



Driving under the Influence of Alcohol - Epidemiological Profile of the Victims in Mato Grosso State, Midwest Brazil

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Abstract. Blood Alcohol Concentration (BAC) refers to the amount of ethanol present in the blood of an individual. Ethanol is among the most common substances encountered in forensic toxicology because ethanol abuse is related to fatal traffic accidents and general anti-social behavior. The objective was to describe the profile of victims of fatal traffic accidents in the state of Mato Grosso between 2013 and 2015. We analyzed 3,045 case records from Mato Grosso state Official Public Forensic Institution, Politec. Positive results for the presence of ethanol in the blood of victims of fatal traffic accidents was higher for males 1,162 (83.1%), from 21 to 30 years of age, and occurred predominantly during the weekends. Traffic accidents in Cuiabá County had the highest mortality coefficient per 100 thousand inhabitants (28.9%) than the rest of the state. Regarding the months of the year, there was a homogenous distribution with a discrete predominance of cases in October, November and December. The incidents were more frequent between 22h, 8h and 11h/12h am. This study contributes not only for the identification of the individuals most likely to be involved in traffic accidents where ethanol was consumed, but also to subsidize public policies aimed towards intervening and raising awareness of damages due to association among driving and ethanol use or abuse.

Keywords: Blood alcohol concentration; Ethanol; Forensic toxicology; Fatal traffic accidents.

1. Introduction

Blood Alcohol Concentration (BAC) is the level of alcohol present in the blood of an individual, or, in other words, the amount of alcohol per liter of blood¹.

Ethyl alcohol, popularly known as simply alcohol, is among the most common substances in forensic toxicology, since its consumption and abuse are usually related to fatal accidents, traumatic deaths, suicides, violent crimes and general anti-social behavior².

Ethanol is absorbed mainly through the digestive system, while the small intestine is the region where most of the substance (80%) is absorbed. Ethanol absorption occurs through simple diffusion and its distribution to the tissues is fast^{3,4}. Ethanol plasmatic concentration reaches its peak from 30 to 90 minutes after ingestion³.

Around 2% of the ingested ethanol is excreted, usually unaltered, mainly by kidneys and lungs. When high doses are consumed, this value could reach 10%^{3,5}. The level of ethanol in the blood relies mostly on three factors: the amount ingested, the speed of absorption in the digestive tract and the elimination capability of the organism through biotransformation and excretion⁶.

Traffic accidents, as an important factor of general morbidity, are considered to be a true public health issue in many countries, especially in Brazil⁷. The combination of drugs (including ethanol) and driving is considered the cause of great part of traffic accidents, especially the ones with high severity index^{8,9}. Researches performed during the last 50 years have shown the direct relationship between drivers' BAC levels and the risk of accidents¹⁰.

According to Hoffmann¹⁰, traffic accidents can be considered an extremely severe socioeconomic phenomenon, both due to the growing indexes perceived in a national and international perspective as well as due to their fatality. Worldwide, around 700 thousand deaths occur due to traffic accidents and over 15 million individuals are injured in these incidents.

According to the latest report depicting road safety, developed by AMBEV & FALCONI¹¹ and organized by the World Health Organization (WHO), violence in traffic has become an epidemic. It did not appear among the main causes of death in

2010 but it was 10th on the list in 2015. If changes are not readily implemented, it is predicted that it will be 7th cause of death by 2030.

Due to the necessity of public regulation for the reduction in traffic accidents involving alcohol consumption in Brazil, law n^o 11705/2008 was enacted, limiting BAC to under 0.6 mg/L. According to Art. 276 of the Brazilian Traffic Code, “any concentration of alcohol per liter of blood subjects the driver to the sanctions provisioned in Art. 165 of this code”. However, after that law went into effect, the number of traffic accidents was maintained, suggesting that a change in drivers’ behavior should take place, since these behavior changes did not occur as expected¹².

In this regard, law n^o 12760/2012 went into effect, known popularly as “the new dry law”, altering the following articles of the Brazilian traffic code: 165, 262, 270, 276, 277 and 306. In order to promote the reduction of traffic accidents associated with alcohol consumption, that law states that: “any concentration of alcohol per liter of blood or per liter of alveolar air subjects the driver to the sanctions provisioned in Art. 165 of this code”¹³.

