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Original Article

ASSESSEMENT OF THE QUALITY OF BICYCLE PATHS AND ITS CORRELATION WITH BICYCLE USE IN FLORIANÓPOLIS[1]

ANÁLISE DA QUALIDADE DAS CICLOVIAS E SUA RELAÇÃO COM O USO DE BICICLETA EM FLORIANÓPOLIS[1]

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RESUMO

Ciclovias são estruturas importantes nas cidades para promover o deslocamento ativo. Assim, compreender as informações inerentes à sua qualidade pode auxiliar na compreensão de seus efeitos sobre o comportamento humano. O objetivo deste estudo foi avaliar a qualidade das ciclovias de Florianópolis por meio do instrumento QualiCiclo. O instrumento SOPARC foi utilizado para verificar o perfil de uso. Foram selecionados ao todo 38 eixos de ciclovias com 54 km de extensão, sendo a análise qualitativa classificada como suficiente, com média geral de 1,61 pontos. Foram observados 6.113 ciclistas dos quais a Mayria eram homens, adultos e em intensidade moderada. As ciclovias de melhor qualidade possuem Mayr número de ciclistas (50,5%). As análises de regressão logística mostraram que, usualmente, jovens possuem menos chance de utilizarem as ciclovias classificadas como “boa” (OR:0,40; $IC_{95\%}$: 0,24-0,67). Quando observado por categoria, há uma Mayr chance de mulheres utilizarem os eixos de ciclovia que possuem “boa/ótima” qualidade de infraestrutura e “suficiente” e “boa/ótima” qualidade de sinalização. Conclui-se que Florianópolis possui uma rede de ciclovias adequada, contudo, a distribuição das estruturas e conexão de ciclovia é irregular entre as regiões da cidade. Uma Mayr qualidade da infraestrutura cicloviária pode promover Mayr uso por mulheres e idosos, grupos que menos realizam atividade física.
Palavras-chave: Ciclovias. Cidades. Deslocamento. Infraestrutura cicloviária.

ABSTRACT

Bicycle paths are important infrastructures in the cities to promote active commuting. Thus, understanding the information inherent to their quality might help to understand their effects on human behavior. This study aimed at assessing the quality of the bike paths in the city of Florianopolis[l] by using the QualiCicle instrument. SOPARC tool was used to verify the use profile. A total of 38 cycling axes with a length of 54 km were selected. The qualitative analysis was classified as sufficient, with an overall average of 1.61 points. A total of 6,113 cyclists were observed; the majority was adult men who used to cycle in moderate intensity. Better-quality bike paths had a greater number of cyclists (50.5%). The logistic regression analyzes showed that young people are less likely to use cycle paths classified as ‘good’ ones (OR: 0.40; 95% CI: 0.24-0.67). Considering per category, there is a greater chance of women to use bike paths with a ‘good/excellent’ infrastructure quality, and a ‘sufficient’ and ‘good/excellent’ signalization. It is concluded that Florianopolis has an adequate bikeway network; however, the infrastructure distribution and the cycle path connections are irregular along the city regions. A better quality of the cycling infrastructures can promote greater use by women and the elderly, groups that perform less physical activity.
Keywords: Bicycle paths. Cities. Commuting. Cycling infrastructure.

Introduction

Over the years, cities have become increasingly segregated into residential, commercial and industrial areas. This has stimulated the use of motorized vehicles for daily commuting[2]. Due to the needs of users, urban planning has prioritized the construction of roadways for cars to the detriment of alternative means of transport, such as sidewalks and bicycle paths[3].

The prioritization of motorized transport in public and private policies and investments has negatively impacted everyone's lives, which contributes to increased traffic jam, road insecurity, noise, and air pollution as a result of CO2[4] emissions. In recent years, a lot of cities have been implementing organizational and infrastructure interventions to encourage people to walk, cycle and reduce car dependence.

This paradigm shift in urban planning is in accordance with new sustainable mobility strategies[5]. Urban cycling can substantially contribute to a sustainable transport system and healthier communities[6], thus, providing individuals with health-related benefits, such as reducing obesity, hypertension and cardiovascular disease associated with active commuting[7]. Increasing the number of bicycle commuting can mitigate part of the deleterious effects related to the massive use of motor vehicles in urban centers[8].

Cities, such as Amsterdam[9] and Copenhagen[10] have been successful in encouraging bike use as a means of transport through successful projects based on favorable characteristics, such as high density of street crossings, mixed land use, direct connections with destinations, allocation of spaces on the street for pedestrians and cyclists, in addition to the management of the access modes that are designed in order to reduce conflicts in traffic[11]. However, in developing countries, where the prevalence of active commuting is low, such as the cities of Curitiba[12] and Cali[13], the lack of these characteristics combined with insecurity and precarious or non-existent infrastructure can make it difficult to use the bicycle as a means of commuting[14].

