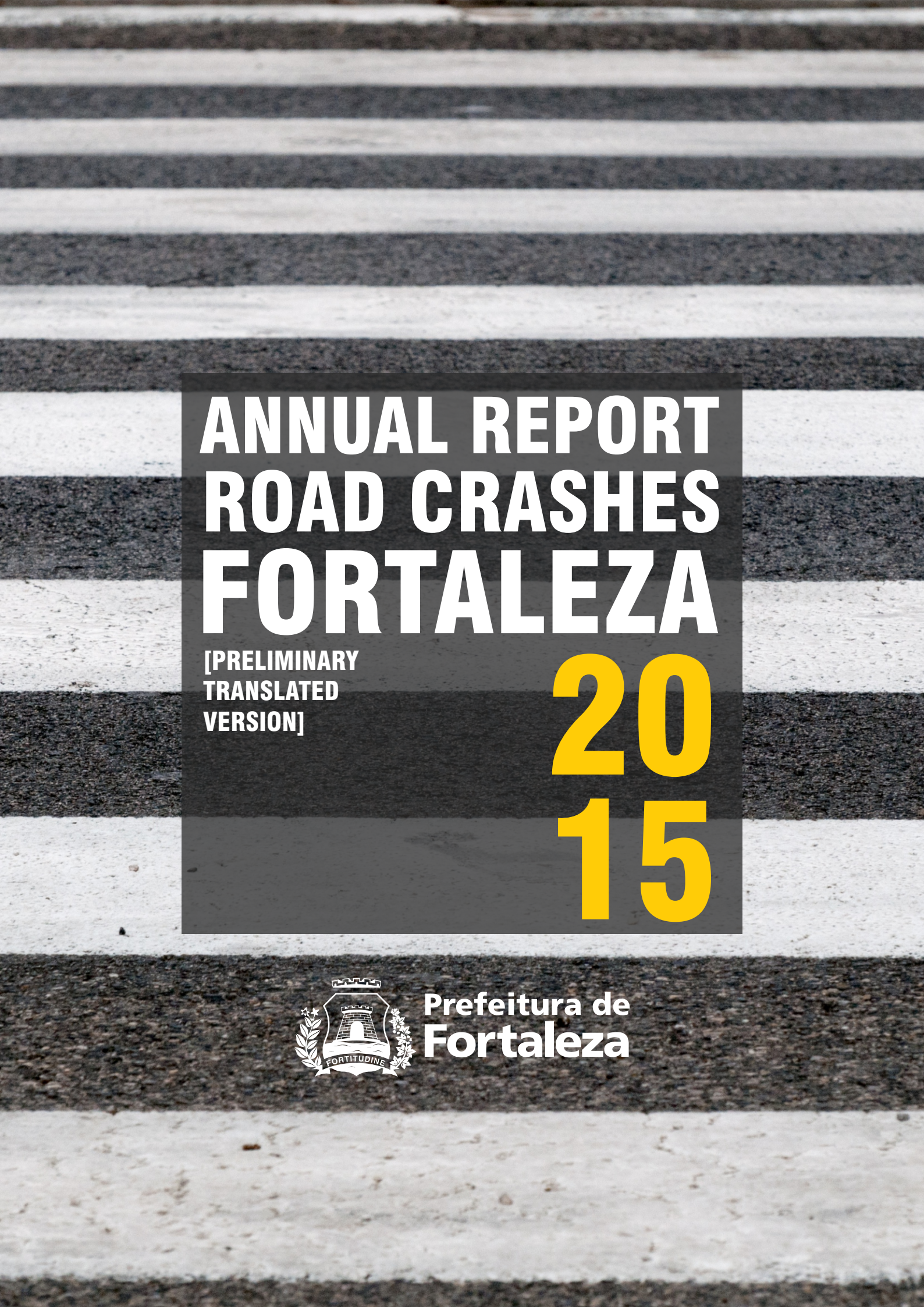

ANNUAL REPORT ROAD CRASHES FORTALEZA

[PRELIMINARY TRANSLATED VERSION]

2015

Prefeitura de Fortaleza

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DECEMBER, 2016

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CITY OF FORTALEZA
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SUPPORT

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INITIATIVE FOR GLOBAL ROAD SAFETY

ELABORATED BY

Prefeitura de Fortaleza
Secretaria Municipal de Conservação e Serviços Públicos
Autarquia Municipal de Trânsito e Cidadania

FOREWORD BY THE MAYOR

Over the last four years, Fortaleza has expanded efforts to address road traffic crashes, by implementing measures to improve road safety citywide. Traffic fatalities and injuries are an increasing challenge for cities around the world.

The social and economic burden of deaths, direct costs of treatment andrehabilitation services for people with disabilities caused by traffic injuries have become a major concern for both road safety experts and public health professionals.

Road traffic crashes continue to take an unacceptably high toll. The alarming number of deaths and injuries, and their impact on public health have led to an increased awareness among national and international organizations. A multidisciplinary approach and evidence based interventions are needed to tackle this problem. Data collection and the use of robust data systems are a critical step in designing effective strategies. Understanding data and putting itinto use is one of the main objectives of this report. The content of this documents is the result of a great collaboration among several municipal, state level and federal agencies to whom we are so grateful for their effort and dedication.

In this challenging mission of improving and enhancing safety in our streets, we are joined by a network of international organizations, sponsored by Bloomberg Philanthropies, in an Initiative that supports nine other cities around the world, determined to find sustainable solutions that can meet our needs. Fortaleza is aligned with the international community in a global effort, led by the United Nations, on the "Decade of Action for Road Safety", to significantly reduce the number of victims in road traffic crashes by the year of 2020. I am convinced that, here in Fortaleza, we will do our best work to preserve life and assure, on a growing scale, the safety and dignity in the coming years.

ROBERTO CLAUDIO RODRIGUES BEZERRA
Mayor of Fortaleza

ACKNOWLEDGMENTS

Working together is more productive and often results in a better quality product. With that in mind, I would like to thank the many sources that, over days and nights, have contributed to the accounting of data on traffic crashes incidents in Fortaleza. Such an effort was vital to make it possible to understand the moment we live with regard to road safety. Far beyond a technical and academic reference, this report is expected to serve as an instrument to foster the culture of road safety.

I start this acknowledgment with the whole team of the Secretaria Municipal de Conservação e Serviços Públicos – SCSP (Municipal Department of Conservation and Public Services), which spent days and nights strategizing, consolidating data, analyzing and designing solutions for our streets and avenues. I would like to highlight our important partnership with Bloomberg Philanthropies, which strongly supported the development of this publication and which supports the City of Fortaleza with an international network of partners, including consultants integrated with the teams of the City of Fortaleza.

On behalf of the entire health services team, including the representatives of the Serviço de Atendimento Móvel de Urgência – SAMU (Emergency Medical Services), Instituto Dr. José Frota – IJF (Dr. José Frota Institute) and other agents, I would like to express our gratitude to the Secretary of Health, Mrs. Socorro Martins. The partners of health services have never spared any efforts to collect data so that this document could be built. We are very grateful to the Polícia Rodoviária Estadual (Ceará State Highway Police) and the Departamento de Trânsito do Estado do Ceará (Ceará State Department of Transportation), key institutions in building a new moment for the road safety in Fortaleza, as well as to the great partnership with the Polícia Rodoviária Federal (Federal Highway Police), which has ensured full support for the municipal policy to combat traffic crashes as well.

I would finally like to thank the Mayor Roberto Cláudio, the main leader of the public policy on road safety in Fortaleza, who plays an essential role in prioritizing the efforts to reduce the alarming rates of traffic violence – which have already started to decline, despite the growth of the fleet of vehicles. With deep gratitude, a greater effort and the express guidance of the mayor, I am sure that we will build an even more virtuous path to ensure more safety for everyone to come and go.

JOÃO DE AGUIAR PUPO
Municipal Department of Conservation And Public Services
City of Fortaleza

1. INTRODUCTION

This report presents the statistics on traffic crashes and their victims registered in the city of Fortaleza throughout 2015. It is part of an effort led by the municipal government to better understand the road safety issues by identifying the pattern of crash events, the profile of the individuals who are most involved in them (at risk groups), among other relevant information on the subject matter. Once this set of information is available, it will be possible to guide the public actions and policies with more efficiency in order to mitigate the intensity of this problem, already recognized by the World Health Organization – WHO – as one of the main causes of mortality in the world and the main cause for people aged from 15 to 29 years old. In addition to the aforementioned statistics, some actions already executed or currently under execution, which contribute to increase road safety, are presented in the end of this document.

The data used here were compiled by the Sistema de Informação de Acidentes de Trânsito de Fortaleza – SIAT (Fortaleza Traffic Crashes Information System), managed by the Autarquia Municipal de Trânsito e de Cidadania de Fortaleza – AMC (Municipal Traffic Department of Fortaleza), since 2001. This system is constantly improved and integrates information from various agencies, allowing quantitative and qualitative analysis of the occurrence of traffic crashes in the city of Fortaleza.

In addition to the information collected by AMC, SIAT integrates information generated by the following agents: Coordenadoria Integrada de Operações de Segurança – CIOPS (Integrated Security Operations Coordination); Departamento Estadual de Trânsito do Ceará – DETRAN-CE (Ceará State Department of Transportation); Perícia Forense do Ceará – PEFOCE (Forensic Institute of Ceará); Instituto Dr. José Frota – IJF (Dr. José Frota Institute); Polícia Rodoviária Estadual do Ceará – PRE (Ceará State Highway Police); Polícia Rodoviária Federal – PRF (Federal Highway Police); Serviço de Atendimento Móvel de Urgência – SAMU (Emergency Medical Services) and the Sistema de Informações de Mortalidade – SIM (Mortality Information System), managed by the Secretaria Municipal de Saúde – SMS (Municipal Department of Health).

While analyzing the data, it is important to note that there are two main points of view from which the phenomenon of

traffic violence can be observed: that of the crashes and that of the victims. A road crash is defined as a collision or any impact on a road that may cause death, injury or material damages (Associação Brasileira de Normas Técnicas – ABNT, 2015; Brazilian Association of Technical Standards). A road victim, in turn, refers to every person that gets injured or dies as the consequence of a traffic crash. Therefore, the number of traffic crashes involving dead or injured victims tends to be lower than the number of victims, since a given crash may have more than one traffic victim.

This annual report is divided into eight sections, the first one being an introduction. While reading the following sections, the reader shall notice the gap of information between 2012 and 2014, whose data are currently undergoing treatment and consolidation. Therefore, all the comparative analysis was carried out based on the data of 2015 and 2011, which is the most recent year with consolidated data. By the next annual report, the data of the other years are intended to be recovered so as not to lose the historical series compiled by SIAT.

The second section presents an overview of the city of Fortaleza by providing the context of the local reality. Right after, the third section, along with its subsections, is dedicated to the quantification, classification and presentation of the time-space patterns of crashes, emphasizing the problematic geographic regions and critical periods. On the fourth section, the perspective of analysis is changed to the victim's point of view, and the profile of the dead and injured victims involved in such events is presented. Afterwards, the fifth section makes use of the WHO recommended indicators to characterize morbidity and mortality in the cities' traffic and present the results for Fortaleza. Those indicators constitute the global reference list (WHO, 2013) for public health evaluation and are aligned with the strategic goals 3.6 and 11.2 of the United Nations 2030 Agenda – NU (NU, 2016).

The sixth section presents the estimated financial costs of the local phenomenon of crashes rates over the public health system. The seventh section demonstrates the critical points, divided into two types: signalized and non signalized intersections. At last, the eighth section describes the actions developed in order to reverse the problem discussed throughout the report.

2. FORTALEZA IN NUMBERS

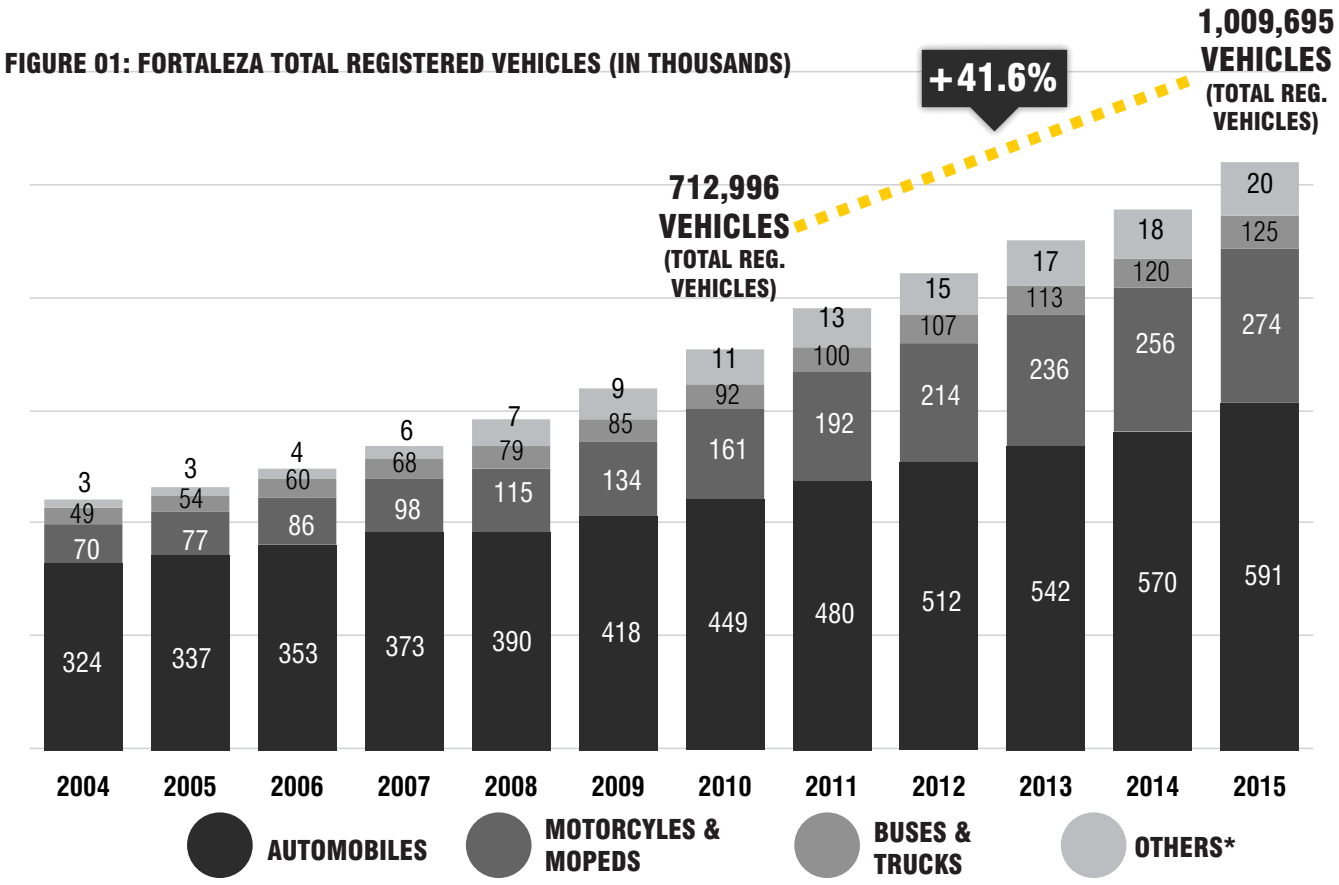
The city of Fortaleza, capital of the State of Ceará, is the 5th biggest city in Brazil, with a population of around 2.59 million people estimated for 2015 and an area of 314.9 km². It is the densest among the capitals of Brazilian States, according to the 2016 census of Instituto Brasileiro de Geografia e Estatística – IBGE (Brazilian Institute of Geography and Statistics).

The city has approximately 4,000 km of road network and a vehicle fleet estimated at 1,009,695 units in December 2015, according to the Departamento de Trânsito do Estado do Ceará – DETRAN/CE, 2015 (Ceará State Department of Transportation). The capital has currently a motorization rate of 2.56 inhabitants / vehicle.

IN 2015, THE TOTAL REGISTERED VEHICLES OF FORTALEZA EXCEEDED ONE MILLION VEHICLES, WITH MOTORCYCLES PRESENTING A CONSIDERABLE GROWTH IN THE PAST FEW YEARS.

It is important to highlight that, between 2010 and 2015, the population of Fortaleza grew by 5.7% while the fleet of vehicles increased by 41.6%.

FIGURE 01: FORTALEZA TOTAL REGISTERED VEHICLES (IN THOUSANDS)



*OUTROS: CFLATBED TRAILERS, SIDE-CARS, TRACTORS, TRICYCLES, PICKUP TRUCKS

Figure 01 shows the evolution of fleet by type of vehicle, with emphasis to the motorcycles, which presented the highest growth compared to the other types.

According to DETRAN/CE (2015), the number of cars grew by 82.4% from 2004 to 2015, while the amount of motorcycles increased by 291.4%, four times as much, as shown in Figure 01.
In 2015, the percentage of motorcycles over the city's total fleet of vehicles rose from 15.7% to 27.1%. Automobiles accounted for a raise of 58.6%.

AREA 314.9 KM²

POPULATION 2,591,188 INH.

REGIS. VEHICLES 1,009,695 VEHICLES
591,119 AUTOMOBILES
273,709 MOTORCYCLES
124,758 BUSES AND TRUCKS

MOTORIZATION RATE 2.56 ($\frac{\text{INH.}}{\text{VEHICLE}}$)

IN 2015, THE NUMBER OF REGISTERED MOTORCYCLES REPRESENTED 27.1% OF THE TOTAL OF VEHICLES

BETWEEN 2010 AND 2015, THE RATE OF INHABITANTS PER VEHICLE DECREASED FROM 3.56 TO 2.56, WHICH INDICATES A HIGHER CONCENTRATION OF VEHICLES IN THE URBAN AREA.

3. ROAD CRASHES 2015

3.1 QUANTIFICATION AND CLASSIFICATION

The section related to the characterization of road crashes is divided into three subsections and the first one has the purpose of quantifying and classifying the events. The second subsection presents their temporal distribution, considering variations by months, days and time-slots. The last subsection is dedicated to the spatial patterns of road crashes by making it possible to identify the critical spots in the urban area of Fortaleza.

Table 01 shows the annual evolution in the total number of road crashes, as well as in partial numbers distributed by the types of victims involved. There was a reduction of 62 crashes with fatal victims between 2011 and 2015, representing a decrease of 16.9%. With regard to the crashes with injured victims, it can be observed that 10,058 crashes were registered in 2015. The comparison with 2011 is not recommended in this case, since SAMU databases were not computed that year, causing underreporting of these accidents.

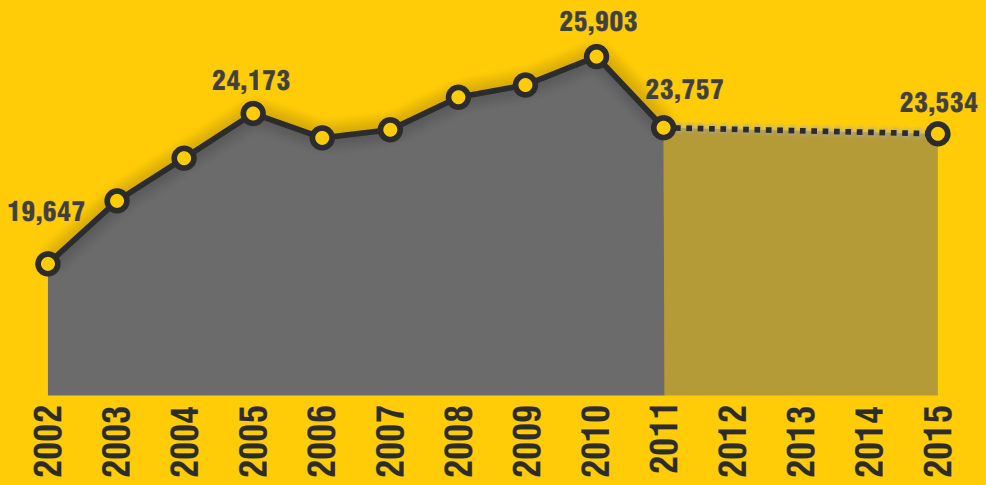
TABLE 01: ROAD CRASHES IN FORTALEZA, 2002 - 2015

YEAR	FATAL	INJURED	DMG. ONLY	TOTAL
2002	360	8,704	10,583	19,647
2003	317	9,637	11,587	21,541
2004	318	10,979	11,544	22,841
2005	355	12,105	11,713	24,173
2006	325	11,593	11,525	23,443
2007	327	10,768	12,607	23,702
2008	332	9,961	14,370	24,663
2009	305	9,910	14,812	25,027
2010	351	9,933	15,619	25,903
2011	367	7,961	15,430	23,757
2012	-	-	-	-
2013	-	-	-	-
2014	-	-	-	-
2015	305	10,058	13,171	23,534

IN 2015, THERE WAS A REDUCTION OF 62 FATAL CRASHES, WHICH REPRESENTS A DECREASE OF 16.9%.