As reported by the National Health Survey (PNS), led by the Ministry of Health in partnership with the Brazilian Institute of Geography and Statistics (IBGE), 24.3% of Brazilian drivers admit to abusing alcoholic beverage and driving. Therefore, the survey indicates that one in four persons admits to driving after drinking alcohol¹⁴.

In December of 2017, law n^o 13,546/2017 passed, altering the Brazilian traffic code, which went into effect on April 19, 2018. The sanction was raised for drivers that kill or injure people in traffic after consuming alcohol or other psychoactive drug¹⁴.

In Mato Grosso, BAC exams are performed using gas chromatography, which is the physicochemical method of separation where sample components are separated when it is injected inside a column and comes into contact with two phases: the mobile and stationary phases. The mobile phase is composed of an inert gas and the stationary phase is composed of liquid or polymer on a solid support, where separation takes place through adsorption or partition processes¹⁵.

Currently, a gas chromatograph associated with a headspace sampler is the most used equipment for BAC exams. This association can extend the lifespan of the column and prevent the contamination of the sample injector while also being a very

well established technique in forensic toxicology for decades¹⁶⁻²⁰. The blood samples are vacuum collected in a tube containing 1% sodium fluoride due to its preservative and anticlotting properties³.

According to everything that was stated above, this study aimed at describing the epidemiological profile of the victims of traffic accidents in the state of Mato Grosso, Brazil, through assessment of case records from 2013 to 2015.

2. Materials and Methods

The study was regulated by a formal consent of the Official Public Forensic Institution State of Mato Grosso, using the documentary records of the institution during the period established, with the participation of researchers from educational institutions and technical professionals from Official Public Forensic Institution. This research based its results on documentary records on file, being this research was approved by the Research Ethics Committee under the register (CAAE nº. 407494.14.4.0000.5167).

This is an epidemiologic retrospective-descriptive study with quantitative approach, using statistical methods. The study was carried out in the Cuiabá County, Midwest Brazil, comprising data from all of the state's counties, with population around 3,265,486 inhabitants²¹.

Of the 141 Counties in Mato Grosso state, the four most populated (over 100,000 inhabitants) are: Cuiabá, 590,118 inhabitants; Várzea Grande 268,594; Rondonópolis, 215,320 and Sinop, 129,916 inhabitants²¹.

In this study, we included 3,045 entrances of victims of traffic accidents in Cuiabá County, located at the coordinates 15° 35' 46" - 56° 05' 48", using demographic variables obtained from BAC exams of these victims. The study took place in the government forensic institution Politec, at the Forensic Laboratory, where case records were archived.

BAC exams were considered positive when levels were above 0.6 mg/L, according to Brazilian law.

Data were compiled using Microsoft Excel[®] 2010 software. Case records of traffic accidents (collision, run over, motorcycle fall, rollover, among others) that occurred from January 1st, 2013 to December 31st, 2015 were analyzed. Mortality Coefficients by traffic accidents were calculated for 100 thousand inhabitants, where the numerator was the number of deaths by traffic accidents and the denominator,

the number of inhabitants of the respective County. The size of the population was obtained from 2015 estimates of the Brazilian Institute of Geography and Statistics (IBGE).

3. Results

From the 3,045 samples sent for BAC exam at the Politec forensic laboratory, there were 2,498 (82.1%) occurrences of death in public highways (cyclists, motorcycle fall, collision, run over and rollover), 498 (16.3%) deaths at hospitals soon after the accident and 49 (1.6%) were not informed (Table 1).

From the measurements of alcoholic dosages performed, 1,647 (54.1%) records resulted negative measurement and 1,398 (45.9%) records had their blood pressure checked positive. Of the positive records, 863 (61.7%) were drivers, 236 (16.9%) were passengers and 299 (21.4%) were pedestrians. Considering the observed data, it is possible to verify a balance between the qualitative results of the victims of traffic accidents in the municipalities of the State of Mato Grosso in the period from 2013 to 2015.

With respect to qualitative results, the outcome was balanced: 1,647 (54.1%) samples were negative, and 1,398 (45.9%) were positive. These data confirm the initial hypothesis that a significant number of fatal traffic accident victims in the time period and region studied reached BAC levels above the limit established by Brazilian legislation.