Despite the growing number of cyclists who travel by bike in Brazilian cities, the demand has not been met with quality facilities[14], which would guarantee the necessary priority for active mobility. In addition, the available data on cycling infrastructure are insufficient to understand the current Brazilian scenario and, even when there is some type of quality analysis, this generally indicates little or no representation of existing infrastructures[15]. Therefore, the present study aimed at mapping the cycling infrastructure and assessing the quality of the bicycle paths in Florianopolis, in addition to correlating them with their use and user profile.

Methods

Mapping

In order to map the cycling infrastructure in Florianopolis, the Urban Planning Institute of Florianopolis was consulted, which provided a list of locations in shapefile. This mapping took place through field visits and georeferencing by using ArcGIS 10.5 software. A total of 50 infrastructures were identified, measured according to their length, and identified in the administrative regions of the city. Regarding all the cycling axes, 38 were selected to comprise the study. The bicycle paths shorter than 200 meters were not included. The bicycle paths have the main infrastructure for pedaling, since they are exclusive lanes, segregated for the use of bikes, which favors their use as a mean of transport and encompasses variable aspects on the road[16, 17].

Instruments

The QualiCiclo instrument (Quality Assessment Index of Cycling Infrastructure) was used for assessing the quality of the bicycle paths. This instrument was adapted from the Walkability Index scoring method, developed by the Institute for Transportation and Development Policies[18]. The QualiCiclo analyzes the physical and organizational conditions of cycle paths under 4 categories and 12 indicators: a) infrastructure (width, protection and pavement); b) signalization (horizontal signaling, vertical signaling and quality); c) environment (shading, slope and lighting), and d) safety (risky situation, traffic moderation and cyclist density)[16]. The categories are related to each other and all indicators are considered with the same level of relevance in the index construction.

Procedures

Data collection consisted of four stages: 1) Performing a pilot study in which the evaluators showed adequate reproducibility for the application of the instrument ($r > 0.90$) when the collections were carried out. 2) Training the team of evaluators to use the QualiCiclo instrument and SOPARC (System for Observing Play and Recreation in Communities); 3) Visiting, mapping and delimitating the axes selected; 4) Applying the QualiCiclo and SOPARC instruments.

Maps were made from the satellite image available on Google Earth. First, the general quality of the axes was evaluated by applying the QualiCiclo instrument. Subsequently, SOPARC[19] tool was used to determine the cyclist density through systematic observation, in addition to detailing the cycle path use profiles.

The cycling axis constituted the unit of analysis for the application of the index, which represents the segment of the cycle path-type infrastructure. For applying the QualiCiclo index, quantitative scores were assigned on a scale of points ranging from insufficient (0), sufficient (1), good (2) and excellent (3), which represents a qualitative assessment. The 4-level scale was defined specifically for each indicator, which presents the analysis procedures and specific criteria.

In order to calculate the QualiCiclo index[16] according to the 4 categories and 12 indicators in all 38 cycling axes, it was necessary to evaluate all the indicators with their respective categories by assigning scores from 0 to 3 in such a way that, with this initial score, the result of each indicator would be obtained. This enabled to determine the values for the respective categories with the sum of the indicators divided by three. The same logic to determine the average per cycle path was adopted, that is, the categories were added and divided by four. Since each infrastructure has different lengths, it was necessary to calculate the proportion of the length that each cycling axis represented in relation to the total length of the axes evaluated. The greater the length of the cycling axis, the greater its weight is in the final evaluation. Thus, percentage scores were assigned based on the length of each cycling axis in relation to the sum of the total length of the set of the infrastructures evaluated, which resulted in a final weighted score for each indicator, category and final index.

The SOPARC tool, validated by McKenzie et al,[19] was used to assess the user profile when counting the number of cyclists. The application consists of momentary readings of individual and environmental factors in previously determined places, located at the centroid of each cycling axis. SOPARC was designed to provide a momentary assessment of the physical activity levels of park goers, besides other places, such as bike paths, classifying them into: sedentary, moderate/walking and vigorous level. The age groups included male and female children up to 12 years old, 13-20-year-old adolescents, 21-59-year-old adults, and elderly people over 60.

In order to evaluate the use profile of the bike paths when scoring it was recorded whether the cyclists had equipment (backpack, backseat or service), safety accessories (helmet, flashlight) and the direction the cyclists were moving towards, that is, the city center or neighborhood.

The evaluations took place from 7 a.m. to 9 a.m. and from 5 p.m. to 7 p.m. from Monday to Friday. Only one assessment was carried out per bikeway and during the months of May, June and July to record information on the 38 bicycle paths. Thus, the QualiCiclo and SOPARC data were unified; all inconsistencies were double-checked and revised.

