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Cross-culturally approaching cycling safety from a behavioural perspective: a study in 19 countries

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Abstract

While promoting urban cycling has shown to represent several benefits for public health, risky behaviours might endanger cycling safety outcomes and discourage people from shifting to active transportation. Therefore, examining the relationships among riding behaviour, safety, and country-based figures seems valuable for promoting a safer and sustainable development of urban cycling worldwide. For this study, 7,001 urban cyclists from 19 countries provided data on their mobility patterns, cycling behaviours and safety outcomes. The results show that positive behaviours are overall more prevalent than risky ones. However, behavioural patterns largely vary depending on riders' demographics and country-based indexes. It supports the idea that cycling behaviour remains a key contributor to cycling outcomes, as well as the need to fill many gaps endangering riding safety across many countries.

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Keywords: Urban cycling; riding behaviour; cross-cultural approach; traffic crashes; cycling safety.

1. Introduction

Transport dynamics in urban areas have changed substantially in recent years. Motorised transport generates major mobility and pollution problems in cities. These are reasons that have influenced the need to reduce motorised vehicle trips, replacing them with more sustainable means of transport (Useche et al., 2019). Consequently, there has been an expansion of non-motorised personal micro-mobility vehicles, especially bicycles.

Bicycles are a means of transport with multiple advantages for users. In addition to its sustainability, many users opt for this means of transport because of the autonomy and flexibility it provides. All this at a reduced economic cost and with direct benefits for the physical health of cyclists (De Hartog, 2010; Kummeneje and Rundmo, 2020).

Traditionally, Europe is the continent where most people use bicycles for their regular trips. However, in recent years there has been a major expansion of cycling in Latin America. Meanwhile, Africa is the region with the least number of cyclists. These differences could be influenced by the levels of socio-economic development of the regions. Thus, Europe and Oceania have a large number of High-Income Countries, while Africa and Latin America have more Low and Middle-Income Countries. These differences have a direct impact on the level of education of the population as well as on the state of the road infrastructure and, consequently, on transport dynamics.

The current health situation, caused by COVID-19, has contributed to this increase in the cycling community, as it is a generally individual means of transport that allows for respecting interpersonal safety distance. In this respect, it is not surprising that countries around the world have seen an increase in the cycling community. Data show that between February and June 2020, there was a 69% increase in requests for cycling routes on Google Maps worldwide (Haubold, 2020). And in some countries, such as Finland, Poland and Canada, the increase was more than 300%.

The increase in cycling is essential for traffic flow in urban areas. For this reason, this process must be accompanied by preventive measures and adequate road infrastructure. Cyclists are a vulnerable sector given their lack of protection and their interaction with motorised vehicles. Even so, data indicate that around 25% of crashes involving cyclists were caused by risky road behaviours (Linea Directa Foundation, 2018).

The present study conducts a large-scale cross-cultural research to understand the attitudes and behaviours of bicycle users in 19 countries across five continents. The CBQ questionnaire is used, covering safe and unsafe cycling behaviour. The data provide a global perspective on the human factor of bicycle users, making it possible to analyse hypothetical differences between regions and offer relevant data to establish preventive measures for this vulnerable user group.

2. Materials and methods

2.1. Sample

The sample for this cross-sectional study consisted of n= 7,001 cyclists from 19 countries. The subjects' ages ranged from 16 to 83 years, with a mean age of M = 36.63 (SD = 14.72) years. In terms of gender, 2,696 participants were female (38.8%), and 4,255 were male (61.8%) (50 participants did not identify as female or male). Table 1 describes the distribution of the sample according to country of residence and gender.

Table 1. Descriptive data of the study sample.

