Años potenciales de vida perdidos y análisis espacial de incidentes viales en peatones de Medellín 2015-2020

Potential years of life lost and spatial analysis of pedestrian road incidents in Medellin from 2015-2020.

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Abstract

Objective: To describe the Years of Potential Life Lost (YPLL), and the spatial distributions of mortality caused by road accidents in Medellin pedestrians between the periods of 2015-2020.

Methods: A descriptive study with a secondary source of information was carried out, and all the records of pedestrians killed in road accidents were analyzed. The calculation of the YPLL was carried out by five-year age groups and the Life Expectancy at Birth of Colombia as the age limit estimated by DANE for the period 2015-2020 was chosen. To know the geographical distribution of the deaths, point maps, and kernel density estimation with a standard quantile classification were created. The proximity analysis was performed by the multiple ring buffer method, with distances of 100, 200 and 300 meters.

Results: During the years 2015-2020, 696 pedestrian deaths were registered in Medellin, from which 514 (73.9%) were men and 182 (26.1%) were women. The neighborhoods with the highest mortality were Candelaria with a percentage of 31.2% (217 deaths), and Castilla with a percentage of 8.8% (61 deaths). The most frequent injuries were polytrauma with a total of 401 cases (57.6%), and head injuries in 231 cases (33.2%). In total, the city's pedestrians lost 14,553 YPLL due to road accidents. From the total number of fatal pedestrian accidents, 400 (57.5%) of them occurred within a 300-meter radius of a pedestrian bridge.

Conclusion: Male pedestrians had the highest YPLL rates of the period, and they are the ones who die the most on the road. Head and skull injuries

are the most fatal, especially if they are suffered by older adults. The loss of labor and economic power is high for the city, but the social and family loss is incalculable.

Key words: Years of potential life lost, pedestrians, mortality premature, wounds and injuries, accidents, traffic.

Introduction

Walking or walking as a recreational activity in large cities has become a high-risk activity. The lack of infrastructure, signage, public space invasion and disrespect for the rules mean that pedestrians often must share the same space with motorized users, a situation that increases the risk of dying or being injured on the road (1,2).

At the beginning of the twentieth century, cities began a process of urban transformation that encouraged the increase in road infrastructure as a solution to the problem of mobility, under the hypothesis that increasing the road system will reduce the negative effects of mobility, operating costs, and travel times (3,4). Wrong hypothesis that increased the number of circulating vehicles due to improvements in the roads, excessive increase in the speed of circulation and growth in the number of fatal and non-fatal victims due to road incident (4).

In view of the growing problem, the construction of pedestrian bridges was encouraged as a possible solution; the above under the scoop that by segregating pedestrians in elevated structures would benefit their mobility and safety. However, today the number of pedestrians hit continues to increase, and pedestrian bridges have become factors that stimulate the development of high speeds, and together with contextual, citizen safety and accessibility factors make pedestrians choose not to use them (4).

Since the first fatal record of a pedestrian incident on London roads in 1896, and after more than a hundred years, mortality from road incidents has grown to epidemic behavior (5), leaving 1.4 million people dead on roads and highways around the world each year, by low- and middle-income countries being the ones with the highest mortality (5). Half of the people

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who die from this cause are vulnerable road users, pedestrians, cyclists, and motorcyclists. Young people die more frequently and prematurely, by the age group of 15 to 29 years being the one with the most deaths (5). Premature mortality due to road incident is avoidable, and like other causes of the same nature prevent or slow down the increase in life expectancy (5).

Walking is a daily necessity for many people in America, a region where 11% of road traffic deaths occur in the world, almost 155,000 a year, the mortality burden is disproportionately assumed by young, poor men with low levels of schooling, who have greater difficulty accessing health care when they are injured, and therefore, less likelihood of recovery and return to work, school or society (5). In Latin America there have been some improvements, especially in institutional management, however, in terms of legislation and user behavior on the roads, the task remains pending (5). To try to reverse this situation, the United Nations (UN) in September 2020 approved the second Decade of Action for Road Safety (DARS) by 2030, and welcomed the conclusions of the 3rd Ministerial Conference on Road Safety held in Stockholm, which recommended the world to migrate from motor and private vehicles to active and public ones, and comprehensively manage speed; ratifying again an unpostponable and unavoidable commitment to reduce by 50% deaths and injuries due to road incidents worldwide, after the failed attempt in the first Decade of Action for Road Safety 2010-2020 (6).