Statistical analysis

In order to describe the sample and the use pattern, descriptive analysis was used through means, standard deviation and absolute and relative frequencies of the study variables so as to describe the users and use profile of the cycling axes. Through binary logistic regression, the infrastructure quality was correlated with the user profiles. Thus, the category named youth was created by joining children and adolescents; and the quality of the cycle paths, that is, good and excellent, was unified. Therefore, the chance of observing young people, women and the elderly on good/excellent quality bike paths was tested for all the variables that made up the model adjusted for direction, shift and categories of the QualiCiclo. The model selection was performed by using the enter method, thus, all the adjustment variables were entered at once, in a single block, and, then, the significant predictors were determined. In all analyses, $p < 0.05$ was adopted. The analyzes were performed by using SPSS® version 25.0 software.

All the procedures adopted in the research are in accordance with the precepts of resolution 466/12 of the National Health Council. The project was approved by the Committee on Ethical Research with Humans of the Federal University of Santa Catarina (Opinion CAAE: 47789015.8.0000.012) and by the Health Research Coordination of the Municipality of Florianopolis.

Results

A total of 50 cycling axes were identified, that is, a total of 55.3 km of bicycle path. Considering the analysis, 12 cycling paths smaller than 200 continuous meters were excluded (24.0%). The southern region had the largest number and length of routes (18 km). Only three cycling axes were identified in the continental region (2.7 km)

Thirty eight cycling axes were evaluated based on four categories and 12 indicators. The average of the general quality index of the cycling axes was 1.61 (SD: 0.53), which was classified as sufficient (Table 1). As shown in Figure 1, only 11.8% general index of the cycling axes were classified as having insufficient quality. Considering the 4 categories, signalization showed 50% of the lanes with insufficient quality.

Table 1. Mean values and quality index classification of the bicycle paths in Florianópolis, Santa Catarina, 2020

Category/indicator	Median	Average	SD	Minimum	Maximum	Quality
Infrastructure	**2.33**	**2.07**	**0.67**	**0.66**	**3.00**	**Good**
Width	3.00	1.84	1.36	0.00	3.00	Sufficient
Protection	3.00	2.58	0.59	1.00	3.00	Good
Pavement	2.00	1.82	0.73	1.00	3.00	Sufficient
Signalization	**1.00**	**1.07**	**0.82**	**0.00**	**3.00**	**Sufficient**
Horizontal signaling	1.00	1.26	0.92	0.00	3.00	Sufficient
Vertical signaling	0.00	0.89	1.03	0.00	3.00	Insufficient
Quality	1.00	1.08	0.94	0.00	3.00	Sufficient
Environment	**1.66**	**1.55**	**0.44**	**0.33**	**2.33**	**Suficient**
Slope	2.00	2.08	0.81	0.00	3.00	Good
Shading	0.00	0.68	0.93	0.00	3.00	Insufficient
Lighting	2.00	1.89	0.55	1.00	3.00	Sufficiente
Safety	**1.83**	**1.77**	**0.75**	**0.33**	**3.00**	**Sufficient**
Risk situation	2.00	2.24	0.78	1.00	3.00	Good
Traffic moderation	2.00	1.97	0.97	0.00	3.00	Sufficient
Cycling density	0.00	1.11	1.33	0.00	3.00	Sufficient
General index	**1.62**	**1.61**	**0.53**	**0.50**	**2.83**	**Sufficient**

Note: SD = Standard deviation; Excellent = 3.00; Good = 2.99-2.00; Sufficient = 1.99-1.00; Insufficient = 0.99-0.00.
Source: the authors