Figure 02 illustrates the annual distribution of total road crashes while Figure 03 shows the number of crashes with injured and fatal victims.

FIGURE 02: ROAD CRASHES IN FORTALEZA, 2002 - 2015



23,534
ROAD CRASHES IN FORTALEZA IN 2015

FIGURE 03: ROAD CRASHES WITH FATAL AND INJURED VICTIMS IN FORTALEZA, 2002-2015

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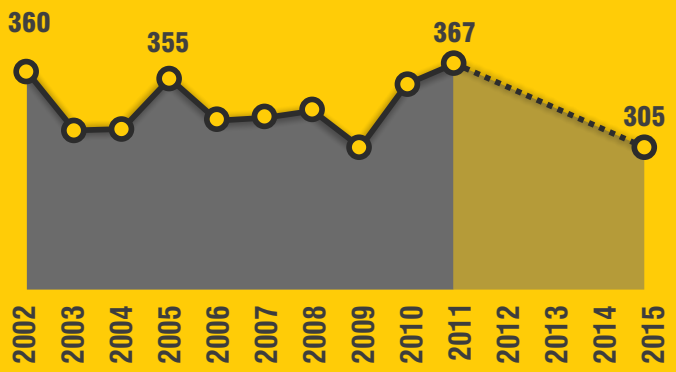


INJURED

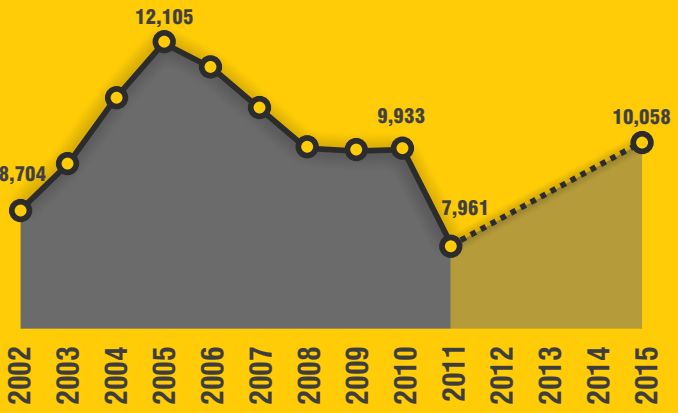


FIGURE 04: ROAD CRASHES BY TYPE AND SEVERITY

TYPE OF CRASH AND SEVERITY

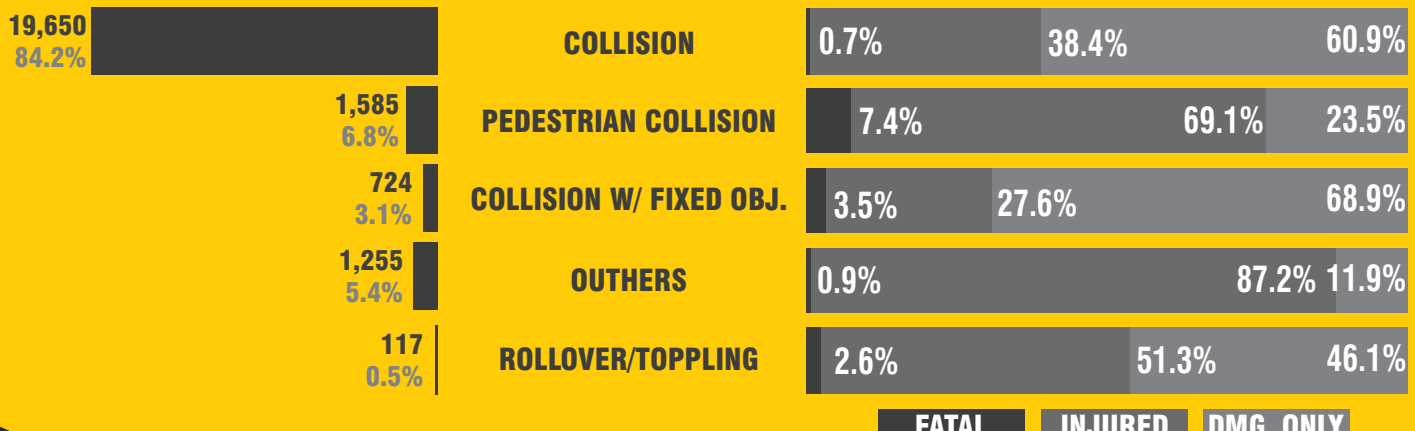


Figure 04 demonstrates that vehicle collisions are the most frequent type of road crash, followed by a smaller amount of pedestrian collisions.

In spite of representing only 10.4% of all accidents, as shown in Figure 04, crashes like hitting a fixed object, pedestrian collisions and rollovers/toppling resulted in 147 crashes with fatal victims. In Table 02, the collisions are distributed by type over 2011 and 2015.

Still in Figure 04, it is possible to observe that pedestrian collisions have a relatively high level of severity. There is one fatal victim in 7.4% of all pedestrian collisions, given the physical fragility of pedestrians when compared to other vehicles.

Further exploring the pedestrian collisions, it is possible to verify that motorcycles and automobiles are largely responsible, in absolute numbers, for the crashes involving injured and/or fatal victims, as seen in Table 03 and Figure 05. However, although numerically similar, it is necessary to distinguish these two types of vehicles.

TABLE 02: COLLISIONS BY TYPE, COMPARISON WITH LAST CONSOLIDATED YEAR

TYPE	W/ FATAL VICT.		W/ INJURED VICT.	
	2011	2015	2011	2015
ROLLOVER/ TOPPLING	1	3	58	60
COLLISION W/ FIXED OBJ.	25	25	636	200
PEDESTRIAN COLLISION	143	119	1,580	1,108
COLLISION	165	146	5,096	7,541
OTHERS	20	11	298	1,079
MISSING	13	1	292	70
TOTAL	**367**	**305**	**7,960**	**10,058**

TABLE 03: VEHICLES INVOLVED IN PEDESTRIAN COLLISIONS – 2015

VEHICLE	W/ FATAL VICT.	W/ INJURED VICT.	DMG. ONLY	TOTAL
MOTORCYCLE	49	463	13	**525**
AUTOMOBILE	48	403	12	**463**
BICYCLE	0	7	0	**7**
BUS	11	78	2	**91**
OTHERS	9	67	5	**81**
MISSING	2	77	339	**418**
TOTAL	**119**	**1,095**	**371**	**1,585**

Motorcycles represented approximately 26.3% of all the municipal fleet registered in 2015, but were responsible for 42.2% of pedestrian fatalities or injuries. Automobiles, in turn, responded for approximately 60% of the fleet in the same year, but were responsible for 37.2% of pedestrian deaths or injuries. Such discrepancy evidences the main role of motorcycles as the problematic focus with regard to the phenomenon of pedestrian collisions as well.

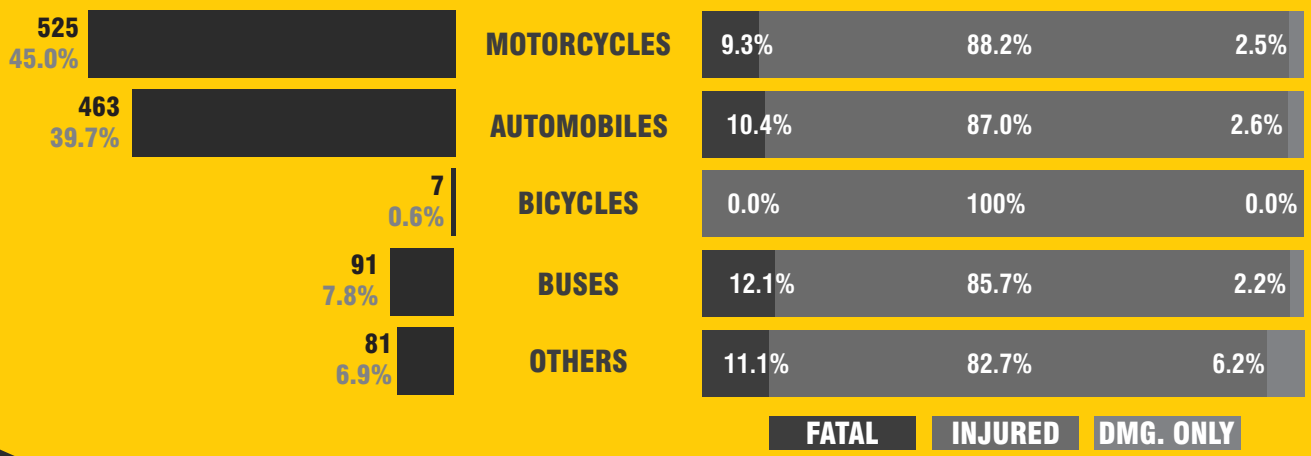
BOX 1: CRASHES BY ROAD JURISDICTION

THE NUMBER OF ROAD CRASHES WITH FATAL VICTIMS DECREASED BY 65.5% ON HIGHWAYS UNDER FEDERAL JURISDICTION, WHICH OFTEN WORK AS URBAN ROADS. AN IMPORTANT REDUCTION CAN ALSO BE OBSERVED ON STATE HIGHWAYS, AS SEEN ON TABLE 04.

TABLE 04: CRASHES BY ROAD JURISDICTION

TIPO	2011	2015	%
FEDERAL	61	21	-65.6%
STATE	29	15	-48.3%
MUNICIPAL	277	269	-2.9%
TOTAL	**367**	**305**	**-16.9%**

FIGURE 05: PEDESTRIAN COLLISIONS BY TYPE OF VEHICLE AND SEVERITY (2015)



3.2 DISTRIBUTION OF CRASHES OVER TIME

This subsection presents the temporal distribution of crashes, disaggregating the analysis by month, day and time-slots.

The month of December presented the highest level of severity, while April presented the lowest one, considering both fatal and injured victims. Figure 06 and Table 05 illustrate the monthly distribution of road crashes with fatal and injured victims.

TABLE 05: ROAD CRASHES PER MONTH

MONTH	TOTA	FATAL	INJURED
JANUARY	2,287	25	865
FEBRUARY	1,772	25	727
MARCH	1,936	23	797
APRIL	1,747	14	666
MAY	2,163	31	891
JUNE	2,007	24	877
JULY	1,905	23	843
AUGUST	2,035	27	818
SEPTEMBER	1,830	29	898
OCTOBER	1,945	28	841
NOVEMBER	1,910	25	912
DECEMBER	1,997	31	923
TOTAL	23,534	305	10,058

FIGURE 06: ROAD CRASHES PER MONTH

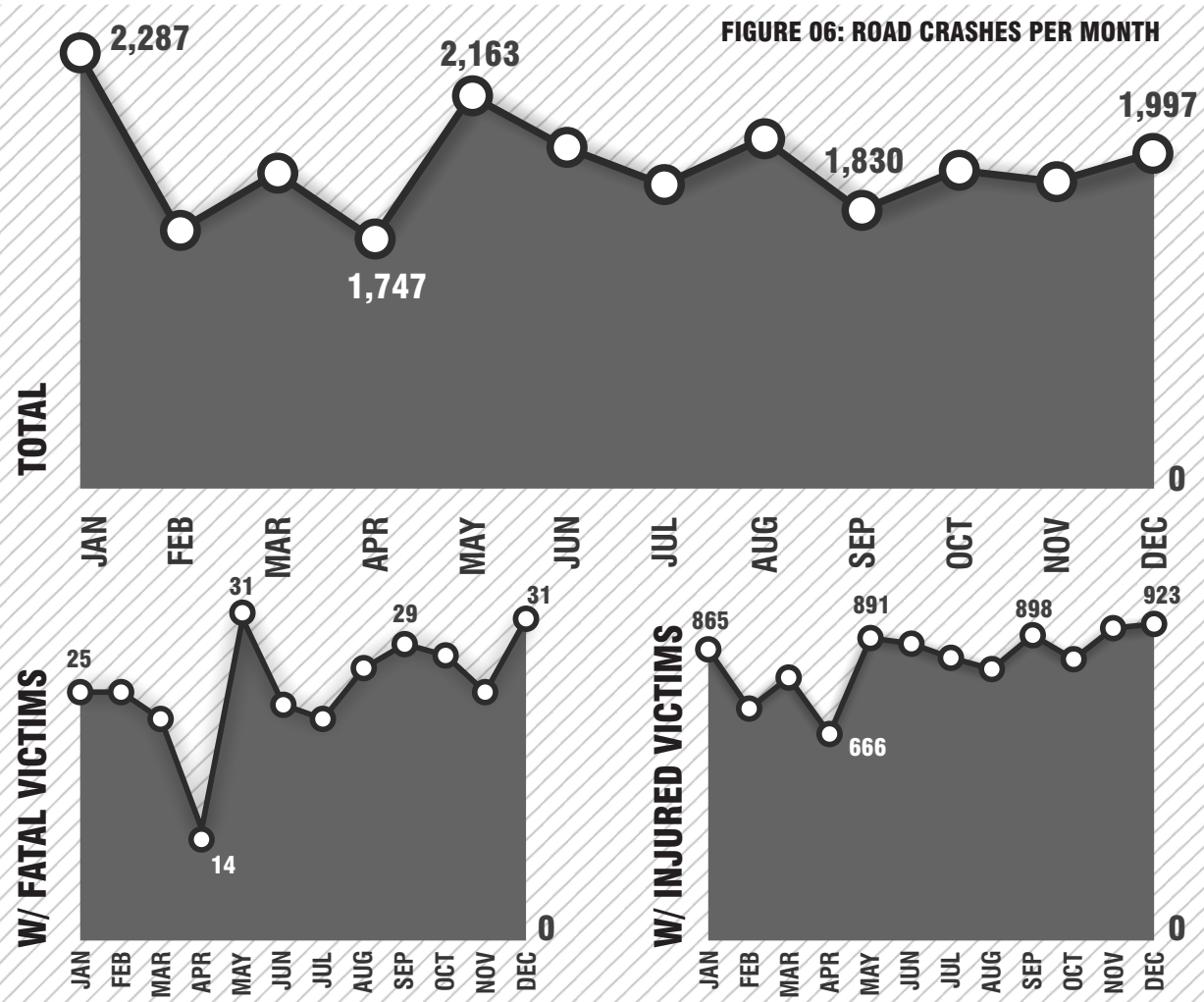
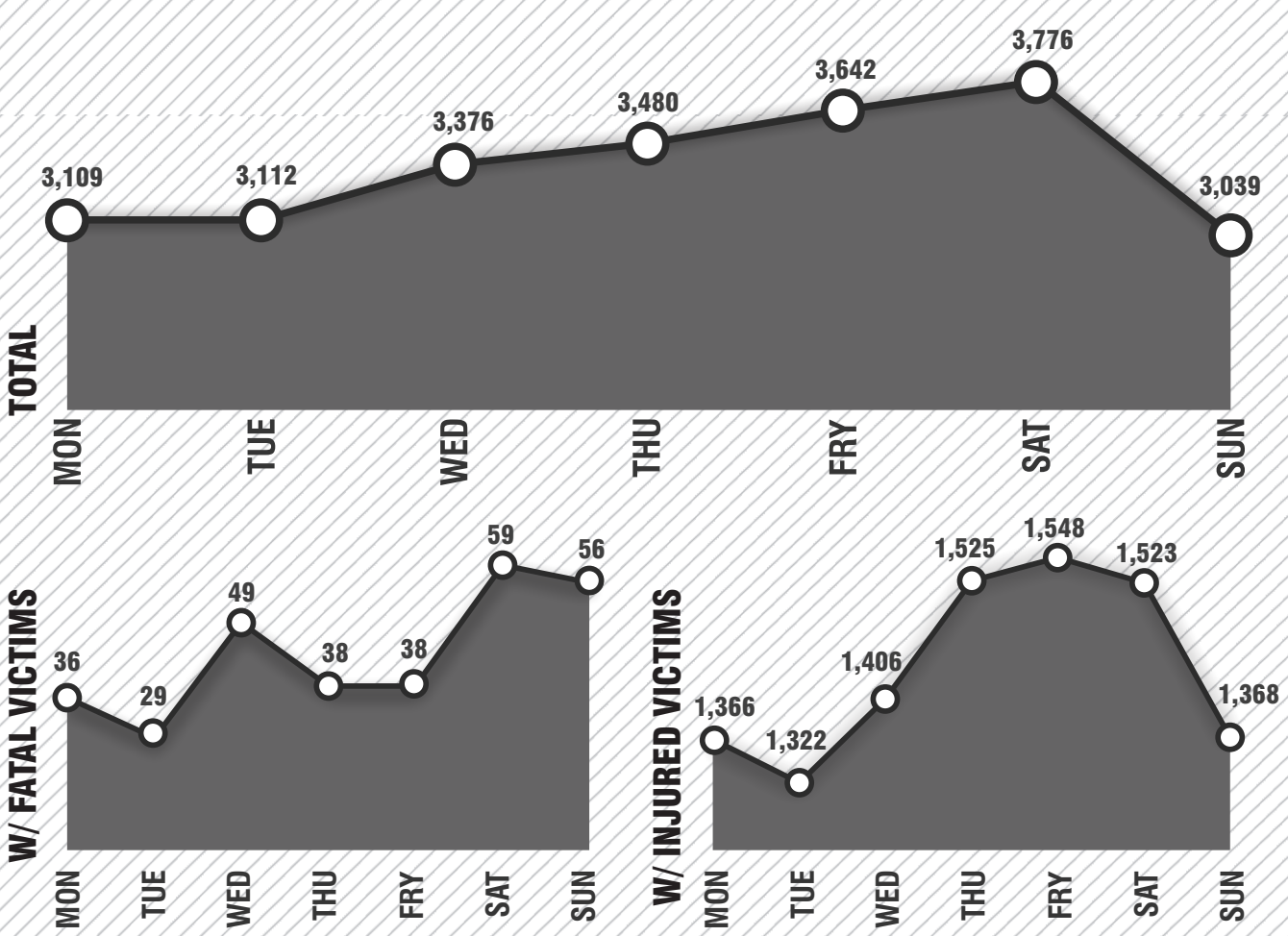


FIGURE 07: ROAD CRASHES PER WEEK



The distribution of traffic crashes throughout the week shown on Figure 07 and Table 05 demonstrates the intensification of the pattern of crashes with injured victims on Thursdays, Fridays and Saturdays.

Fatal crashes happened more frequently during the weekends, when the majority of trips has the purpose of leisure and the incidence of alcohol consumption tends naturally to be higher, leading to a risky behavior.

TABLE 06: ROAD CRASHES PER WEEK

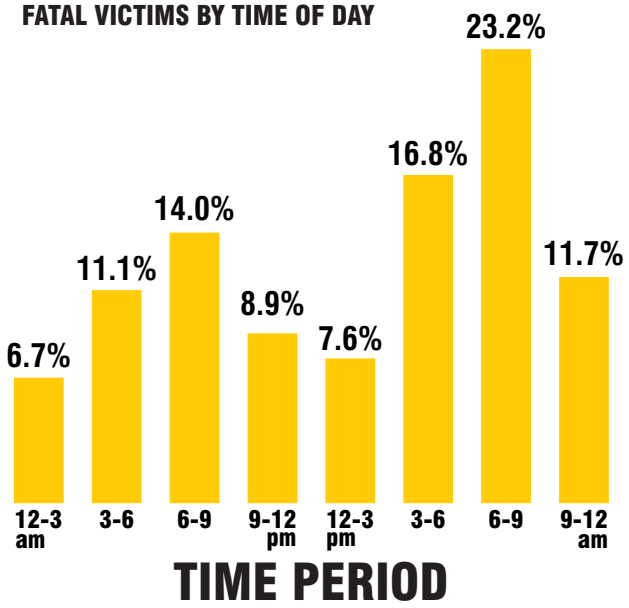
DAY	TOTAL	FATAL	INJURED
MONDAY	3,109	36	1,366
TUESDAY	3,112	29	1,322
WEDNESDAY	3,376	49	1,406
THURSDAY	3,480	38	1,525
FRIDAY	3,642	38	1,548
SATURDAY	3,776	59	1,523
SUNDAY	3,039	56	1,368
TOTAL	23,534	305	10,058

The following tables present road crashes data disaggregated by day of the week and time-slots, allowing a deeper analysis of such patterns. The index to the right lists the contents of these tables.

In general, it is observed that, on weekdays, business hours represent the time-slot with the highest rate of traffic crashes, extending until the end of the evening peak (7:00 am – 8:00 pm). On Saturdays, there was a high concentration of crashes, extending from the late morning until the dawn of Sunday. On weekdays, the concentration of crashes with injured and fatal victims is observed during the morning peak (7:00 am – 8:00 am).