In Colombia in the last decade an average of 6,500 people died per year in road incidents, the mortality rate in 2019 was 14 deaths per 100 thousand inhabitants, and the non-fatal injuries totaled almost 37,000 (7). Medellín capital of the Antioquia department and second city of the country with the highest number of inhabitants, contributed in 2019 the 27% of road mortality, and 55% of the non-fatal injuries of the department (7), the number of pedestrians killed amounted to 80 fatalities (7). By gender, men are more injured than women when they walk around the city (8). 20 years after being executed and sanctioned by the Swedish parliament, Medellín by decree 261 of April 2019, adopted Vision Zero as an approach and strategy to reduce death and road injury (9). Strategy that should have been adopted two decades ago, as a principle and roadmap to meet human goals and commitments to life and the planet.

The recent emergence of global and local pedestrian leagues advocates for pedestrian rights and call for pedestrians to fight for them, trying to

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highlight the problem that cities face due to lack of adequate pedestrian infrastructure, and to reduce the risk of exposure when walking (4). This situation evidences the health and inequitable problem faced by cities that requires an urgent change, especially due to the adoption of Vision Zero as a horizon to 2030 where international commitments to life and the environment are assumed, in this case related to the reduction of road death and injury, positioning it as one of the fundamental goals of social transformation and of the same order as other events of surveillance in Public Health. Therefore, the interest of this work focused on describing the Potential Years of Life Lost and the spatial distribution of mortality due to road incident in pedestrians of Medellín 2015-2020.

Methods

A descriptive, retrospective study with a quantitative approach was conducted to describe mortality and Potential Years of Life Lost (PYLL) due to road incident in pedestrians in Medellín; mortality analysis was performed by place of incident and date of death. Secondary information was used, collected through the Information System Network of Disappeared and Corpses (SIRDEC by its acronym in Spanish), technological platform implemented in 2007, in which reports of missing persons and information on corpses subjected to a medical-legal necropsy are permanently recorded (10). The database was provided by the National Institute of Legal Medicine and Forensic Sciences (INMLCF by its acronym in Spanish), a benchmark of excellence in Colombia to quantify mortality caused by road incidents, takes as a basis the records on necropsies performed and filters them to take only those that correspond to the definition of death by road incident (11). The reference population consisted of all the deaths in Medellín recorded in the INMLCF mortality database in the study period; the unit of analysis was the record of each death, where the basic cause of death was classified as violent death and associated with transport events in pedestrian road users. No calculation was made for sample selection, all records that met the following criteria were analyzed: a) violent death in transport; b) the dead

road user was a pedestrian; c) the place of the incident; d) death had been in Medellín; e) during the period 2015-2020. Records of death in transport of other road users were excluded and, for the spatial location of events, records without information, poorly completed or that did not meet geocoding standards were excluded.

To estimate the PYLL, the general methodology set out in the epidemiological literature was adopted, this being an indicator of health impact and used for the study of premature mortality, which illustrates the loss suffered by society as a result of the death of young people or before reaching the maximum life expectancy at birth (LEB) (12). The age limit was the LEB of Colombia estimated by the National Administrative Department of Statistics (DANE) for the period 2015-2020, it was specific by year and gender. The calculation of the PYLL was carried out by five-year groups to ensure the uniform distribution of deaths in each of the age groups (12). The class mark was estimated in each age group, the weighting factor was estimated from the difference between LEB and the class mark, the PYLL were obtained by multiplying the weighting factor by each of the deaths recorded in each age group (12). The Index of Potential Years of Life Lost (IPYLL) is the result of dividing the PYLL and the population projection of the DANE according to age group, gender, and year, multiplied by a constant (12).

The layers of road mesh, neighborhoods, and communes necessary to georeferenced the information were downloaded from the Medellín city maps web catalog, arranged and freely accessible by the Administrative Department of Planning of the Municipal Mayor's Office. The geodatabase of the pedestrian bridges was supplied by the Secretariat of Physical Infrastructure of the city. The analysis and mapping of fatal incidents in pedestrians was done through thematic maps according to the site of the incident; the events were georeferenced by direction of place using the massive geocoder of Medellín "MapGis", which uses a deterministic relationship model through web services, and through a unique identifier allows to distinguish unequivocally the entity (13). Street and road addresses were normalized and standardized according to a deterministic approach (13). The initial percentage of geocoded addresses located in the road network was 96.0%, those not found were reviewed one by one to detect possible inconsistencies, which made it possible to increase the initial percentage of location to 96.3%.

After georeferencing of fatal incidents in pedestrians, a Kernel density map was made. The Kernel Density tool calculates a magnitude per unit area from point or polyline features, thus adapting a smoothly narrowed surface to each point or polyline; allowing to visualize sites with high and low density to identify spatial patterns of mortality or points of greater concentration (14). The Kernel density was classified with the standard-quantile method, which assigns the same number of data values to each class, there are no empty classes, with too many or few values (14).