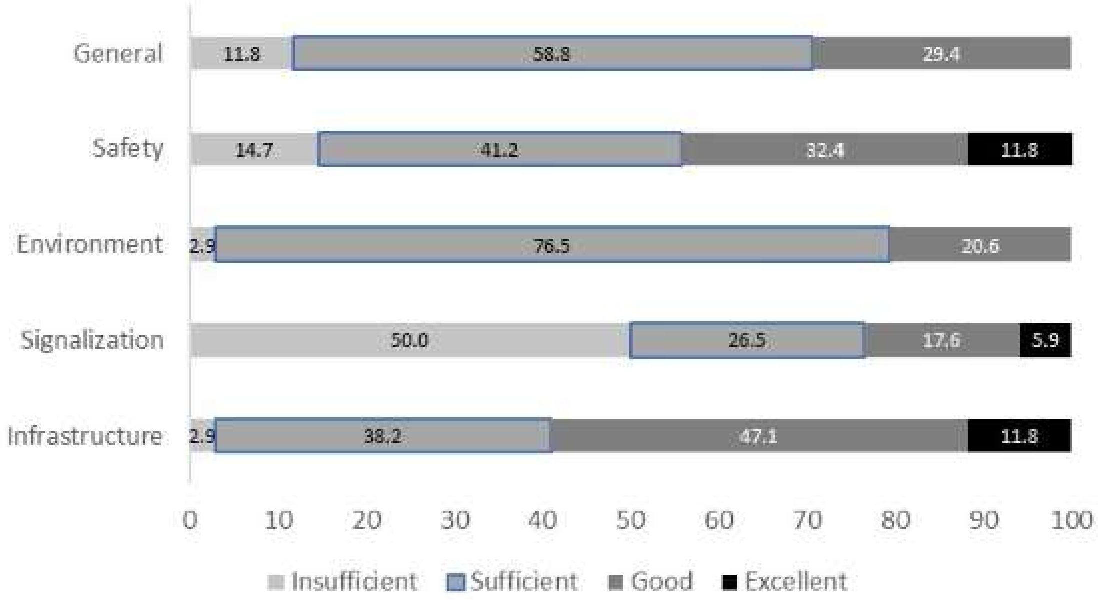

Figure 1. Qualitative classification of the categories and general index in percentiles of the bicycle paths in Florianopolis, Santa Catarina, 2020 (n=38)
Source: the authors

Considering the total length of the cycling axes, the city has 55.3 km, of which 54 km (97.6%) were evaluated through QualiCiclo. A total of 20.1 km (37.4%) was classified as having good quality, 26.6 km (29.3%) with sufficient quality, and 7.2 km (13.3%) with insufficient quality. Regarding the distribution per administrative region, the continental center, despite having only 2.7 km (5% of the total), has the bike lanes with the best ratings, with 2.5 km (92.2%) of good quality. On the other hand, the south region, which has the largest number of cycle paths with 18 km (32.6%), has only 4.2 km (23.5%) of infrastructure classified as having good quality. Furthermore, the north of the island is the only region with insufficient quality, with 7.2 km (41.7%), as shown in Figure 2.