Figure 08 presents the hourly distribution of crashes with fatal victims. The critical time-slot is from 6:00 pm to 9:00 pm, when 23.2% of the fatal crashes of 2015 happened. The range from 3:00 pm to 6:00 pm has also presented a high frequency of fatal crashes, accounting for 16.8% of fatalities.

FIGURE 08: ROAD CRASHES WITH FATAL VICTIMS BY TIME OF DAY



01 TABLE 07: ROAD CRASHES W/ INJURED VICTIMS

HOUR	MON	TUES	WED	THURS	FR	SAT	SUN	TOTAL
12pm-1am	33	11	13	20	25	26	68	196
1am-2am	21	9	9	12	19	27	33	130
2am-3am	14	4	7	13	12	29	33	112
3am-4am	9	2	5	7	11	27	30	91
4am-5am	9	10	9	16	10	30	33	117
5am-6am	24	10	12	22	28	40	49	185
6am-7am	72	61	53	72	72	54	47	431
7am-8am	106	119	137	120	108	86	45	721
8am-9am	95	77	104	97	75	66	40	554
9am-10am	66	64	80	96	86	69	54	515
10am-11am	79	72	65	81	71	63	43	474
11am-12pm	60	55	58	81	62	70	44	430
12pm-1pm	76	57	73	64	77	69	57	473
1pm-2pm	67	80	80	81	69	67	71	515
2pm-3pm	76	61	69	67	72	71	54	470
3pm-4pm	65	75	71	70	80	88	71	520
4pm-5pm	65	84	78	76	111	85	58	557
5pm-6pm	93	92	87	84	95	91	84	626
6pm-7pm	90	81	89	127	105	92	86	670
7pm-8pm	86	96	95	92	97	89	98	653
8pm-9pm	55	76	69	66	84	80	81	511
9pm-10pm	43	56	63	60	81	82	77	462
10pm-11pm	34	44	54	56	49	58	58	353
11pm-12am	20	23	24	40	45	60	45	257
MISSING	8	3	2	5	4	4	9	35
TOTAL	1,366	1,322	1,406	1,525	1,548	1,523	1,368	10,058

02 TABLE 08: ROAD CRASHES W/ FATAL VICTIMS

HOUR	MON	TUES	WED	THURS	FRI	SAT	SUN	TOTAL
12am-2am	2	3	2	0	0	4	5	16
2am-4am	1	1	1	2	2	3	2	12
4am-6am	3	2	4	0	3	6	8	26
6am-8am	6	3	5	6	6	3	1	30
8am-10am	3	1	3	2	8	3	3	23
10am-12pm	2	4	3	2	1	3	3	18
12pm-2pm	3	1	4	2	2	2	0	14
2pm-4pm	5	2	1	2	3	4	7	24
4pm-6pm	6	4	8	2	2	12	3	37
6pm-8pm	4	6	10	7	7	6	10	50
8pm-10pm	0	1	4	8	3	7	11	34
10pm-12am	1	1	4	5	1	6	3	21
MISSING	0	0	0	0	0	0	0	0
TOTAL	36	29	49	38	38	59	56	305

03 TABLE 09: COLLISIONS W/ INJURED VICTIMS

HOUR	MON	TUES	WED	THURS	FRI	SAT	SUN	TOTAL
12pm-1am	27	6	9	14	20	18	48	142
1am-2am	12	6	3	8	10	19	17	75
2am-3am	8	1	4	10	6	15	18	62
3am-4am	3	2	1	4	6	14	10	40
4am-5am	7	6	5	7	3	17	21	66
5am-6am	14	7	5	16	19	24	31	116
6am-7am	53	43	42	54	58	37	30	317
7am-8am	87	97	106	84	86	61	26	547
8am-9am	75	68	81	79	61	59	30	453
9am-10am	55	49	63	71	70	56	42	406
10am-11am	60	65	52	61	54	51	32	375
11am-12pm	45	47	46	64	49	57	34	342
12pm-1pm	62	44	56	49	60	61	41	373
1pm-2pm	57	66	63	65	55	55	51	412
2pm-3pm	67	52	56	55	59	61	32	382
3pm-4pm	50	63	57	59	65	71	54	419
4pm-5pm	53	67	62	59	89	65	40	435
5pm-6pm	74	66	68	65	76	69	66	484
6pm-7pm	72	64	66	93	84	63	64	506
7pm-8pm	62	76	62	63	71	62	64	460
8pm-9pm	40	55	52	49	62	50	50	358
9pm-10pm	31	37	39	39	58	59	58	321
10pm-11pm	22	33	44	38	30	35	41	243
11pm-12am	15	16	17	30	32	40	27	177
MISSING	6	3	2	5	3	3	8	30
TOTAL	1,057	1,039	1,061	1,141	1,186	1,122	935	7,541

04 TABLE 10: COLLISIONS W/ FATAL VICTIMS

HOUR	SUN	TUES	WED	THURS	FRI	SAT	SUN	TOTAL
12am-2am	1	1	1	0	0	3	4	10
2am-4am	1	1	1	1	2	1	1	8
4am-6am	0	1	1	0	1	2	2	7
6am-8am	3	1	3	3	5	2	0	17
8am-10am	1	0	2	1	1	0	3	8
10am-12pm	2	2	1	0	0	0	1	6
12pm-2pm	2	0	4	1	2	1	0	10
2pm-4pm	3	1	1	1	2	3	3	14
4pm-6pm	3	1	6	0	2	8	2	22
6pm-8pm	2	4	2	1	1	2	5	17
8pm-10pm	0	0	4	2	1	2	6	15
10pm-12am	1	1	1	4	0	4	1	12
MISSING	0	0	0	0	0	0	0	0
TOTAL	19	13	27	14	17	28	28	146

05 TABLE 11: PEDESTRIAN COLLISIONS W/ INJURED VICTIMS

HOUR	MON	TUES	WED	THURS	FRI	SAT	SUN	TOTAL
12pm-1am	0	1	0	3	0	1	9	14
1am-2am	4	0	0	0	1	2	3	10
2am-3am	1	0	2	0	0	3	3	9
3am-4am	2	0	1	1	0	1	4	9
4am-5am	0	2	0	0	2	6	2	12
5am-6am	2	0	0	0	4	0	1	7
6am-7am	7	4	1	9	7	3	3	34
7am-8am	7	11	16	11	9	9	5	68
8am-9am	8	3	4	6	7	2	4	34
9am-10am	7	8	9	9	7	7	4	51
10am-11am	10	1	9	9	8	6	3	46
11am-12pm	10	4	5	9	7	6	2	43
12pm-1pm	6	7	6	8	9	4	10	50
1pm-2pm	6	7	12	5	10	3	8	51
2pm-3pm	5	4	7	5	10	4	13	48
3pm-4pm	5	8	9	5	5	11	2	45
4pm-5pm	9	6	12	6	10	9	6	58
5pm-6pm	8	13	8	10	12	8	9	68
6pm-7pm	14	13	14	23	14	17	15	110
7pm-8pm	16	10	22	16	12	16	18	110
8pm-9pm	7	10	13	10	11	19	13	83
9pm-10pm	1	9	12	10	13	8	6	59
10pm-11pm	6	3	5	9	7	11	5	46
11pm-12am	1	1	3	3	7	11	3	29
MISSING	0	0	0	0	1	0	0	1
TOTAL	142	125	170	167	173	167	151	1,095

06 TABLE 12: PEDESTRIAN COLLISIONS W/ FATAL VICTIMS

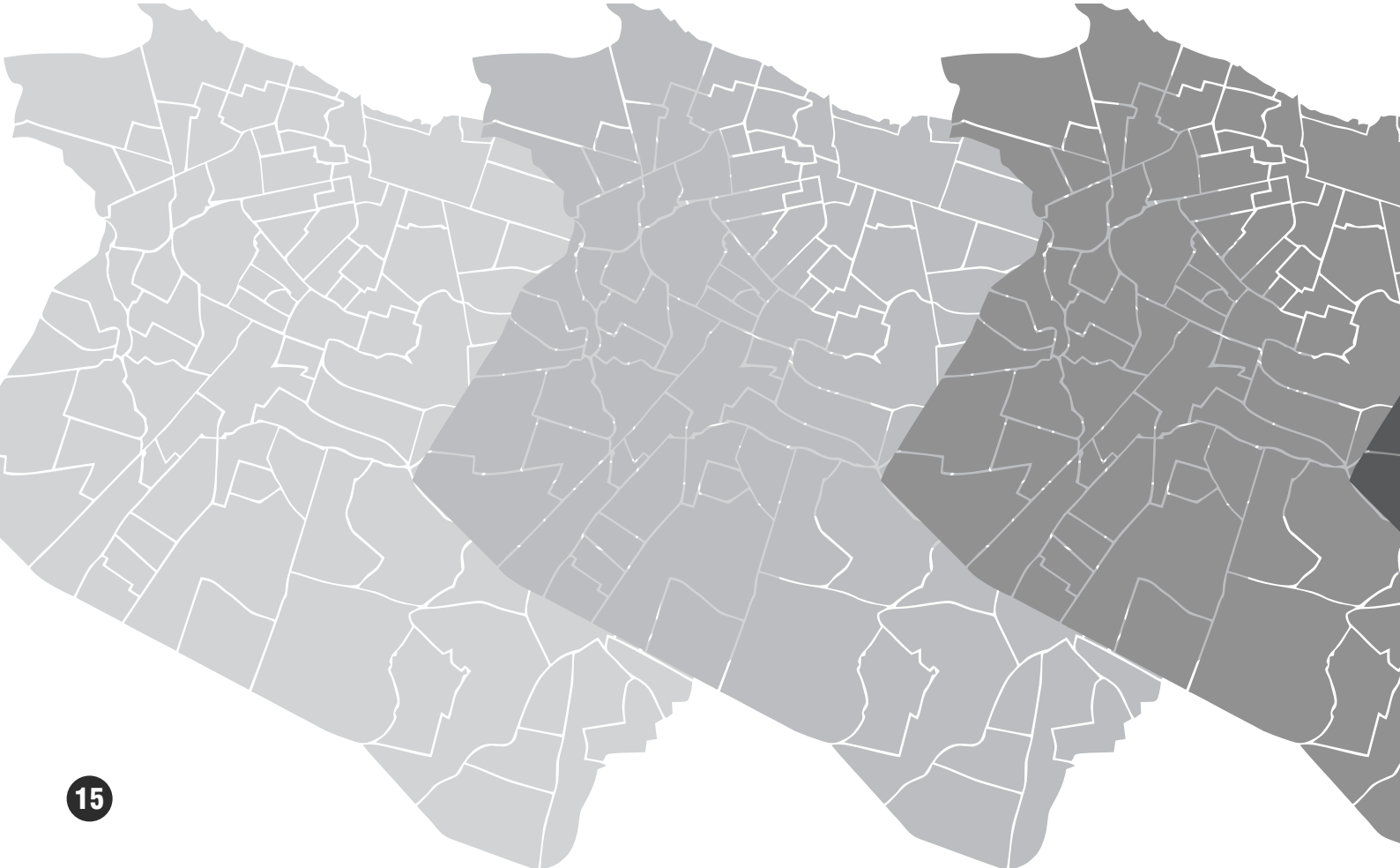
HOUR	MON	TUES	WED	THURS	FRI	SAT	SUN	TOTAL
12am-2am	0	1	0	0	0	1	1	3
2am-4am	0	0	0	1	0	0	0	1
4am-6am	0	0	1	0	0	0	2	3
6am-8am	2	1	2	3	1	1	0	10
8am-10am	2	1	1	1	7	2	0	14
10am-12pm	0	1	2	2	1	1	2	9
12pm-2pm	1	1	0	1	0	0	0	3
2pm-4pm	2	1	0	1	1	1	3	9
4pm-6pm	2	3	1	2	0	4	1	13
6pm-8pm	2	2	8	6	6	3	5	32
8pm-10pm	0	1	0	5	2	3	4	15
10pm-12am	0	0	2	1	1	1	2	7
MISSING	0	0	0	0	0	0	0	0
TOTAL	11	12	17	23	19	17	20	119

3.3 DISTRIBUTION OF CRASHES IN SPACE

Kernel maps (heat maps) were generated for the spatial analysis of crashes patterns. This tool allows estimating density curves using statistical methods for the spatial relationships among observations. The spatial distribution of crashes, together with the identification of critical time periods, allows a more efficient orientation for enforcement and education actions in areas where critical intensities are identified.

The index below lists the generated maps from A to H, which will be presented over the following pages. It is important to mention that heat maps allow for a comparative analysis between different densities in the same map; however, there are different scales for each generated map, and the comparison of those intensities between maps is not recommended.

For example, by analyzing Map A (Figure 09), which illustrates the spatial distribution of road crashes with injured or fatal victims, it can be observed their concentration in central areas, neighborhoods Centro and Aldeota, as well as in access routes to these areas and other smaller centralities like Parangaba and Montese. In Map B (Figure 10), it is possible to identify critical areas related to traffic crashes with fatal victims, with emphasis to stretches of Av. Leste-Oeste and Av. Silas Munguba, among others.



