectivity to transport.
- Safety: Perceived safety characteristics, safety at intersections, and potential conflicts with traffic.

Additionally, the audit form developed included a comment section for recording the researcher's subjective observations and perceptions while utilizing the system, that may not have been directly related to any of the variables initially considered.

Conducting the UX Bike Audit of EnCicla in El Poblado

All the routes surveyed covered an area of approximately two miles (see Figure 36). The audit was carried out in Medellin, Colombia, between July 31 and August 6, 2019, at different time intervals between the hours of 8:00 am and 7:00 pm. All the data was collected while conducting bike trips, with the aid of the prepared audit checklist form. Additionally, the camera and voice note applications available from the researcher's smartphone facilitated the collection of supporting information. User experience observations were recorded while on the trips via fast written notes, and via photographic record. The purpose of the audit checklist was to facilitate swift annotation of observations, while photographs helped convey the entire experience.

The first day of data collection in Medellin was dedicated to exploring the EnCicla system, including signing up to EnCicla, which can only be performed in person. After securing the first steps of enrollment into the system, a pre-fieldwork examination was performed to test the

prepared audit checklist form for content and usability. During this pre-fieldwork examination, it was determined that the most effective way to collect and process data and images while in the field in Medellin was to make fast handwritten and coded notes on the prepared audit forms, and to limit the use of a smartphone and recording device for comfort and safety considerations.

Administering the audit: Fieldwork limitations

Because the audit involved engaging people on the street while cycling alone, it was administered at times of the day considered safe by the researcher, mostly during the opening hours of local business, when there was a considerable volume of street activity, typically between 8:00 am and 6:00 pm.

Initially, the researcher's intention was to become an EnCicla user and to conduct all cycling trips in the area with an EnCicla bike. However, because of EnCicla's highly complex and time consuming in-person signup process, it was not possible to become a member of the system within a week time. Nevertheless, all trips were conducted using a rented Towny bike similar to the one developed for EnCicla. The researcher was able to borrow an EnCicla bike from a user in exchange for a tip for a test ride. This enabled the researcher to personally assess the overall qualities and limitations of the EnCicla bike. To approximate as much as possible to the EnCicla cycling experience, the researcher limited the usage of gears to the first three gears available on the Towny bike, as the EnCicla bicycle is enabled with only three gears.

B. Intercept Interviews

These are in-person, semi open-ended intercept interviews intended to engage both users and non-users of EnCicla while administering the cycling audit. The purpose of conducting interviews while surveying the area was to gain important insights about what was being observed and recorded, from other people's perspectives.

Overview

A slightly different questionnaire was designed to approach users of EnCicla, and non-users intercepted in the surrounding areas of the EnCicla stations. Questionnaires were designed to be completed in two to five minutes, and to provide the following information:

- Local knowledge about EnCicla. To obtain additional information about EnCicla from local perspectives, in a manner that the audit alone was not able to accomplish.
- Factors that affect usage. To identify the factors that people think are more/less supportive of EnCicla as a mobility option. Understanding other people's views helped put into perspective the information gathered through the literature review and audit,

as some of the factors that affect bike share use that seemed very important from the researcher's point of view were not so important to other individuals.

▪ Characterization of current and potential riders. To gather important observations about users and non-users of EnCicla, including whether or not the concept of bike share mobility was part of the interviewee's worldview, and whether or not specific respondents may be more or less likely to use the system (e.g. women vs. men).

▪ Accessibility barriers for non-users: To identify barriers for non-users that may be interested in using the system.

▪ Aspects of user satisfaction: To assess the level of satisfaction with the bike share system.

▪ Travel patterns: To better understand the travel patterns of users of EnCicla in this area of the system.

▪ Cycling worldview: To obtain information about the cycling culture (or absence thereof) of non-users.

Conducting these interviews at the same time as the audit facilitated the process of contrasting observations from different points of views, while utilizing the tools of urban environment under study.

Interview Questions

Table 6 summarizes the interview parameters for approaching users of EnCicla during the UX audit. Appendix A includes the interview questionnaires used during the audit.

Table 6. EnCicla User Intercept Interview Parameters

Objectives	Questions and observations
Local knowledge of EnCicla	- Membership time - Trip purpose
Factors that affect usage	- Factors that improve safety perception - Factors that increase safety concerns - Suggested changes or improvements - Bike comfort and usability
Characterization of users	- Occupation - Observed gender - Observed approximate age cohort
Factors that affect user satisfaction	- Before and after expressed level of satisfaction
Travel patterns	- Origin

| | - Destination |
| | - Time of use |

Table 7 summarizes the interview parameters for approaching non-users during the user experience audit of EnCicla.

Table 7. EnCicla Non-User Interview Parameters

Objectives	Questions and observations
Knowledge of EnCicla	- Awareness about EnCicla and bike share - Historic membership
Accessibility barriers	- Membership interest - Reason for not signing up - Level of cycling experience - Perception of the quality of bikeways and the cycling environment - Proximity to EnCicla stations from home to frequent destinations
Characterization of non-users	- Occupation - Observed gender - Observed approximate age cohort - Cycling habits
Cycling worldview	- Bicycle use (intensity) - Bike ownership

Conducting Intercept Interviews in El Poblado

A conscious effort was made to avoid issues of bias by ensuring to approach all potential interviewees, regardless of age, gender, or perceived friendliness and socioeconomic background.

A total of forty-eight interviews were collected while conducting the UX audit from 8:00 am to 7:00 pm, over the seven days of fieldwork the researcher spent in Medellín. Thirty-five of the interviews completed corresponded to EnCicla users, while fifteen respondents were non-users of the bike share system. Interviews were designed to be very short, and some interviewees indeed spent less than two minutes answering questions. Nevertheless, some interviewees spent much more time than what was requested and provided additional information and opinions. Moreover, some interviewees asked the researcher questions about the purpose of the study, and some interviews became more like conversations.

Since the main purpose of the interviews was not to gather a large quantity of responses, but

to gather a diversity of perspectives, the researcher spent as little or as much time as interviewees decided to devote to the interview process.

Administering the interview questionnaire: Fieldwork limitations

Although the interviews proposed for this research were not designed as a survey and randomness was not essential, the initial intention was to try to avoid issues of bias by randomly selecting potential interviewees; to be approached mainly at/near EnCicla stations, and at the main businesses in the proximity of this area of the bike share system like restaurants, coffee shops, and major employment or gathering centers (e.g. banks, office buildings, museums, etc.). This approach was tested during the first day of data collection, but it was quickly discarded because it did not yield the expected results. Because of the complexity of conducting interviews while cycling, it was determined that any individual spotted picking up or dropping off bikes at EnCicla stations, or resting along routes, would be approached to request a two-minute interview for the purpose of this research. This approach yielded much better results in terms of the ability of the researcher to swiftly engage available individuals while using the system.

Interview responses were intended to be recorded. Nevertheless, the researcher noticed that the level of comfort of respondents, and the quality of responses, was highly affected when a recording device was introduced. In fact, some individuals approached with a recording device declined to be interviewed. To eliminate this effect, all answers were recorded using a prepared handwritten questionnaire laid out in a notepad, to facilitate the collection of binary responses (e.g. do you own a bicycle?) This was not the most efficient way to collect interview information for the purpose of coding and analysis, but it proved the most comfortable for respondents, resulting in richer statements and sometimes, more elaborate thoughts and opinions. Individuals tended to be more likely to engage in the interview process when the notepad was used intermittently.

C. Expert Interviews

These are open and partially unstructured interviews to gain expert insights about the challenges for planning, developing, and administering bike share systems or bike share programs in Medellín. Interviews were performed in-person or over the phone during the course of this research.

An "expert" [248] for the purposes of this research is a person that:

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248. Leo Van Audenhove, "Expert interviews and interview techniques for policy analysis," Vrije Universiteit Brussel, accessed September 25, 2018, https://www.ies.be/files/060313%20Interviews_VanAudenhove.pdf.

- Has access to privileged information about EnCicla or bike share systems in Medellín and Colombia.
- Has been involved with the development/operation of EnCicla and other bike share systems elsewhere.
- Has a deep understanding of the complexities of cycling as a transport mode in Medellín and other locales in Colombia.

This interpretation facilitated the identification of potential experts to be interviewed. Expert insights about bike share principles and challenges in Medellín and other locales in Colombia helped understand what makes EnCicla unique in the Colombian context and, more importantly, what can be learned from other systems and bike share experiences elsewhere that would be applicable to Medellín.

Experts were consulted during after data collection. Five scouting interviews were conducted during fieldwork in Medellín to better understand the challenges of cycling as a transport mode in the city, and to better understand the potential of EnCicla to attract diverse users and become a trigger for mode shift in El Poblado. The main purpose of these interviews was to identify new issues about cycling in Medellín as a transport mode, or new knowledge about EnCicla not previously considered during the research. Appendix B includes a complete list of prepared questions of some interviews performed.

With the benefit of fieldwork results from the user experience audit, and a better understanding of user/non-user perceptions about EnCicla in El Poblado, three additional experts were consulted post fieldwork to try to answer more specific questions about the challenges of EnCicla, and the type of users that are able to access the system.

The main purpose of these interviews was to obtain quick access to specific information about the system's administration, operation, and trip data, that may help explain some aspects of usability and accessibility found during research. Additionally, this interview process helped identify suitable recommendations to address issues of bike share appeal and accessibility in the neighborhood El Poblado.

The following chapter of this report describes and analyzes this research's findings. Chapter 5 focuses on the insights gained from the UX audit, analyzing challenges for bike share users; and accessibility barriers for non-users of EnCicla that may affect the bike share system's uptake in this section of the system.

CHAPTER 5
ASSETS AND CHALLENGES OF ENCICLA

This chapter reviews infrastructure, accessibility, and operational qualities of EnCicla in El Poblado assessed from the user experience audit; and highlights individual perceptions about the system's appeal recorded via interviews.

The audit was completed while cycling in this section of the system using a prepared checklist form, as detailed in the previous chapter. A total of forty-eight individuals were interviewed while conducting the audit, between August 1 and August 5, 2019, at different times of the day. Thirty-three EnCicla users and eleven non-users found in the vicinity of the EnCicla stations surveyed were interviewed.

Analysis of main findings from the bike audit and interviews conducted resulted in the identification of significant infrastructure and operational challenges for EnCicla, and perceived barriers to bike sharing in El Poblado. Furthermore, the research conducted resulted in a bike share user characterization in the neighborhood, denoting the most and least supported riders in this section of the system.

5.1 Summary of Findings

5.1.1 Infrastructure and operational challenges

The main infrastructure voids and operational issues that affect a positive cycling experience and impact user satisfaction in this section of the bike share system are summarized below.

EnCicla has a rebalancing problem in this section of the bike share system

Observations indicate that some stations frequently run out of bicycles at peak hours in El Poblado, while some stations are seemingly underutilized outside of peak hours. This poses significant issues to users because they may not find bicycles when needed; or they may not drop off a rented bike at a desired station if it lacks available docks. Approximately twenty-four percent of bike share users interviewed reported frequent issues with bike/dock availability, and some of these users indicated they would like to have more stations closer each other (see Table 20).

There is untapped connectivity between EnCicla and the Metro system in El Poblado

EnCicla could be easily connected to the Metro station *El Poblado*, providing better accessibility to many users towards this highly serviced and populated area of the city.[249] Approximately forty-five percent of bike share users interviewed reported they would like to have more stations in El Poblado.

Bike facilities and infrastructure are for the most part adequate along main roads, but the cycling environment is severely affected by traffic volume

Air and noise pollution and erratic motorist behavior negatively affect the cycling experience in this area of El Poblado. Although most users interviewed did not highlight issues of air and noise pollution as the most pressing for cycling, the majority of users interviewed highlighted issues with traffic and lack of separated biking facilities as one of the most pressing issues for the entire bike share system.

Bike facilities and infrastructure are grossly inadequate on secondary streets

Cycling and even walking along tributary streets of the neighborhood poses major risk in the absence of appropriate facilities. These areas are also mostly devoid of supporting infrastructure like public bike-parking and seating areas. The majority of users interviewed reported lack of protected bikeway facilities as the single most important aspect of safety that adversely affects the cycling experience.