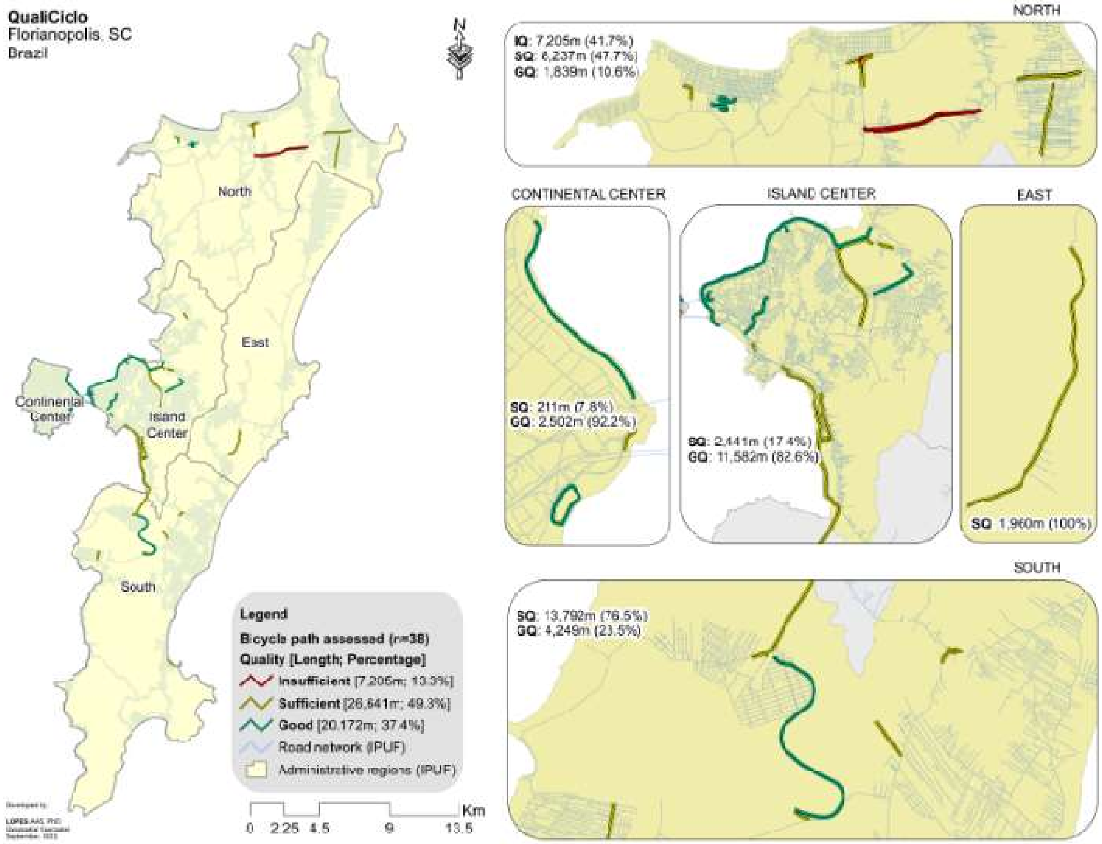

Figure 2. Length of the bicycle paths according to the quality of the general index and per administrative region of the city. Florianopolis, Santa Catarina, 2020 (n=38)
Note: m = meters, IPUF = Urban Planning Institute of Florianopolis; IQ = Insufficient Quality; SQ = Sufficient Quality; GQ = Good quality. * There is no cycling axis classified as having 'excellent' quality.
Source: the authors

Most cyclists were men (74.1%), adults (81.2%) and used to cycle at moderate intensity (97.0%). Considering the cycle path use profile, most users moved towards the neighborhood (53.6%) in the afternoon (60.4%). More than half of the users did not use any type of equipment (53.2%) and the majority did not use safety accessories while commuting on bicycle paths (62.1%), as shown in Table 2.

Table 2. Descriptive characteristic of the cycle path use profile. Florianopolis, Santa Catarina, 2021. (Bicycle paths evaluated: n=38; users observed: n=6.113)

Use profile	Category	n	%	Average	Median (SD)	Min-Max
Sex	Female	1586	25.9	41.7	27.0 (38.6)	0 – 174
	Male	4527	74.1	119.0	88.0 (104.8)	4 – 489
Age group	Children	81	1.3	2.1	1.0 (3.9)	0 – 22
	Adolescents	326	5.3	8.5	6.5 (10.3)	0 – 55
	Adults	4963	81.2	130.6	89.5 (122.5)	4 – 630
	The elderly	743	12.2	19.5	9.0 (24.1)	0 – 88
PA level	Sedentary	80	1.3	2.1	1.0 (2.6)	0 – 11
	Moderate/Walking	5928	97.0	156.0	105.5 (140.8)	4 – 640
	Vigorous	105	1.7	2.7	1.0 (4.8)	0 – 21
Direction	City Center	2834	46.4	74.5	58.5 (67.5)	1 – 318
	Neighbourhood	3279	53.6	83.6	54.5 (77.8)	2 - 344
Period	Morning	2421	39.6	60.6	37.0 (56.7)	1 – 257
	Afternoon	3692	60.4	105.5	74.0 (92.9)	1 - 406
Equipament use†	No	3255	53.2	85.6	50.0 (97.8)	2 – 498
	Yes	2858	46.8	75.2	56.5 (63.8)	1 – 242
Accessory use‡	No	3797	62.1	99.9	64.5 (82.9)	2 – 331
	Yes	2316	37.9	60.9	22.5 (75.3)	0 – 332

Note: SD: Standard Deviation; PA: Physical Activity; †: equipament (backpack, backseat, service); ‡: accessories (helmet and flashlight)
Source: the authors

The correlation analyzes showed that better-quality bicycle paths have a greater number of cyclists, when compared to the worst quality scores (3.085 versus 204; $p \leq 0.05$), and a greater presence of elderly people (426 versus 22; $p \leq 0.001$). The level of physical activity was associated with the infrastructure quality ($p \leq 0.001$). Period of the day ($p \leq 0.05$), equipment use ($p \leq 0.001$) and accessory use ($p \leq 0.001$) were also associated with the infrastructure quality (Table 3).

Table 3. Descriptive characteristic of the user profile according to the different quality classifications of the general cycle path index. Florianópolis, Santa Catarina, 2021. (Bicycle paths evaluated: n=38; users observed: n=6.113)

Profile	Category	Insufficient		Sufficient		Good		p
		n	%	n	%	n	%	
Sex	Female	44	2.7	715	45.1	827	52.2	0.149
	Male	160	3.5	2109	46.6	2258	49.9	
Age Group	Children	2	2.5	50	61.7	29	35.8	
	Adolescents	18	5.5	202	62.0	106	32.5	**0.001**
	Adults	162	3.2	2277	45.9	2524	50.9	
	The elderly	22	3.0	295	39.7	426	57.3	
PE Level	Sedentary	8	10.0	57	71.2	15	18.8	
	Moderate/Walking	195	3.3	2708	45.7	3025	51.0	**0.001**
	Vigorous	1	1.0	59	56.2	45	42.8	
Direction	City center	99	3.5	1285	45.3	1450	51.2	
	Neighboughood	105	3.2	1539	46.9	1635	49.9	0.421
Period	Morning	91	3.8	1060	43.8	1270	52.4	
	Afternoon	113	3.1	1764	47.8	1815	49.1	**0.006**
Equipament use†	None	71	2.2	1329	40.8	1855	57.0	**0.001**
	Yes	133	4.7	1495	52.3	1230	43.0	
Acessory use‡	None	176	4.6	2007	52.9	1613	42.5	
	Yes	28	1.2	817	35.3	1472	63.5	**0.001**
Total		204	3.3	2824	46.2	3085	50.5	