Finally, the creation of proximity zones with specific distances around pedestrian bridges was carried out by the multi-ring buffer method, with distances of 100, 200 and 300 meters. The result of the use of this tool is the generation of a polygon that surrounds a geometry as a function of a fixed or variable distance, thus allowing the identification and quantification of cases within the selected vicinity. The rings were classified with a color palette that delimits the proximity pattern, with the dark color being the one with the shortest distance from the reference point, and the light one being the one with the greatest (15)

This research followed guidelines and ethical aspects agreed in Resolution 8430 of 1993 of the Ministry of Health, which classifies it in its article 11 as risk-free (16). And the right to personal and family privacy and good name was guaranteed according to Article 15 of the Political Constitution of Colombia (17). For the processing, analysis and presentation of the information, the statistical software IBM SPSS 21®, massive geocoder of Medellín "MapGis", ArcGIS 10®, Microsoft Excel and Word were used.

The limitations are related to the choice of the LEB at the local level as a limit value for the calculation of the PYLL, since these values limit the international comparison, but favor the local and regional comparison adjusted to the population profile of the country.

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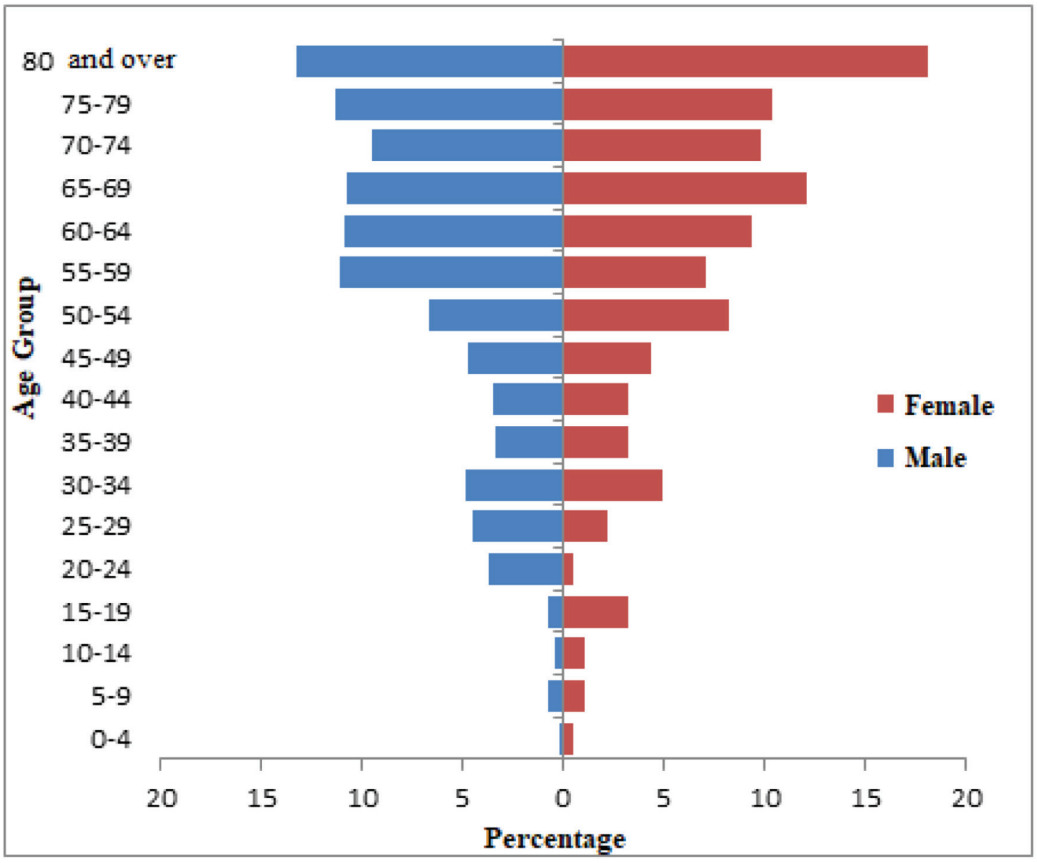
Results

In Medellín during the years 2015-2020 the INMLCF registered a total of 696 deaths due to road incident in pedestrians, 514 (73.9%) were men and 182 (26.1%) were women, all killed in two- and more-wheeled motor vehicle accidents. In years, the youngest person at the time of death was 1 and the oldest 97, the 50% of the pedestrians killed were 62 or younger. As the age increases, the deaths due to road incidents in pedestrians increase, by being those over 50 years of age who died the most, with a notorious predominance of women over 80 years of age (Graph 1). The superiority of road death was evidenced in male pedestrians, with a ratio of 3 to 1.