5.1.2 User Characterization

Observations and interviews performed in this section of EnCicla helped identify some user characteristics, including approximate age, occupation, gender, trip purpose, origin-destination, and frequency of bike share use. These findings were contrasted with the user information available for the entire EnCicla system, indicating some significant similarities and differences between El Poblado and other areas of the system.

Men are using the system at a much higher rate than women in El Poblado

In average, out of ten individuals observed using the system (i.e. loaning or dropping off a

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249. Carolina Barros et al, "Plan de Desarrollo Comuna 14- El Poblado," accessed November 15, 2019, https://www.medellin.gov.co/irj/go/km/docs/wpccontent/Sites/Subportal%20del%20Ciudadano/Planeaci%C3%B3n%20Municipal/Secciones/Plantillas%20Gen%C3%A9ricas/Documentos/Plan%20Desarrollo%20Local/Documento%20Plan%20de%20Desarrollo%20de%20El%20Poblado.pdf.

bike), eight to nine were men, and two to one were women. Approximately sixty-seven percent of the bike share users interviewed in El Poblado were men, and thirty-three percent were women (see Table 10). According to EnCicla experts consulted for this study, a significant difference between male and female riders is likely to be found in other areas of the system. [250] According to Metropol, twenty-eight percent of EnCicla riders in 2013 were women, and seventy-two percent were men.[251] In 2018, only 29.5% of EnCicla trips were made by women, indicating that male/female usage differences are persistent systemwide.[252]

Most EnCicla users interviewed were approximately between 30 and 40 years old

About fifty-one percent of users interviewed in El Poblado were approximately in the 30-40 age cohort, while thirty-nine percent of users interviewed were in the 19-29 age cohort (see Table 10). By contrast, according to Metropol, less than eighteen percent of EnCicla users are in the 30-40 age cohort systemwide,[253] while approximately sixty percent of EnCicla users are between 18 and 29 years old.[254]According to an EnCicla expert interviewed for this research, this difference may be due to a higher percentage of industrial workers using EnCicla in this section of the system because of the proximity to industrial employment centers. Occupation information gathered through interviews supports this explanation.

Most bike share users interviewed in El Poblado were workers cycling for commute

According to the municipality fifty-three percent of EnCicla users are students,[255] but the majority of bike share users interviewed in this section of the system were workers: Approximately seventy-five percent of users interviewed were employees, while twenty-four percent of users reported to be students (see Table 11). Furthermore, the majority of users that reported to be students were also employees in the area.

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250. Carolina Barros et al, "Plan de Desarrollo Comuna 14- El Poblado," accessed November 15, 2019, https://www.medellin.gov.co/irj/go/km/docs/wpccontent/Sites/Subportal%20del%20Ciudadano/Planeaci%C3%B3n%20Municipal/Secciones/Plantillas%20Gen%C3%A9ricas/Documentos/Plan%20Desarrollo%20Local/Documento%20Plan%20de%20Desarrollo%20de%20El%20Poblado.pdf.

251. Ibid.

252. Data provided by EnCicla expert of recent surveys conducted by Metropol on October 12, 2019.

253. Metropol, "Celebramos los primeros diez millones de préstamos de EnCicla," accessed November 15, 2019, https://www.metropol.gov.co/Paginas/Noticias/celebramos-los-primeros-diez-millones-de-prestamos-de-encicla.aspx.

254. Ibid.

255. Metropol, Plan Maestro Metropolitano de la Bicicleta Para El Valle de Aburrá 2015-2030, http://www.amc.gov.co/convenio_051/Presentaci%C3%B3n%20Ciclo%20Ruta%20Medell%C3%ADn.pdf.

The main trip purpose reported was commuting to and from work or school

The second most common trip purpose reported was running errands nearby or in downtown. Only one user interviewed reported to be using the system regularly for leisure.

Most bike share users interviewed in El Poblado reported frequent use of the system

Additionally, a significant number of users (approximately thirty-six percent) characterized themselves as occasional users (riding at least once per week- Table 14).

Almost half of the users interviewed in El Poblado have been members of EnCicla for more than a year

Users interviewed in El Poblado range from novice users (less than six months) to longtime users (more than three years). Metropol estimates that between 2016 and 2019 more than eight million trips in Medellín have been completed with EnCicla, and the municipality frequently highlights its longtime users.[256]

The vast majority of EnCicla users interviewed in El Poblado are not residents of the commune

Only one bike share user interviewed reported to be a resident of El Poblado. All other users that were initiating or ending trips in El Poblado reported to live in other communes.

Most users interviewed were travelling long distances to complete trips

Only five people interviewed were using EnCicla as a first-last mile solution, or to complete short trips. The majority of the people interviewed are traveling long distances with EnCicla.

5.1.3 Accessibility barriers and other user/non-user perceptions

Interview questions related to the level of user satisfaction and barriers to bike share provided important insights about the perceived factors that may be affecting the user experience, and that may deter potential users to become members of EnCicla.

Women interviewed are reportedly less likely to sign-up to EnCicla because they are not supported by the current level of service

Woman in El Poblado have more varied trip purposes. Additionally, cycling paradigms and

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256. Metropol, "Celebramos los primeros diez millones de préstamos de EnCicla," accessed November 15, 2019, https://www.metropol.gov.co/Paginas/Noticias/celebramos-los-primeros-diez-millones-de-prestamos-de-encicla.aspx.

heightened risk perception seems to have an impact on female bike share interest in El Poblado.

The most cited reasons not to sign-up to EnCicla are the complex and time-consuming signup process, followed by owning a bike

Most non-users interviewed were not willing to go through EnCicla's signup process and justified not needing the system because of bike ownership or accessibility.

Reported overall positive perception about the bike share system is not impacted by critical system's failures

The majority of bike share users interviewed rated EnCicla very highly. None of the users interviewed rated the system poorly, and only about twenty-one percent of them downgraded their perceived level of satisfaction with the service after describing negative user experiences (see Table 18). Remarkably, one user reported a higher level of satisfaction with EnCicla after relaying significant system failures.

5.2 Analysis of Findings and User Experience Insights

To facilitate the analysis of the observations and the variables recorded through the experienced-based bike audit, the key features identified for this section of the bike share system were summarized in an opportunities/challenges matrix (see Figure 37). The matrix is intended to help explain the following aspects:

Key features
The factors and characteristics that make EnCicla an appealing mobility option in this area of the city.

Key barriers
The factors and characteristics of the system that make it inconvenient as a mobility option.

Main users
Observed characterization of the current ridership in this area of the city, and observations about potential users that may be excluded due to operational or infrastructure constraints.

Bike share accessibility
The factors and characteristics of the system and the surrounding infrastructure that make it

appealing and accessible, and observed/experienced issues of accessibility.

Experience satisfaction

The micro-environmental factors and characteristics of the system and the surrounding urban environment that may support the user satisfaction with EnCicla.

Observations and experiences recorded through the audit indicate that EnCicla has significant infrastructure assets that support cycling and bike share use, including a network of protected bike lanes and a dense cluster of stations strategically placed in areas of high volume of activity. Some of the factors found in the literature that may support bike share uptake across different regions were identified, including aspects like proximity to transit and station density, as described in Table 8.

Opportunities: Key Features   **Most Supported Riders**

Positive Experience

- Easy to use
- Protected bike lanes and intersections
- Seating, shade, and open space
- Transit connectivity- Metro Industriales
- Proximity to residential addresses and multiple land uses
- Availability to food and beverage services

- University students employed in industrial area of El Poblado
- Workers and employees
- Men between 19 and 40 years old

Accessibility

Negative Experience

- Signup and registration
- Connectivity to popular destinations in El Poblado- Metro El Poblado
- Intensive car-use and parking sprawl
- Bikeway invasion and other blockages
- Traffic, noise, and air pollution
- Bike availability at peak hours
- Dock availability at slow hours

- Residents of El Poblado
- Women
- University students
- South bound metro commuters
- Users over 50 years old

(-)

Challenges: Key Barriers   **Least Supported riders**

Figure 37. Analysis of observed findings

Table 8. Factors supporting ridership and bike share membership in El Poblado

Factors	Description
Time savings	Shorter travel time, especially during peak hours
Adequate infrastructure	Protected bike lanes and supporting infrastructure and services (e.g. shade, seating areas, and proximity to food and drinks)
Station proximity to transit	Stations adjacent to Metro and Bus
Proximity to residential addresses	Protected bike lane and some stations less than 500 m away from residential pocket
High density of stations	Stations 500-800 meters away from each other

Nevertheless, these supporting factors may not be making the impact they could on bike share uptake and ridership because they are curtailed by fragmentation and discontinuity. There is a bike share station at the Metro station *Industriales* at the gateway of the neighborhood, but there is no bike share station by the Metro station *El Poblado*, which is only a mile away, and arguably represents the most important center node of activity in the entire neighborhood.

The user-based survey highlighted significant operational challenges that adversely affected the user experience in this section of the system. There are not enough bike share stations connecting areas of the neighborhood identified as suitable for bike share,[257] and protected bikeways are discontinuous, resulting in fragmented service routes to important transportation nodes in the neighborhood. Some of the factors found in the literature that may adversely affect bike share ridership across different regions were identified, including aspects of safety, adverse environmental conditions, and convenience.

Table 9. Factors affecting ridership and bike share membership in El Poblado

Factors	Description
Entitled motorist behavior	Traffic not always yields to cyclists
Safety (risk perception and protection from incoming traffic)	Vulnerability at intersections, some bikeway sections, and inner neighborhood streets
Air quality	High levels of air pollution

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257. Área Metropolitana, "Sistema de bicicletas públicas EnCicla. Planeación, implementación y operación," accessed November 26, 2018, http://www.emov.gob.ec/sites/default/files/Andr%C3%A9s%20Alvarez%20-%20Sistema%20de%20Bicicletas%20P%C3%BAblicas%20ENCICLA%20SIM_0.pdf.

Speed and momentum	Protected bike lane parallel to main road is interrupted by multiple intersections. There are no alternative protected routes.
Lengthy pre-registration	Double registration: First registration with Metro System to obtain the civica card; second registration through EnCicla, pending 48 to 72-hour verification process.

Additionally, the survey helped identify significant physical obstacles for cyclists navigating this section of the bike share system, including car parking overflow. Systematic observations recorded indicate that there is a significant amount of public, private, and on-street parking available in this area of the neighborhood: there was a car parking lot every 200 to 500 meters throughout the audited area, and most streets surveyed had available on-street parking at least on one side of the street. Figure 38 illustrates the general location of the eight EnCicla stations surveyed, and some of the most significant observations about the existing bikeway infrastructure found during the survey.

The following subsections describe the observations and experiences recorded through the bike audit tool. These observations and experiences were overlaid into a "qualitative journey map"[258] illustrated by photos of key locations, to help identify the stages of the journey that generated specific concerns or emotional responses.[259] The analysis of this journey map generated significant insights about specific aspects of the system, or the journey, that seemed appealing and accessible, or not.

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258. Bejarano et.al, "A user centered assessment of a new bicycle sharing system in Medellín," Transportation research, 44 (2017):145-158.

259. Ibid.

There is no bikeway infrastructure outside of protected bikeways on major roads

An important section of the neighborhood suitable for bikeshare is disconnected from the system

High gradient slopes make cycling almost impossible in most areas of El Poblado

Protected bike lanes adjacent to increased slopes are underutilized

Figure 38. EnCicla Stations in El Poblado

5.2.1 User and non-user perceptions of EnCicla

The intercept interviews performed during the user experience bike audit helped contextualize the researcher's findings and observations discussed in the previous chapter. Most importantly,

intercept interviews provided new critical information about the typical users in this part of the system, and the accessibility barriers that other individuals have identified.

A. EnCicla User Characterization in the Neighborhood El Poblado

A total of thirty-three EnCicla users were interviewed. Twenty-two of these users were men, and eleven of these users were women. Four different age cohorts were identified among these users.

Table 10. Age cohorts of EnCicla users interviewed

Age Cohort (years)	Female Users	Male Users	Total Users
20-30	4	9	13
30-40	7	10	17
40-50	0	3	3
50-60	0	1	1

The majority of the users interviewed were local employees between the ages of 20 and 40 years old. Eight of the people interviewed were students, five of which were also employed in the area. Only one of the students interviewed was a woman.