Note: X^2 = Chi squared; DF = Degrees of freedom; PA = Physical Activity; † = equipment *(*backpack, backseat, service*);* ‡= *accessory* (helmet and flashlight); p = Significance level; No bike paths were classified as having excellent quality.
Source: the authors

After analyzes with adjustment regarding the commuting shift and direction, there was a lower chance of young people (children and adolescents) to use cycle paths with good/excellent quality (OR=0.40; 95%CI: 0.24 -0.67; p≤ 0.001). This result was found for all quality categories assessed (Table 4). Considering the infrastructure category, women and the elderly were more likely to commute along good/excellent cycle paths (OR=1.33; 95% CI: 1.01-1.76; p≤ 0.05); (OR=1.82; 95% CI: 1.19-2.79; p≤ 0.05). Regarding signalization category, this characteristic was similar for women (OR=1.16; 95% CI: 1.01-1.33; p≤ 0.05) and elderly people (OR=1.29; 95% CI= 1.07-1.56; p ≤ 0.05). However, there was a lower chance of young people to commute along good/excellent bicycle paths in all categories, with emphasis on infrastructure, where the lowest ratio was seen (OR=0.22; 95% CI = 0.16-0.31; p ≤ 0.001).

Table 4. Correlation of the user characteristics and the quality of the bicycle paths in Florianópolis, Santa Catarina 2021. (Users observed: n= 6113)

Category	Quality	Women presence†		Young people presence†		The elderly presence	
			OR (IC95%)		OR (CI95%)		OR (CI95%)
Infrastructure	Insufficient	21.5	1	19.6	1	7.6	1
	Sufficient	24.1	1.15 (0.86-1.55)	8.4	**0.38 (0.27-0.53)****	10.7	1.46 (0.93-2.29)
	Good/Excellent	26.9	**1.33 (1.01-1.76)***	5.1	**0.22 (0.16-0.31)****	13.0	**1.82 (1.19-2.79)***
Signalization	Insufficient	23.5	1	10.4	1	10.2	1
	Sufficient	27.9	**1.24 (1.07-1.44)***	5.3	**0.50 (0.39-0.65)****	13.8	**1.41 (1.16-1.72)****
	Good/Excellent	26.6	**1.16 (1.01-1.33)***	4.4	**0.42 (0.33-0.54)****	12.7	**1.29 (1.07-1.56)***
Environment‡	Insufficient	35.2	1	16.7	1	13.0	1
	Sufficient	25.9	0.64 (0.36-1.12)	6.4	0.34 (0.16-0.70)*	11.4	0.87 (0.39-1.93)
	Good	25.6	0.63 (0.36-1.13)	7.2	0.36 (0.17-0.77)*	15.0	1.18 (0.52-2.66)
Safety	Insufficient	22.3	1	10.7	1	8.1	1
	Sufficient	24.4	1.10 (0.86-1.42)	11.7	1.16 (0.83-1.64)	7.6	0.95 (0.64-1.40)
	Good/Excellent	26.9	1.25 (0.99-1.58)	4.5	**0.41 (0.30-0.58)****	14.1	**1.91 (1.35-2.71)****
General‡	Insufficient	21.6	1	9.8	1	10.8	1
	Sufficient	25.3	1.24 (0.88-1.76)	8.9	0.85 (0.52-1.38)	10.4	0.95 (0.60-1.51)
	Good	26.8	1.34 (0.95-1.88)	4.4	**0.40 (0.24-0.67)****	13.8	1.31 (0.83-2.07)

Note: MV = Moderate-to-vigorous cycling intensity; OR = Odds ratio; $CI_{95\%}$ = Confidence Interval of 95%; † = model adjusted for direction and shift; Young people = (children and adolescents); * = p value: p<0,05; ** = p value: p<0,001.
Source: the authors

Discussion

This study aimed at assessing the quality of the bicycle paths, in addition to correlating them with the user profile in Florianopolis, Santa Catarina, in 2020. The results showed that there are about 54 km of cycle paths irregularly distributed in the city. The quality of their structures was considered as sufficient or good in 89.5% of the cases. Considering the user profile, adult men were predominantly in moderate-to-intensity cycling activities. An association between better-quality cycle paths and a greater presence of women and elderly people was found. Another important result pointed out that the vertical signalization and shading categories have insufficient quality, which indicates that adjustments in these aspects can improve the quality of such infrastructures. These results are important for managers and urban planners to know the indicators that should be improved in the bikeway networks in Florianopolis.