Graphic 1. Mortality due to road incident in pedestrians by age group and gender, Medellín 2015-2020.

The largest number of dead pedestrians had low academic levels: elementary 285 (40.1%) and high school 154 (22.1%), with university level 27 (3.9%), and 1 (0.1%) dead pedestrian with specialization level. It was found 36 (5.2%) cases without any academic level, and 186 records without information. According to marital status, single pedestrians were the ones who died the most 244 (35.1%), followed by those married with 176 (25.3%) deaths. When analyzing the occupations of deceased pedestrians, those who die the most are housewives 78 (42.9%), followed by retired men 56

(10.9%), and unemployed men with 40 (7.8%). There are 14 (2.0%) cases of homeless who died as pedestrians in the study period. By place of the incident, the neighborhoods in which more pedestrians died were in Candelaria with 217 (31.2%) pedestrians killed, followed very far by Castilla with 61 (8.8%) deaths, Laureles Stadium with 58 (8.3%) deaths and Aranjuez with 48 (6.9%). In townships, four of the five townships that the city has presented mortality due to road incident in pedestrians, the highest record was in San Cristóbal with 16 (2.3%) deaths, and the lowest in San Antonio de Prado with 11 (1.6%) pedestrians killed (Table 1).

Table 1. Sociodemographic characteristics of pedestrians killed in road incident, Medellín 2015-2020

Variables	GENDER				TOTAL (N=696)	%
	Male (n=514)	%	Female (n=182)	%		
Academic level						
Elementary	204	39,7	81	44,5	285	40,9
High school	113	22,0	41	22,5	154	22,1
Technical/technology	11	2,1	1	0,5	12	1,7
Bachelor	15	2,9	12	6,6	27	3,9
Specialization	0	0,0	1	0,5	1	0,1
None	27	5,3	9	4,9	36	5,2
No information	144	28,0	37	20,3	181	26,0
Marital status						
Single	178	34,6	66	36,3	244	35,1
Married	136	26,5	40	22,0	176	25,3
Living common - law	70	13,6	18	9,9	88	12,6
Widowed	29	5,6	40	22,0	69	9,9
Divorced	20	3,9	6	3,3	26	3,7
No Information	81	15,8	12	6,6	93	13,4
***Occupation**						
Housewife	0	0,0	78	42,9	78	11,2
Retired	56	10,9	18	9,9	74	10,6
Unemployed	40	7,8	1	0,5	41	5,9
General services	31	6,0	4	2,2	35	5,0
Seller	26	5,1	6	3,3	32	4,6
Informal seller	21	4,1	5	2,7	26	3,7
Independent	25	4,9	0	0,0	25	3,6
Student	10	1,9	5	2,7	15	2,2
Homeless	11	2,1	3	1,6	14	2,0
None	19	3,7	5	2,7	24	3,4

Township/neighborhood						
La Candelaria	167	32,5	50	27,5	217	31,2
Castilla	46	8,9	15	8,2	61	8,8
Laureles Estadio	42	8,2	16	8,8	58	8,3
Aranjuez	36	7,0	12	6,6	48	6,9
Guayabal	39	7,6	9	4,9	48	6,9
Robledo	22	4,3	13	7,1	35	5,0
Belén	24	4,7	7	3,8	31	4,5
Manrique	18	3,5	8	4,4	26	3,7
Doce De Octubre	19	3,7	6	3,3	25	3,6
La América	20	3,9	5	2,7	25	3,6
El Poblado	12	2,3	5	2,7	17	2,4
Santa Cruz	7	1,4	8	4,4	15	2,2
San Javier	11	2,1	4	2,2	15	2,2
Buenos Aires	13	2,5	2	1,1	15	2,2
Popular	9	1,8	5	2,7	14	2,0
Villa Hermosa	7	1,4	4	2,2	11	1,6
San Cristóbal	8	1,6	8	4,4	16	2,3
San Antonio De Prado	6	1,2	5	2,7	11	1,6
Palmitas	4	0,8	0	0,0	4	0,6
Alta vista	4	0,8	0	0,0	4	0,6

* First ten occupations of pedestrians killed in road incident.

The topographic diagnosis of the injury indicated that 401 (57.6%) of the dead pedestrians suffered polytrauma on their bodies, 231 (33.2%) suffered head injuries, and 14 (2.0%) had chest trauma. The least recurrent lesions were in the lower limbs and face, with 2 (0.3%) and 1 (0.1%) cases respectively (Figure 1). The year of most pedestrian road deaths was 2015 with 147 (21.1%) deaths, august with 75 (10.8%) and Saturday with 111 (15.9%) deaths.