Country	Gender				Total	
	Female		Male			
	n	%	n	%	n	%
Austria	61	47.3 %	68	52.7 %	129	1.9 %
Australia	322	29.4 %	774	70.6 %	1096	15.8 %
Belgium	207	60.5 %	135	39.5 %	342	4.9 %
Brazil	115	51.1 %	110	48.9 %	225	3.2 %
Cameroon	19	16.0 %	100	84.0 %	119	1.7 %
Chile	92	30.6 %	209	69.4 %	301	4.3 %
China	107	19.8 %	434	80.2 %	541	7.8 %
Colombia	217	36.0 %	385	64.0 %	602	8.7 %
Denmark	323	56.9 %	245	43.1 %	568	8.2%
Dominican Republic	136	35.4 %	248	64.6 %	384	5.5 %
Finland	96	46.6 %	110	53.4 %	206	3.0 %
Germany	316	70.1 %	135	29.9 %	451	6.5 %
Malaysia	18	9.8 %	165	90.2 %	183	2.6 %
Mexico	98	30.0 %	229	70.0 %	327	4.7 %
Poland	16	13.8 %	100	86.2 %	116	1.7 %
Russia	116	31.4 %	253	68.6 %	369	5.3 %
Slovakia	93	39.9 %	140	60.1 %	233	3.4%
Spain	140	41.9 %	194	58.1 %	334	4.8%
United Kingdom	204	48.0 %	221	52.0 %	425	6.1%
Total	2,696		4,225		6951	100%

2.2. Study design, procedure and analysis

For this empirical investigation, participants completed the CBQ self-report questionnaire administered online. Participants were selected through a convenience (and non-probabilistic) sampling method, based on their availability and/or willingness to collaborate. The survey distribution methods were slightly different depending on the country of implementation. However, distribution was generally through institutional mailing lists, cycling federations and social networks. Participants were informed about the general aims of the study and the protection of their personal data by means of an informed consent form. Descriptive analyses were carried out to understand the safe and unsafe behaviour and attitudes of cyclists, contrasting the data according to the country and region in which the questionnaire was administered.

2.3. Description of the questionnaire

The Cycling Behaviour Questionnaire (CBQ) is a questionnaire developed by Useche et al. (2018) with the aim of analysing the behaviour of cyclists. The CBQ comprises items on both positive and risk behaviour of cyclists on the road. It is composed of 29 items, through which the following three factors or subscales have been identified:

- Traffic violations: composed of 8 items assessing the frequency with which cyclists deliberately break traffic rules.
- Riding Errors: includes 15 items that measure a cyclist's unintentional behaviour as a consequence of not achieving a previously planned action.
- Positive Behaviours: composed of 6 items that assess actions that cyclists actively and deliberately take that contribute to their safety and security as road users.

The CBQ's internal consistency and validity have been confirmed through administration in countries such as Argentina, Colombia and Mexico, China, Australia and Belgium, as well as in multicultural studies with samples from Europe, Latin and North America.

3. Results

Table 2 shows the results for each of the countries in which the research was conducted. In general, the data indicate that the items reporting inappropriate manoeuvres and errors have low scores, while the factor concerning safe behaviours has moderate to high scores.

There were significant differences between the groups in the factor "violations" ($F(18,6982)=41.194$; $p<.001$). Thus, inappropriate behaviour and violations of cyclists occur to a lesser extent in the United Kingdom, Spain and Australia. In contrast, Cameroon has the highest self-reported traffic violations in this road group. The factor "errors" also shows significant differences ($F(18,6982)=70.891$; $p<.001$), with the United Kingdom, Denmark and Brazil being the countries with the least self-reported driving errors. In this case, Cameroon is again by far the country where cyclists make the most errors during their journeys. On the other hand, positive behaviours are more reported by Brazilian and Mexican cyclists. China, Cameroon and Russia are the countries with the lowest scores on this factor. ($F(18,6982)=34.339$; $p<.001$).