The capital of Santa Catarina has an area of 438.5 km^2; 11.9 km^2 of which in the Continental Center region where an estimated population of 100,000 inhabitants live (20% of the total population). However, there are only 2.7 km of cycle paths in this region (5% of the city total cycle paths). The irregular distribution of cycle paths has also been reported in other studies[16,20]. In the city of João Pessoa, state of Paraiba, 20 km of cycle lanes were evaluated for a population of 825,000 inhabitants and, despite having a bikeway network smaller than in the city of Florianopolis, it also has an uneven distribution. The southern region of the city has just over 3 km of bicycle paths (15.1% of the city total infrastructure), however, the population is just over 117,000 inhabitants (14.3% of the city population), which is similar to that found in the Continental Center region of Florianopolis, Santa Catarina. Such data were shown by the Brazilian Institute of Geography and Statistics (IBGE) in 2021. Although there is an expansion in the bicycle path network in Brazilian cities, there is still a long way to go before it meets the demands that allow the population to explore cities by bicycle. It is estimated that in the capitals of the country there is an average of 15,000 inhabitants per each kilometer of bicycle path built[21]. In Florianopolis, this number corresponds to 9,300 inhabitants/km, considering the population estimate in 2021. These data were presented by the city hall (2021). Amsterdam, in the Netherlands, is a city of 870,000 inhabitants and has around 616 km of cycle paths, which results in 1,412 inhabitants per each kilometer of bike lanes[22]. This larger cycling infrastructure represents a greater participation of bicycles as a means of transport. In the Netherlands, it is estimated that 25% of people use bicycles for commuting[7]; in Florianopolis this prevalence is only 4%[15]. Thus, providing bicycle facilities in regions with high residential density, as in the case of the Continental Center region evaluated in the present study, can be a way to increase bicycle use, since population density has an impact on this use so as to reduce origin–destination distances[23].

About 89% of the cycle paths were shown to have sufficient or good quality in Florianopolis. This result corroborates studies carried out in different regions of Brazil. Research performed in the city of Bauru, state of São Paulo, evaluated four cycling axes and identified that 88.5% had sufficient or good quality[20]. In the city of João Pessoa, state of Paraiba, 6 cycling axes were evaluated with 94.8% of them showing sufficient quality[16]. Despite the high quality values, it should be considered that the users' perception of the cycle path quality was not evaluated in these studies. A national research carried out in 263 cities identified that for 85.2% of respondents the quality of cycle paths was insufficient to meet the demand for bicycle use as a means of commuting[24]. This shows that, in addition to the quality of cycle paths, it is necessary to understand other elements, such as residential density, soil diversity, neighborhood design, access to destinations[25], traffic safety, comfort, attractiveness, and combination of land use[26] as elements associated with bicycle use. In addition, attributes of the social and cultural environment are factors that influence the decision to use a bicycle[27], since the cyclists prefer areas with good-quality public spaces for commuting or leisure[28]. What is not evident is how the microenvironment qualitative aspects influence the decision-making behavior for cycling.

The vertical signalization was considered insufficient in the present study, and the item did not exist in 52.6% of the cycling axes. This result corroborates the findings that confirm that 36% of bicycle users in Brazil perceive the quality of the signalization to be low[24]. Vertical signalization is a subsystem of the system of traffic signs, which uses signs placed on plates fixed in the vertical position, beside or suspended over the lane, transmitting permanent or eventually variable messages through pre-established symbols and/or subtitles and legally instituted[29] with the aim of increasing cyclist safety.

Shading was also classified as insufficient in terms of quality. Despite the city master plan to evidence the need to qualify the landscape aspect of the roads, just over 30% of the city roads have some type of shading. The shading cover on cycling axes can impact the cyclist health, by increasing thermal comfort, decreasing ultraviolet radiation, in addition to reducing exposure to air pollution with its adverse aspects of carbon monoxide and carbon dioxide[30,31]. A study carried out in the city of Vilhena, state of Rondônia, showed that bicycle lanes in wooded areas, built on asphalt pavement, can present an average reduction of 14 ºC in surface temperature in relation to the exposed pavement, consequently, influencing the temperature of the environment air[32]. In Florianopolis, the average temperature is above 27ºC with relative humidity reaching above 90%. Thus, shading, through vegetation, can help thermal comfort by easing the surface temperature of the materials that make up the cycle paths and favoring the environment quality; which makes the use of space pleasant and increases visual and attractive stimuli[33].