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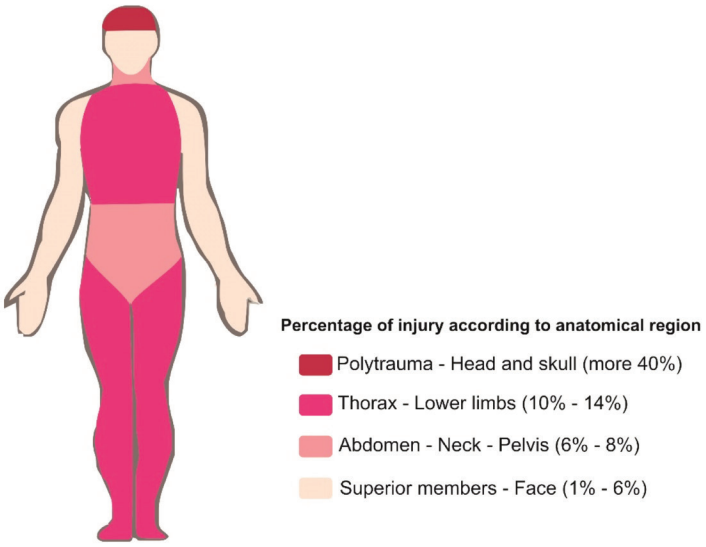

Figure 1. Topographic diagnosis of the injury according to anatomical region of the pedestrian fatally injured in road incident, Medellín 2015-2020.

In the five-year study, a total of 14,553 potential years of life were lost due to pedestrians' road incidents in Medellín, which means an index of 104 PYLL per 100,000 inhabitants. Regarding to gender, male pedestrians were the ones who lost the most years of life 9616 PYLL in total, more than double the PYLL in women, who contributed 4172 PYLL in pedestrian road mortality. 2015 was the year in which men contributed the most PYLL 2382 (IPYLL =225 x 100,000 inhabitants), while the highest PYLL in women was registered in 2017 with a total of 805 (I PYLL =65 x 100,000 inhabitants). The years 2015, 2016 and 2017 contributed 55% of the PYLL of the study period, the one with the lowest contribution was 2020, a fact that may be associated with restrictions on mobility due to the COVID-19 pandemic (Table 2).

Table 2. PYLL for pedestrian deaths in road incidents by gender in Medellín 2015-2020

YEAR	Males		Females		Total	
	PYLL	IPYLL	PYLL	IPYLL	PYLL	IPYLL
2015	2382	224,5	613	51,0	3215	143,4
2016	1736	161,7	766	62,9	2641	116,3
2017	1261	115,8	805	65,2	2153	93,6
2018	1462	132,0	736	58,6	2291	97,9
2019	1581	139,5	774	60,4	2481	103,8
2020	1194	103,2	479	36,7	1771	72,8
Total	9616	145,2	4172	55,6	14.553	104,1

The highest density in pedestrian road mortality occurred in the neighborhood Commune 10, La Candelaria, a downtown area of the city that receives a large amount of people who make their journeys on foot every day. In this Commune, the neighborhoods of San Benito, Corazón de Jesús, Candelaria, Chagualo, Colón, Prado, Boston, Guayaquil and Jesús Nazareno presented the highest density of road deaths in pedestrians (Map 1). Other neighborhoods with high density in pedestrian death were to the north: Caribe, Castilla, and Toscana of the Commune 5 Castilla, to the south Cristo Rey and Santa Fe of the commune 15 Guayabal, and to the west the neighborhoods Conquistadores, Lorena, and Carlos E Restrepo in the commune 11 Laureles (Map 1). By frequency in pedestrian death the greatest happened on roads with a high number of vehicles and that are traditionally poorly classified as highways or "fast" roads, and that lack road infrastructure that protects the lives of pedestrians and other road users. Carrera 62 between streets 44 and 67, was the stretch of road with the highest mortality 34 (4.9%) deaths, followed by street 44 that crosses the city from east to west where 31 (4.5%) pedestrians died.