A ROAD CRASHES W/ FATAL OR INJURED VICTIMS

B ROAD CRASHES W/ FATAL VICTIMS

C PEDESTRIAN COLLISIONS W/ FATAL OR INJURED VICTIMS

D PEDESTRIAN COLLISIONS W/ FATAL VICTIMS

E MOTORCYCLE CRASHES W/ FATAL OR INJURED VICTIMS

F MOTORCYCLE CRASHES W/ FATAL VICTIMS

G ROAD CRASHES W/ FATAL OR INJURED VICTIMS ON WEEKENDS

H ROAD CRASHES W/ FATAL VICTIMS ON WEEKENDS

FIGURE 09: ROAD CRASHES W/ FATAL OR INJURED VICTIMS

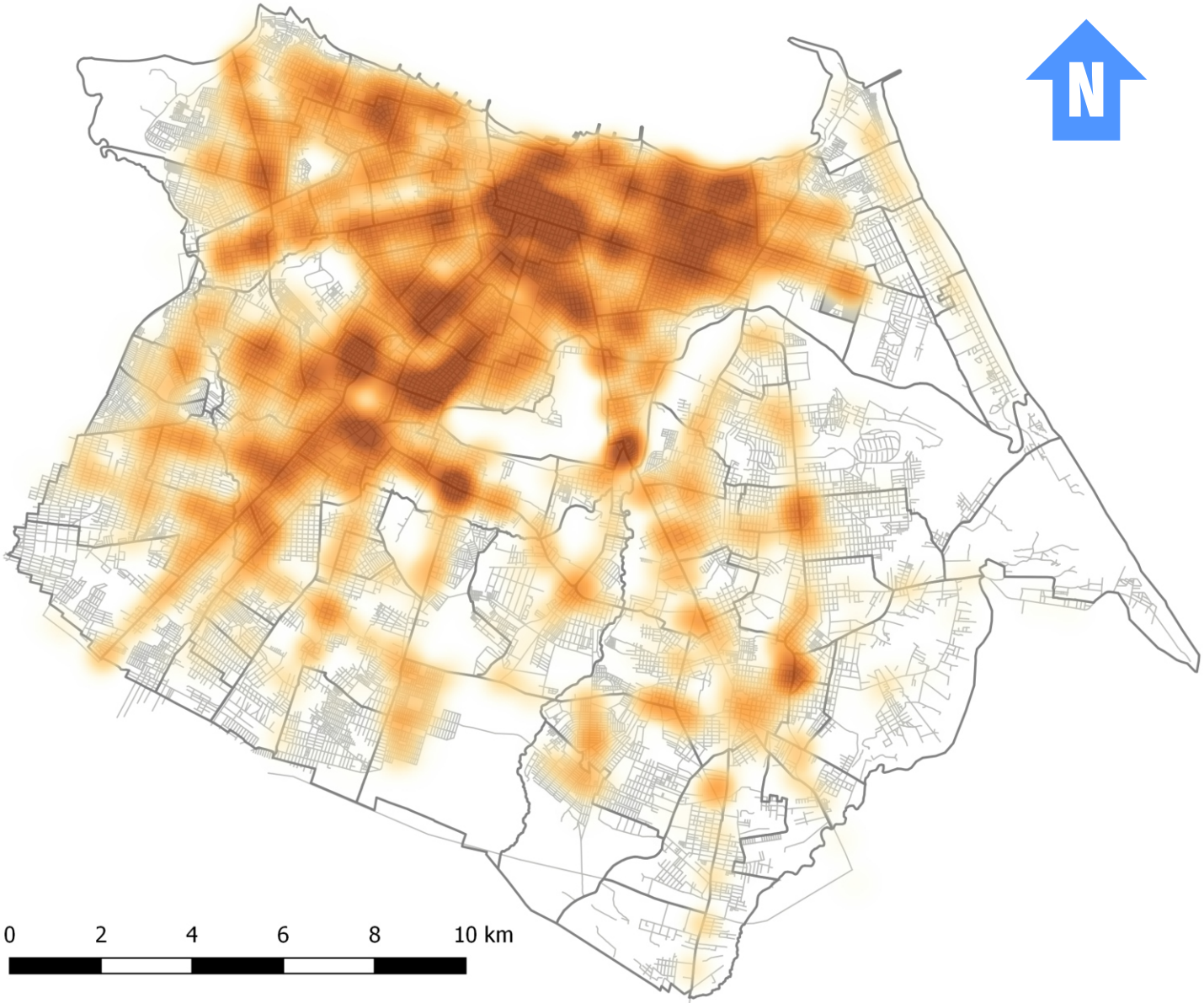


FIGURE 10: ROAD CRASHES W/ FATAL VICTIMS

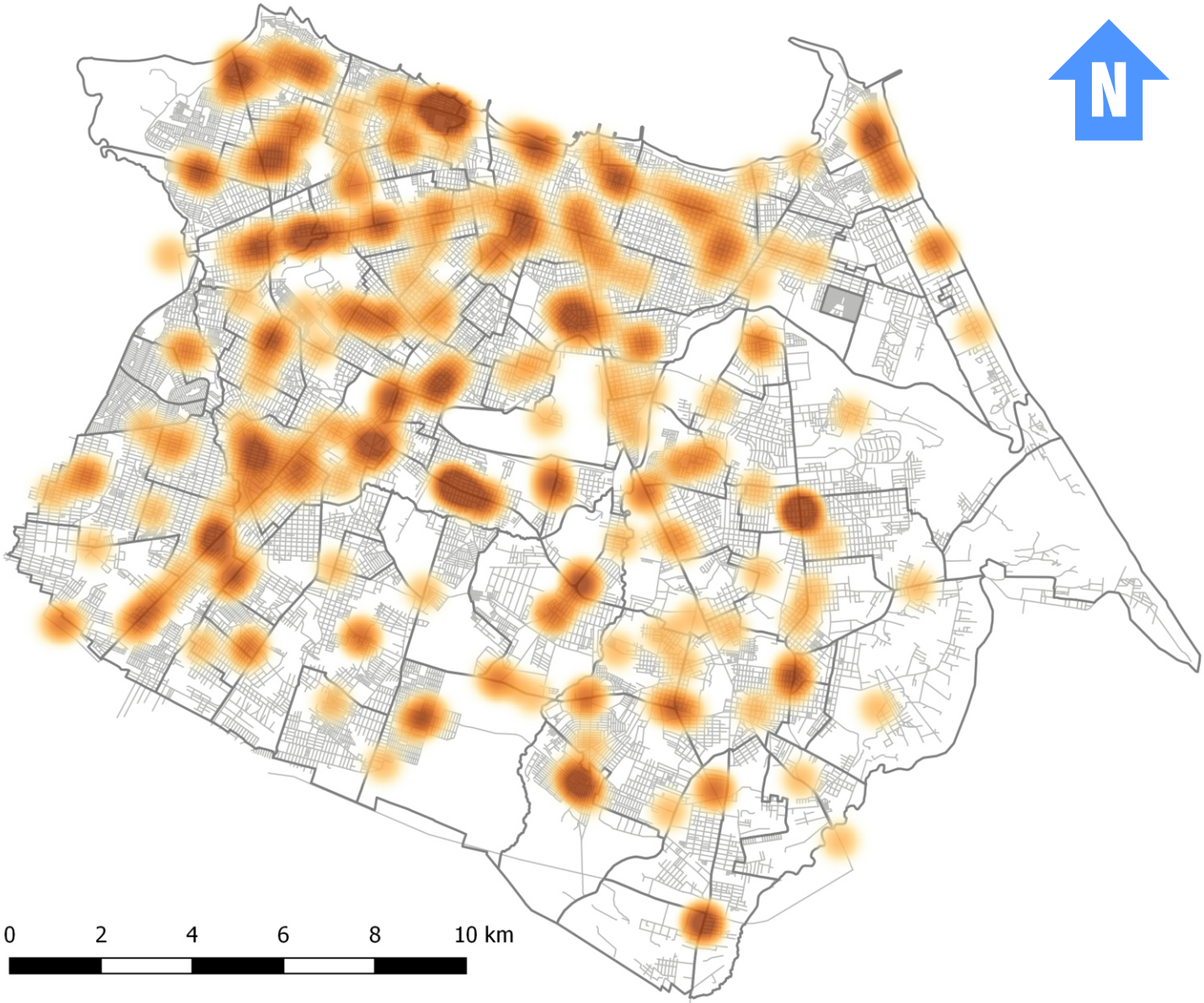


FIGURE 11: PEDESTRIAN COLLISIONS W/ FATAL OR INJURED VICTIMS

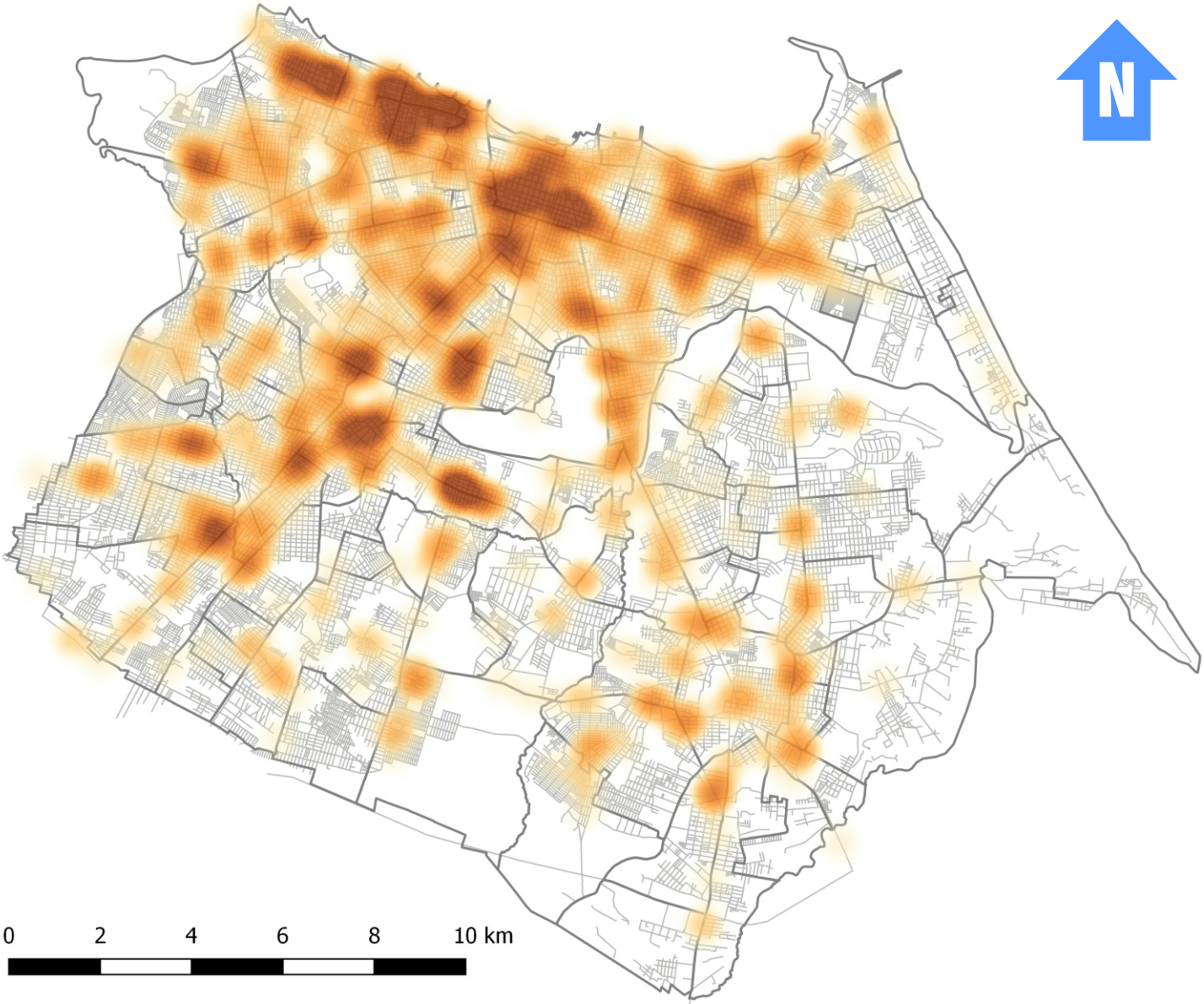


FIGURE 12: PEDESTRIAN COLLISIONS W/ FATAL VICTIMS

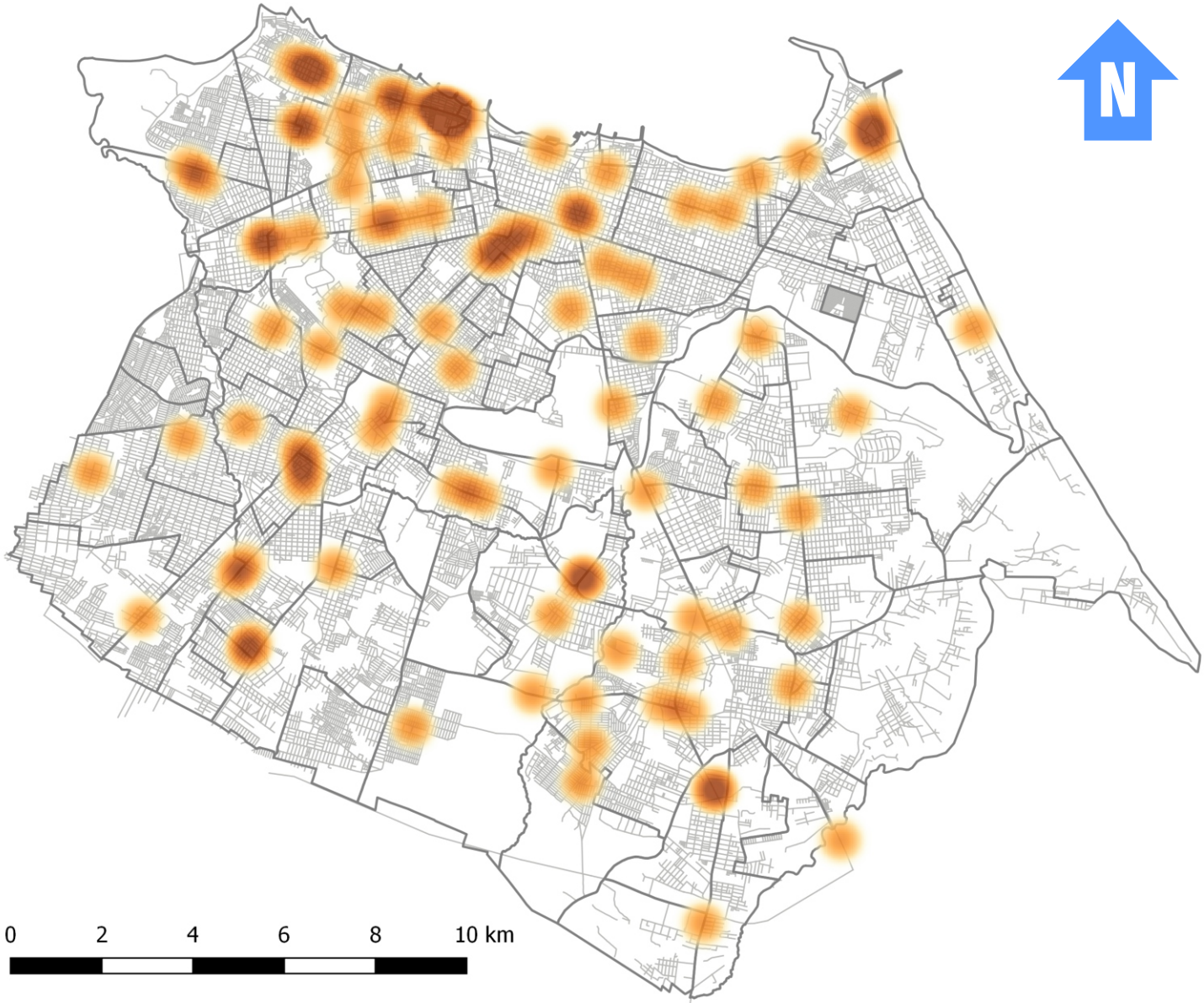


FIGURE 13: MOTORCYCLE CRASHES W/ FATAL OR INJURED VICTIMS

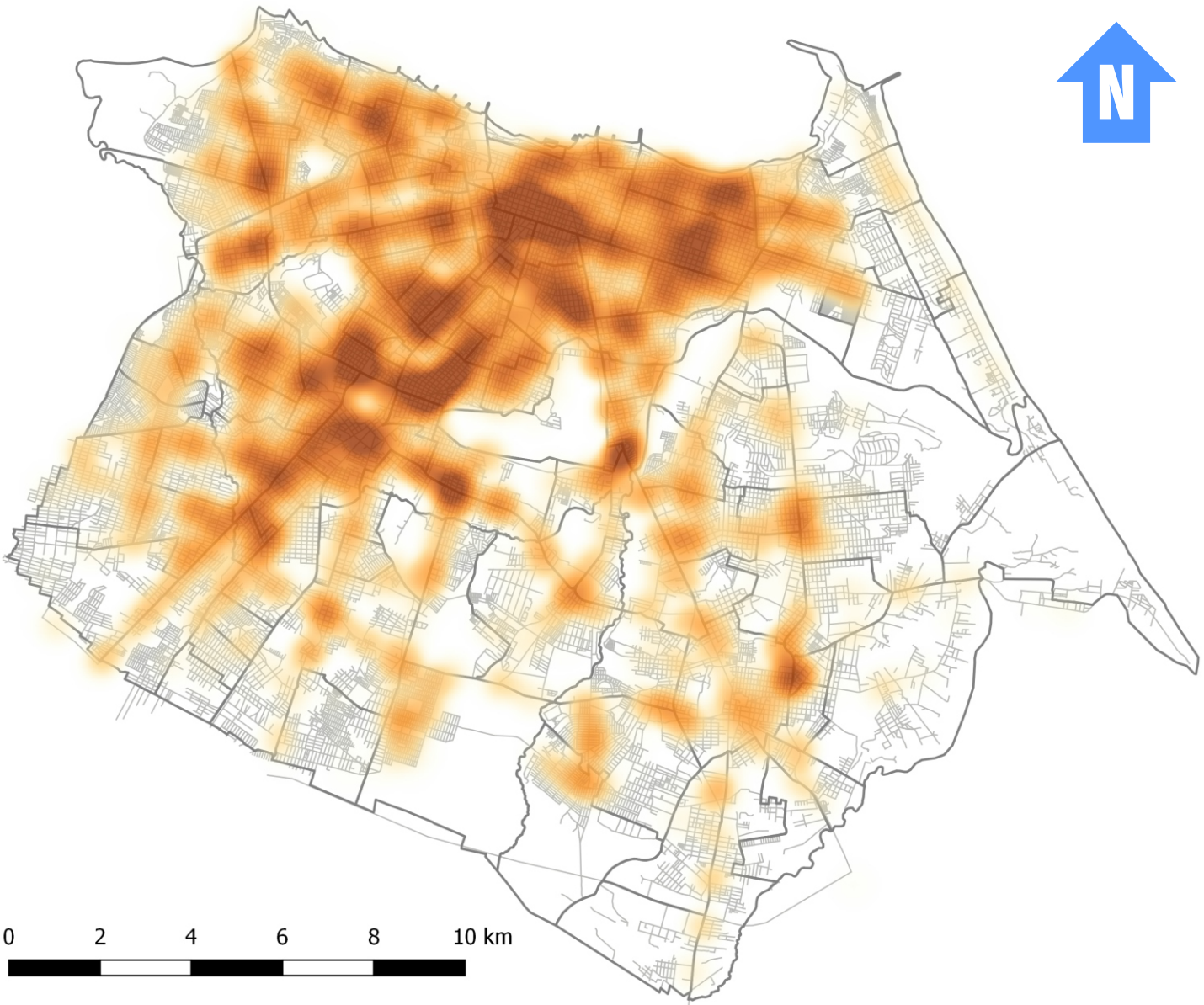
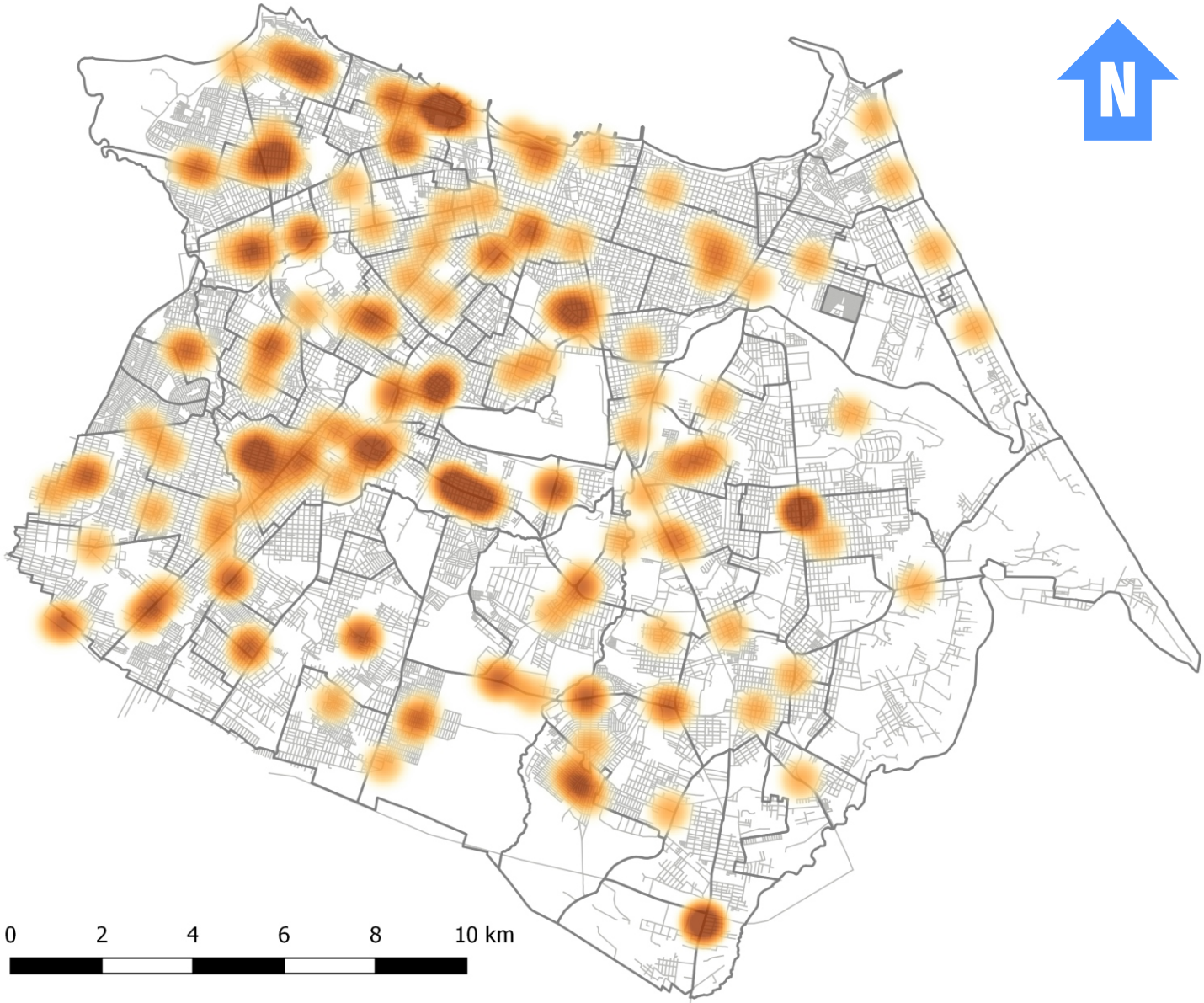


FIGURE 14: MOTORCYCLE CRASHES W/ FATAL VICTIMS



G FIGURE 15: ROAD CRASHES W/ FATAL OR INJURED VICTIMS ON WEEKENDS

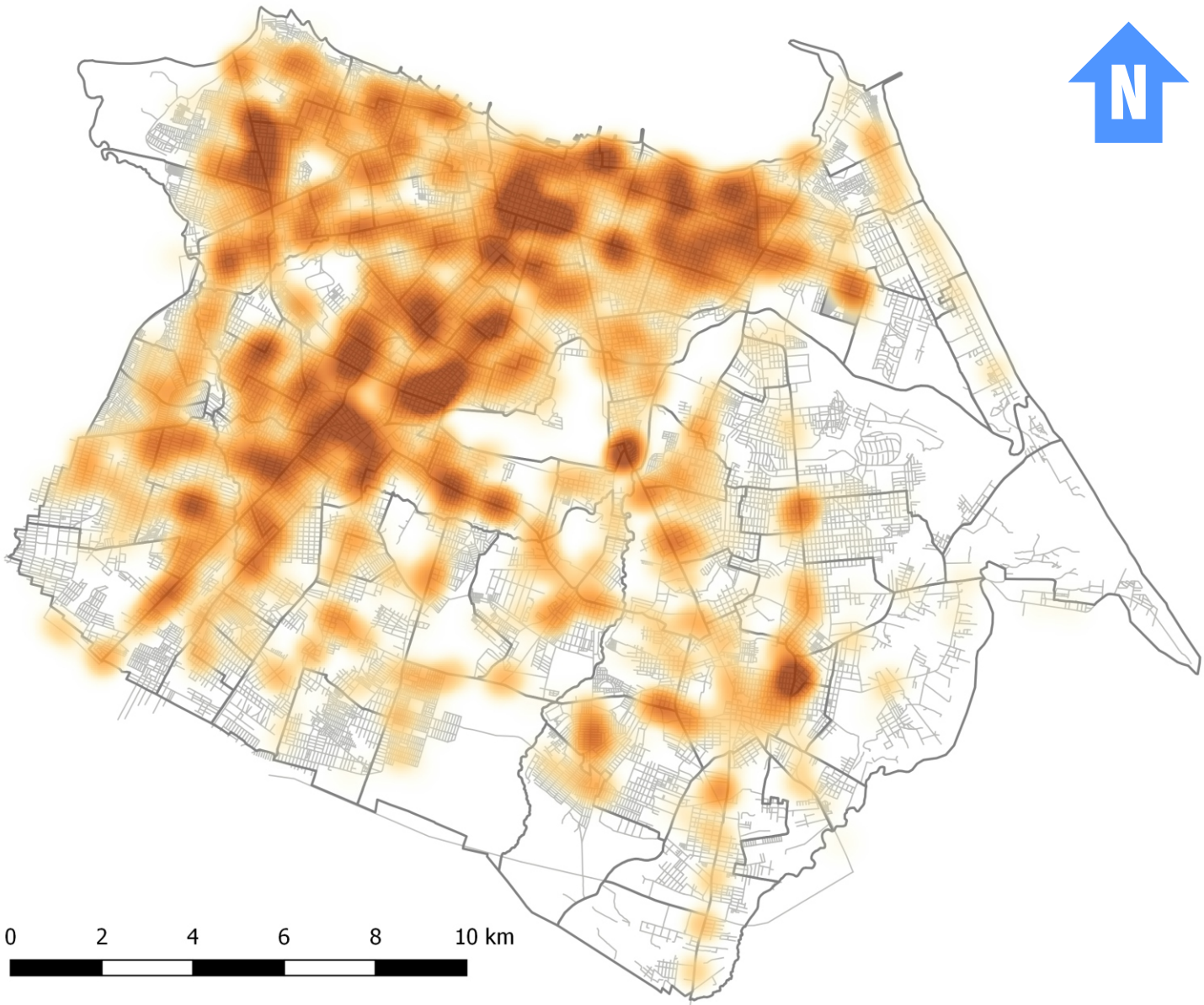
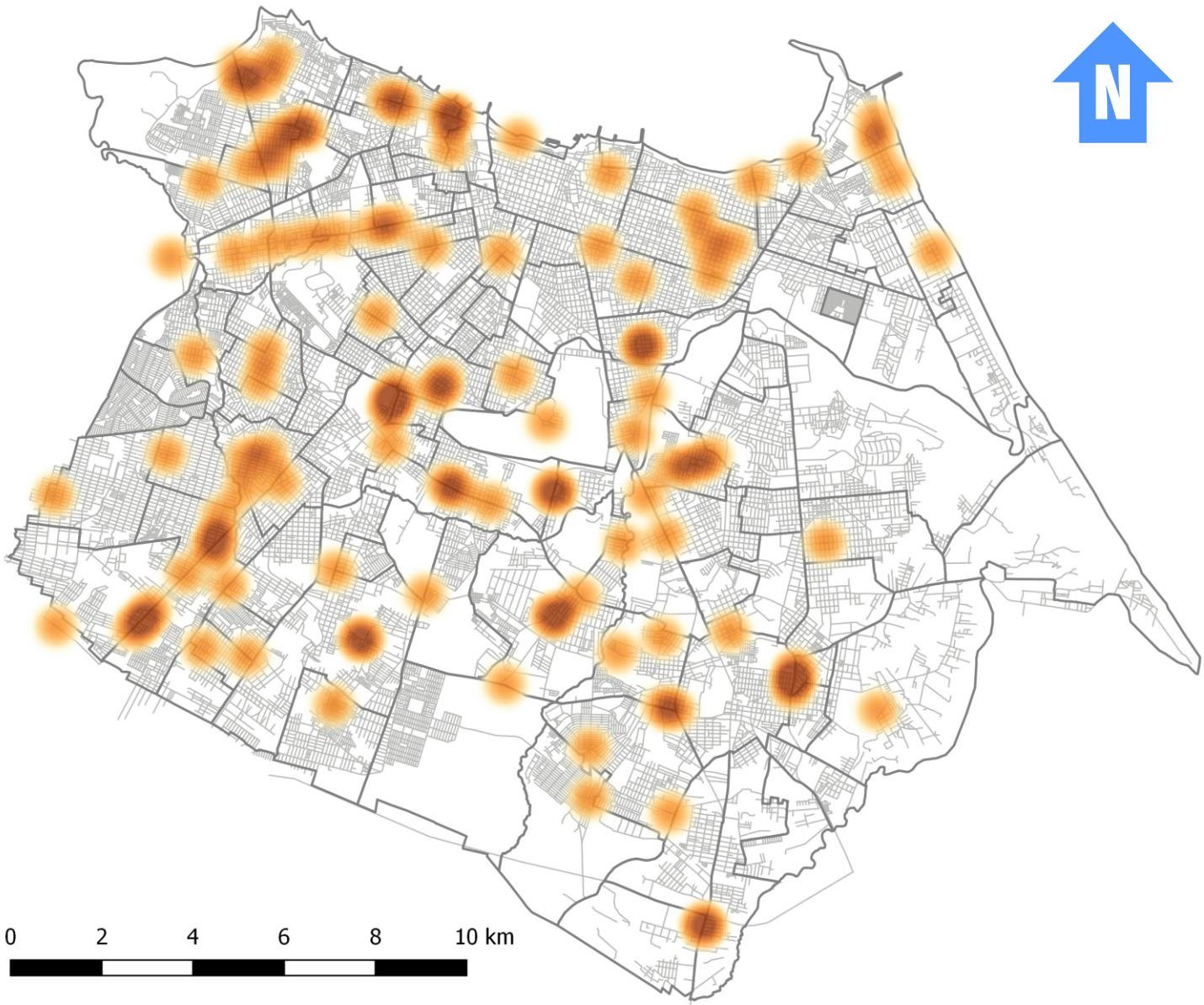


