Methodological proposal for generating a Pedestrian Crosswalk Safety Index (PCSI)

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1. ABSTRACT

We propose a Pedestrian Safety Index for crosswalks along main roads in Mexico to reduce fatalities and improve crossing conditions. The pedestrian crosswalk safety index intends to be a useful tool for stakeholders, allowing them to assess crosswalk quality and identify issues to be improved. One of the main findings is that both land use mix and crossing distance are the most important variables in predicting traffic incidents, both being positively correlated and statistically significant. The second one is that roughly 90% of the surveyed crosswalks in Mexico City do not meet the minimum design criteria to ensure a secure and comfortable crossing.

2. RATIONALE & MAIN GOALS

Traffic incidents are considered as negative externalities derived from car-oriented transit policies. In Mexico, traffic fatalities are the first death cause among children between 5 and 14 years old and the second one between 15 to 29. According to the Ministry of Public Security (Secretaría de Seguridad Pública SSP), within Mexico City 61% of those fatalities happen over main streets.
The main goal of this proposal is to produce a Pedestrian Crosswalk Safety Index (PCSI), in order to reduce fatalities and to improve crosswalk design conditions.

3. METHODOLOGY

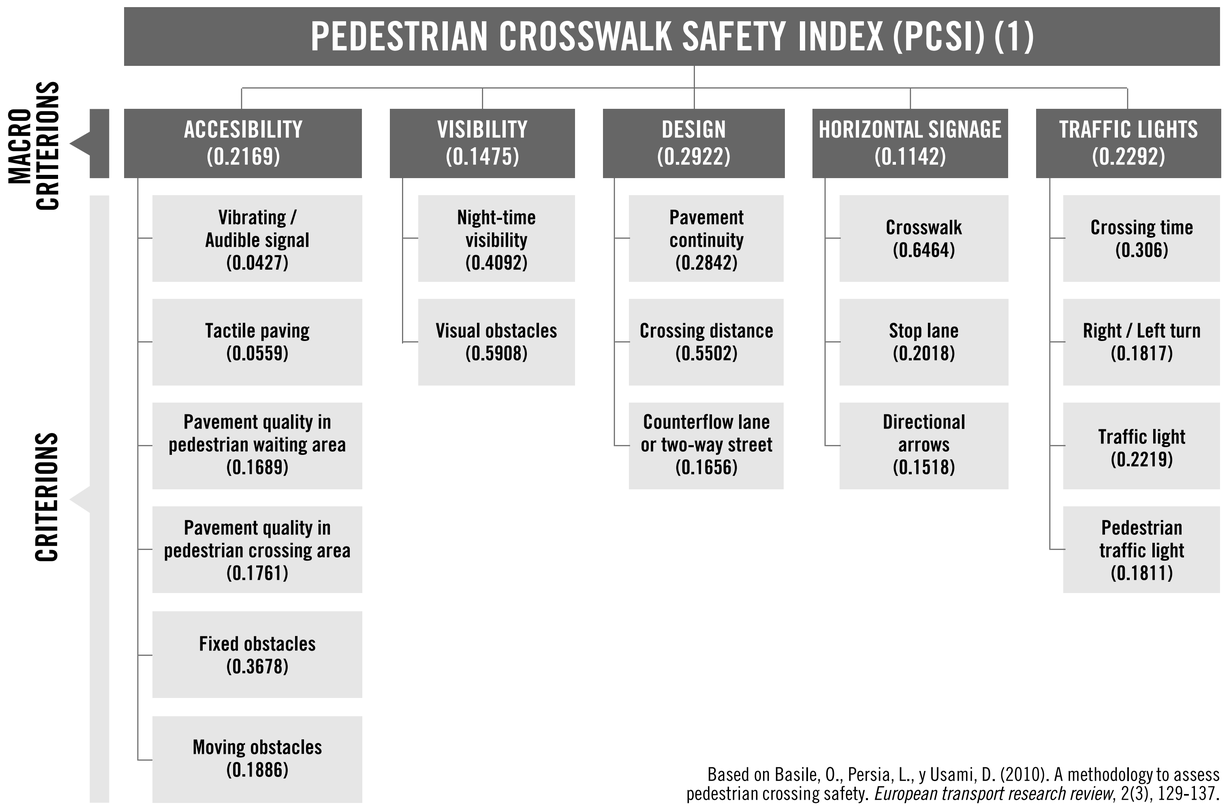
Our team developed a proposal for a PCSI following a five-step model: i) identification, hierarchization and criterion selection; ii) criteria rating (range of values) and criteria weighting through AHP (Analytic Hierarchic Process); iii) Testing the instrument in field; iv) PCSI calculation; v) 'validation' of the PCSI against 2010-2016 fatalities geodatabase (from the SSP). (i) FOR CRITERIA SELECTION we performed an extensive literature review, from which 94 criterions were selected. Later on, an Expert Panel workshop was designed in which the experts selected a final list containing 18 criterions arranged within five macro criterions: Accesibility, Visibility, Design, Horizontal Signaling, Level of Signaling (Traffic Lights). (ii) FOR CRITERIA RATING (RANGE OF VALUES) AND WEIGHTING, an AHP online method was used. It allows to weight each criteria at different levels in order to acquire a final value which will become the PCSI. For weighting each criteria, a panel of ten experts weighted each criterion. (iii) THE RESULTING INSTRUMENT WAS TESTED ON THE FIELD. A stratified statistical sample of 503 signalized crosswalks were surveyed at day and night. For that purpose a mobile app was developed and installed in digital tablets to a) help the survey teams complete their task in less time and b) gather the collected data into a remote server in real time. (iv) THE PCSI WAS COMPUTED AUTOMATICALLY. (V). NEXT, DATA WAS ANALYZED a) quantitatively and b) qualitatively. For (a), two approaches were used: Zero inflated models (regressions) and Fast and Frugal Decision Trees. For (b), micro criterions were analyzed and graphed in order to understand the importance of each variable accounting for a better crossing.