Table 2. Results of the CBQ factors by country

Country	Violations		Errors		Positive Behaviours	
	Mean	SD	Mean	SD	Mean	SD
Austria	.72	.47	.40	.37	2.93	.64
Australia	.53	.42	.43	.36	3.18	.53
Belgium	.77	.44	.47	.30	2.46	.54
Brazil	.77	.46	.36	.37	3.36	.59
Cameroon	1.66	.99	1.71	.95	2.71	.73
Chile	.68	.47	.41	.37	3.17	.59
China	.85	.51	.80	.43	2.69	.79
Colombia	.80	.69	.60	.56	2.96	.87
Denmark	.65	.42	.32	.31	3.13	.68
Dominican Republic	.68	.78	.68	.82	2.86	1.16
Finland	.66	.43	.33	.38	2.91	.61
Germany	.89	.56	.45	.41	2.93	.67
Malaysia	.57	.45	.44	.47	3.41	.80
Mexico	.69	.45	.46	.39	3.32	.52

Poland	.51	.61	.42	.58	3.11	.74
Russia	.74	.99	.67	.98	2.73	1.34
Slovakia	.61	.49	.47	.46	3.11	.57
Spain	.49	.51	.38	.39	2.92	1.01
United Kingdom	.44	.37	.32	.30	3.07	.52

Analysing each of the factors by continent, there were significant differences in all of them: traffic violations (F(4,6996)=117.238; p<.001), errors F(4,6996)=226.666; p<.001) and positive behaviour F(4,6996)=22.301; p<.001). Figure 1 graphically represents the distribution of the scores for each of the factors.

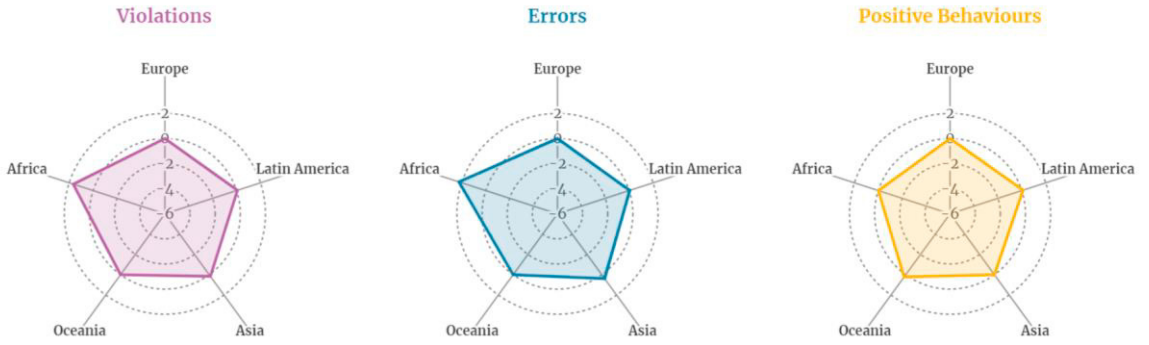

Fig. 1. Graphical representation of the results of the CBQ factors by region (standardised values)

Table 3 shows the results according to the continent where cyclists live. Violations and infringements by cyclists are particularly prominent on the African continent. In contrast, Oceania and Europe are the regions where the least self-reported inappropriate behaviour is reported. Asia and Latin America are in between, also constituting the only two regions that do not differ significantly from each other.

This trend is repeated in the driving errors factor, with Europe and Oceania again having the lowest scores. Africa is the country with the highest number of unintentional errors. In terms of safe driving behaviour, Oceania and Latin America are the regions with the highest scores, while Africa is the region with the lowest. Europe and Asia have intermediate scores on this factor.

Regarding gender differences, men report more violations and errors than women in most continents. While women self-report more positive behaviours. Only in Asia is there the opposite trend, with female cyclists reporting more inappropriate behaviour than men (table 3).

Table 3. Results of the CBQ factors by region (continent).