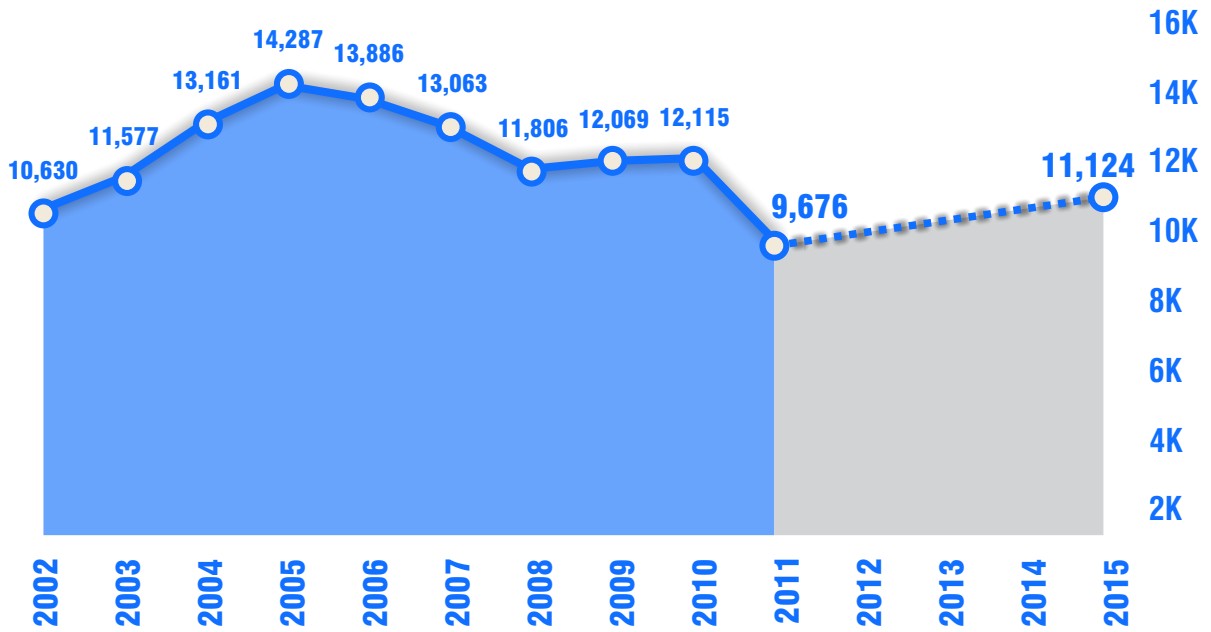
FIGURE 16: ROAD CRASHES W/ FATAL VICTIMS ON WEEKENDS



4. PROFILE OF VICTIMS

INJURED

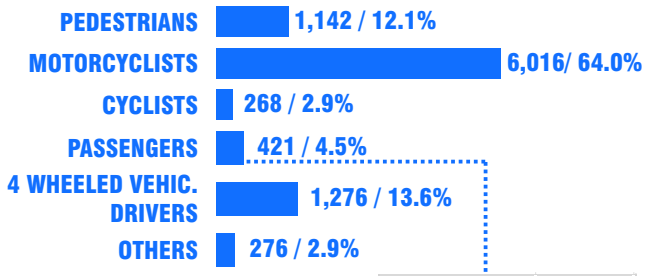
FIGURE 17: INJURED VICTIMS, 2002-2015



Throughout 2015, a total 11,124 injured victims were registered as having been involved in traffic crashes (Figure 17). By analyzing the evolution curve of this number over the years, it is possible to note its increase in comparison to 2011, the last consolidated year. It is important to stress, however, that the data from 2011 did not include events from the SAMU (Emergency Medical Services) database, which is one of the most relevant sources regarding the registry of injured victims. Therefore, comparative analysis for this type of victim between the years of 2015 and 2011 is not recommended.

The distribution of injured victims (Figure 18) follows a global trend for low- and middle-income countries, where motorcyclists stand out

FIGURE 18: DISTRIBUTION OF INJURED VICTIMS BY TYPE (2015)

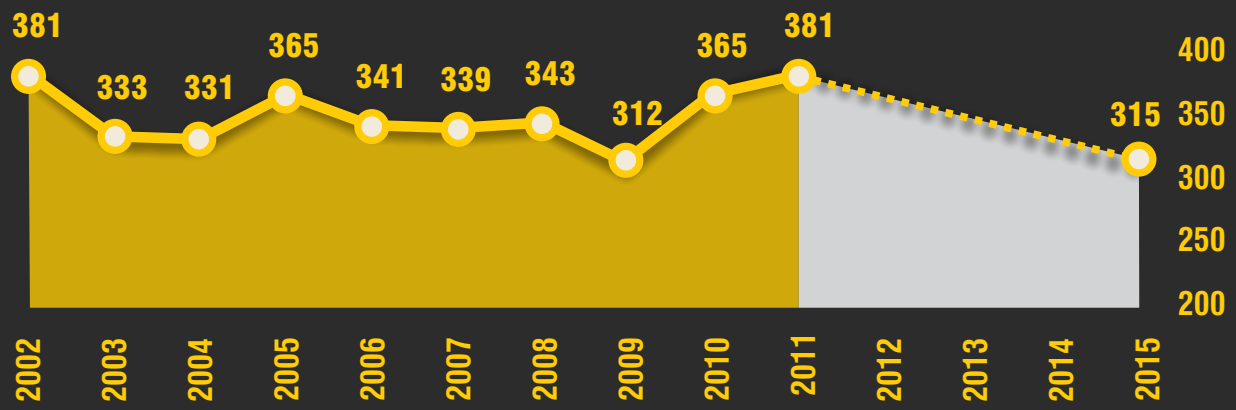


TYPE OF VEHICLE	PASSEN.
2 OR 3 W.	245
4 + W.	126
MISSING	50
TOTAL	**421**

representing 64% of these victims. Even when analyzing the distribution of passengers of two or three wheeled vehicles and those of four or more wheeled vehicles of, it is seen that motorcycle passengers also represent the largest percentage of victims, becoming the focal point of the phenomenon of traffic violence in Fortaleza.

FATAL

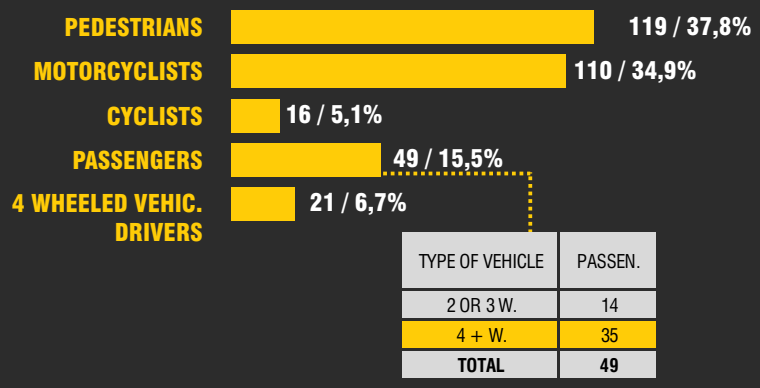
FIGURE 19: FATAL VICTIMS, 2002-2015



Unlike the set of data related to injured victims, there was no variation on how the data regarding fatalities were collected, resulting in an effective reduction of 66 traffic deaths between 2011 and 2015, representing 17.3% less fatal victims (Figure 19).

By the distribution of fatal victims by type shown in Figure 20, it can be seen that pedestrians are the users most likely to be killed on traffic (37.8% of victims), in spite of being ranked in third place among injured victims. It suggests a higher probability of high level of severity in crashes involving this type of user, which is expected due to the absence of physical protection when they are struck by vehicles.

FIGURE 20: DISTRIBUTION OF FATAL VICTIMS BY TYPE (2015)



TYPE OF VEHICLE	PASSEN.
2 OR 3 W.	14
4 + W.	35
TOTAL	49

In second place, outlining how problematic this mode is, are the motorcyclists, representing 34.9% of deaths in traffic in 2015. Regarding the distribution of passengers by type of vehicle, however, the cars with four or more wheels present the highest percentage of passengers' fatalities.

In Table 13, below, it is possible to see the historical series of injured victims disaggregated by type of user. Injured motorcyclists almost doubled in absolute numbers between 2002 and 2015 (from 3,213 to 6,016), drawing attention to the severity of problem related to this category of victims. Proportionately, the situation is equally serious, as the annual representation of motorcyclists has grown from 30.2% of all injured victims in 2002 to 54.1% in 2015, more than half of the victims this year.

In conclusion, the problem severity regarding motorcyclists is evidenced from various points of view by the numbers presented throughout this work. A historical decrease in the number of injured cyclists and pedestrians can also be observed, a positive fact given the physical vulnerability of these types of non-motorized users.

It should be noted that, in this table, all passengers are aggregated in the same category, regardless of their type of vehicle. In 2015, this category was disaggregated, specifically quantifying the passengers of two- or three-wheel vehicles and those who occupied vehicles of four or more wheels. This differentiation is available in Table 15, page 29.

TABLE 13: INJURED VICTIMS BY TYPE OF USER, 2002-2015

YEAR	DRIVER	PASSENGER	PEDESTRIAN	CYCLIST	MOTORCYCLIST	OTHERS	MISSING	TOTAL
2002	1,160	1,373	2,469	1,611	3,213	441	363	10,630
2003	1,145	1,477	2,401	1,896	3,969	478	211	11,577
2004	1,445	1,550	3,000	1,972	4,505	286	403	13,161
2005	1,474	1,463	3,092	2,150	5,380	427	301	14,287
2006	1,565	1,542	2,723	1,884	5,634	357	181	13,886
2007	1,454	1,548	2,706	1,409	5,382	266	298	13,063
2008	1,178	1,220	2,260	1,351	5,406	220	171	11,806
2009	1,135	1,485	2,360	1,208	5,529	201	151	12,069
2010	1,319	1,381	2,033	1,043	6,066	222	51	12,115
2011	1,271	965	1,729	590	4,933	152	38	9,678
2012	-	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-	-
2015	1,276	421	1,142	268	6,016	276	1,725	**11,124**

FATAL

Table 14, below, shows the historical series of fatal victims, disaggregated by type of user. By observing how the distribution of victims has evolved over the years, is can be seen that, while the absolute number of killed pedestrians has decreased between 2011 and 2015 (from 169 to 119), the number of fatalities among motorcyclists has been steadily increasing since 2003. The difference of only nine fatalities between motorcyclists and pedestrians in 2015 resulted in similar percentage shares compared to all other categories of victims for that year.

The category of cyclists had the greatest historical decrease, both in absolute numbers – when comparing the numbers of 2002, when 60 cyclists were killed, and 2015, with only 16 – and in relative numbers – when analyzing the percentage participation of these users year after year. Cyclists accounted for approximately 15% of fatalities in 2002 and for about 5% of all deaths in 2015.

EVERY YEAR, PEDESTRIANS AND CYCLISTS REPRESENT THE MAJORITY OF FATAL VICTIMS. THE CITY OF FORTALEZA RECOGNIZES THIS PATTERN AND HAS BEEN ORIENTING ACTIONS RELATED TO EDUCATION, COMMUNICATION AND ENFORCEMENT DEDICATED TO THESE TWO CATEGORIES OF USERS. THE PILOT PROJECT OF SLOW-SPEED ZONE OF RODOLFO TEÓFILO NEIGHBORHOOD IS AN EXAMPLE OF INFRASTRUCTURAL INTERVENTION FOR THE PURPOSE OF INCREASING PEDESTRIANS' SAFETY.

TABLE 14: FATAL VICTIMS BY TYPE OF USER, 2002-2015

YEAR	DRIVER	PASSENGER	PEDESTRIAN	CYCLIST	MOTORCYCLIST	OTHERS	MISSING	TOTAL
2002	30	40	150	60	75	14	12	381
2003	27	34	140	67	54	7	4	333
2004	27	32	135	61	66	7	3	331
2005	30	34	160	58	73	10	0	365
2006	19	32	141	58	76	10	5	341
2007	12	35	143	63	74	10	2	339
2008	31	28	138	61	80	5	0	343
2009	17	20	140	42	79	9	5	312
2010	27	31	156	39	105	5	2	365
2011	25	32	169	38	104	9	4	381
2012	-	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-	-
2014	-	-	-	-	-	-	-	-
2015	21	49	119	16	110	0	0	**315**

Figure 21 presents the percentage distribution of injured victims by age in 2015 and 2011, except those with missing data, making it possible to observe a similarity of patterns. To identify the relationship between ages and types of users, a matrix was generated (Table 15) to evidence the variation of intensity from a classification with colors (excluding "Others" and "Missing data"). The conclusion is that the victims are, in their majority, motorcyclists aged between 18 and 59 years old.

FIGURE 21: INJURED VICTIMS BY AGE BETWEEN 2011 AND 2015

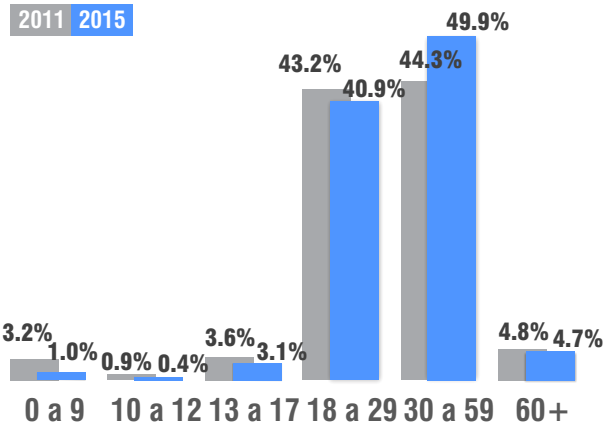


TABLE 15: TYPE AND AGE OF USER, FOR INJURED VICTIMS (2015)

AGE	DRIVER	MOTORC.	CYCLIST	2W-PASSEN.	4W-PASSEN.	PEDES.	OTHERS	MISSING	TOTAL
0-9	2	9	4	5	3	52	2	15	92
10-12	0	6	0	5	4	17	0	6	38
13-17	10	87	9	19	12	54	17	79	287
18-29	363	2,384	55	69	21	202	84	650	3,828
30-59	576	2,551	125	48	27	499	130	716	4,672
60+	91	67	18	2	3	197	12	53	443
MISSING	234	912	57	127	76	121	31	206	1764
TOTAL	1,276	6,016	268	275	146	1,142	276	1,725	**11,124**

Figure 22 provides a comparison of distribution by gender between 2011 and 2015, showing no relevant differences. In sequence, Table 16 displays a matrix that crosses the variables gender and type of user, highlighting the intensity by color. The simultaneous analysis of Tables 15 and 16 establishes, after all, that the basic profile of injured victims consists of male motorcyclists aged between 18 and 59 years old.

FIGURE 22: INJURED VICTIMS BY GENDER BETWEEN 2011 AND 2015

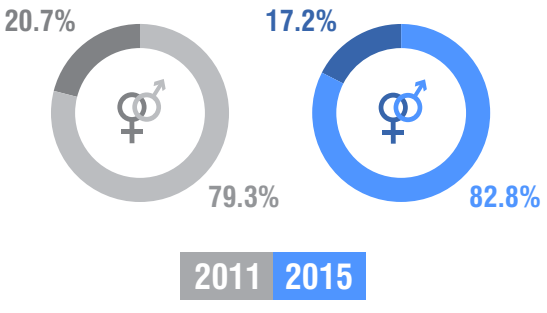


TABLE 16: TYPE AND GENDER OF USER, FOR INJURED VICTIMS (2015)

GENDER	DRIVER	MOTORC.	CYCLIST	2W-PASSEN.	4W-PASSEN.	PEDES.	OTHERS	MISSING	TOTAL
MALE	889	4,838	208	97	49	701	224	1237	8,243
FEMALE	255	488	29	152	72	369	32	319	1,716
MISSING	132	690	31	26	25	72	20	169	1,165
TOTAL	1,276	6,016	268	275	146	1,142	276	1,725	**11,124**

FATAL

The comparative distribution of ages of fatal victims between 2011 and 2015 is illustrated in Figure 23, which shows no substantial variations. Table 17, below, contains a matrix that connects the data related to age and type of user and adopts the same methodology used to analyze the injured victims, presenting, as a result, the pedestrians over 30 years old as the main fatal victims.

FIGURE 23: FATAL VICTIMS BY AGE BETWEEN 2011 AND 2015

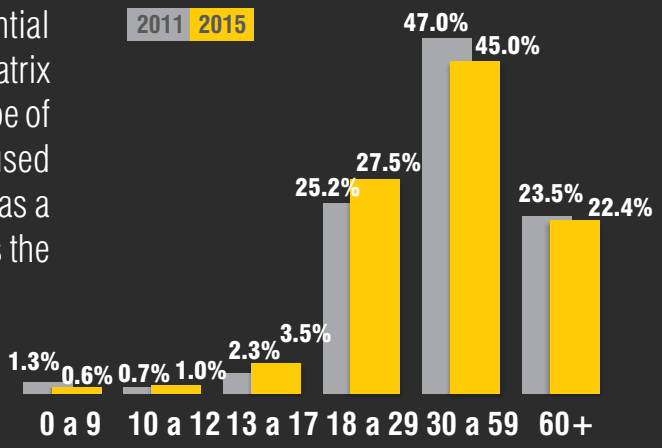


TABLE 17: TYPE AND AGE OF USER, FOR FATAL VICTIMS (2015)

AGE	DRIVER	MOTORC.	CYCLIST	2W-PASSEN.	4W-PASSEN.	PEDES.	OTHERS	MISSING	TOTAL
0-9	0	0	0	0	0	2	0	0	2
10-12	0	0	0	1	1	1	0	0	3
13-17	0	2	0	7	0	2	0	0	11
18-29	10	51	5	9	5	6	0	0	86
30-59	10	53	4	15	5	54	0	0	141
60+	1	3	7	3	3	53	0	0	70
MISSING	0	1	0	0	0	1	0	0	2
TOTAL	21	110	16	35	14	119	0	0	**315**

With regard to gender distribution (Figure 24), it can be seen that the percentage of women killed in traffic increased from 15.1% in 2011 to 24.1% in 2015. Table 18 presents the matrix that connects the variables of gender and type of user. When analyzed in conjunction with Table 17, it is noted that the profile of fatal victims consists of male pedestrians over 30 years old, being male motorcyclists equally relevant.