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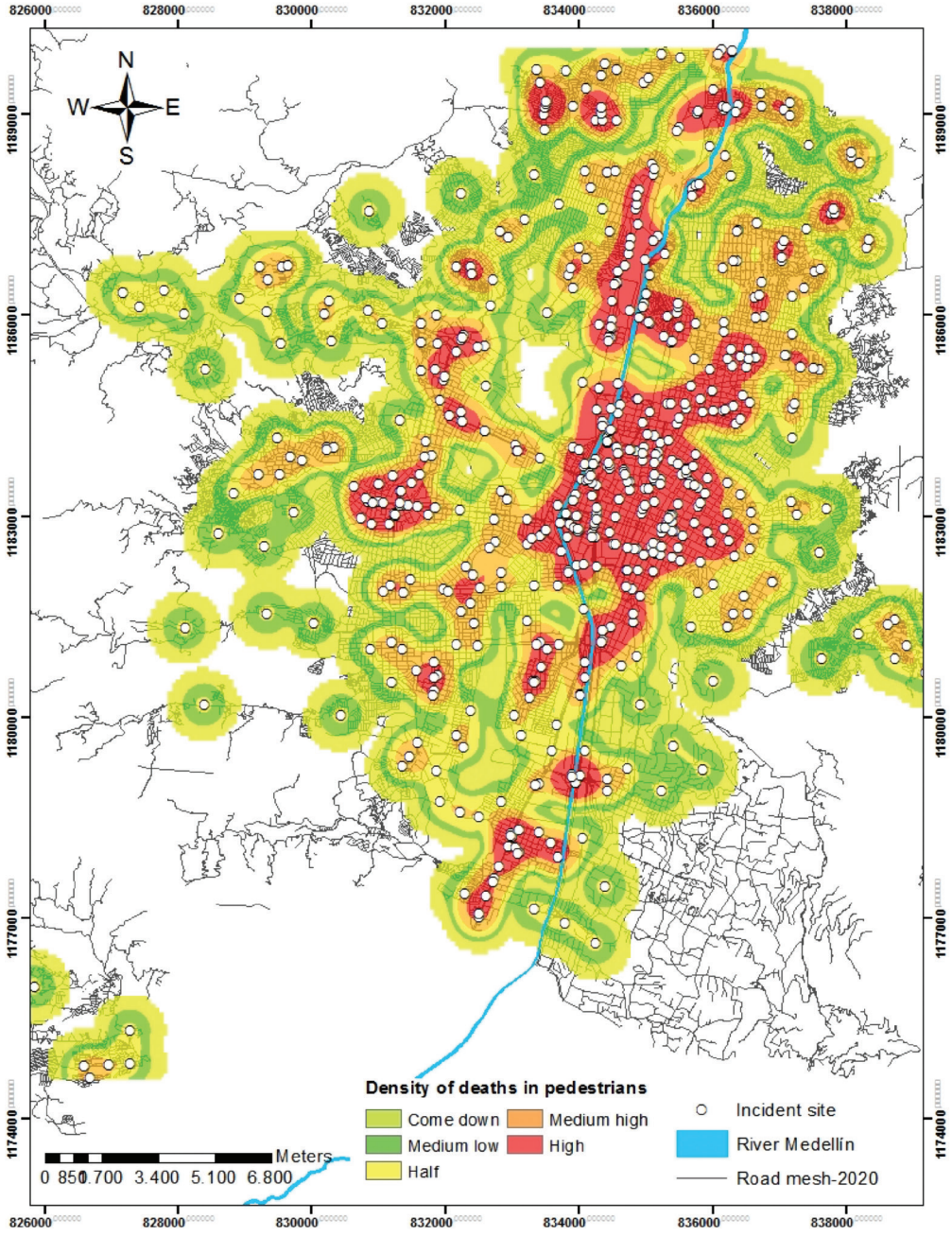
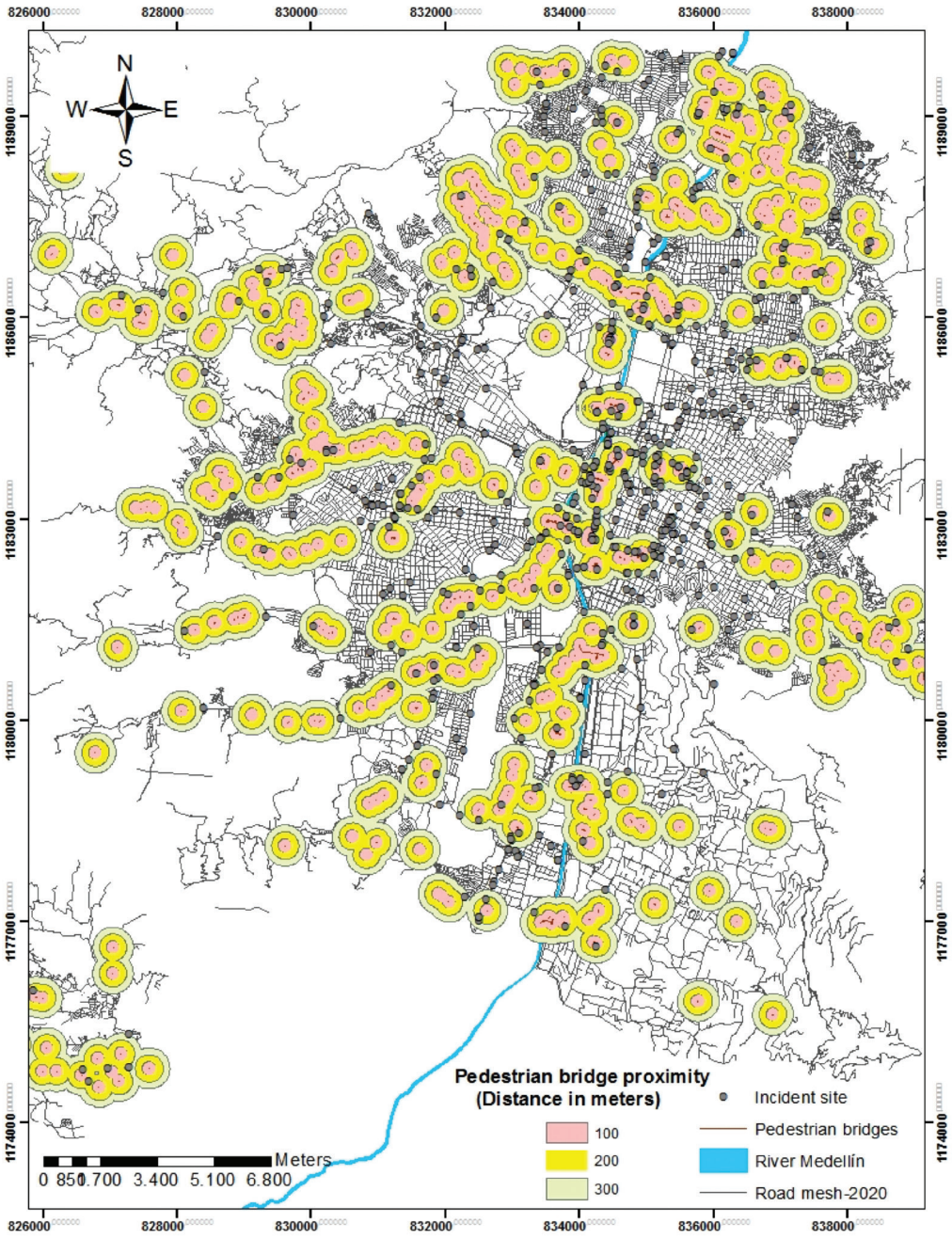