Region	Violations			Errors			Positive Behaviours		
	Mean	SD	Mean diff.*	Mean	SD	Mean diff.*	Mean	SD	Mean diff.*
Europe	.66	.57	-5.94 ; p<.001	.42	.49	-2.25; p=.024	2.93	.64	6.40; p<.001
Latin America	.73	.62	-8.22; p=.001	.53	.56	-2.76; p=.006	3.09	.84	2.91; p=.004
Asia	.78	.51	2.88; p=.004	.70	.46	2.42; p=.016	2.87	.85	-3.87; p<.001
Oceania	.53	.41	-5.72; p<.001	.43	.35	-2.16; p=.031	3.18	.53	6.43; p<.001
Africa	1.66	.99	-3.28; p=.001	1.71	.95	-1.92; p=.058	2.71	.73	0.19; p=.847

*Student's t test for mean differences. Categorical factor: Gender.

4. Discussion and conclusions

This research analyses the risk behaviours and safe behaviours performed by the cycling population in 19 countries with different socio-demographic characteristics. The results indicate that the frequency of positive behaviours is higher than the frequency of violations or inappropriate behaviours. Furthermore, although the differences are minimal, cyclists report more deliberate rule violations than unintentional errors during their journeys.

The differences between territories suggest that a country's income level is a relevant variable in cycling behaviour. Thus, Africa stands out as the region with the highest number of traffic violations and the lowest self-reported safe cycling behaviour. In contrast, Oceania and Europe are territories where cyclists show better behaviour during their journeys, with countries such as the United Kingdom, Spain and Poland standing out in particular. Substantial differences in the socio-economic development of the regions mentioned may influence cycling behaviour. Coherently with previous studies, countries with lower income levels have shown to be less prone to invest in road infrastructure, especially in regard to active transportation means (Thomas and DeRobertis, 2013; Useche et al., 2021). Thus, the maintenance and condition of vehicles are not fully adequate. This phenomenon has consequences for citizens' perception of risk and the willingness to cycle and the travel dynamics of users.

Evidence indicates that low-income countries have higher death rates caused by traffic crashes, especially for vulnerable cyclists and motorcyclists (Staton et al., 2016). These figures could be reduced with greater financial investment in preventive road safety training measures and improved cycling infrastructure. Promoting protective cycling behaviour and raising awareness of the importance of complying with traffic laws and regulations seems to be, in sum, fundamental towards this purpose.

Finally, and linked to both preceding studies on cycling safety and the outcomes of this particular study, riding safety education and training programmes must consider cultural specificities, weaknesses and strengths, in order to maximize their performance at improving positive cycling behaviours, preventing risky manoeuvres and enhance mid- and long-term safety results among bicycle riders.

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References

De Hartog, J.J., Boogaard, H., Nijland, H., Hoek, G. 2010. Do the health benefits of cycling outweigh the risks?. Environmental health perspectives, 118(8), 1109–1116. doi:10.1289/ehp.0901747

Haubold, H. 2020. ¿El aumento de la movilidad ciclista a raíz de la COVID-19 es real? ¡Los números dicen que sí! VeloCity: Cicle Diversity. Lisboa.

Kummeneje, A.-M., Rundmo, T. 2020. Attitudes, risk perception and risk-taking behaviour among regular cyclists in Norway. Transportation Research Part F: Traffic Psychology and Behaviour, 69, 135-150. https://doi.org/10.1016/j.trf.2020.01.007

Linea Directa Fundation. La muerte silenciosa. Los accidentes de tráfico en los usuarios vulnerables: peatones, ciclistas y motoristas (2007-2016), Oct. 2018.

Staton, C., Vissoci, J., Gong, E., Toomey, N., Wafula, R., Abdelgadir, J., Hocker, M. 2016. Road traffic injury prevention initiatives: a systematic review and metasummary of effectiveness in low and middle income countries. PloS one, 11(1), e0144971. doi: 10.1371/journal.pone.0150150

Thomas, B., DeRobertis, M. 2013. The safety of urban cycle tracks: a review of the literature. Accident Analysis & Prevention, 52, 219-227. doi: 10.1016/j.aap.2012.12.017

Useche, S.A., Alonso, F., Montoro, L., Sanmartin, J. 2019. Healthy but risky: A descriptive study on cyclists' encouraging and discouraging factors for using bicycles, habits and safety outcomes. Transportation Research Part F: Psychology and Behaviour, 62, 587-598. doi: 10.1016/j.trf.2019.02.014

Useche, S.A., Hezaveh, A.M., Llamazares, F.J., Cherry, C. 2021. Not gendered… but different from each other? A structural equation model for explaining risky road behaviors of female and male pedestrians. Accident Analysis & Prevention, 150, 105942. doi: 10.1016/j.aap.2020.105942

Appendix A.