FIGURE 24: FATAL VICTIMS BY GENDER BETWEEN 2011 AND 2015

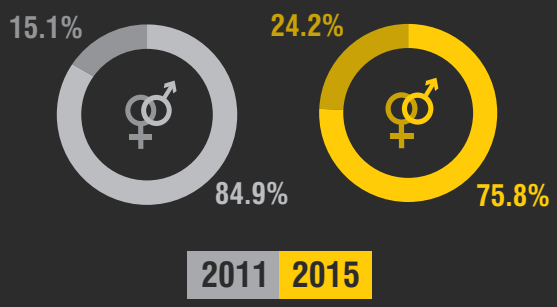


TABLE 18 TYPE AND GENDER OF USER, FOR FATAL VICTIMS (2015)

GENDER	DRIVER	MOTORC.	CYCLIST	2W-PASSEN.	4W-PASSEN.	PEDES.	OTHERS	MISSING	TOTAL
MALE	21	100	16	16	7	78	0	0	238
FEMALE	0	9	0	19	7	41	0	0	76
MISSING	0	1	0	0	0	0	0	0	1
TOTAL	21	110	16	35	14	119	0	0	**315**

5. WHO METRICS

The World Health Organization, on the document "Global Reference List of 100 Core Health Indicators" (WHO, 2015), mentions the rates of mortality and morbidity caused by traffic crashes as a global reference to assess the intensity of traffic violence problem compared by local, national and international levels, applicable to urban contexts.

There are two ways of characterizing the morbidity and mortality rates, distinguishing them by denominator. In the first case, they are calculated by dividing the number of injured or dead victims by the number of registered vehicles, which makes it possible to analyze the problem according to the annual growth of fleet. In the second case, the number of injured or dead victims is divided by 100.000 inhabitants, relating morbidity and mortality to population growth. In this section, the two indicators will be presented, disaggregated by certain types of vehicles and users.

Table 19 shows that the year of 2015 presented positive results when compared to 2011, with a reduction of 35.7% of deaths per 10.000 registered vehicles and of 21% of deaths per 100.000 inhabitants. Both rates are the lowest registered since 2002, as it can be observed in Figures 25 and 26.

By disaggregating both rates by type of user, it is seen that pedestrians and cyclists had the highest percentage reduction for the rate of deaths per 100.000 inhabitants, whereas motorcyclists were the users who had the highest percentage reduction for the rate of deaths per 10.000 vehicles, even with the increase of the absolute number of deaths between 2011 and 2015.

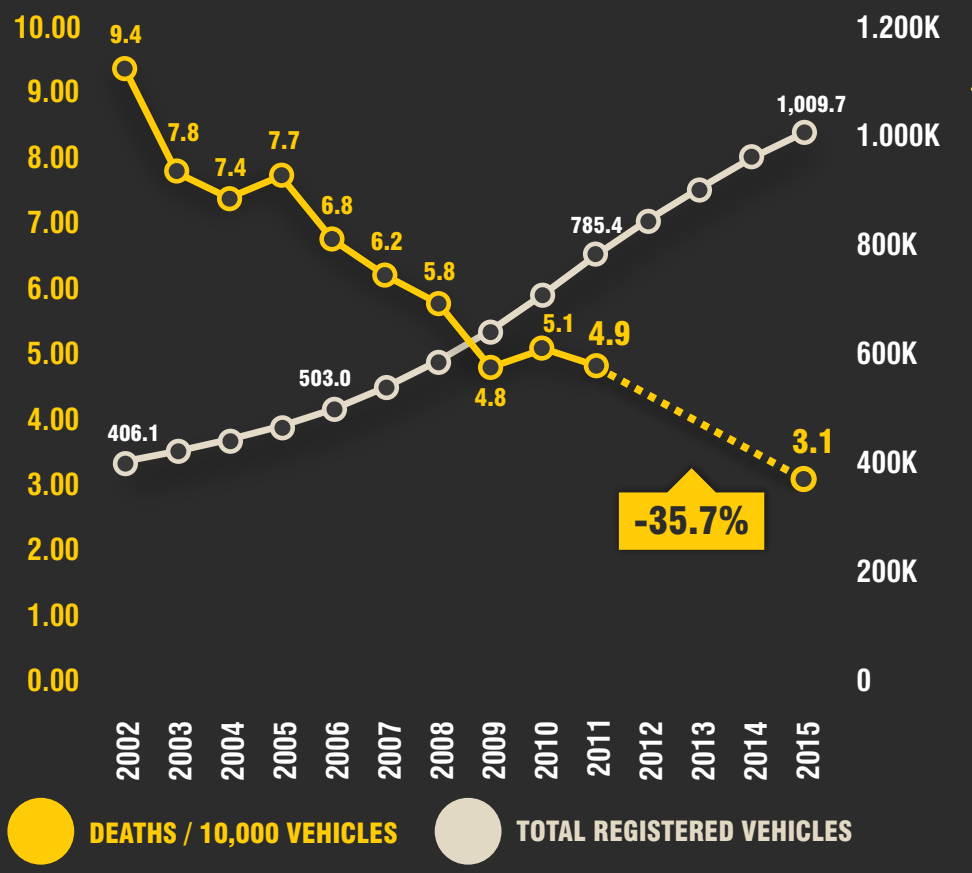
TABLE 19: DEATHS/10.000 VEHICLES AND DEATHS/100.000 INHABITANTS; (2002-2015)

YEAR	DEATHS/ 10,000 VEHICLES	TOTAL REGISTERED VEHICLES	DEATHS/ 100,000 INHABITANTS	POPULATION
2002	9.38	406,057	17.16	2,219,837
2003	7.80	426,712	14.76	2,256,233
2004	7.41	446,570	14.19	2,332,657
2005	7.75	470,985	15.37	2,374,944
2006	6.78	503,044	14.11	2,416,920
2007	6.24	543,634	13.70	2,473,614
2008	5.80	591,375	13.87	2,473,614
2009	4.83	645,765	12.45	2,505,552
2010	5.12	712,996	14.88	2,452,185
2011	4.85	785,370	15.38	2,476,589
2012	-	848,297	-	2,500,194
2013	-	908,074	-	2,551,806
2014	-	964,724	-	2,571,896
2015	**3.12**	1,009,695	**12.16**	2,591,188

DEATHS/ 100,000 INHABITANTS

TYPE	2011	2015	15/11%
DRIVER	1.01	1.00	-0.6%
MOTORCYCLIST	4.20	4.17	-0.7%
CYCLIST	1.53	0.62	-59.8%
PEDESTRIAN	6.82	4.52	-33.8%

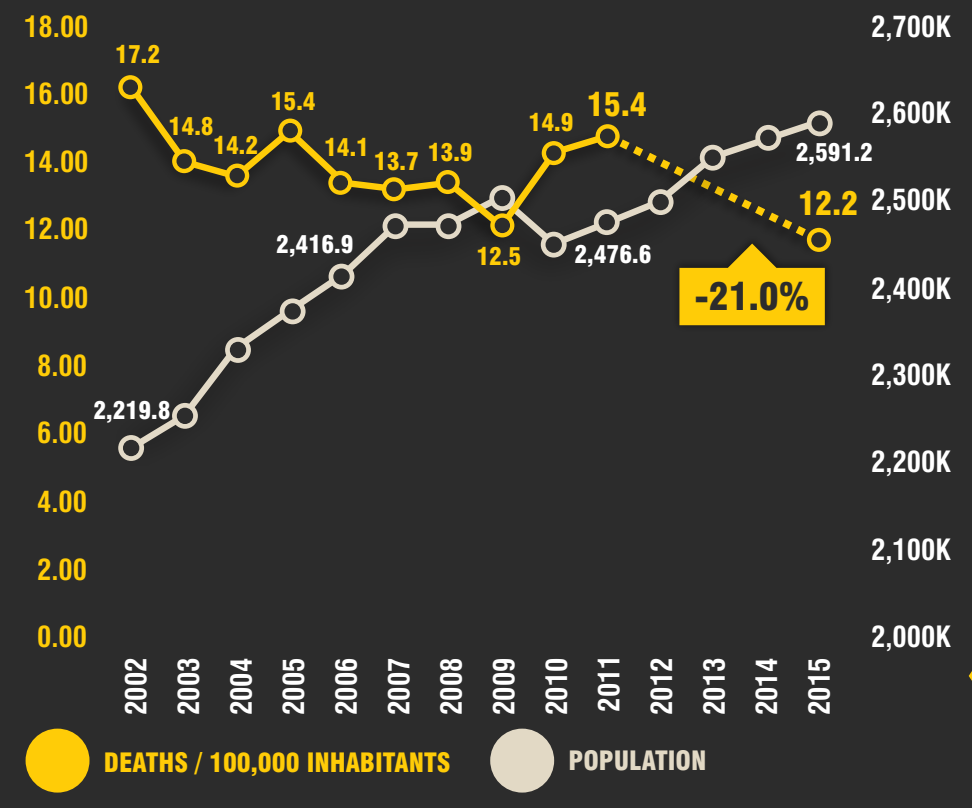
FIGURE 25: TOTAL DEATHS / 10.000 VEHICLES



TOTAL FATAL VICTIMS PER YEAR

TOTAL REGISTERED VEHICLES PER YEAR

FIGURE 26: TOTAL DEATHS / 100.000 INHABITANTS



TOTAL FATAL VICTIMS PER YEAR

TOTAL POPULATION PER YEAR

Table 20 presents the historical series for rates of deaths per 10.000 vehicles among vehicles of four or more wheels and motorcycles, as well as the annual fleet registration of those two types of vehicles. It is possible to observe a clear trend towards a decrease in the number of crashes involving motorcyclists over the years, despite the large increase in motorcycles fleet. It is worth mentioning that the number of vehicles presented comes from official records of DETRAN/CE.

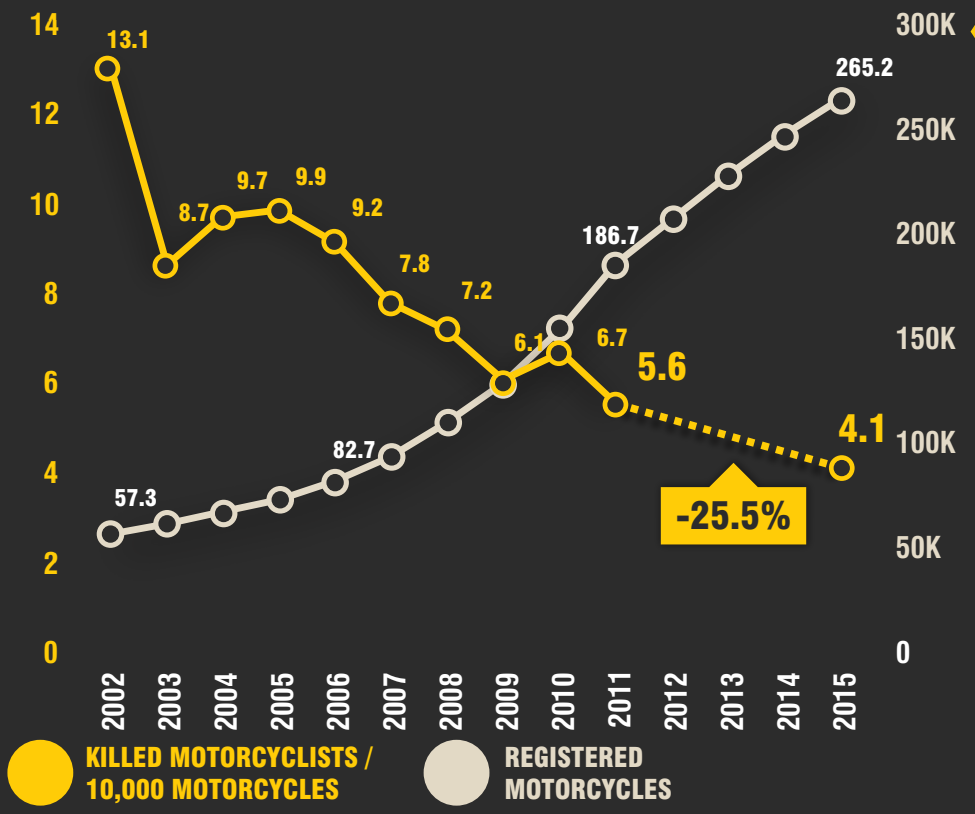
The trend towards a decrease in the rate of crashes involving vehicles of four or more wheels is not as clear, as demonstrated by 2007 and 2009 valleys and 2008 peak. However, the year of 2015 presents the second lowest historical record since 2002, only higher than the number registered in 2007 (Figures 27 and 28).

The comparison between the numbers of crashes involving motorcycles and those related to vehicles with four or more wheels shows that motorcyclists face more severe problems – with rates of deaths per 10.000 vehicles five to ten times higher in some years. These data stress the position of this group of users as the focal point of the problem.

TABLE 20: DEATHS /10.000 VEHICLES, DISAGGREGATED BY FOUR OR MORE WHEELED VEHICLES (4-W.V.) AND MOTORCYCLES

YEAR	DEATHS/ 10,000 4-W VECHILES	REGISTERED 4-W VEHICLES	DEATHS/ 10,000 MOTORCYCLES	REGISTERED MOTORCYCLES
2002	0.87	346,222	13.09	57,283
2003	0.75	359,981	8.67	62,304
2004	0.72	373,676	9.74	67,750
2005	0.77	391,306	9.89	73,834
2006	0.46	413,333	9.19	82,722
2007	0.27	440,399	7.83	94,467
2008	0.66	469,760	7.23	110,659
2009	0.34	502,935	6.10	129,447
2010	0.50	541,114	6.73	156,026
2011	0.43	579,965	5.57	186,738
2012	-	619,187	-	208,184
2013	-	655,784	-	229,154
2014	-	691,012	-	247,794
2015	**0.29**	716,255	**4.15**	265,237

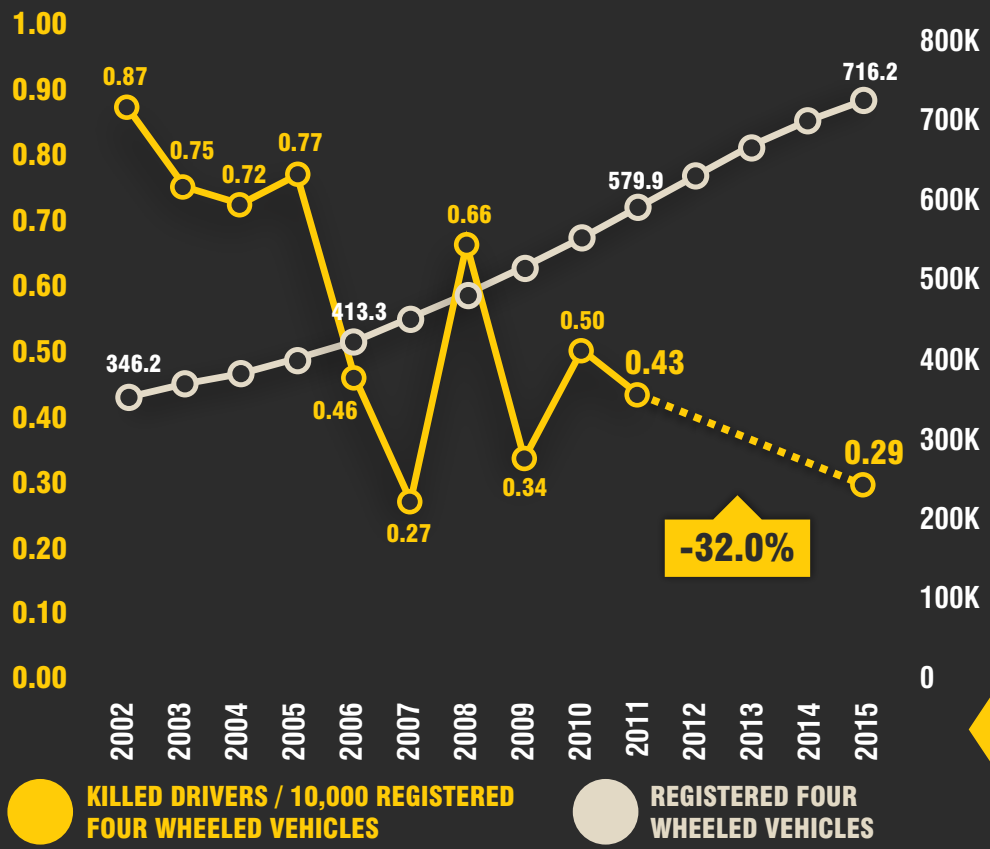
FIGURE 27: KILLED MOTORCYCLISTS / 10,000 MOTORCYCLES



NUMBER OF KILLED MOTORCYCLISTS PER YEAR

REGISTERED MOTORCYCLES PER YEAR

FIGURE 28: KILLED DRIVERS OF FOUR WHEELS VEHICLES / 10,000 REGISTERED FOUR WHEELED VEHICLES



NUMBER OF KILLED DRIVERS OF FOUR OR MORE WHEELED VEHICLES

FOUR OR MORE WHEELED REGISTERED VEHICLES PER YEAR

As for injured victims (Table 21), it can be immediately observed, by the historical series and number of crashes, that the level of severity is overwhelmingly higher.

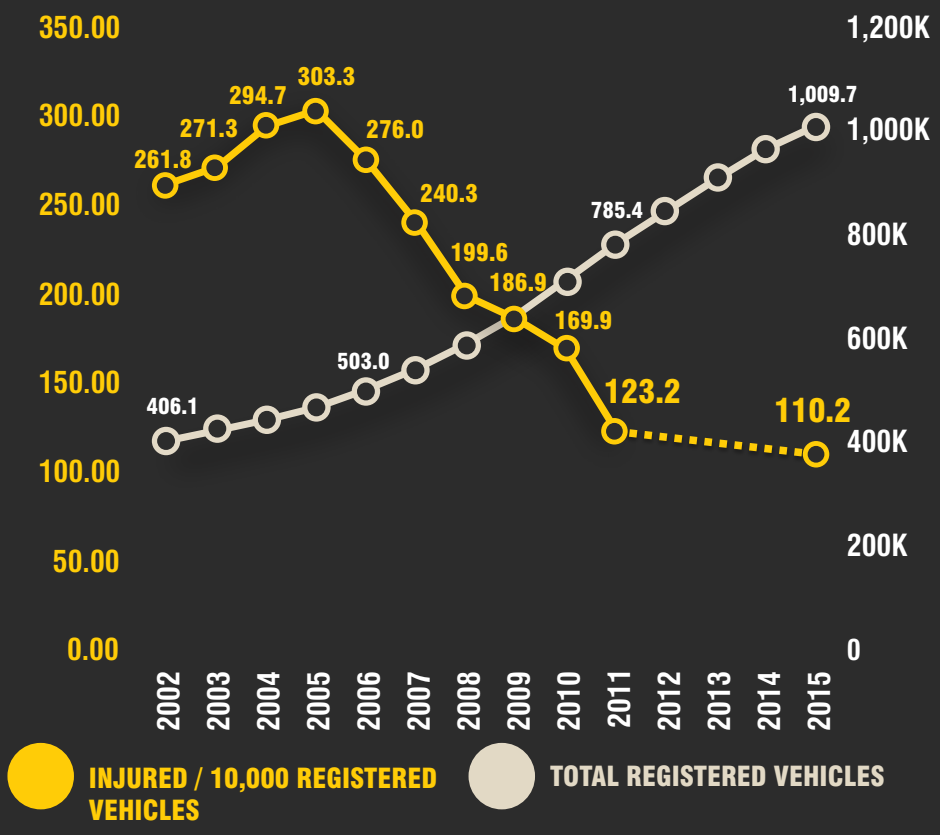
One more time, it should be noted that SAMU data were not used in 2011; therefore the numbers of that year and the ones of 2015 should not be directly compared. The historical series, as a whole, allows to observe that the rate of injured per 10.000 vehicles has presented a trend towards a decrease over the years, whereas the rate of injured per 100.000 inhabitants has remained stable.

It is important to emphasize that the slopes on these indicators curves are different because the annual rate of fleet growth is constantly higher than the annual rate of population growth (Figures 39 and 30). Such difference demonstrates the importance of the simultaneous use of two distinct metrics for a broader comprehension of the problems related to road safety.