4. AHP

$$\text{PCSI} = \sum_m w_m \cdot \sum_j \left(w_j^m \cdot A_j \right) \quad \text{Where:}$$

w_j^m is the weight of general criterion A_j associated to general macro-criterion C_m;

w_m is the weight of general macro-criterion C_m contributing to the general goal.



Based on Basile, O., Persia, L., y Usami, D. (2010). A methodology to assess pedestrian crossing safety. *European transport research review*, 2(3), 129-137.

5. ZERO INFLATED MODELS

	Model 1 (without land use mix)				Model 2 (with land use mix)			
	Zero-inflated model (Poisson count model)		Zero-inflated model (logit model)		Zero-inflated model (Poisson count model)		Zero-inflated model (logit model)	
	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
Intercept	1.613	(0.097) ***	-1.788	(0.579) **	1.075	(0.109) ***	-0.612	(0.661)
Tactil paving (Dummy)	0.222	(0.080) **	-0.148	(0.538)	0.160	(0.080) *	0.028	(0.558)
Pavement quality in pedestrian crossing area (ref= 0 'bad')								
Regular	-0.164	(0.046) ***	-0.520	(0.285) .	-0.166	(0.046) ***	-0.540	(0.292) .
Good	-0.195	(0.061) **	0.288	(0.316)	-0.260	(0.062) ***	0.310	(0.328)
Fixed Obstacles (ref = 0 'More than one obstacle')								
One obstacle	0.089	(0.063)	0.294	(0.386)	-0.036	(0.065)	0.429	(0.400)
No obstacles	0.204	(0.073) **	0.716	(0.416) .	0.156	(0.074) *	0.768	(0.427) .
Moving obstacles (Dummy)	-0.334	(0.044) ***	0.120	(0.259)	-0.283	(0.044) ***	0.058	(0.267)
Night-time visibility (ref = 0 'Bad')								
Regular	-0.125	(0.065) .	-0.034	(0.333)	-0.090	(0.065)	-0.047	(0.343)
Good	0.059	(0.067)	-0.490	(0.372)	0.051	(0.068)	-0.553	(0.386)
Visual Obstacles (Dummy)	0.156	(0.051) **	-0.048	(0.286)	0.182	(0.052) ***	-0.130	(0.292)
Pavement continuity (ref = 0 'There is step')								
Very steep	0.144	(0.059) *	-0.642	(0.416)	0.131	(0.059) *	-0.599	(0.429)
Suitable	0.348	(0.067) ***	-0.038	(0.414)	0.346	(0.066) ***	0.037	(0.427)
Counterflow lane or two-way street	-0.125	(0.047) **	0.460	(0.300)	-0.156	(0.047) ***	0.503	(0.307)
Crosswalk (ref= 0 'It is not marked partially / totally)								
Not clear	-0.109	(0.055) .	-0.207	(0.309)	-0.105	(0.056) .	-0.259	(0.320)
Well marked and visible	-0.004	(0.077)	-0.609	(0.465)	0.044	(0.077)	-0.784	(0.487)
Stop lane (ref = 0 'It is not marked /does not apply')								
Not clear	0.259	(0.056) ***	0.249	(0.314)	0.229	(0.057) ***	0.353	(0.327)
Well marked and visible	0.068	(0.082)	0.250	(0.477)	0.038	(0.083)	0.327	(0.498)
Directional arrows (Dummy)	0.233	(0.068) ***	0.374	(0.399)	0.214	(0.070) **	0.498	(0.408)
Pedestrian light (Dummy)	0.140	(0.047) **	-0.211	(0.297)	0.077	(0.047)	-0.089	(0.309)
Red light time	0.001	(0.001) *	0.000	(0.004)	0.001	(0.001) .	0.001	(0.004)
Crossing distance	0.008	(0.001) ***	0.013	(0.007) .	0.006	(0.001) ***	0.016	(0.007) *
Land use mix					1.846	(0.162) ***	-4.560	(1.216) ***
Log-likelihood	-1608				-1535			
McFadden's Pseudo R2	0.098				0.139			
Cox & Snell's Pseudo R2	0.511				0.637			
Nagelkerke Pseudo R2	0.512				0.638			

Note: Statistical significance 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

6. RESULTS

The most important variables for predicting traffic incidents within this model are land use mix (the more mixed, the more traffic incidents) and crossing distance (at longer crossing distances there are more chances of being hit by a motorized vehicle). The land use mix variable can be operating as a proxy for pedestrian flow density. From this qualitative analysis, it can be stated that 95% of pedestrian crossings are not suitable for people with visual impairments; 81% has fixed obstacles over their trajectory; 74% are too long to be deemed safe; 77% of the traffic lightshave too short times for pedestrian to cross at a fixed speed; and in 61% of the surveyed cross walks, pedestrians have to wait too much time to cross.