The number of victims related to recklessness in traffic shows that 2,696 (88.5%) were males and 349 (11.5%) were females. Of the victims that presented positive BAC results ($n=1,398/45.9\%$) it was observed that 83.1% of the cases studied were related to males (1,162 records) and 16.9% to females (236 records). It was evident the massive contribution of males as victims of alcohol abuse.

When assessing the age group of the victims of traffic accidents in this study, it was verified that most of the individuals involved were young, with age ranging from 21 to 30 (32.9%) and of the male gender. The next age groups were 31 to 40 (24.6%) and 41 to 50 (16.2%) (Table 1).

Twenty-three counties in Mato Grosso State appeared in the BAC exam records analyzed: Água Boa, Alta Floresta, Araguaia, Barra do Garças, Cáceres, Campo Novo dos Parecis, Chapada do Guimarães, Confresa, Cuiabá, Várzea Grande, Diamantino, Juína, Lucas do Rio Verde, Poconé, Pontes e Lacerda, Porto

Alegre do Norte, Primavera do Leste, Rio Branco, Rondonópolis, Sinop, Sorriso, Tangará da Serra and Vila Rica.

Table 1. Characteristics of individuals involved in traffic accidents, from 2013 to 2015 in Mato Grosso state counties.

Demographic variables	2013		2014		2015		TOTAL	
	N	%	N	%	N	%	N	%
Gender	705		1,142		1,198		3,045	
Male	635	90.1	998	87.4	1,063	88.7	2,696	88.5
Female	70	9.9	144	12.6	135	11.3	349	11.5
Ethnicity/ skin color								
White	109	15.5	292	25.6	302	25.2	703	23.1
Black	227	32.2	307	26.9	323	27.0	857	28.1
Yellow	43	6.1	69	6.0	92	7.7	204	6.7
Indigenous	17	2.4	32	2.8	33	2.7	82	2.7
Brown	306	43.4	437	38.3	440	36.7	1,183	38.9
Not informed	3	0.4	5	0.4	8	0.7	16	0.5
Educational level								
Primary education	232	32.9	375	32.9	324	27.0	931	30.6
Secondary education	275	39.0	391	34.2	409	34.1	1,075	35.3
Higher education	182	25.8	353	30.9	450	37.6	985	32.3
Not informed	16	2.3	23	2.0	15	1.3	54	1.8
BAC exam								
Positive	335	47.5	517	45.3	546	45.6	1,398	45.9
Negative	370	52.5	625	54.7	652	54.4	1,647	54.1
Death								
At hospital (after accident)	92	13.0	198	17.3	208	17.4	498	16.4
Highway (cyclist)	23	3.3	26	2.3	32	2.7	81	2.7
Highway (motorcycle fall)	43	6.2	72	6.3	97	8.1	212	7.0
Highway (collision)	48	6.8	55	4.8	78	6.5	181	5.9
Highway (rollover)	10	1.4	13	1.1	15	1.2	38	1.2
Highway (run over)	232	32.9	387	33.9	449	37.5	1,068	35.1
Highway (collision+run over)	244	34.6	355	31.1	319	26.6	918	30.1
Not informed	13	1.8	36	3.2	0	0.0	49	1.6
Day of the week								
Sunday	149	21.1	268	23.5	231	19.3	648	21.3
Monday	107	15.2	187	16.4	189	15.8	483	15.9
Tuesday	82	11.6	117	10.2	149	12.4	348	11.4
Wednesday	58	8.2	121	10.6	157	13.1	336	11.0
Thursday	80	11.3	120	10.5	135	11.3	335	11.0
Friday	103	14.6	121	10.6	142	11.9	366	12.0
Saturday	124	17.6	205	18.0	192	16.0	521	17.1
Not informed	2	0.3	3	0.3	3	0.3	8	0.3
Age group (years)								
under 10	0	0.0	7	0.6	7	0.6	14	0.5