Table 11. Employee Vs student users

Occupation	Total
Employees	25
Students	3
Employees + students	5

Most notably, only one EnCicla user interviewed lived in El Poblado and was using the system to complete relatively short trips. Most users interviewed were completing long distance trips from their homes in distant neighborhoods to their workplaces in El Poblado. Only four people interviewed were using EnCicla as a last/first mile solution to reach the Metro station *Industriales.*

Table 12. Trip origin and destination

Trip origin	Total
El Poblado	6
Outside El Poblado	27
Trip destination	
El Poblado	2
Outside El Poblado	31

The majority of users interviewed have been using EnCicla for more than six months and are relatively frequent users of the system.

Table 13. Length of membership

Time of membership	Total
1 - 6 months	8
7 months - 12 months	10
13 months < 2 years	1
2 years < 3 years	7
3 years	3
4 years	4

Most individuals reported using EnCicla at least three times per week. Individuals that reported more frequent usage tended to be recent members of the system, while the two individuals that reported rare use have been members of EnCicla for at least four years.

Table 14. Frequency of use reported

Frequency of use	Total
Frequent (more than once per week)	16
Occasional (at least once per week)	12
Everyday	1
Rarely	2

B. User perceptions of EnCicla

Safety

Individuals were asked about the aspects that make them feel safe or unsafe while using the system. Content analysis of user responses helped identify the following categories of positive and negative safety perceptions:

Positive Safety Categories:

- Protected bikeways
- Good bike quality
- Good bike lane quality

Negative Safety Categories:

- Unprotected bikeways
- Poor bike quality
- Bikeway invasion
- Erratic motorist behavior

Table 15. Negative safety perception

Category	Total
Unprotected bikeways	21
Unprotected intersections	11
Bikeway invasion	23
Erratic motorist behavior (not yield)	11

People interviewed overwhelmingly identified protected bikeways as an element of the system that made them feel safe, followed by bike and bike-lane quality. Similarly, respondents identified unprotected bikeways as one of the elements of the system that made them feel most unsafe. However, bikeway invasion by pedestrians and motorists was the factor that people most mentioned. Other factors that made people feel unsafe included unprotected intersections, and erratic motorist behavior. Tables 15 and 16 summarize the frequency of responses for these categories.

Table 16. Positive safety perception

Category	Total
Protected bikeways	31
Good bike quality	1
Good bike lane quality	1

Bike Quality

Individuals were asked to assess the quality of the EnCicla bike. The vast majority of users reported that EnCicla bikes where high quality, comfortable, and easy to adjust. Complaints

about the EnCicla bikes were related to the limited gears of the bike, and poor maintenance. The following table summarizes the general bike quality perceptions of EnCicla users interviewed.

Table 17. Bike quality perception

Bike quality perception	Total
Mediocre	1
Good	19
Very good	11
Excellent	2

User satisfaction

During the interview, people where asked first if they were satisfied with the bike share system. The following questions were designed to try to elicit issues of usability, including potential accessibility and safety concerns. Once people were able to ponder about aspects of the system that may have generated some level of dissatisfaction, they were asked again, as a last question, if they were overall satisfied with the bike share system. The purpose of asking this question at the beginning and at the end of the interview was to try to measure changes in the level of user satisfaction reported by users, once they were able to recollect potential difficulties in using the system.

Table 18. Levels of satisfaction reported for EnCicla

Initial level of Satisfaction Reported	Total
Excellent/marvelous	9
Very good	15
Good	9

The majority of the people interviewed reported extremely high to high levels of satisfaction with the system, and very few respondents revised their first reported level of satisfaction after recounting considerable issues that they have experienced with the bike share service. In fact, one respondent reported increased levels of satisfaction with the system after recalling some difficulties experienced. These results are consistent with the results found by Bejarano et al 2017[260] of user perceptions about the EnCicla pilot. It seems that users of the system continue

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260. Bejarano et.al, "A user centered assessment of a new bicycle sharing system in Medellín," Transportation research, 44 (2017):145-158.

to override considerable drawbacks of EnCicla because of other perceived benefits. Bejarano et al 2017 argued that this was in part related to feelings of pride extending from the Metro Culture. Here it will be argued that the main factor driving the high level of user satisfaction overriding other operational difficulties is related to cost: The system is free, and that is a supreme reason for users to override system failures.

Table 19. Post-interview changes in satisfaction

Changes in level of satisfaction reported	Total
From excellent to very good	3
From very good to good	4
From very good to excellent	1

Desired Changes

Individuals were asked about the aspects of EnCicla they would like to change or see improved, and respondents were led to refer to desired changes in El Poblado. Nevertheless, the majority of respondents discussed desirable changes for the entire system, including a variety of improvements like additional protected bikeways, and the ability to bring the bikes into the Metro. Furthermore, some people alluded to the Metro Culture, and suggested EnCicla do a better job educating motorists and pedestrians to yield for cyclists and stop invading cycle paths.

The most significant changes people referred to, when speaking about El Poblado, were related to system expansion (more stations), improved bike availability, closer stations, longer night schedule, and longer rental period. The following table summarizes stated desired changes for EnCicla in El Poblado and systemwide.

Table 20. Desired changes and improvements

Desired changes	Total
More protected bikeways	18
More protected intersections	3
More pedestrian crossings	2
Additional stations in El Poblado	16
Closer stations	2
More bikes (El Poblado stations)	8
E-bikes	4

Additional bike parking	2
Taking bikes on Metro	3
Education (motorists and pedestrians)	2
Better bike maintenance	3
Longer night Schedule (El Poblado)	2
Improved connectivity to other communes	4

C. Non-user perceptions of EnCicla

Fifteen non-EnCicla users were interviewed, eight of which were male, and seven were female. Most non-users interviewed were approximately between the ages of twenty and fifty years old. Only one of the individuals interviewed reported no interest in cycling, while all the rest reported cycling for recreation during weekends and Ciclovía. All but one individual interviewed reported to have some vague information about EnCicla and bike-sharing.

None of these individuals interviewed reported ever using EnCicla, and most of them were not interested in becoming EnCicla members. The following table summarizes the reasons given by non-users not to join EnCicla.

Table 21.Interest in EnCicla membership

Reasons not to sign-up to Encicla	Total
Owning a bike	9
Time-consuming signup process	13
Perceived poor service/bikes of EnCicla	4
No interest in Cycling	1
Leisure cycling	7

The majority of the people interviewed reported to own a bike or have access to a bike through a friend or family member. Individuals that reported no interest in signing up to EnCicla cited owning a bike as one of the reasons not to sign up. Some of these individuals cited issues of poor bike quality as a reason not to use EnCicla, but none of them were actually certain, as they've never been EnCicla members.

By contrast, some individuals that did not own bikes directly but had access to bikes, expressed interest in signing up to EnCicla. This finding is significantly different to what Guo et

al, and yang et al found about bike share membership in China, where owning a bike does not affect bike share uptake.[261]

Another reason not to sign up to EnCicla highlighted by all individuals interviewed was the difficult and time-consuming sign up process. When asked if they understood what the process entailed, none of the individuals interviewed had accurate information about EnCicla's registration, but they had a vague idea that the process takes hours in line and days in waiting, and it was simply not worth the trouble.

Remarkably, three of the people interviewed reported having EnCicla stations next to where they worked (where interviews were conducted), near their places of residence, and/or near universities. These were the only individuals that expressed interest in signing up to EnCicla because of the convenience of station proximity. Nevertheless, these individuals remained unsure about signing up to EnCicla due to the required pre-registration. One interviewee remarked that working and studying full time doesn't allow for time spent processing the EnCicla membership.

All but one woman interviewed reported not to be interested in EnCicla because they never cycle for commute, only for recreational purposes. When asked if they would be interested in travelling to work or school by bike, non-users reported issues of safety (e.g. poor bikeway infrastructure, vehicles not yielding to cyclists, and personal safety), and adverse environmental conditions not to cycle for commute.

5.2.2 User experience journey map

This subsection describes the bike share and urban environment in this area of the neighborhood, and the emotional responses registered by the researcher during the audit, from signup to completion of daily trips.

A. Impossible registration

Easy registration is a critical aspect of convenience that supports bike share usage, [262] but EnCicla's registration process is anything but easy or convenient.

EnCicla bikes can only be unlocked via the Cívica card, an integrated transit system card that enables riding in all Metro transport modes (Metro, Metrobus, Cable, and Tram). EnCicla is not

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[261] Guo et al and Yang et al

262. Yanyong Guo, et al, "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," PLOS (2017), https://doi.org/10.1371/journal.pone.0185100, accessed September, 12 2018.

part of the Metro Company but of Metropol. Nevertheless, it is enabled by the Cívica card managed by the Metro system. EnCicla users must signup twice: once to obtain the Cívica card, and once more to register in EnCicla's separate information system. Signing up to EnCicla involves the following steps:

1. Obtain the Metro Cívica card in-person at one of the Metro stations where the card can be processed. The Cívica card cannot be processed online.

The line to process the Cívica card usually takes between 20 to 40 minutes for taking fingerprints, verifying documentation, and taking a photograph.

Figure 39. Obtaining the Cívica Metro System Card at Metro San Antonio

2. Sign-up to EnCicla with the Cívica card. This process is conducted through EnCicla's online platform, and it involves filling out residential information, and scanning documents (ID and Cívica) and a passport picture. [263] The process can be performed at one of the amazing Biblio-Metro, which are micro libraries strategically located at major Metro stations in Medellín, equipped with computer stations connected to the internet for easy public access.

3. Email Verification. After completing an online verification form sent via email, aspiring users receive a confirmation message indicating to wait at least three business days for information verification; and to receive instructions about the "next-steps" to complete the registration process.

4. Cívica *Activation*. Once aspiring users receive an email conformation of successful online registration to the system, users must appear in person to the main offices of Metropol during

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263. Instructions for signing up to EnCicla, accessed October 12, 2019, http://www.encicla.gov.co/como-funciona/

business hours to finish processing the registration. At this point, users are ready to enjoy EnCicla.

Figure 40. Biblio-Metro at Metro Station San Antonio

It must be noted that the researcher was never able to complete this last step because the system found an insurmountable error: non-residents of Medellín must sign-up to EnCicla with a passport, matching the Cívica registration. Because the researcher completed the Cívica registration with a driver's license (listed as a valid form of documentation for tourists), she may never register to EnCicla unless Metro de Medellín agrees to change the original documentation of the Cívica registration to a passport. It must be noted that visitors of Medellín can enjoy EnCicla only for a limited period of time (typically a week). According to Metropol, only 1% of daily EnCicla trips systemwide are made by tourists.

Figure 41. Adjustable EnCicla bike

After registration, using the system is fairly easy and convenient. With the aid of an existing user, the researcher was able to utilize the system, and confirmed that bike rentals and returns take seconds for both automatic and manual stations.

Additionally, the EnCicla bike is easily adjustable. Because of its law central bar and overall design, is suitable for individuals of different heights and cycling abilities.

B. Protected bikeways, open spaces and connectivity

There are two main bikeways in this section of the system, known as Ciclorruta Las Vegas, and Ciclorruta Villa Carlota. Both bikeways share similar conditions: they are two-lane bikeways, laid at one side of the road, connected to the Metro station *Industriales*, with significant barriers to protect cyclists from traffic.

Bikeway Las Vegas is highly utilized due to the proximity to a high mix of land uses, commercial activity, and transportation options. There is a significant variety of business in this section of El Poblado, including restaurants, hotels, coffee shops, banks, among others. It is perhaps this mixture of services, destinations, and scenes that enhances the cycling experience in this area. By contrast, the protected bikeway Villa Carlota is rather underutilized, as it transects the most industrial-like part of the neighborhood. This bikeway runs over an area that has less variety of commercial activities and land uses, and has significantly less transit connectivity (i.e. bus stations) as it leads further southeast into El Poblado. Nevertheless, this route provides accessibility to the open space park at the Telemedellín station.