Cycling Behaviour Questionnaire, CBQ (29 items)*

Instruction: *Please estimate how often you do the following when cycling, using this scale:*
0 = Never; 1 = Almost never; 2 = Sometimes; 3 = Frequently; 4 = Almost always / always

	Item content	Frequency				
Factor 1: Traffic Violations						
1.	Cycling under the influence of alcohol and / or other drugs or hallucinogens.	0	1	2	3	4
2.	Circulating against the traffic (wrong way).	0	1	2	3	4
3.	Zigzagging between vehicles when using a mixed lane.	0	1	2	3	4
4.	Handling potentially obstructive objects while riding a bicycle (food, packs, cigarettes ...).	0	1	2	3	4
5.	Feeling that sometimes I'm going at a higher speed than I should be going at.	0	1	2	3	4
6.	Crossing what appears to be a clear crossing, even if the traffic light is red.	0	1	2	3	4
7.	Carrying a passenger on my bicycle without it being adapted for such a purpose.	0	1	2	3	4
8.	Having a dispute in speed or "race" with another cyclist or driver.	0	1	2	3	4
Factor 2: Errors						
9.	Unintentionally crossing the street without looking properly, thus making another vehicle brake to avoid a crash.	0	1	2	3	4
10.	Colliding (or being close to it) with a pedestrian or another cyclist while cycling distractedly.	0	1	2	3	4
11.	Braking suddenly and being close to causing an accident.	0	1	2	3	4
12.	Failing to notice the presence of pedestrians crossing when turning.	0	1	2	3	4
13.	Not braking on a ‘‘Stop” or ‘‘Yield” sign and being close to colliding with another vehicle or pedestrian.	0	1	2	3	4
14.	Braking very abruptly on a slippery surface.	0	1	2	3	4
15.	While I am distracted, I do not realise that a pedestrian intends to cross a crosswalk, and therefore I do not stop to let him or her do so.	0	1	2	3	4
16.	Not realising that a parked vehicle intends to leave and consequently having to brake abruptly to avoid a collision.	0	1	2	3	4
17.	When driving on the right side, not realising that a passenger is getting out of a vehicle or bus, and thus being close to hitting him or her.	0	1	2	3	4
18.	Trying to overtake a vehicle that had previously used its indicators to signal that it was going to turn, consequently having to brake.	0	1	2	3	4
19.	Misjudging a turn and hitting something on the road, or being close to losing balance (or falling).	0	1	2	3	4
20.	Unintentionally, hitting a parked vehicle.	0	1	2	3	4
21.	Failing to be aware of the road conditions and falling over a bump or hole.	0	1	2	3	4
22.	Confusing one traffic signal with another, and manoeuvring according to the latter.	0	1	2	3	4
23.	Trying to brake but not being able to use the brakes properly due to poor hand positioning.	0	1	2	3	4

Factor 3: Positive Behaviours					
24. I stop and look at both sides before crossing a corner or intersection.	0	1	2	3	4
25. I try to move at a prudent speed to avoid sudden mishaps or braking.	0	1	2	3	4
26. I usually keep a safe distance from other cyclists or vehicles.	0	1	2	3	4
27. When I use the bike path (or bike-lane), I always use the indicated lane.	0	1	2	3	4
28. I avoid circulating under adverse weather conditions.	0	1	2	3	4
29. I avoid circulating if I feel very tired or sick.	0	1	2	3	4

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