Map 1. Density of deaths due to road incident in pedestrians in the municipality of Medellín, 2015-2020.

The Secretariat of Physical Infrastructure of Medellín has a registry of 504 pedestrian bridges distributed throughout the urban and rural areas of the city. Of the 696 fatal incidents in pedestrians, 400 (57.5%) occurred within a distance of 300 meters from a pedestrian bridge, 260 (37.4%) at 200 meters and 100 (14.4%) at 100 meters; the remaining percentage of fatal incidents occurred outside the radius of 300 meters (Map 2).



Map 2. Deaths due to pedestrian road incident in influence area of pedestrian bridges in Medellín, 2015-2020

Discussion

In a large percentage of Colombian territory, road incidents are poorly catalogued and misclassified, offering a connotation of accidental origin, making it unforeseeable, unpredictable, and impossible to avoid (18); contrary to their incidental origin, by nature preventable, avoidable, and coming from a continuous incidence that expresses the probability that an individual belonging to a population at risk will develop an event in relation to time

(19). Since 1961 and continuously the WHO has been ratifying that "The accident is not accidental" and expresses its disagreement about the wrong use of the word accident to refer to road incidents (20). Therefore, road incident refers to a situation that is preventable (18), and its incidence could be avoided through public health interventions such as: health promotion, disease prevention, risk communication, specific protection measures and implementation of public, sectoral, and extra sectoral policies (21).

The findings of this study indicate that at an older age increases mortality, a result similar to previous research, where human factors associated with age such as reduced visual acuity, hearing loss, reduced locomotion and environmental factors such as inaccessible pedestrian bridges, lack of accessible crosswalks at ground level, proper signaling, invasion of public space and the short time interval available to cross an intersection, are risk factors that combined with advanced age increase the risk of suffering injuries or fractures in the head with fatal outcome (2). A situation that confirms the state of vulnerability of pedestrians on the road, a fact that is documented in the scientific literature and in the model of safe system as human frailty, a scenario that means that in these age groups mortality is not only the result of a higher incidence, but of a greater lethality, compared to the other population groups (2,22,23). Thus, this study confirms what has been stated in other research, where it is suggested that older pedestrians have more serious injuries, and in case of hospital care require longer periods of hospitalization than young pedestrians (2,22).