Figure 42. Bikeway Las Vegas at the station Río Aburrá

Las Vegas bikeway lays immediately adjacent to the pedestrian facility at a slight elevation from the street level. This bike-lane represents a small section of the much larger protected bikeway that connects downtown Medellín with the southernmost part of the city through the neighborhood El Poblado. At this section, the bike lane has no significant slopes or unevenness surfaces.

Figure 43. Bikeway Villa Carlota

The bikeway Villa Carlota easily connects the stations Primavera, Av.19, and Telemedellín. This section of EnCicla provides bike share accessibility to the most industrial-like section of the neighborhood, with an important presence of businesses and commercial activity.

The bikeway connects significant open space areas, and leads to the steeper Avenida El Poblado, providing cycling connectivity to other areas of the neighborhood.

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Figure 44. Bikeway Villa Carlota

For most of the area, only one side of the street has relatively adequate infrastructure for both cyclists and pedestrians.

The pedestrian infrastructure on the opposite side of bikeways is typically very precarious. These facilities can hardly accommodate pedestrians, and they are mostly unsuitable for walking a bike.

EnCicla in El Poblado has appropriate bikeway infrastructure on major avenues, but not on inner neighborhood streets. High-density of businesses, services, and housing developments in this area support cycling and walking. Nevertheless, cycling and walking through tributary neighborhood streets can feel very much unsafe due to the absence of bike lanes and the inadequacy of alternative pedestrian infrastructure.

Figure 45. Poor cycling infrastructure & obstacles

Because these two-way bikeways are laid out on one side of the street, reaching destinations located at the opposite side of the street is not always easy. Travelling on the opposite direction of the street to reach destinations that are not next to a protected intersection feels extremely unsafe due to the lack of bikeway infrastructure, so cyclists must merge into traffic.

While cycling in this area of the system one can feel significant air pollution resulting from high traffic volume, and there is audible noise pollution that increases significantly between the stations Río Aburrá and Industriales due to confluence of major arteries at the Metro station. These adverse environmental conditions are perhaps the most unpleasant aspects of cycling in this area of the bike share system, and correspond to some of the factors found in the literature that adversely affect cycling and bike share ridership in other regions of the world like China.[264] Nevertheless, these adverse environmental conditions are mitigated by reduced time travel when compared to other transport modes at peak traffic hours, when traffic can reach a standstill. This was also found by Bejarano et al in Medellín,[265] and Guo et al in China.[266]

To reach a destination on the opposite side of the bike lane of Avenida Regional cyclists must travel a long distance to reach an acceptable intersection crossing, and then travel on the roadway, as there is no bike lane on the opposite side of the Avenue.

Figure 46. Avenida Regional near the Metro Station Industriales

264. Andrew Campbell et al, "Factors Influencing the Choice of Shared Bicycles and Shared Electric Bikes in Beijing," *Transportation Research: Part C* 67 (2016):399-414.

265. Mauricio Bejarano et al, "A user-centered assessment of a new bicycle sharing system in Medellin," *Transportation Research Part F: Traffic Psychology* 44 (2017):145-158.

266. Yanyong Guo, et al, "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," *PLOS* (2017), accessed September, 12 2018, https://doi.org/10.1371/journal.pone.0185100.

The sidewalks of this street accommodate signs and utilities, but not pedestrians. In this case, the sidewalk is basically built to accommodate cars and utilities.

Figure 47. Limited pedestrian infrastructure
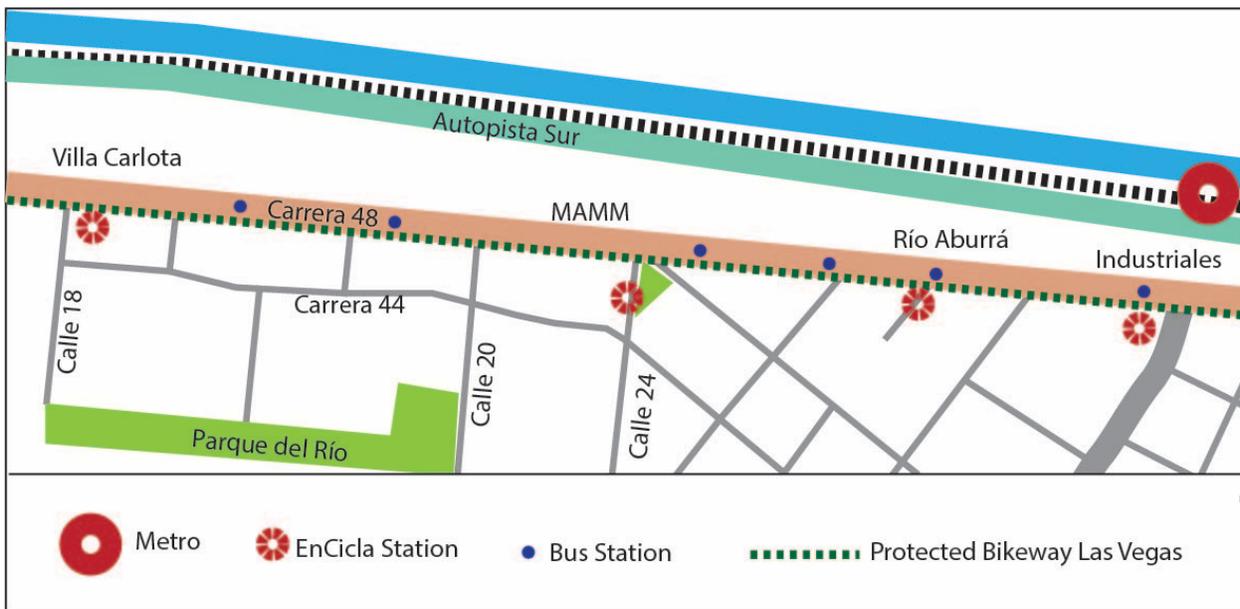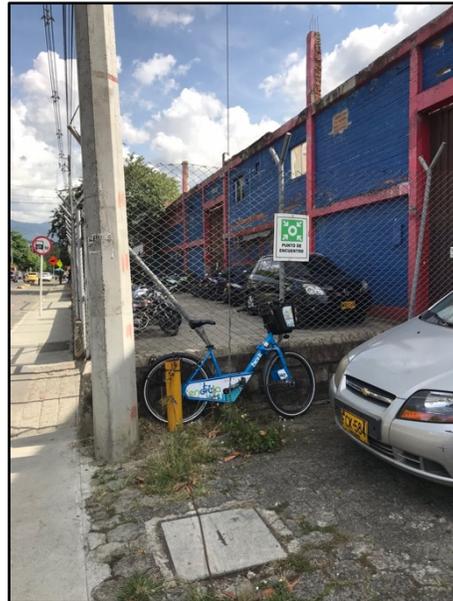
Figure 48. Connecting from the Metro

The protected bikeway Las Vegas easily connects four EnCicla stations: Industriales Metro, Río Aburrá, MAMM, and Villa Carlota, as portrayed in Figure 48 above. This is perhaps the most active area in this section of the neighborhood in terms of commercial activity and variety of destinations. Nevertheless, EnCicla has limited coverage to other areas of the neighborhood suitable for cycling with comparable levels of activity.

Furthermore, there are two important open space areas that could facilitate travel between different sections of the neighborhood, but they are disconnected: Parque del Río and Parque Canal Gabriel García Márquez.

Parque del Río is one of the most significant open space areas in this part of the commune. The park is surrounded by a high density mixed-use residential area, most of it under construction, and it extends to the back of the Museum of Modern Art of Medellín. The eastside of the park is flanked by highly permeable streets for pedestrians, but the streets towards the westside of the park lead to a dead-end block that prevents access towards other sections of the neighborhood with significant bike share and protected bike lane infrastructure.
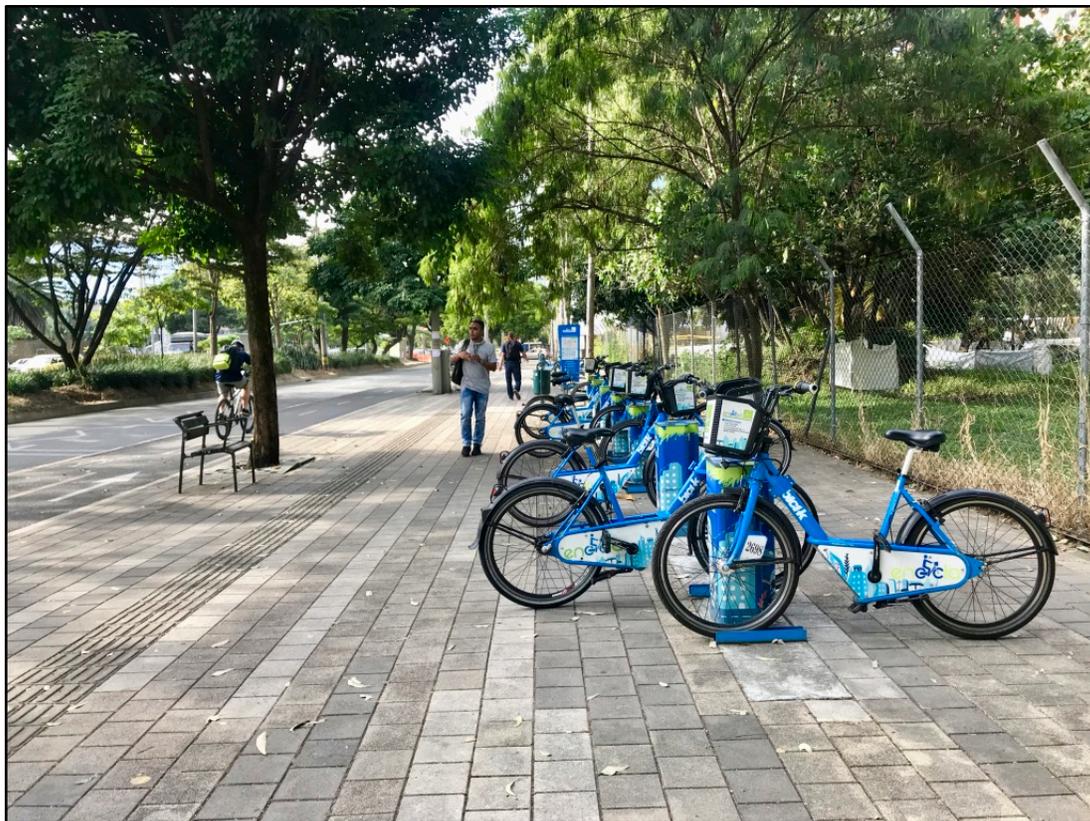
Figure 49. Villa Carlota Station

Behind the industrial building at the end of this street there is an underutilized protected bike lane that leads to other sections of the neighborhood with multiple land uses, businesses, and services.

Figure 50. Dead-end street on the westside of Parque del Río

Traffic volume is very high on main thorough streets, especially on *Avenida Los Industriales* parallel to the bikeway *Las Vegas*, with buses, cars, and taxis populating the road at all times of the day. There is a significant amount of pollution that makes cycling unpleasant at peak hours. High volumes of traffic and pollution negatively impacted the researcher's personal safety perception during the audit.

Nevertheless, this section of EnCicla transects important open space areas and secondary neighborhood streets that shelter cyclists from traffic. Open spaces areas and mature trees offer refuge from traffic, noise, and pollution.

Trees along bikeways also offered significant perceived benefits, especially when the bikeway had additional buffers to separate cyclists from traffic. This was the case for a section of the bikeway Las Vegas that is adjacent to a forked parallel road that carries significantly less traffic, which lessens the perception of traffic adverse effects.

Parque del Río has trails that make the cycling experience more enjoyable. Many leisure cyclists were observed in this area during the audit.

Figure 51. Parque del Río

One of the main features of this section of the system is the availability of shade provided by trees and vegetation. There is a significant number of trees along this section of the bikeway, making it very comfortable for cyclists during the warmest hours of the day.

Figure 52. Reduced traffic volume on parallel drive lane

The Telemedellín bike share station provides accessibility to the headquarters of the local television channel, which is surrounded by an urban open space area known as Canal Parque Gabriel García Márquez.

Figure 53. Station Telemedellín

EnCicla users may leave their bikes at the Telemedellín station and continue on foot throughout the park to reach Avenida El Poblado.