TABLE 21: RATES OF INJURED VICTIMS/10.000 VEHICLES

YEAR	INJURED/ 10,000 VEHICLES	TOTAL REGISTERED VEHICLES	INJURED/ 100,000 INHABITANTS	POPULATION
2002	261.8	406,057	392.1	2,219,837
2003	271.3	426,712	427.1	2,256,233
2004	294.7	446,570	470.7	2,332,657
2005	303.3	470,985	509.7	2,374,944
2006	276.0	503,044	479.7	2,416,920
2007	240.3	543,634	435.3	2,473,614
2008	199.6	591,375	402.7	2,473,614
2009	186.9	645,765	395.5	2,505,552
2010	169.9	712,996	405.1	2,452,185
2011	123.2	785,370	321.5	2,476,589
2012	-	848,297	-	2,500,194
2013	-	908,074	-	2,551,806
2014	-	964,724	-	2,571,896
2015	**110.2**	1,009,695	**388.2**	2,591,188

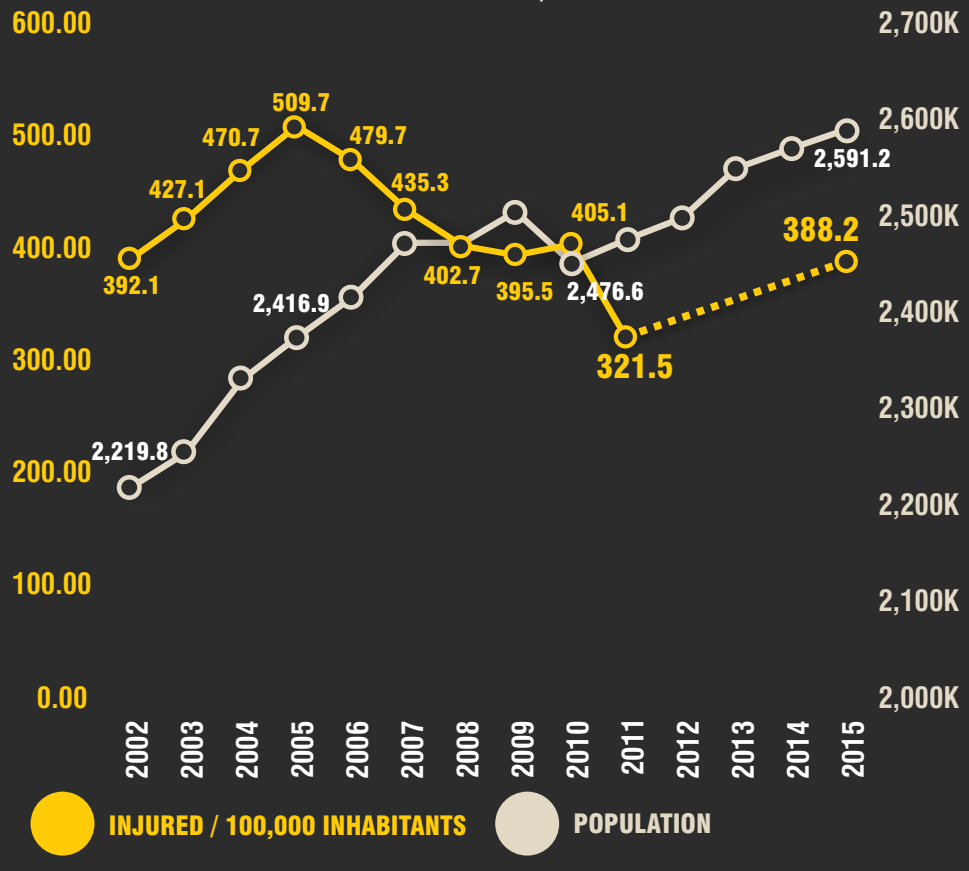
FIGURE 29: TOTAL INJURED VICTIMS / 10.000 REGISTERED VEHICLES



TOTAL INJURED VICTIMS PER YEAR

TOTAL REGISTERED VEHICLES PER YEAR

FIGURE 30: TOTAL INJURED VICTIMS / 100.000 INHABITANTS



TOTAL INJURED VICTIMS PER YEAR

TOTAL POPULATION PER YEAR

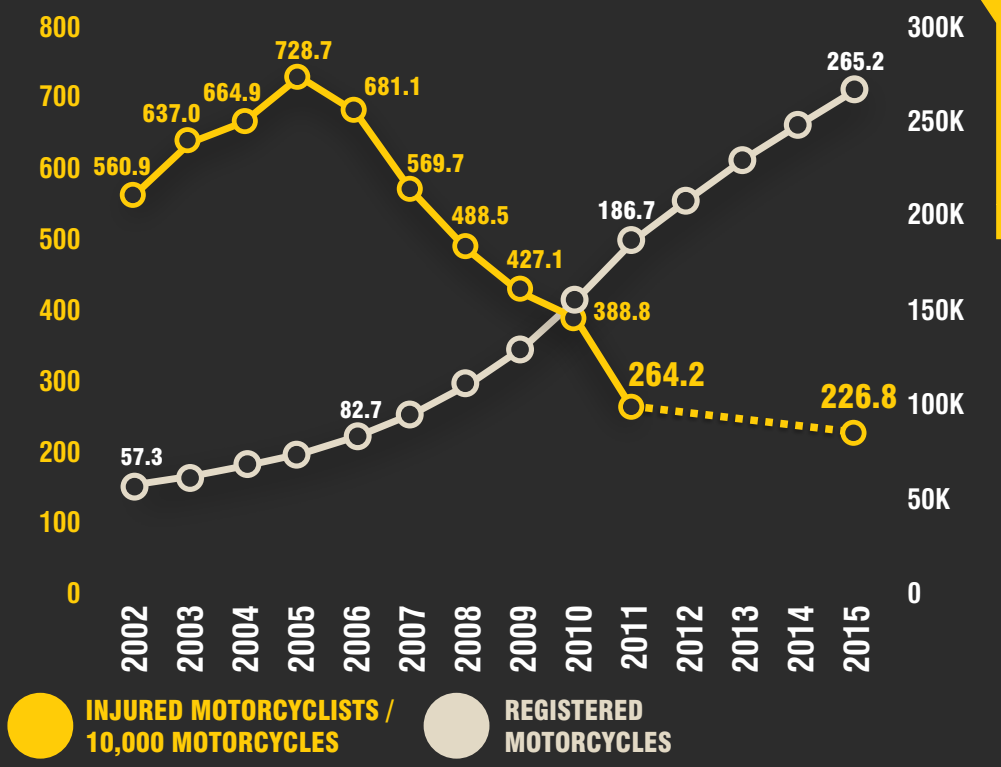
By disaggregating the rate of injured per 10.000 vehicles by motorcycles and vehicles with four or more wheels, it can be seen that the distribution follows the same pattern previously identified, as the number of crashes with motorcyclists involved is significantly higher than that with drivers of vehicles with four or more wheels, as shown in Table 22 and Figures 30 and 31.

The year of 2015, however, presented the lowest rates for both types of victims and vehicles in the historical series since 2002. This fact is a direct consequence of the fast fleet growth of these two types of vehicles over the past ten years (between 2005 and 2015).

TABLE 22: RATES OF INJURED VICTIMS/10.000 VEHICLES, DISAGGREGATED BY FOUR OR MORE WHEELED VEHICLES (4-W.V.) AND MOTORCYCLES

YEAR	INJURED/ 10,000 4-W VECHILES	REGISTERED 4-W VEHICLES	INJURED/ 10,000 MOTORCYCLES	REGISTERED MOTORCYCLES
2002	33.5	346,222	560.9	57,283
2003	31.8	359,981	637.0	62,304
2004	38.7	373,676	664.9	67,750
2005	37.7	391,306	728.7	73,834
2006	37.9	413,333	681.1	82,722
2007	33.0	440,399	569.7	94,467
2008	25.1	469,760	488.5	110,659
2009	22.6	502,935	427.1	129,447
2010	24.4	541,114	388.8	156,026
2011	21.9	579,965	264.2	186,738
2012	-	619,187	-	208,184
2013	-	655,784	-	229,154
2014	-	691,012	-	247,794
2015	**17.8**	716,255	**226.8**	265,237

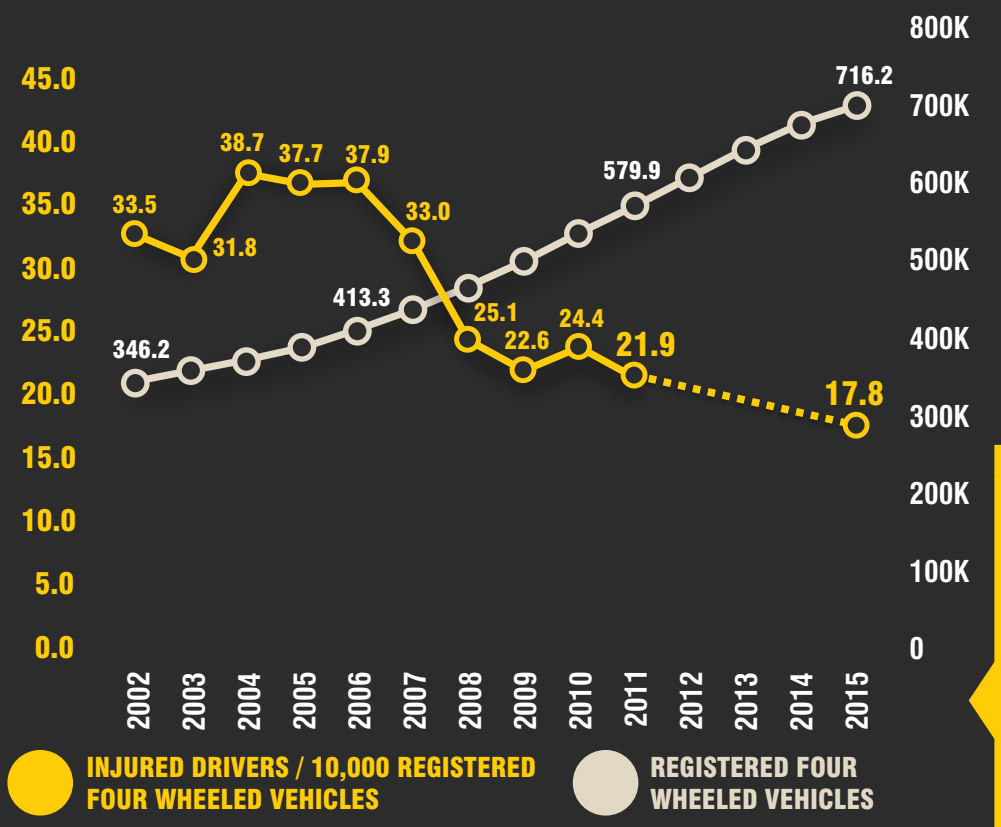
FIGURE 31: INJURED MOTORCYCLISTS / 10,000 MOTORCYCLES



NUMBER OF INJURED MOTORCYCLISTS PER YEAR

REGISTERED MOTORCYCLES PER YEAR

FIGURE 32: INJURED DRIVERS OF FOUR WHEELS VEHICLES / 10,000 REGISTERED FOUR WHEELED VEHICLES



NUMBER OF INJURED DRIVERS OF FOUR OR MORE WHEELED VEHICLES

FOUR OR MORE WHEELED REGISTERED VEHICLES PER YEAR

6. ESTIMATED COST

This section presents the estimated costs of traffic crashes in the city of Fortaleza. The monetary values used for this purpose were presented by the Instituto de Pesquisa e Economia Aplicada – IPEA (Institute of Research and Applied Economics) in the 2003 report entitled "Impactos Sociais e Econômicos dos Acidentes de Trânsito nas Aglomerações Urbanas Brasileiras" ("Social and Economic Impacts of Traffic Crashes in Brazilian Urban Agglomerations"). Table 23 presents the monetary value of average costs of traffic crashes according to IPEA.

It should be noted that the total costs of traffic crashes presented in IPEA report were estimated taking only the direct and indirect costs into account. However, "there are intangible and subjective costs related to the expected survival of people killed in traffic, the physical and psychological suffering of the victims, their relatives and friends", as quoted in the same report. Considering the reporting of 305 traffic crashes with fatal victims, 10,058 with injured victims and 13,171 with no victims in 2015, and updating the values estimated by IPEA to December, 2015 (12/31/2015) based upon the Índice Nacional de Preços ao Consumidor Amplo – IPCA (Extended National Consumer Price Index), the estimated costs of traffic crashes in Fortaleza totaled approximately R$ 507,000,000 (around USD 160,000,000), representing an increase of 6.4% compared to 2011 – although the numbers of this year are underestimated due to the lack of SAMU data.

TABLE 23: ESTIMATED ANNUAL COST BY TYPE OF VICTIM

YEAR	TYPE	UNIT COST BY TYPE	CRASHES BY TYPE	PARTIAL COST BY TYPE	TOTAL ANNUAL COST
2011	DMG. ONLY	R$ 7,116.24	15,432	R$ 109,817,815.68	R$ 476,561,930.36
	W/ INJURED	R$ 31,542.54	7,960	R$ 251,078,618.40	
	W/ FATAL	R$ 315,164.84	367	R$ 115,665,496.28	
2015	DMG. ONLY	R$ 7,116.24	13,171	R$ 93,727,997.04	**R$ 507,108,140.56**
	W/ INJURED	R$ 31,542.54	10,058	R$ 317,254,867.32	
	W/ FATAL	R$ 315,164.84	305	R$ 96,125,276.20	

500 MILLION*

***ESTIMATED COST BASED UPON A STUDY CONDUCTED BY IPEA (2003)**

7. BLACK SPOTS

The twenty signalized and not signalized intersections displayed on the following maps and tables are considered the most critical ones in the city in terms of frequency and severity of traffic crashes over 2015. The method used to identify them, known as Critical Rate Method – CRM, consists in the calculation of the Observed Critical Rate – OCR and the Expected Critical Rate– ECR of each intersection, assuming that the occurrences of traffic crashes follow the Poisson probability distribution. The difference between these rates was the criteria adopted to rank the critical spots.

Traffic crashes tend to occur more frequently at intersections whose observed critical rate (OCR) is higher than expected critical rate (ECR) not for random reasons, but rather for their own deficiencies. The first step of the method consisted of the calculation of OCR according to Equation 1. This rate measures the traffic crashes by their severity, through the calculation of the Severity Index – SI of each intersection, according to Equation 2. For this measurement, for example, a traffic crash with fatal victim has a weight of 13 while a traffic crash with no victim has a weight of 1. Afterwards, the exposure, which is equivalent to the amount of vehicles passing by an intersection, is calculated over the analysis period, according to Equation 3. A spot with lower vehicular volume tends to be more critical than a busier spot if both present the same severity of traffic crashes. It should be noted that the estimated Average Daily Traffic Volumes– ADTV were based on the data provided by Controle de Tráfego por Área de Fortaleza – CTAFOR (Fortaleza Traffic Control Department) and those provided by enforcement equipment, using the expansion factors of Modeling in Support for Decision on Planning, Operation and Management of Public Transportation and Road Traffic Systems of Fortaleza report (relatório de Modelagem no Apoio à Decisão no Planejamento, Operação e Gestão dos Sistemas de Transporte Público e de Circulação Viária de Fortaleza – ASTEF/UFC, 2015).

After calculating the Observed Critical Rate, the Expected Critical Rate of each intersection was calculated (Equation 4). This rate defines the value of severity of each intersection, considering their operational features. For this purpose, the signalized and not signalized intersections were separated into two groups. Finally, the difference (Δ) between OCR and ECR was calculated, according to Equation 5, ranking the intersections.

$$OCR = \frac{SI}{MVE} \quad (1)$$

$$SI = 1a + 4b + 6c + 13d \quad (2)$$

$$MVE = \frac{ADTV \times t \times 365}{10^6} \quad (3)$$

$$ECR = \lambda + k\sqrt{\frac{\lambda}{MVE} + \frac{1}{2 \times MVE}} \quad (4)$$

$$\Delta = OCR - ECR \quad (5)$$

SI - Severity Index;
MVE - Millions of Vehicles Entering the intersection in t years, where t = 1 for the present analysis.
ADTV - Average Daily Traffic Volumes
a - Damage only crashes
b - Crashes with injured victims
c - Crashes with injured pedestrians
d - Crashes with fatal victims
λ - Observed Crash Rate.
k - Constant that indicates the adopted trust level. For this application, it was considered 90% (k=1,64);