In accordance with what has been evidenced at the local and international level on road incident mortality, the results of this study indicated superiority in road deaths of male pedestrians compared to female, contributing 74% of deaths and 66% of the PYLL with respect to the total; similar figures to what was revealed by the WHO for the world, and by Gallego et al for Ecuador, where male pedestrians died more and contributed 64% of PYLL (23); similar figures for the case of Colombia, where in 2020 the National Road Safety Agency indicated that men in the country died mostly compared to women, and contributed on average 80% of premature mortality due to road incident (11).

Polytrauma and cranio-encephalic trauma are one of the main injuries in pedestrians hit by vehicles (24). Head and neck injuries sustained by pedestrians at the time of the incident have been shown to account for nearly 60% of all injuries (24). Another relevant result is the frequency of polytrau-

ma in the topographic diagnosis of the injury, where 58% of the pedestrians who died in Medellín suffered it, a situation that is not distant from what was found in other investigations, where for the particular case of Chile, it was described that the main causes of deaths associated with road incident were linked in 47% of cases to multiple traumatisms, followed by intracranial trauma with 28%, injuries that together explain 75% of deaths due to road incident (25).

Another remarkable result for its magnitude is the loss of potential years of life of pedestrians in economically active age 15 to 64 years, who stopped living 10,500 years, this fact shows the loss of workers for the city's productive sector and the decrease in generated income, not including social and family losses (26.27). There is also a cost for the loss of human capital of young people and adults who did not complete their academic cycle, leaving unfinished the creation of knowledge or business generation (26,27), so the impact of road death for society and life expectancy is high. The economic cost of road incidents in Medellín in 2019 was estimated at COP$ 922,030 million, a very high and scandalous figure for a problem that is preventable (28).

The streets and sidewalks of cities are useful for many things, part of the space intended for pedestrians has multiple uses that limit the traffic of its citizens, making walking from urban centers an unsafe and dangerous activity (1,2,29). The invasion of public space by street sellers, beggars, illegal activities and the presence of construction materials, or poorly parked vehicles block and constrict pedestrian traffic (1), which means that people must travel on the same road as motor vehicles, thus increasing the probability of being injured or killed in a road incident (2,29). This is confirmed by figures from Latin America, where the segment with the highest risk of injury or death in a road incident occurs in pedestrians with 23% of the total road deaths in the region (5). Rapid urbanization, high road mortality and the city designed for the automobile as an axis of development made cities rethink and begin to develop as walkable, accessible, and universal cities, giving priority to pedestrians and non-motorized ways of mobility (1). These transformations are usually crossed by social determinants of health, which by being intervened are expected to significantly result in healthy environments, reduced risk, and increased life expectancy.

This study shows the inequalities and inequities when moving, as evidenced in Mexico, where the level and forms of urbanization could explain

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the differences in mortality according to road users (1,4). The relationship between pedestrian behaviors and environmental characteristics are an indispensable factor in determining the usability of urban infrastructure, especially pedestrian bridges, the reasons for their use or disuse are directly related to the ability of pedestrians to cross them (4). To this date, there are no or few studies that evaluate the accessibility, vulnerability, and social exclusion that these infrastructures can represent for people with disabilities, reduced mobility, the elderly, pregnant women, children (4). Therefore, modifying urban architecture reduces the risk of death in pedestrians and other road users, among other reasons, because changes in the environment improve behaviors and enable a cultural transformation (1,29).

In the Mobility Plan 2014-2020 of Medellín, it is proposed local actions and goals to reduce road deaths, identify aspects related to the mobility of the city such as: vehicular saturation of the road system, little integration in means of transport, high rate of road incidents and absence of the pedestrian mobility component in road planning, evidencing a critical situation in the downtown of the city, which shows high vehicular flow and invasion of space for pedestrian traffic (30); this is related with the geographical analyses carried out, where the sites of greater density in pedestrian death are those with high vehicular flow, where high speeds develop, or there is greater invasion of public space, pointing out these areas or stretches of road as environments that make the activity of walking an imminent risk. The finding suggests that sites of greatest road death are fully identified, lack of intervention, modification of the environment and road safety education for all participants.

In conclusion, male pedestrians presented the highest rates of PYLL of the study and are the ones who die the most on roads in Medellín. Head and skull injuries are the most fatal, especially if it is older adults who suffer them, and it is these who are at greater risk of death when walking, because personal factors (gender, age, physical limitations) and environmental (signaling, time to cross, speed, accessibility and invasion of public space) affect the decisions of pedestrians, since their road behavior is guided by

the environment and past experiences, causing them to be forced to develop high-risk behaviors that seem common in this type of user. The loss of labor and economic force is high for the city, but the social and family loss is incalculable. The results help entities, policy makers and authorities to design interventions that improve the walkability of the city through the development of infrastructure and educational programs that transform urban centers into walkable, accessible, and universal cities for all its inhabitants.

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