Figure 54. Parque Canal Gabriel García Márquez, Telemedellín channel HQ

C. Station density and rebalancing issues

This section of the system has excellent connectivity to other transportation modes, including bus, Metro and Taxi, but EnCicla users travelling further into El Poblado beyond this industrial sector must end their trip by the Villa Carlota Station (unless returning the bike within the hour, as there is no option to increase rental time in the absence of stations). This makes the system useful primarily to industrial workers, occasional riders traveling to and from industrial El Poblado, and leisure riders travelling to open space areas like Parque del Río.

Travelling through this part of the system it became apparent that EnCicla has important rebalancing issues, with some stations remaining empty for long periods of time at low demand hours, while other stations close by are full, with no docks available to leave a bike at the end of a trip. In both cases, station density becomes critical for users who must find bikes or docks at other nearby stations, incurring in additional travel time. This additional travel time will ultimately depend on the proximity between stations.

EnCicla users in this section of the neighborhood rely on the manual station Primavera when bikes or docks are unavailable at other stations. Manual stations typically have a greater stock of bikes and can accommodate extra returns in the absence of docks at nearby stations.

Figure 55. Station Primavera

Figure 56. Station Calle 19 Villa Carlota

Three stations frequently run out of bicycles at peak hours in El Poblado: Av. 19, Industriales Metro, and Río Aburrá. Conversely two stations are seemingly underutilized outside of peak hours: Telemedellín, and Ciudad del Río.

D. Transportation environment, micro-environmental characteristics, and supporting amenities

Speed limit on Avenida Los Industriales is 30 mph. This limit is hardly exceeded due to traffic conditions. Sometimes traffic yields to cyclists and pedestrians when merging from arterial streets, but motorist behavior at intersections is rather erratic, especially as traffic conditions worsens. Motorists that do yield to cyclists or pedestrians can get dangerously close to them, and sometimes, seem to be intending to yield, but don't.

There was a sheltered parking garage every 300 to 500 meters on most street segments. Additionally, there is a significant amount of street parking available in this area of El Poblado, forcing cyclists to move closer to the center of the street against incoming traffic, and generating issues of poor visibility at intersections. Cyclists riding on sidewalks was a common sight in this section of the neighborhood.

There is a significant amount of spillover motor vehicle parking in the neighborhood that creates blockages for both cyclist and pedestrians.

Figure 57. Street Parking

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At peak hours traffic does not yield to pedestrians, cyclists, or scooter riders.

Crossing intersections was not easy because of traffic blocking the intersections, and oftentimes because pedestrians tended to merge towards the more visible bikeways while crossing the street. Traffic and pedestrians blocking intersections interrupts cycling momentum and increases risk perception for cyclists.

Figure 58. Cyclists merging into traffic at intersections

Medians in many avenues have been converted into bike lanes to facilitate bike travel and minimize the impact of pedestrian/motorist invasion. Intersections on these avenues were intervened and painted to create safe crossings for cyclists. Nevertheless, in the absence of light/audible signals, cyclists struggle to cross intersections at peak traffic hours.

As in other areas of El Poblado, there was also a significant amount of motorcycle parking, indicating a significant usage of this mode in Medellín.

Figure 59. Motorcycle parking across Station Ciudad del Río

There is not much bike parking available in this area, but there is a lot of motor vehicle parking on-streets and garages.

Figure 60. Limited bike parking

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There are very few signals available for crossing intersections and there are no audible signals. However, some intersections are protected, and all intersections are painted with high visibility markings that make cyclists more visible to incoming traffic.

Figure 61. Pedestrians merging to bikeway at intersection crossings

Due to poor pedestrian infrastructure and oftentimes underutilized bikeways, pedestrians invade bikeway facilities.

Figure 62. Pedestrians walking on bikeway

Bikeways keep cyclists safe from incoming traffic, but one must watch for potential obstructions.

Obstructions along the route are mostly related streetcar vendors and pedestrians using the bikeway instead of the adjacent pedestrian facility, generating blockages, and oftentimes posing incredible hazards. These bikeway invasions force cyclist to ride at much lower speeds.

Figure 63. Traffic yields Next to Station Villa Carlota

Sections of the bikeway without a vegetated strip by the roadside devoid the bikeway of an essential barrier to further separate traffic from cyclists. Nevertheless, in some of these sections, the bikeway was separated from pedestrian facilities by a furniture zone, minimizing pedestrian invasion of the bikeway.

Some sections of the bikeway do not include a vegetated strip separating traffic from cyclists.

These sections of the bikeway are extremely close to the adjacent road, generating the sensation that one is riding too close to traffic.

Figure 64. Bike lane close to the roadway

There is a significant volume of parking entrances along Avenida Regional. Under high traffic conditions, vehicles tend to block these parking entrances- and the bike lane that runs through.

Figure 65. Motorists blocking bikeway at parking entrance

Overall the area seemed considerably safe to navigate, and it is brightly illuminated at night-time. Police presence seemed scarce at all times, although there were many security guards at building entrances facing the street. No significant suspicious activity was perceived during the survey of the area. There were no homeless encampments present in this segment of EnCicla, though homeless individuals were spotted resting under shaded areas. These individuals did not exhibit erratic or aggressive behavior. One important feature of this area that can make people feel safer is the presence of street vendors every few feet along the bikeway and near most stations. Nevertheless, after 7:00 pm, pedestrian traffic and the presence of vendors was significantly reduced. This had a negative effect on the researcher's safety perception for evening riding.

This section of El Poblado has some attractive modernist architectural design features, and there is significant variability of type of buildings. The pedestrian plaza in front of the Museum of Modern Art by the MAMM station is an important gathering space for this section of the system.

Figure 66. MAMM Station

There is a large and diverse number of services and places of interest that can be easily reached by bike, including Medellín's Museum of Modern Art.

Aspects that improve the micro-environmental conditions for cycling in this section of the neighborhood include physical and aesthetic features like minimum disorder, the presence of vegetation and open space, and architectural diversity. Furthermore, there are supporting amenities that enhance the urban cycling experience like shade, seating space, and accessibility to food and beverage services. The audit checklist form facilitated the identification of supporting facilities and services available in stations and on routes like street furniture, public phones, and public bathrooms, among other elements.

Apartment, office complex, and hotel above a commercial pedestrian paseo.

Figure 67. Mixed-land uses

Streets are lively at most hours. The majority of individuals observed were young, to middle age adults, and seemingly in equal proportion between men and women. There were few young children and elderly adults observed in this area of El Poblado.

There was minimum physical disorder in this segment of the bike share system, and most streets were clean and pleasant to navigate.

Figure 68. Shaded public bike parking facility and seating areas

There are no water fountains or public restrooms available at EnCicla stations. Nevertheless, there are public restrooms available at adjacent shopping areas and at the Metro station.

Figure 69. Shaded bikeway and affordable street snacks

The absence of water fountains was mitigated by the proliferation of street vendors along the route offering water, fresh juice, and packaged/local snacks and treats.

Disposing of trash was facilitated by the significant number of trash cans carefully positioned at the pedestrian eye level all over the city. Additionally, there are ample and shaded seating areas along the bikeway where cyclists can stop to rest.

An unexpected service found along this route was the availability of public pay phones approximately every 500 meters.

These phones seemed to be heavily used, probably because cell phone service is extremely expensive in Colombia.

Figure 70. Public pay phones

There was hardly any marketing signage present in this section of EnCicla, and this is true for most of Medellín, especially at Metro and transit stations. The absence of commercial or institutional billboards and signs minimizes visual pollution.

EnCicla users must complete trips within an hour, plus a fifteen-minute rental grace period. After this time, users must return bikes or extend the rental period at an EnCicla station using the Cívica card.[267] Because there are no other stations beyond this area of El Poblado, trips to other areas of the neighborhood are not supported, unless users complete trips within the hour. The penalty for exceeding the rental period is membership suspension for three days.[268] According to an EnCicla staff member interviewed for this report, at least fifty percent of EnCicla user penalties are for exceeding the rental period.

267. EnCicla, "Sanciones," accessed November 30, 2019, http://www.encicla.gov.co/sanciones/
268. Ibid.

Figure 71. Seating Area by the Station Primavera

Figure 72. Street Vendors Along the Route on Avenida Regional

Figure 73. EnCicla User Information Map on Electronic Booths, Station Villa Carlota

Wayfinding for EnCicla is surprisingly scarce, especially considering that there are highly visible and consistent wayfinding features at the Metro and other transit stations throughout the city. Nevertheless, EnCicla stations are highly visible and provide key user information, including a wayfinding map depicting other stations and bike routes, and indicating connectivity to the Metro system.

The following chapter further analysis these findings and observations, discusses inferences and conclusions, and explores the implications of this study for future research.

CHAPTER 6
CONCLUSIONS

Over the past twenty years the city of Medellín has developed an innovative, convenient, and highly respected public transportation system, fundamentally grounded on a social equity agenda aimed at alleviating poverty and violence.

Conceivably, Medellín's socially infused urban transportation infrastructure has improved the lives of hundreds of thousands of residents that for decades did not have equitable access to transport. EnCicla, the city's public bike share system, is conformingly grounded on equity principles, initially targeting a limited segment of Medellín's student population.[269]

Today EnCicla is undergoing a significant expansion. The system has grown from a localized pilot, to a metropolitan bike share system intended to serve almost four million residents.[270] Nevertheless, EnCicla's targeted user population is still very narrow. According to staff members of Metropol consulted during this study, EnCicla is intended primarily for residents of Medellín, and should be accessible mainly to those residents that cannot afford other transport modes.

In North America, especially in the United States, bike share providers and cities struggle to attract low income communities to bike share.[271] By contrast, in Medellín, over sixty percent of bike share users are considered low-income.[272] This is consistent with the literature reviewed in this report indicating that low income individuals in Latin American cities are more likely to bike share to save on transport costs and travel time, in otherwise congested modes.[273]

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269. Mauricio Bejarano et al, "A user-centered assessment of a new bicycle sharing system in Medellin," *Transportation Research Part F: Traffic Psychology* 44 (2017):145-158.

270. Departamento Administrative Genral de Estadísticas (DANE). "Censo General 2005, Resultados," accessed December 3, 2019, https://www.dane.gov.co/files/censo2005/resultados_am_municipios.pdf.

271. N. McNeil et al, "Breaking Barriers to Bike Share: Lessons on Bike Share Equity," *Institute of Transportation Engineers. ITE Journal* 88, issue 2 (2018): 31-35.

272. Área Metropolitana, "Celebramos los primeros diez millones de préstamos de EnCicla," accessed December 3, 2019, https://www.metropol.gov.co/Paginas/Noticias/celebramos-los-primeros-diez-millones-de-prestamos-de-encicla.aspx.

273. Karla Gámez-Pérez, et al, "Defining a primary Market for bikesharing programs. A study of habits and usage intentions in León, México," *Transportation Research Record* 2634 (2017): 50-56; and Marianne Fay et al,

EnCicla's administration achieved this level of low-income ridership partly through pricing, as the system is free to users, and partly by carefully placing stations in areas of the city that would be most accessible to the lowest income residents, students, and workers of the Metropolitan Area.[274]

EnCicla's low-income ridership is undoubtedly a remarkable achievement. Nevertheless, one of this study's main observations is that informally defining EnCicla as a "low-income public service," is helping reproduce socioeconomic segregation in Medellín, especially in communes like El Poblado, where higher income residents are less likely to cycle for commute, and less likely to use any form of public transportation.[275]

This study evaluated bike share accessibility in El Poblado through a user experience bicycle audit; and analyzed the perceptions of thirty-three EnCicla users and fifteen non-users, to identify potential barriers to bike share in this area of Medellín. This analysis helped identify existing assets and amenities of EnCicla in El Poblado that can be enhanced to make the bike share system more accessible and appealing to a diversity of users. Furthermore, this report analyses potential strategies and recommendations to overcome existing barriers to bike sharing in the commune.