FIGURE 33: SIGNALIZED INTERSECTIONS

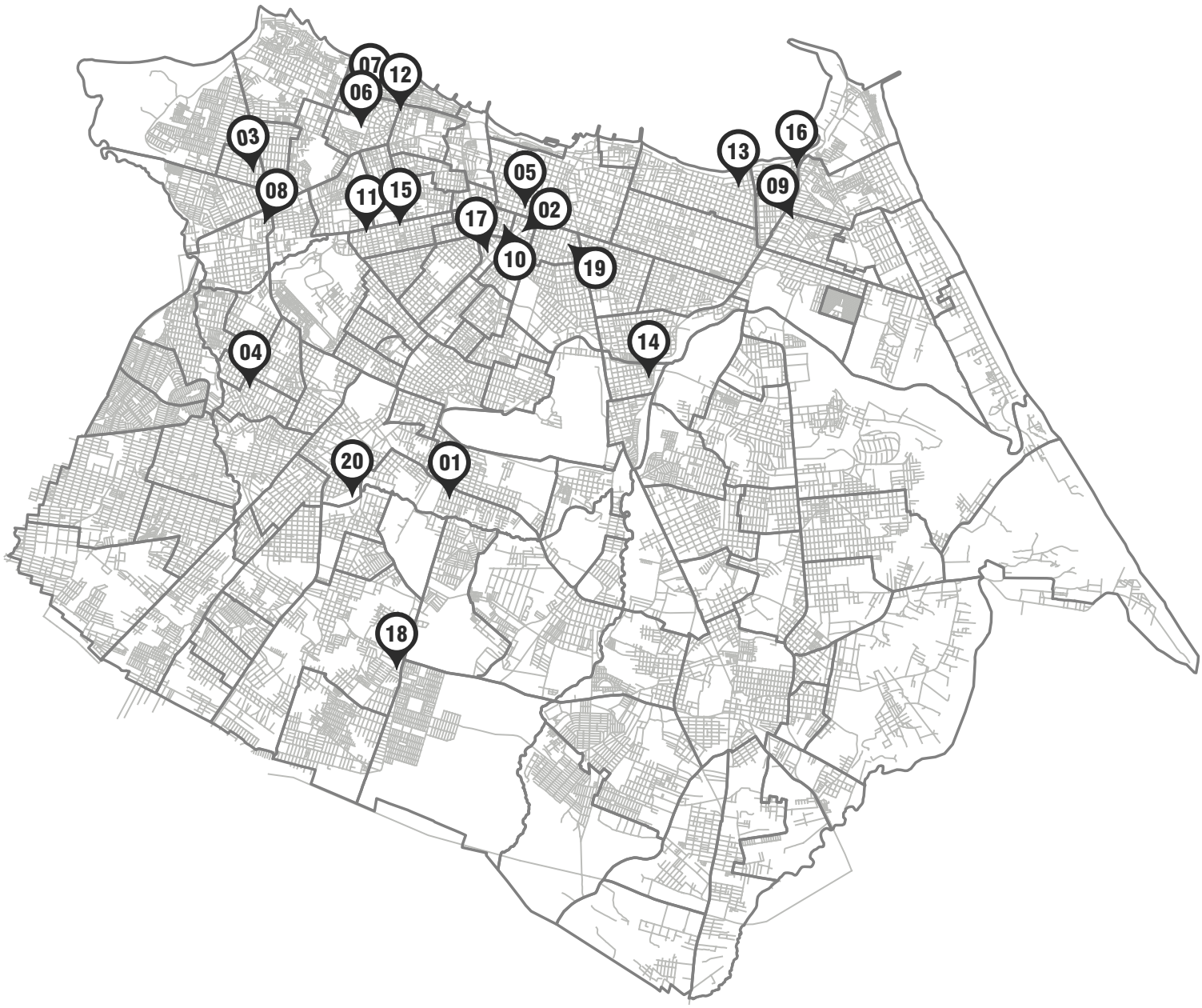


FIGURE 34: NOT SIGNALIZED INTERSECTIONS

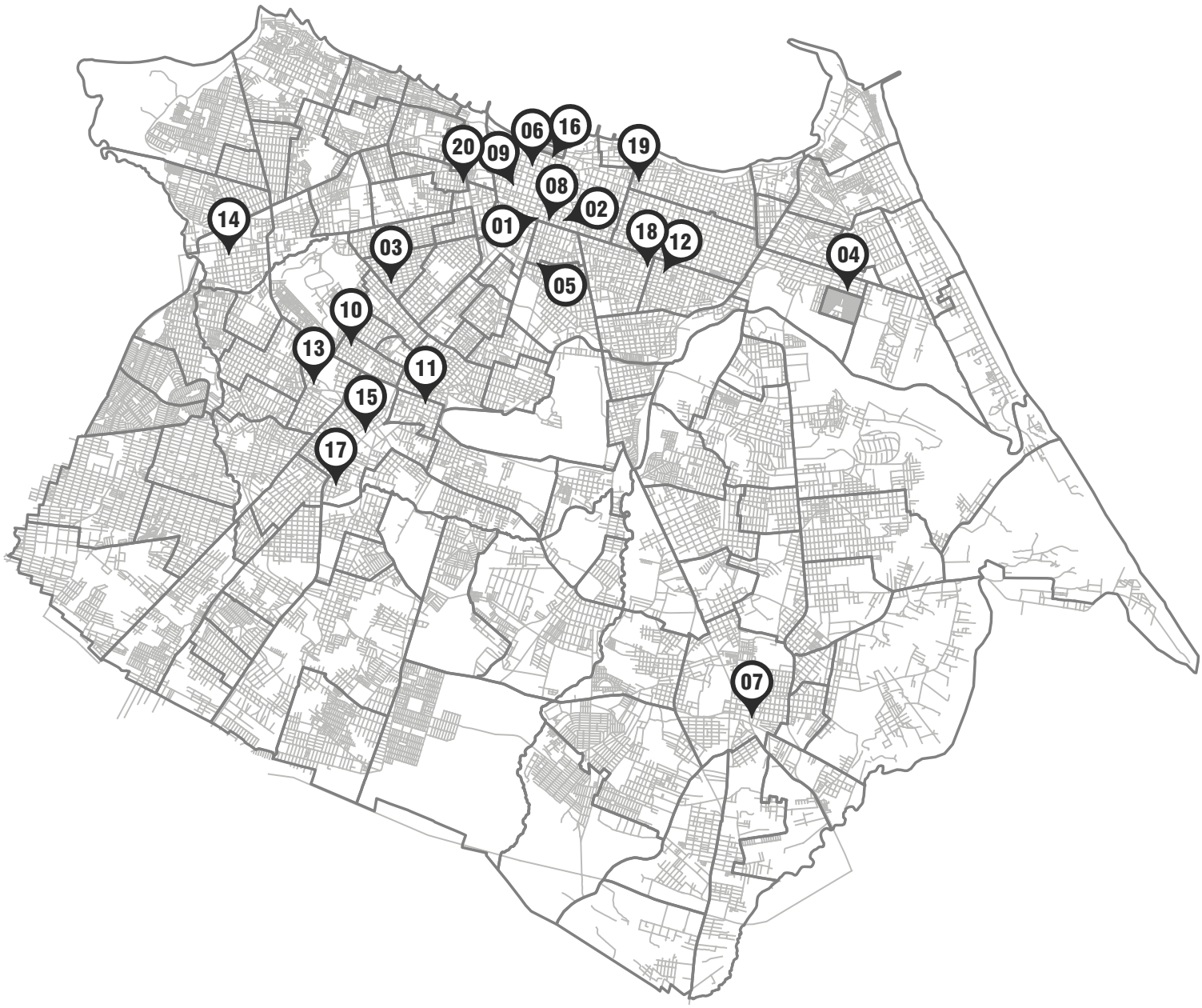


TABLE 24: SIGNALIZED INTERSECTIONS

RANKING	INTERSECTIONS	ROAD CRASHES			SI	OCR	ECR	Δ
		FATAL	INJURED	DMG. ONLY				
1º	Av Dr Silas Munguba X Av Dos Expedicionarios	2	15	11	97	3.9	2.6	1.3
2º	Av Domingos Olimpio X Av Da Universidade	1	5	9	52	3.2	2.8	0.5
3º	Av Cel Carvalho X Av Maj Assis	0	8	11	51	2.9	2.7	0.2
4º	R. Pro Heribaldo Costa X R. Porto Velho	1	6	10	49	2.9	2.9	0.1
5º	Av Duq Caxias X R. Vinte E Quatro De Maio	0	9	12	48	2.8	2.8	0.0
6º	Av Francisco Sa X Av Dr Theberge	0	9	5	47	2.7	2.7	0.0
7º	Av Prs Castelo Branco X Av Dr Theberge	0	8	7	47	2.4	2.7	-0.3
8º	Av Cel Carvalho X Av Sgt Herminio Sampaio	0	8	10	46	2.4	2.8	-0.4
9º	Av Eng Alberto Sa X Av Eng Santana Junior	1	6	5	42	2.3	2.8	-0.5
10º	Av Domingos Olimpio X Av Imperador	0	7	13	41	2.1	2.6	-0.5
11º	Av Bezerra De Menezes X R.Amadeu Furtado	0	9	1	39	2	2.7	-0.6
12º	Av Prs Castelo Branco X Av Pasteur	0	8	7	39	1.9	2.6	-0.7
13º	Av Abolicao X R. Julio Ibiapina	0	7	8	38	2	2.7	-0.8
14º	Av Gov Raul Barbosa X Av Gal Murilo Borges	0	5	16	36	1.7	2.6	-0.9
15º	Av Bezerra De Menezes X Rua Dom Lino	0	6	11	35	1.8	2.7	-0.9
16º	Av Alm Henrique Saboia X Av Abolicao	0	7	7	35	1.7	2.7	-1.0
17º	Av Carapinima X Av 13 De Maio	1	5	1	34	1.5	2.6	-1.1
18º	Av Dos Expedicionarios X Av Prs Costa E Silva	0	7	4	34	1.6	2.6	-1.1
19º	Av Antonio Sales X Av Aguanambi	1	4	5	34	1.5	2.6	-1.1
20º	Av Godofredo Maciel X R.Nereu Ramos	1	3	7	32	1.5	2.6	-1.1

TABLE 25: NOT SIGNALIZED INTERSECTIONS

RANKING	INTERSECTIONS	ROAD CRASHES			SI	OCR	ECR	Δ
		FATAL	INJURED	DMG. ONLY				
1º	R. Meton De Alencar X R. Maj Facundo	0	12	11	55	10.4	7.5	3
2º	R.Jaime Benevolo X R. Gal Clarindo De Queiroz	0	13	6	50	10.3	7.6	2.7
3º	R.Cesar Fontenele X R. Pro Lino Encarnacao	0	10	15	36	9.9	7.9	2
4º	R.Francisco Matos X R. Bento Albuquerque	0	9	14	61	9.1	7.3	1.8
5º	R. Assuncao X R.Saldanha Marinho	1	7	5	58	8.9	7.3	1.7
6º	R. Sen Alencar X Av. Tristao Goncalves	0	10	6	46	8.5	7.5	1.1
7º	R. Antonino Barros X R. Pergentino Maia	0	9	9	36	8.8	7.7	1
8º	R.Floriano Peixoto X R. Meton de Alencar	0	7	15	43	8.2	7.5	0.7
9º	R. Prc Isabel X R. Pedro Pereira	0	7	12	39	7.9	7.5	0.3
10º	R. Rio Grande do Sul X R. Rio Grande do Norte	0	6	15	46	7.6	7.4	0.3
11º	R. 15 de Novembro X R. Alberto Magno	0	8	7	45	7	7.3	-0.3
12º	AV. Antonio Sales X R. Nunes Valente	0	8	7	38	6.8	7.4	-0.6
13º	AV. Sen Fernandes Tavora X Tr. Helena de Maria	0	7	11	37	6.6	7.4	-0.9
14º	R. Hugo Vitor X R. Martins Neto	0	6	14	32	6.3	7.5	-1.2
15º	R. Con de Castro X R. Eduardo Perdigao	1	6	1	39	5.9	7.3	-1.4
16º	R. Sen Pompeu X R. Sen Jaguaribe	0	8	5	39	4.4	7	-2.7
17º	R. Tchecoslovaquia X R. Nereu Ramos	0	5	16	38	4.4	7.1	-2.7
18º	AV.Antonio Sales X R. Silva Paulet	1	5	3	40	3.8	6.9	-3.1
19º	R. Ildefonso Albano X R. Dep Moreira Da Rocha	0	6	9	39	3.5	6.9	-3.4
20º	AV. Jose Jatahy X Av. Duq Caxias	1	4	3	33	3.1	6.9	-3.8

OCR: OBSERVED CRITICAL RATE
ECR: EXPECTED CRITICAL RATE

8. IMPLEMENTED POLICIES AND ACTIONS

Between 2012 and 2016, the paradigm of urban planning has undergone an evolution, strongly incorporating the concepts that prioritize sustainable modes of transportation such as public transport, bicycles, pedestrian circulation, as well as the concept of preservation of human life as a motto for the coexistence of road users, strengthening a vision of global safety in traffic.

The City of Fortaleza understands the dramatic dimension of road safety problem, not only for the city itself, but also at a global level. Such problematic context demands an analytical approach to integrate several fields of knowledge, as well as multi-sectorial and multi-thematic proposals for intervention. For this purpose, in December of 2015, the City of Fortaleza released the Traffic Safety Program (Programa de Segurança no Trânsito), consisting of actions on the fronts of Traffic Engineering (Urban Design), Traffic Enforcement and Education and Data Generation and Analysis.

Therefore, this section includes the set of interventions that have been implemented since 2013 in the fields of Urban Design, Traffic Enforcement and Education and Data Generation and Analysis.

The first theme, Urban Design, presents the infrastructural interventions, encompassing the Expansion of Cycle Network Program (Programa de Expansão da Malha Cicloviária), the Implementation of Exclusive Lanes Program (Programa de Implantação de Faixas Exclusivas), the Slow-Speed Zone (Área de Trânsito Calmo) and the Support to Pedestrian Circulation Program (Programa de Apoio à Circulação de Pedestres). After that, the actions on enforcement are presented, specifically focusing on prevention and monitoring of risky behavior, followed by the achievements in the field of traffic education, which increasingly fostered the ideals of road safety based on the protection of life and prioritization of the physically more fragile modes of transport. Finally, the actions undertaken with regard to the recording and analysis of traffic crashes data that subsidize the aforementioned actions are presented.

FIGURE 35: DIAGONAL CROSSINGS AT INTERSECTION OF AV. 13 DE MAIO AND AV. DA UNIVERSIDADE

EXPANSION OF CYCLING INFRASTRUCTURE PROGRAM

Between 2013 and 2016, the cycling road network of Fortaleza increased by 180%, and its infrastructure was allocated in accordance with the recommendations of the Cycling Master Plan (Plano Diretor Cicloviário). In absolute numbers, the network grew from 68.4 km to 193.8 km during that period. The act of cycling becomes more comfortable as a consequence of the reorganization of the road space, which aims to provide safer commuting for cyclists.

Making the roads friendlier to cyclists impacts their flow, as exemplified by its growth of 70% in Rua Ana Bilhar between 2013 and 2014. Simultaneously to the treatment of the streets network, the City of Fortaleza encouraged the use of bicycles as a mode of transport by implementing 80 bicycle share stations (Bicicletar system) and 5 bicycle rental stations (Bicicleta Integrada system). Both systems are integrated to the public transportation system, which ensures they are free of charge to those who have a Bilhete Único (Unified Ticket), the municipal transit card.

IMPLEMENTATION OF BUS DEDICATED LANES PROGRAM

The prioritization of collective transport is also an action that favors the increase of road safety and traffic humanization, as the improvement in quality and efficiency of this mode makes it more attractive than other means of transportation historically more prone to be involved in traffic crashes, like motorcycles. Between 2013 and 2015, the extension of bus dedicated lanes in Fortaleza grew from 3.3 km to 98.2 km. Such intervention directly impacts the operational speed of transit, as observed at Av. Dom Luiz and Av. Santos Dumont. Transit vehicles presented a speed increase of 144% and 207% on these avenues, respectively, during the peak hour.

FIGURE 36: BICYCLE SHARE STATION OF BICICLETA AT PARANGABA TRANSIT HUB

OPTIMIZING TRAFFIC FLOW

It is possible to reduce the number of conflict areas, as well as to implement bus and bicycle lanes, by redistributing the direction of streets and avenues and optimizing the traffic flow with an adequate treatment of adjacent areas and cross streets. For this purpose, some interventions were executed between 2014 and 2016, in the neighborhoods of Montese, Messejana, Aldeota, Rodolfo Teófilo, Parangaba, São Gerardo, Parquelândia, Papicu, Bela Vista, among others.

FIGURE 37: BICYCLE LANE AT AV. RUI BARBOSA

A INTEGRADA SYSTEM

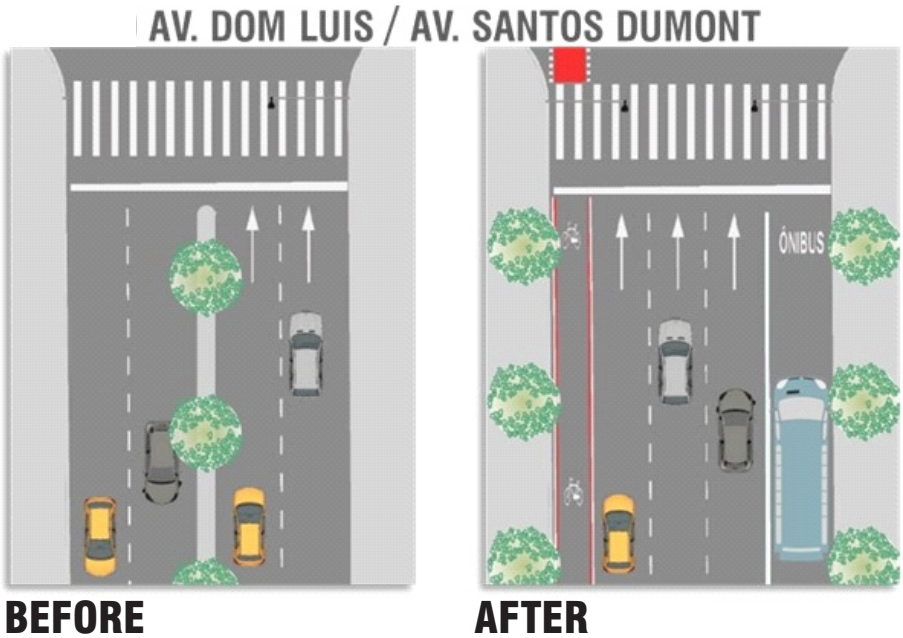


FIGURE 38: CHANGING OF ROAD CIRCULATION, BETWEEN AV. DOM LUIS AND AV. SANTOS DUMONT

SLOW-SPEED ZONE

In 2016, the first Slow-Speed Zone (Área de Trânsito Calmo) was inaugurated in Fortaleza, in an area containing hospitals and the Universidade Federal do Ceará – UFC (Federal University of Ceará) campus Porangabussu, in neighborhood Rodolfo Teófilo. In a given block, fourteen sidewalks were extended, three raised crossings were implemented, the speed limit was reduced to 30 km/h and the vertical and horizontal elements of signage were remodeled, focusing the pedestrian as the priority user on the area.

SUPPORT TO PEDESTRIAN CIRCULATION PROGRAM

This project consists of the implementation of different infrastructural elements, such as sidewalk extensions, raised crossings, refugee islands, diagonal crossings and educational speed bumps, which are distributed in strategic locations of the road system with the purpose of increasing the road safety for pedestrians.

FIGURE 39: VERTICAL AND HORIZONTAL SIGNAGE - SLOW-SPEED ZONE

FIGURE 40: RAISED CROSSING, M MICRO-ACCESSIBILITY AT SLOW-SPEED ZONE

Between 2015 and 2016, 26 raised crossings were implemented, along with other strategies as direct sources of lighting, reduction of local speed limit to 30 km/h or 40 km/h, installation of regulation signage, tactile paving, remodeling and broadening of sidewalk, in addition to educational and communication actions involving the local community. The pilot project that guided this type of infrastructure was first implemented in four spots of neighborhood Messejana, in front of public schools. It was successfully accepted by part of the population and later became a policy to be expanded citywide.

In 2016, three diagonal crossings were implemented, infrastructural elements that, besides ensuring safety, optimize pedestrian crossing times in intersections with high vehicular volumes. Six refugee islands were built to reduce the exposure risk for pedestrians.

FIGURE 41: SPEED LIMIT IMPLEMENTED AT SLOW-SPEED ZONE PILOT PROJECT. NEIGHBORHOOD RODOLFO TEÓFILO

**IEDIAN EXTENSION AND MEASURES OF
:, WITH MAXIMUM SPEED REGULATED TO 30 KM/H**

FIGURE 42: RAISED PEDESTRIAN CROSSING IMPLEMENTED AS PART OF THE SUPPORT FOR PEDESTRIANS CIRCULATION PROGRAM

EDUCATION

The educational process was applied focusing on two convergent targets. Firstly, it is necessary to foster the positive behavioral change of the various types of users, aiming to reduce morbidity and mortality in traffic. AMC's Traffic Education Management (Gerência de Educação para o Trânsito) developed and executed several campaigns with specific focuses according to the different types of users.

Besides the dissemination of contents about traffic laws and safe conducts, there is a task of spreading quality information concerning the problem of traffic violence, performed in order to make society understand the tragic dimension of the number related to injuries and deaths and the overburden of the health public system.

With this information, it is possible to understand that the user behavior in traffic is largely responsible for its problems, but can also help promote the solution.

As a transversal educational* and basis action, the City of Fortaleza re-inaugurated the School of Mobility and Traffic (Escola de Mobilidade e Trânsito), that focuses on early childhood education, teaching basic concepts and stimulating peaceful and safe coexistence of different modes. Educational campaigns focused on inadequate use of helmet and the act of drinking and driving, are planned to take place in 2017.

FIGURE 43: EDUCATIONAL ACTION FOCUSED IN URBAN CYCLING DIRECTED TO CHILDREN – RE-INAUGURATION OF THE SCHOOL OF TRAFFIC AND MOBILITY

FIGURE 44: EDUCATIONAL ACTIONS FOCUSED IN PEDESTRIANS, CYCLISTS AND MOTORCYCLISTS

The World Health Organization recognizes the laws based on evidences that provide for strict and adequate sanctions, in addition to education, as a relevant factor for prevention and reduction of number of fatal and injured victims of traffic crashes.

In this context, AMC resumed enforcement checkpoints in 2015, specifically aiming to combat the risk factors caused by the lack or inadequate use of helmets by motorcyclists and the act of drinking and driving. Simultaneously, the Manual of Operational Procedures (Manual de Procedimentos Operacionais) was elaborated, standardizing the procedures adopted by traffic agents and establishing the processes for the correct installation of blitzes.

Another relevant step consisted of the acquisition of equipment to measure blood alcohol level, which increased the reach of enforcement actions in the fight against this risk factor.

FOTO: EDUARDO BIAVATI

FIGURE 45: AMC AGENTS TAKING A COURSE ON THE STANDARD OPERATIONAL PROCEDURES MANUAL

FOTO: EDUARDO BIAVATI

FIGURE 46: CHECKPOINT (BLITZ) FOCUSED ON THE USE AND/OR PROPER USE OF HELMET

In 2015, the processes of integration and tabulation of data related to traffic crashes coming from over 10 sources were resumed. Among these sources, there were institutions representing the areas of health, public security and traffic agency. The compilation of this set of information is the foundation to describe the patterns of traffic crashes, making it possible to identify critical regions and periods and define the profile of injured and fatal victims.

For this purpose, an effort was made to promote an institutional rapprochement of AMC and its contributing sources through meetings to present SIAT and its objectives and results. On these summits, technical details were discussed aiming at improving the processes of sharing and integration of databases.

The analysis obtained from the consolidation of traffic crashes statistics allowed for starting planning actions of engineering, enforcement and education, disaggregating the goals of each project according to the types of users and the risk factors related to them. For example, placing checkpoints at locations and time slots with high number of injured motorcyclists.

In 2016, Comissão Gestora de Dados de Mortalidade (Death Review Committee) started working. This group is composed of members of SAMU, IJF, PEFOCE, SMS, AMC and SCSP with the objective of investigating the probable causes of death of all victims killed in traffic during that year. The meetings happen on a monthly basis and the debates result in quantitative and qualitative evaluation of the conditions of road signage and geometry, the medical and emergency services provided, the weather conditions and the victim risky behavior that may have contributed for a fatality

.

In addition to these actions, a survey on the incidence of risky behavior was carried out in Fortaleza, as the result of a partnership between Universidade Federal do Ceará (Federal University of Ceará) and Johns Hopkins University. Three stages were carried out between 2015 and 2016. The complete record of these last two productions will be published in Anuário de Acidente de Trânsito de 2016 (ANNUAL REPORT ON TRAFFIC CRASHES IN FORTALEZA, 2016).

FIGURE 48: INAUGURAL MEETING OF DEATH REVIEW COMMITTEE

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