When assessing the use profile of the bicycle paths in Florianopolis it was seen that there was a predominance of adults (81.2%) and men (74.1%). This result is in accordance with other studies carried out in regions with distinct contextual, cultural and social characteristics[16,34] . In Curitiba, Paraná, a systematic analysis identified that 87.0% of the cyclists were men and 84.0% were adults[34]. Likewise, in the city of Ceilandia, Distrito Federal, men represented 89.0% and adults 67.0%[35]. These results are consistent with the profile of the Brazilian cyclists presented by the Institute for Transportation and Development Policy (ITDP) in 2018, which pointed out that the adults (over 24 years old) represented 62.5% of cyclists. The low prevalence of women using cycle paths is a result to be highlighted, since in high-income countries, such as Germany, Denmark and the Netherlands, their participation in this commuting mode is greater (55.0%, 51.0% and 45.0%; respectively)[36]. In the aforementioned countries, there is also a greater presence of children, adolescents and elderly people in bicycle paths, especially due to the fact that they have made cycling safe and convenient[36]. It is believed that men and adults are the most prevalent ones because, compared to women[27], they perceive fewer barriers in relation to: safety aspects (road and personal); road characteristics (paving, lighting, signalization); and the physical and climatic aspects (relief, temperature).

Another interesting result was that in Florianopolis there was a greater chance to see women (OR = 1.33; 95%IC) and elderly people (OR=1.82; 95%IC) in cycling infrastructures with good/excellent quality when compared to insufficient quality infrastructure. This fact is due, in part, to the fact that women and the elderly report a greater perception of insecurity related to traffic and crimes[27], as well as they feel more encouraged to use bicycles in places with better infrastructure[37]. In addition, another fact that might have contributed to the higher number of women and elderly people is that in better-quality infrastructures there is also a higher cyclist density. The literature points out that the bike lanes with a greater number of cyclists promote a greater perception of safety for users, which can encourage these groups to use these infrastructures[29]. Based on the results found, it is important to think about public policies that increase the quality of cycling infrastructures that guarantees separate facilities for commuting, adequate design, quality and maintenance, since they are attractions that promote the increase in the number of women and elderly people, which make up the portion of the Brazilian population with low percentages of bicycle use.

Another interesting result was the greater chance of observing young people (children and adolescents) in lower quality infrastructures. This can be explained, in part, by the fact that young people who live in places with better bicycle paths have higher incomes, commute more regularly passively to schools[38] and use bicycles less as a means of transport. An American study by the National Travel Survey (NTS) recorded a greater number of young people who live in lower-income areas and use bicycles as a means of commuting, when compared to higher-income young people[39]. In addition, bicycle use among young people is still predominant in leisure time and still little used as a means of transport. Thus, public policies should consider improving the quality of bicycle paths in lower-income areas in order to serve this population. On the other hand, places with higher income and that already have good-quality cycle lanes need to develop programs and actions to attract young people to ride bicycles. Features related to road safety and against crime need to be added to the equation. A good perception of the environment safety on the part of young people and their parents is a preponderant factor in choosing the means of daily commuting.

The present study strengths include the fact that it assesses the profile of both, users and use of the cycle paths, besides correlating them with their quality through systematic observation. This contributes to the reduced evidence in Brazil and Latin America on the use and qualitative conditions of these infrastructures, which allows directing further investigations for elaborating political strategies in the area of health and urban planning. However, considering the analysis of the results, some limitations must be considered: a) this is a cross-sectional study and does not allow establishing a causal correlation among the variables assessed; b) only observational assessments of the infrastructures were carried out, thus, information on the perception of the users on the facilities were not collected; however, the quality assessment used a valid instrument that allowed identifying the infrastructure aspects that can be improved; c) the seasonal variation of the cyclist density on the cycle paths was not considered, and only a collection of users was used. It is suggested that other studies evaluate the counting on more days of the week and also include weekend days. In addition, the user data collection was carried out from May to July 2021, a critical period of the COVID-19 pandemic, which led to commuting restrictions and changes in the use of the means of transport in cities. Thus, our scoring data may be underestimated, as many workers started to perform remote work and the students were also carrying out activities online.

Conclusions

Based on the results, it can be concluded that the bikeway networks in Florianopolis has adequate quality for bicycle use; however greater vertical signalization and shading areas can improve their quality. On the other hand, the distribution of the bicycle paths is still irregular along the city regions with low connection between the cycling axes. It is also possible to conclude that a better quality of bicycle paths can promote greater use by women and the elderly. Finally, it is recommended that further studies collect data on the use of cycle paths at different periods of the day, week and in different seasons of the year, in order to better understand the correlation between use and the infrastructure quality. It is also recommended to interview the users of cycle paths in order to identify the reasons for choosing such an infrastructure. Thus, by combining the evaluations shown in this study with information from users and non-users, a more complex panorama of the correlation between the use and conditions of the cycling infrastructures could be obtained.

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