6.1 EnCicla's low-income users save money and time spent in traffic, but the system is not equitably accessible

According to a report by Ferreiro 2015 about bike share in Latin America, bicycling is becoming increasingly popular in the region as an alternative transport mode to alleviate time spent in traffic.[276] In Medellin, EnCicla is so well integrated to the city's transport system, with bikeways running parallel to bus routes, that individuals oftentimes feel motivated to bike share

"Rethinking infrastructure in Latin America and the Caribbean. Spending better to achieve more," The World Bank, 2017, accessed November 8, 2018, https://openknowledge.worldbank.org/bitstream/handle/10986/26390/114110-REVISED-PUBLIC-RethinkingInfrastructureFull.pdf.

274. Área Metropolitana, "Nuevos tramos y estaciones de EnCicla," accessed December 3, 2019, https://www.metropol.gov.co/Paginas/Noticias/nuevos-tramos-y-estaciones-de-encicla.aspx.

275. Víctor Andrés Álvarez, "Por cada tres habitantes hay un vehículo rodando en Medellín," *El Colombiano,* accessed December 6, 2015, /www.elcolombiano.com/antioquia/movilidad/en-medellin-transita-un-carro-por-cada-tres-habitantes-EB3232363.

276. Leticia Ferreiro, "Cycling gains ground on Latin American streets" World Bank Group, accessed November 8, 2018, http://www.worldbank.org/en/news/feature/2015/06/24/el-pedaleo-gana-espacio-en-las-calles-latinoamericanas.

to avoid seating in a bus stuck in traffic.[277] In El Poblado, the system could be better integrated to the Metro to support a higher diversity of trip purposes.

Under EnCicla's current expansion in El Poblado, bike share users are effectively limited to the industrial area of the commune, benefiting mainly male workers. This study found that students travelling between university campuses through El Poblado are not supported in this part of the system. Students interviewed complained about not being able to travel with EnCicla from public universities in other communes, to the private universities located in the "higher-income" areas of El Poblado suitable for bike share, and in close proximity to a Metro station. Not surprisingly, the majority of users interviewed in El Poblado were employees travelling to and from distant communes, to work in El Poblado. By comparison, about fifty percent of EnCicla users systemwide are students.[278]

EnCicla should continue to place social equity at the forefront of its expansion plan, but it should carefully consider how to make the system accessible to women, older adults, all metropolitan area students, and teenagers (EnCicla allows 16-year-olds to sign up with parental consent). This study found that in El Poblado, women are less likely to bike share. This is the case for EnCicla systemwide,[279] and it is consistent with other bike share systems in Latin America, like EcoBici in Mexico City.[280] Women in Latin America are more likely than men to have multiple trip purposes, as they tend to share a larger burden in childcare, carrying out more household related trips, while also commuting to work.[281] A bike share system that only supports a limited number of trip purposes in a limited geographic area of El Poblado is less likely to support women users.

Another barrier for women and other vulnerable residents like older adults and teenagers in El Poblado, is the onerous and highly complex signup process that is effectively filtering many of these potential users. A student working full time, a parent, a woman working full time with two children, or an older adult, just to list a few categories of potential users than tend to be excluded from bike sharing, may not have the time, the ability, nor the inclination to spend

277. Mauricio Bejarano et al, "A user-centered assessment of a new bicycle sharing system in Medellin," *Transportation Research Part F: Traffic Psychology* 44 (2017):145-158.

278. Área Metropolitnana, Plan Maestro Metropolitano de la Bicicleta Para El Valle de Aburrá 2015-2030.

279 Área Metropolitana, "Celebramos los primeros diez millones de préstamos de EnCicla," accessed December 3, 2019, https://www.metropol.gov.co/Paginas/Noticias/celebramos-los-primeros-diez-millones-de-prestamos-de-encicla.aspx.

280. United Nations Climate Action, "Women using EcoBici, Mexico City's bikesharing program," accessed December 5, 2019, https://unfccc.int/climate-action/momentum-for-change/activity-database/momentum-for-change-women-using-ecobici_-mexico-city%5Cs-bike-sharing-program.

281. Ibid.

hours in line and appear in person on multiple occasions, to complete EnCicla's membership agreement.

6.2 EnCicla's membership process increases user accountability, but it is inflexible, inconvenient, and exclusionary

One of the main barriers to bike sharing in Medellín found by Bejarano et al through the first EnCicla pilot study is that pre-registration is required.[282] Fishman et al 2014 consider pre-registration a barrier to bike share because it hinders spontaneity.[283] Nevertheless, Midgley 2011 considers that, although pre-registration may deter some users, it reduces rates of theft and improves accountability.[284] This is certainly one of the main arguments provided by Metropol staff members when questioned about the rationale behind EnCicla's complex signup process. According to Bejarano et al, EnCicla users are never considered occasional users, but rather full-time members with obligations and benefits.[285]

Whether or not improving user accountability substantiates the need for a complex pre-registration process, the main issue seems to be that EnCicla's current administration is struggling to achieve a high level of articulation with the Metro company to settle the signup process. EnCicla's administration resides in Metropol, not the Metro company. Nevertheless, EnCicla utilizes the Civica technology platform as part of an agreement between Metro de Medellín and Metropol, in an effort to adopt a seamless mobility platform for the entire metropolitan area.[286]

However, the partnership between Metro de Medellín and Metropol only covers a partial integration of the Metro's information technology platform. While EnCicla can be unlocked through the Civica card, there is no actual transfer of information between Metro and

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282. Mauricio Bejarano et al, "A user-centered assessment of a new bicycle sharing system in Medellin," *Transportation Research Part F: Traffic Psychology* 44 (2017):145-158.

283. Elliot Fishman et al, "Bike share's impact on car use: evidence from the United States, Great Britain, and Australia." *Transportation Research Part D: Transport and Environment* 31 (2014): 13–20.

284 Peter Midgley, "Bicycle sharing schemes: Enhancing sustainable mobility in urban areas," Commission on Sustainable Development report, United Nations, New York, May 2011, accessed November 14, 2018.https://sustainabledevelopment.un.org/content/dsd/resources/res_pdfs/csd-19/Background-Paper8-P.Midgley-Bicycle.pdf.

285. Mauricio Bejarano et al 2017.

286. Information obtained and corroborated via interviews with Metro Company and Metropol staff members, September 2019.

Metropol, and EnCicla has a separate signup procedure to register and collect user information. [287] According to an EnCicla expert consulted during this study, lack of effective sharing of user information between Metro de Medellin and EnCicla has exacerbated the burden users need to bear to sign up for bike share.

From 2016, Metropol assumed the operation and infrastructure expansion of EnCicla, which used to be managed through a specialized third-party operator. [288] This seems to have affected the agency's ability to focus on more pressing planning issues, like improving the level of service and accessibility for the growing pool of users of the bike share system.

As explored in the Prologue of this report, public transportation policy in Medellín develops under high levels of public-private articulation, which was identified in the literature reviewed for this study as one of the key factors that support successful bike share systems in China, Europe, and Canada. According Midgley 2011, successful bike share systems that are managed by municipalities and that are virtually free of charge to users, like the systems in Hangzhou (China), and Montreal (Canada), also boast higher levels of articulation between the local governments and the private sector.[289] This was also observed by Zhang et al 2014 in his comparative analysis of bike share systems in China.[290]

According to the literature reviewed for this study, high levels of articulation between public and private sectors allow municipalities to ensure the fulfillment of bike share system's supporting policies, and in many cases, incorporate complementary sources of private funding.[291] The Metropolitan Authority and the City of Medellín have successfully coordinated with the private sector the promotion of several programs that provide significant incentives for people that cycle to work, fully funded by private companies that host these programs under city guidelines.[292] EnCicla could take advantage of higher levels of articulation with the private sector to expand the user base of the system via partnerships with other shared micro-mobility operators, or via collection of user fees from non-residents through the Metro Company. Additionally, a closer public-private articulation may help advance information sharing between Metro and EnCicla.

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287. Information obtained and corroborated through three interviews to staff members of Metropol (September 2019), EnCicla (October 2019), and Metro de Medellín (July 2019).

288. Information shared by EnCicla expert on October 2019.

289. Ibid.

290. L. Zhang et al, "Sustainable bike-sharing systems: Characteristics and commonalities across cases in urban China." Journal of Cleaner Production 97 (2015):124-133.

291. Ibíd.

292. See Prologue section.

6.3 Safe bikeway infrastructure is critical to support a variety of users in El Poblado

This study found that lack of protected bikeway facilities is one of the most critical aspect of safety that adversely affects the cycling experience in El Poblado.

According to Midgley 2011, a comprehensive bikeway infrastructure is essential for bike share success, as it is the case of City Bikes in Stockholm with 760 kilometers, BIXI in Montreal, with 600 kilometers, and Vélo'v in Lyon with 265 kilometers (estimations made in 2010).[293] In Midgley's assessment, other successful schemes that do not have such an extensive bikeway network rely on station density, like Bicing in Barcelona with 400 stations in the city center.[294]

Bogota has the most extensive protected bikeway network in Latin America with 392 kilometers.[295] Medellin's protected bikeway system only has about fifty kilometers,[296] but it compensates this comparatively smaller network of bikeways with other infrastructure enhancements that benefit cyclists. In El Poblado, there are some protected intersections and other physical barriers that provide safety to cyclists from incoming traffic. Nevertheless, this network of protected infrastructure is incomplete. Furthermore, Medellín's attempt to re-design streets into more equitable urban spaces is hindered by the urban development patterns in areas like El Poblado.

According to Medellin's council member and urbanist Daniel Carvahlo, parts of the city like El Poblado are built and continue to be built for the automobile, leading to an *"irrational use"* of cars and motorcycles.[298] Carvahlo believes that in these areas, it is important to implement policies that limit car use (especially on bikeway corridors), that restrict parking, and that

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293. Peter Midgley, "Bicycle sharing schemes: Enhancing sustainable mobility in urban areas," Commission on Sustainable Development report, United Nations, New York, May 2011, accessed November 14, 2018, https://sustainabledevelopment.un.org/content/dsd/resources/res_pdfs/csd-19/Background-Paper8-P.Midgley-Bicycle.pdf.

294 Ibid.

295. Leticia Ferreiro, "Cycling gains ground on Latin American streets" World Bank Group, accessed November 8, 2018, http://www.worldbank.org/en/news/feature/2015/06/24/el-pedaleo-gana-espacio-en-las-calles-latinoamericanas.

296. Alcadía de Medellín, "Rueda Seguro," accessed November 8, 2018, http://www.ruedaseguro.com.co/rutas-en-bici.

298. Daniel Carvahlo, Cual es el problema de la movilidad en Medellín? *El Tiempo*, accessed October 1, 2018, https://www.eltiempo.com/colombia/medellin/las-nuevas-obras-de-movilidad-en-medellin-39821.

support car-free zones.[299] In the case of Bogota, for example, a combination of land-use policies that have included restrictions to motor vehicles, has been determinant for increasing the rate of bike share trips and the diversity of riders in the city.[300]

6.4 EnCicla's goals are not supported by land use policies in El Poblado

Adverse conditions for cyclists are expected to intensify in this area of El Poblado with the increasing availability of car parking in adjacent residential and office developments.

Metropol and the city of Medellin are indeed leveraging EnCicla as a supplemental mode of transport in areas of the city close to the Metro and main employment centers, but not so much as a choice mode of transport in areas of the city that heavily rely on automobile use, like El Poblado. Nevertheless, Medellín is betting on its public bike share system as one of the main strategies to help reach bicycle ridership goals and curb increasing problems of pollution.[301]

In 2016, Medellín was the recipient of the Lee Kuan Yew World City Price for its sustainable mobility solutions,[302] but today Medellín is the most polluted city in Colombia.[303] Medellín's air quality issues are the result of a combination of factors, including: (1) the conglomeration of urban industrial activity; (2) the over-reliance on automobile use; and (3) geographic, topographic, and climatic factors, as the mountains that surround the city's valley prevent the dispersion of pollutants and suspended particles during the driest, hottest months of the year.[304]

A Study by Martínez Jaramillo et al 2017 quantified the CO_2 emissions that would be avoided through the implementation of Medellin's transport energy model through 2040. Their analysis

299. Ibid.

300. John Pucher et.al, "Infrastructure, programs and policies to increase bicycling: An international review," *Preventive Medicine*, 50 (2010): 106-125.

301. Metropol, "Plan Maestro Metropolitano de la Bicicleta del Valle de Aburrá 2030," accessed September 9, 2018, http://www.encicla.gov.co/plan-maestro-metropolitano-la-bicicleta-del-valle-aburra/

302. Lee Kuan Yew World City Price, "Medellín in pictures: Model for urban innovation," accessed October 6, 2019, https://www.leekuanyewworldcityprize.com.sg/media/feature-articles/medellin-in-pictures.

303. World Health Organization, "Climate and Health Country Profile," accessed October 6, 2019, https://apps.who.int/iris/bitstream/handle/10665/208859/WHO_FWC_PHE_EPE_15.05_eng.pdf?sequence=1&ua=1

304. Juan Esteban Martinez Jaramillo et.al, "Assessing the Impacts of Transport Policies Through Energy System Simulation: The case of the Medellin Metropolitan Area, Colombia," *Energy Policy* (February 2017): 101-108.

indicates that current policies will not be sufficient to achieve both local and international emissions targets, including policies based on assumptions of bicycle ridership.[305] There is no indication thus far that Metropol is advancing any land use policy that limits automobile use around EnCicla routes and stations, to further address mode-shift goals and support climate targets.

6.5 EnCicla is supported by critical amenities

Independent of system registration, EnCicla has significant infrastructure assets, including appropriate bikeway infrastructure on major avenues, ease of rental and return process at stations, high station density in areas of high volumes of activity, and important supporting amenities like seating areas, shade, and accessibility to customer service.

Other micro-environmental factors that enhance the urban environment and may support cycling in this area of El Poblado include vegetation, open space, street life,[306] and a close proximity to an array of destinations and transportation options.[307]

Additionally, EnCicla has an adequate information system for its current users. It is enabled by some information technology capabilities, like real-time information availability, application enablement for mobile devices, internet accessibility, and smart card integration. A very sophisticated fourth generation system in Medellin may actually hinder current levels of low-income ridership, as Bejarano et al pointed out, many EnCicla users do not own a smartphone or have credit cards.[308] In fact, EnCicla heavily relies on "hosts" available at "manual" stations to provide information about the system, and to assist users with the sign-up process and route information. Reportedly, hosts even hold periodic pop-up cycling clinics for novice riders. Bejarano et al considered that EnCicla's hosts perform such a critical role to promote ridership, that they recommended the expansion of host activities across the entire system.[309]

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305. Ibíd.

306. Christopher Muhs and Kelly Clifton., "Do characteristics of walkable environments support bicycling? Toward a definition of bicycle-supported development," *Journal of Transport and Land Use* 9, issue 2 (2016): 147-188.

307. Yanyong Guo, et al, "Identifying the factors affecting bake-sharing usage and degree of satisfaction in Ningbo, China," *PLOS* (2017), accessed September, 12 2018, https://doi.org/10.1371/journal.pone.0185100.

308. Mauricio Bejarano et al, "A user-centered assessment of a new bicycle sharing system in Medellin," *Transportation Research Part F: Traffic Psychology* 44 (2017):145-158.

309. Ibid.

6.6 Station density is critical for docked systems like EnCicla

The most significant factors recorded through the user experience audit that supports cycling in this section of the neighborhood are station density and the presence of protected bikeway infrastructure. While station density mitigates user experience issues such as dock/bike availability and proximity to destinations, bikeway facilities that protect cyclists from incoming traffic enable safe bike travel. According to authors García Palomares et al[310] and Zhang et al,[311] These are two of the main factors that positively affect bike share ridership in other regions.

High station density has been identified in the literature reviewed for this report as an important aspect of successful docked bike share systems, as it enhances convenience and supports a diversity of trips.[312] EnCicla has a significant station density in this industrial area of El Poblado. Nevertheless, the potential benefits of high station density for this section of EnCicla may be thwarted by important rebalancing and connectivity issues identified through this study.

EnCicla's network in this part of the neighborhood is disconnected to other important transit and activity nodes in close proximity, like the area by the Metro station *El Poblado*, which is surrounded by important university, commercial, business, and residential nodes. To secure the potential benefits of high station density for supporting a variety of trip purposes, station allocation in critical areas of high volume of activity must be carefully considered. [313]

6.7 EnCicla is more than a bike share system, is a civic builder

This study revealed that negative perceptions of the bike share experience are overridden by current user's perceived value of EnCicla. Nevertheless, this perception was not shared with non-users of the system, indicating EnCicla could further develop its image as an extension of the Metro culture, through seamless enrollment and Metro integration.

The functional aspect of EnCicla as a civic builder is probably very unique to Medellin. The

310. Juan Carlos García-Palomares et al, "Optimizing the location of stations in bike-sharing programs: A GIS approach," Applied Geography 35 (2012): 235-246.

311. L. Zhang et al, "Sustainable bike-sharing systems: Characteristics and commonalities across cases in urban China," Journal of Cleaner Production 97 (2015):124-133.

312. Juan Carlos García-Palomares et al 2012; and L. Zhang et al 2015.

313. Ibid.

pilot study of EnCicla by Bejarano et al reported that initial users expressed feelings of pride about the system because: (1) they felt the city cared about them; (2) they could give back to the city through correct usage of the bike share; and (3) they felt they were pioneers of civic culture.[314] No other similar example of this form of user behavior and user perceptions was found in the literature. The sense of pride for using EnCicla extends to the entire public transportation system of Medellin, as well as to other public places related to the Metro that serve as catalysts for community development and social encounters in the city.

6.8 Study limitations and opportunities for further research

This study analyzed accessibility issues of EnCicla in an area of the system with very specific urban and transportation environment characteristics, which helped identify plausible barriers and facilitators for bike sharing systemwide. Nevertheless, the analysis doesn't account for potential differences in user characterization or trip purpose in other areas of Medellín.

Understanding the local conditions that affect bike share use is critical to develop strategies or policies intended to increase short neighborhood trips in replacement of car trips. Medellín's communes and neighboring municipalities where EnCicla is expanding have distinct geographic, cultural, and urban characteristics. Further research could be focused on understanding the factors that affect bike share in other communes of Medellín to understand the issues that affect specific riders in those areas of the system.

Although this study identified that specific users like woman, adolescents, and older adults are less supported by EnCicla in El Poblado, this study does not provide an in-depth analysis of all the barriers that these users would have to overcome to bike share in this area of Medellín. Further research into accessibility issues for specific community members or age cohorts would help identify strategies to try to attract these users to bike share.

This study identified a common trip purpose for bike share users in this area of El Poblado, which is commuting to work or school. Furthermore, research results indicate that most people bike sharing in this area of the city are not residents of El Poblado. Further research into understanding trip purpose and travel patterns for residents of El Poblado and other communes, may help guide cycling policies intended to increase non-motorized trips in Medellín.

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314. Mauricio Bejarano et al, "A user-centered assessment of a new bicycle sharing system in Medellin," Transportation Research Part F: Traffic Psychology 44 (2017):145-158.

An argument to be made in this report is that the factors identified here that positively or negatively affect bike share ridership and accessibility in El Poblado should not be measured in isolation, as they are for the most part interdependent. It is ultimately the interrelationships between these factors that can positively or negatively affect the bike share user experience.

The following chapter provides recommendations aimed at improving the accessibility and bike sharing experience of EnCicla in El Poblado in a way that may affect mode-shift, accounting for all of the interdependent factors that have been explored throughout this report.

CHAPTER 7
RECOMMENDATIONS

7.1 Significantly streamline the membership process

The complexity of the EnCicla signup process is a significant barrier to potential users, especially for those that have limited time or access to information. EnCicla could establish a robust data sharing agreement with Metro de Medellín, making pre-registration a one-step automatic process when the residents obtain the Cívica card.

7.2 Introduce a rewards program to attract people to signup

If pre-registration is necessary to reduce theft and increase user accountability, reward people for having to go through pre-registration by automatically signing up users to a rewards program that allows them to accumulate points for completed trips. After users accumulate a threshold of trips (e.g. 10 trips), users could exchange their points for valuable perks like Metro tickets, cinema tickets, museum tickets, or additional rental time for EnCicla. Perks offered should be appealing to a variety of users.

Metropol could develop partnerships with the private sector and public agencies to sponsor the rewards program in exchange for advertisement; or by supporting other agencies' environmental sustainability, education, or climate change abatement efforts related to increasing bicycle ridership.

7.3 Extend operation hours on weekends to capture usage from occasional riders

According to a recent survey by Metropol, EnCicla was the first commute-cycling experience for sixty-four percent of bike share users in Medellín.[315] This is a strong indicator that Medellín's public bike share system is key to increase cycling rates in the city. However, many potential

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315. Lina lópez, "Embeding the bicycle in Medellín's transport system," https://mobilizesummit.org/wp-content/uploads/sites/2/2019/07/Lina-Lopez.pdf, accessed December 4, 2019.

users may not have the time during busy weekdays to experiment new forms of commute. By extending the operation hours during weekends from early mornings to late evenings, more people will have the opportunity to try EnCicla. This may benefit woman, who may be less likely to bike share on weekdays because of time constraints and adverse traffic conditions,[316] and teenagers, who are more likely to cycle in groups.[317]

7.4 While the system expands, consider allowing rental period extensions in other areas of El Poblado via the Cívica card through the Metro system

Currently, EnCicla users must return bikes after one hour of use. In El Poblado, there are not enough stations covering all areas suitable for bike share, limiting users to one specific area of the neighborhood for completing short trips. EnCicla could allow users to extend the rental period for another hour, to give them enough time to complete trips to local destinations outside of the immediate area of coverage. Users could complete rental extension transactions using the Civica card via card readers or through hosts (similar to how it is done at manual stations), positioned at Metro stations, universities, or shopping malls, that are not in close proximity to an EnCicla station.

An extended rental period would benefit users with a variety of trip purposes. Users travelling to areas outside of EnCicla's immediate area of coverage would be able to bike share to other areas of El Poblado, and if needed, extend the rental period with the Civica card, and still be able to return the bike to the place of origin without penalty.

This would require establishing a robust data sharing agreement with Metro de Medellín, introducing kiosks or hosts with card readers at Metro stations and other key destinations; and introducing locks on bikes to allow to secure bikes to racks. This alternative would require financial investment, but arguably less than building additional stations equipped with bikes and docks.

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316. Anna Allat, "What is stopping women from cycling?" BBC News, January 21, 2018, https://www.bbc.com/news/uk-england-leicestershire-41737483, accessed November 25, 2019.
317. Jenna Panter et al, "Environmental determinants of active travel in youth: A review and framework for future research," Journal of behavioral Nutrition and Physical Activity 5 (34): 2008, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2483993/, accessed December 2, 2019.

7.5 Incorporate a pay structure targeting non-residents of the Metropolitan Area and tourists

According to the report by Midgley 2011 analyzing bike share user data globally, money savings is one of the main factors that affect the decision to bike share worldwide,[318] but not all bike share systems should adopt completely free schemes. Most successful bike share programs in Europe are free for a limited period of time, usually thirty to sixty minutes, allowing schemes to take advantage of revenue from tourism, for example. To Midgely, what cities should carefully consider is how bike share systems can be sustainable long-term while maintaining very low fees to attract a critical mass and increase accessibility. This may be critical to attract a more diverse pool of users in El Poblado.

EnCicla provides free bike share for low income residents of Medellín and its Metropolitan Area for a limited amount of time, in limited areas of the city, and in El Poblado, oftentimes segregating communities by income. EnCicla could continue to provide one-hour bike rentals for free, while introducing a fee structure for temporary users, like tourists, and for additional services like extending the rental period.

7.6 Partner with other shared micro mobility providers to support subsidized and low-cost electric bike share options

Current low-income bike share users in El Poblado have limited accessibility to areas of the commune that would be very difficult to access without an e-bike. Metropol could consider partnering with private operators in Medellín to provide e-bike accessibility to low income users of EnCicla. A fleet of e-bikes would support varied trip purposes and users.

7.7. Consider developing a land use policy of permeability and connectivity for cycling and pedestrians, incorporating open space areas and calmer inner neighborhood streets

Medellín took the multi-modal concept to a higher level by seamlessly connecting all communes in the city through a carefully designed network of electric escalators, trams,

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318. Peter Midgley, "Bicycle sharing schemes: Enhancing sustainable mobility in urban areas," Commission on Sustainable Development report, United Nations, New York, May 2011, https://sustainabledevelopment.un.org/content/dsd/resources/res_pdfs/csd-19/Background-Paper8-P.Midgley-Bicycle.pdf, accessed November 14, 2018.

gondolas, buses, and metro, dramatically reducing travel times for the farthest communes with the lowest incomes.

Metropol and the City of Medellín could apply the same network concept to pedestrian and cycling mobility. In El Poblado, there are two important parks in close proximity within the area of operation of EnCicla surrounded of nodes of activity, but these parks are non-contiguous.

Metropol could consider promoting a network of protected pedestrian and cycling passageways connecting the two parks. This new route would protect cyclists from traffic and mitigate discomfort from noise and pollution, which are distinctive feature of main bikeways in Medellín.

7.8. Consider limiting on street parking and place additional protected bikeway infrastructure instead

This study found that EnCicla in El Poblado is mostly used to complete entire trips, oftentimes replacing long distance transit trips. Bike share systems are becoming very important to integrated transit systems for cities like Medellin because bike share can be implemented faster than other modes of transport, making them more cost-effective for providing last-mile solutions to transit.[319] From this perspective, it makes more sense for Medellin to invest in bike share and bikeway infrastructure, than in immediately expanding the current metro or bus infrastructure- or build more car parking.

Metropol should consider working on limiting on street parking in El Poblado, placing cycling and pedestrian infrastructure instead, including bike parking. Pedestrian infrastructure is key in El Poblado because pedestrians tend to invade bikeways because of lack of facilities for safe walking. Additionally, the municipality should consider revising the amount of parking allowed in new residential complexes in El Poblado. Furthermore, the municipality could encourage developers to offer bike parking perks, and provide advertisement for EnCicla for new residential buildings in close proximity to EnCicla stations.

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319. Peter Midgley, "Bicycle sharing schemes: Enhancing sustainable mobility in urban areas," Commission on Sustainable Development report, United Nations, New York, May 2011, https://sustainabledevelopment.un.org/content/dsd/resources/res_pdfs/csd-19/Background-Paper8-P.Midgley-Bicycle.pdf, accessed November 14, 2018.

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APPENDIX A. USER EXPERIENCE AUDIT

I. Audit Checklist Form

Segment:

Date:

Time

A. Built Environment

Area Characteristics

Aesthetics

1. Visible physical disorder

No	Few	Some	A lot

2. Observed attractive features

None	Few	Some	Many	
				Architectural Design
				Building Variety
				Vegetation
				Open Space
				Other

Marketing and Promotion

3. Type of signage visible in street segment

no	Few	Some	A lot	
				Cultural
				Political
				Neighborhood
				Sharing sign
				Ped/bike friendly
				Physical activity
				Entertainment/event
				Security
				Trespassing
				Prohibited conduct (no alcohol etc.)
				Billboard
				Vandalized Billboard or sign

Perceived environmental Characteristics

4. How much air pollution can be perceived in this street segment?

None	Few	Some	Many

5. How much noise pollution is audible in this street segment?

None	Few	Some	Many

Social Environment

6. Are people of different ages and genders present in this section of the system?

None	Few	Some	Many	
				Young children
				Elderly adults
				Young adults
				Men
				Women

Land Use Environment

Type of buildings and businesses

7. Residential buildings

None	Few	Some	Many	
				single-family
				Low level multi-family
				Apartment building/condo
				Homeless encampment

8. Commercial buildings

None	Few	Some	Many	
				Gas station
				Fast food restaurant
				Restaurants
				Convenience store
				Supermarket
				Bank
				Pharmacy
				coffee shop
				Laundry/drycleaner
				Entertainment (movie, etc.)
				Hotel
				Shopping mall
				Department store
				office building
				warehouse
				factory
				bar
				Museum/art

				beauty salon
				Street vendor
				other (explain)

9. Public/government buildings

None	Few	Some	Many	
				Health
				Library
				School
				Community Center
				Other (explain)

10. Segment land uses

None	Few	Some	Many	
				Residential
				Commercial/retail
				Light-Industrial
				Office
				Restaurants/entertainment

B. Infrastructure and Facilities

Bikeway characteristics

11. Type of bike lane

Separated	Unprotected	Sharrow	Buffer	
				section
				section

12. Slope

yes	no

13. Proximity to drive lanes

14. Proximity to pedestrian facilities

15. Evenness of path

Poor	Acceptable	Good	Excellent	
				section
				section

Explain

16. Wayfinding

None	Few	Some	Many

Explain

17. Barriers

None	Few	Some	Many	
				Electricity posts
				Signals
				Parked vehicles
				Other

18. Supporting services

None	Few	Some	Many	
				water fountains
				seating areas
				bike parking
				Other

19. Safety concerns

None	Few	Some	Many

Explain

20. Continuity of segment

Continuous	Discontinuous

21. Conflict with pedestrians

None	Few	Some	Many

Explain

22. Conflict with motorists

None	Few	Some	Many

Explain

Station Characteristics and Supportive Services

23. Proximity to other stations

24. Accessibility

25. Proximity to residential areas

26. Signage and instructions

None	Few	Some	Many

27. Usability and convenience

Poor	Acceptable	Good	Excellent

Explain

28. Supporting services

None	Few	Some	Many	
				water fountains

				seating areas
				bike parking
				Other

Bike Adequacy and Cycling Comfort

29. Comfort of bike

Poor	Acceptable	Good	Excellent	
				Height adjustments
				Seat comfort
				Gears

30. Amenability of ride

| Poor | Acceptable | Good | Excellent |
| | | | |

Explain

31. Comfort features present along bikeway

				Shade
				Trees
				Benches
				Water fountain
				Other

C. Transportation Environment

Traffic, parking and transport options

32. Traffic volume

None	Few	Some	Many	
				cars
				taxis
				buses
				bikes
				e-scooters
				others

33. Alternative transportation options

None	Few	Some	Many	
				bus/metro
				taxi
				ride share

34. Connectivity to other modes

| Poor | Acceptable | Good | Excellent |
| | | | |

bus/metro

taxi

ride share

35. Observed speed limit

36. Observed/perceived motorist behavior

yield	Do not yield

Observations

D. Safety

37. Conflict of legal traffic movements

None	Few	Some	Many	Street section

Crossings and Intersections

38. Visual or audible signals

None	Few	Some	Many

39. Traffic yields

yes	no	Sometimes

Explain

40. High visibility markings

None   Few   Some   Many

Explain

41. Long wait at signal

Yes	No

42. Enough time to cross

yes	No

43. Conflict with pedestrian crosswalk

None   Few   Some   Many

Explain

44. Traffic blocking travel

yes   no

Explain

45. Night Illumination

Poor	Acceptable	Good	Excellent

45. Police Presence

None	Few	Some	Many

46. Suspicious Activity

None	Few	Some	Many

Are there people acting hostile?

E. Observations

II. Intercept Interview Questionnaires

a) User perceptions questionnaire

1. What do you do for a living?
2. Where are you travelling from with the bike?
3. Where are you travelling to with the bike?
4. How long have you been using EnCicla?
5. What do you think about EnCicla?
6. What do you think about the EnCicla bike?
7. What makes you feel safe on the road with EnCicla?
8. What makes you feel unsafe on the road with EnCicla
9. What would you change to the EnCicla system?
10. What do you think about EnCicla?

1. ¿A qué te dedicas?
2. ¿De que lugar vienes en bicicleta?
3. ¿Hacia que lugar viajas en bicicleta?
4. ¿Hace cuánto estás utilizando EnCicla?
5. ¿Qué te parece EnCicla?
6. ¿Qué te parece la bicicleta de EnCicla?
7. ¿Qué te hace sentir seguro en la vía con EnCicla?
8. ¿Qué te hace sentir inseguro en la vía con EnCicla
9. ¿Qué le cambiarías al sistema?
10. ¿Qué te parece EnCicla?

b) Non-user perceptions questionnaire

1. Do you know about the EnCicla system?
2. Do you ride a bike?
3. Do you own a bike?
4. (if yes to #2) How often?
5. Do you ride on weekdays to go somewhere or just on weekends?
6. Have you ever tried an EnCicla bike?
7. Are you curious about it?
8. (If yes to #2 or 3) Why haven't you signed up to the system?
9. Do you plan to sign up in the future?
   For Bike users

10   What do you think about bikeways and bike paths in Medellín?

Conoces el sistema EnCicla?
¿Montas bicicleta?
¿Tienes bicicleta propia?
¿Con qué frecuencia montas?
¿Montas entre semana para ir a algún lado o solo los fines de semana?
¿Alguna vez lo has usado?
¿No te da curiosidad?
¿Por que no lo has usado?
¿Planeas usar el sistema en el futuro?

¿Cómo te parecen las ciclorrutas?

Notes:
Interview in first person seemed to make people more comfortable
Questions about safety to allow to focus on this aspect
Repeated question about general perception to see if the perception changed
once users talk about safety concerns and other issues

APPENDIX B. EXPERT INTERVIEW QUESTIONS

1. What difficulties did EnCicla have to overcome to go from a school prototype, to a local project, and later a municipal initiative?
¿Que dificultades se tuvieron que sortear para que EnCicla pasara de ser un prototipo, a un proyecto local, y luego una iniciativa municipal?

2. The administration of EnCicla has always been through the municipality, or has the municipality contracted private administrators?
¿La administración de EnCicla siempre ha sido a través de la municipalidad o la municipalidad ha contratado administradores privados?

3. EnCicla was partly designed as a micro mobility project with important equity objectives. However, in the system's expansion plan there are other objectives linked to other city goals like mode change. Do you think EnCicla will be able to help meet these other goals?
EnCicla se gestó en parte como un proyecto de micro movilidad con objetivos importantes de equidad, y de hecho creo que el sistema ha cumplido unas metas de equidad muy importantes. Sin embrago, en el plan de expansión del sistema hay otros objetivos ligados a metas de la ciudad en cuanto cambio de modo, reducción de emisiones, etc. ¿Crees que con el enfoque en el tema de equidad, el sistema va a poder cumplir estas otras metas?

4. How do you reconcile the issue of equity, with the need to encourage bicycle use in areas like El Poblado, where most trips are short, especially in the lower lands?
¿Cómo conciliar el tema de la equidad con la necesidad de fomentar el uso de la bicicleta en sectores como el Poblado donde la mayoría de los viajes son cortos, sobre todo en zonas planas?

5. Do you know if EnCicla has a data-sharing policy? Where can I find information about trip-data?
¿Sabes si EnCicla tiene una política de compartición de datos? ¿Dónde puedo encontrar información de viajes?

6. Has Metro de Medellín developed any recent studies or plans to integrate micro mobility last miles solutions besides EnCicla?

¿Metro de Medellín tiene estudios o planes para integrar soluciones de última/primera milla, más allá de la integración actual con EnCicla?

7. What are the challenges for integrating this and other micro-mobility options into the Metro system?

¿Cuáles son las barreras para la integración entre el Metro de Medellín y otras iniciativas de nueva movilidad desde el Area Metropolitana u otras organizaciones públicas o privadas?

8. What is the purpose of EnCicla within the multi-modal transport system of Medellín?

¿Que rol tiene la bicicleta compartida dentro del esquema de un sistema de transporte multimodal en la ciudad de Medellín?

9. What type of transportation infrastructure are municipalities considering introducing to improve resiliency and sustainability?

Desde el punto de vista de los problemas de sostenibilidad de la ciudad, ¿que tipo de infraestructura de transporte de micro movilidad y/o tecnologías limpias se puede introducir en el sistema? (e.g. electrificación, vagones para bicicletas, etc.).

10. Electric scooters have made their way in not such a positive way in other regions in the absence of regulatory frameworks for this type of transport. How is Metro de Medellín anticipating to these changes, and how it will affect EnCicla?

Las patinetas eléctricas han irrumpido de manera no muy positiva en otras ciudades en ausencia de un marco regulatorio para este tipo de transporte. ¿Cual es la reacción de la Empresa Metro de Medellín ante este nuevo panorama de movilidad que se avecina?