11—20	86	12.2	126	11.0	142	11.9	354	11.6
21—30	189	26.8	316	27.7	477	39.8	982	32.2
31—40	206	29.2	326	28.5	217	18.1	749	24.6
41—50	120	17.0	200	17.5	173	14.4	493	16.2
51—60	65	9.2	102	8.9	105	8.8	272	8.9
61—70	25	3.5	43	3.8	55	4.6	123	4.0
71—80	9	1.3	11	1.0	19	1.6	39	1.3
81—90	5	0.7	8	0.7	2	0.2	15	0.5
91—96	0	0.0	3	0.3	1	0.1	4	0.1
Month								
January	40	5.7	88	7.7	108	9.0	236	7.8
February	33	4.7	87	7.6	94	7.8	214	7.0
March	49	7.0	76	6.7	69	5.8	194	6.4
April	47	6.7	78	6.8	100	8.3	225	7.4
May	68	9.6	86	7.5	102	8.5	256	8.4
June	49	7.0	91	8.0	113	9.4	253	8.3
July	47	6.7	66	5.8	121	10.1	234	7.7
August	61	8.7	118	10.3	97	8.1	276	9.1
September	103	14.6	96	8.4	79	6.6	278	9.1
October	66	9.4	120	10.5	100	8.3	286	9.4
November	66	9.4	112	9.8	114	9.5	292	9.6
December	76	10.8	124	10.9	101	8.4	301	9.9
County								
Água boa	13	1.8	28	2.5	16	1.3	57	1.9
Alta floresta	3	0.4	24	2.1	25	2.1	52	1.7
Araguaia	0	0.0	3	0.3	0	0.0	3	0.1
Barra do Garças	25	3.5	26	2.3	20	1.7	71	2.3
Cáceres	22	3.1	44	3.9	47	3.9	113	3.7
Campo Novo dos Parecis	0	0.0	0	0.0	1	0.1	1	0.0
Chapada dos Guimarães	0	0.0	3	0.3	3	0.3	6	0.2
Confresa	3	0.4	34	3.0	45	3.8	82	2.7
Cuiabá	334	47.4	639	56.0	735	61.4	1,708	56.1
Diamantino	3	0.4	9	0.8	62	5.2	74	2.4
Juína	0	0.0	4	0.4	3	0.3	7	0.2
Lucas do Rio Verde	2	0.3	0	0.0	2	0.2	4	0.1
Poconé	0	0.0	1	0.1	0	0.0	1	0.0
Pontes e Lacerda	1	0.1	12	1.1	7	0.6	20	0.7
Porto Alegre do Norte	0	0.0	3	0.3	0	0.0	3	0.1
Primavera do Leste	77	10.9	80	7.0	30	2.5	187	6.1
Rio Branco	0	0.0	0	0.0	1	0.1	1	0.0
Rondonópolis	61	8.7	69	6.0	53	4.4	183	6.0
Sinop	91	12.9	71	6.2	57	4.8	219	7.2
Sorriso	13	1.8	35	3.1	32	2.7	80	2.6
Tangará da Serra	49	7.0	51	4.5	45	3.8	145	4.8
Várzea Grande	3	0.4	4	0.4	7	0.6	14	0.5
Vila Rica	5	0.7	2	0.2	7	0.6	14	0.5

Total	705	100	1,142	100	1,192	100	3,045	100
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Five counties: Cuiabá (1,708) records, Sinop (219) records, Primavera do Leste (187) records, Rondonópolis (183) and Tangará da Serra (155) records, were considered the highest accident indexes caused by alcohol consumption (Table 1). However, according to data from IBGE²¹ the counties of Cuiabá, Várzea Grande, Sinop and Rondonópolis presented indexes above 100,000 inhabitants.

Thus, it was possible to observe that individuals in Cuiabá city showed a higher index (28.9 cases/100,000 inhabitants), followed by Sinop (16.8 cases/100,000 inhabitants) and Rondonópolis (8.3 cases/100,000 inhabitants). Although Sinop region shows the second highest number of this type of cases, Rondonópolis had a lower indicator, which suggests its population is less likely to be involved in accidents when compared with people in Sinop.

In relation to the period in which the accidents occurred, the highest incidence occurred at around 22h. (2013, 2014 and 2015). There were also peaks in the morning hours around 22h in the three consecutive years. In the evening period observed activity between 2h and 4h. In the night time, the activities sinister of the accident were observed at 8h, showing its peak during the night between 23h and 0h (Figure 1).

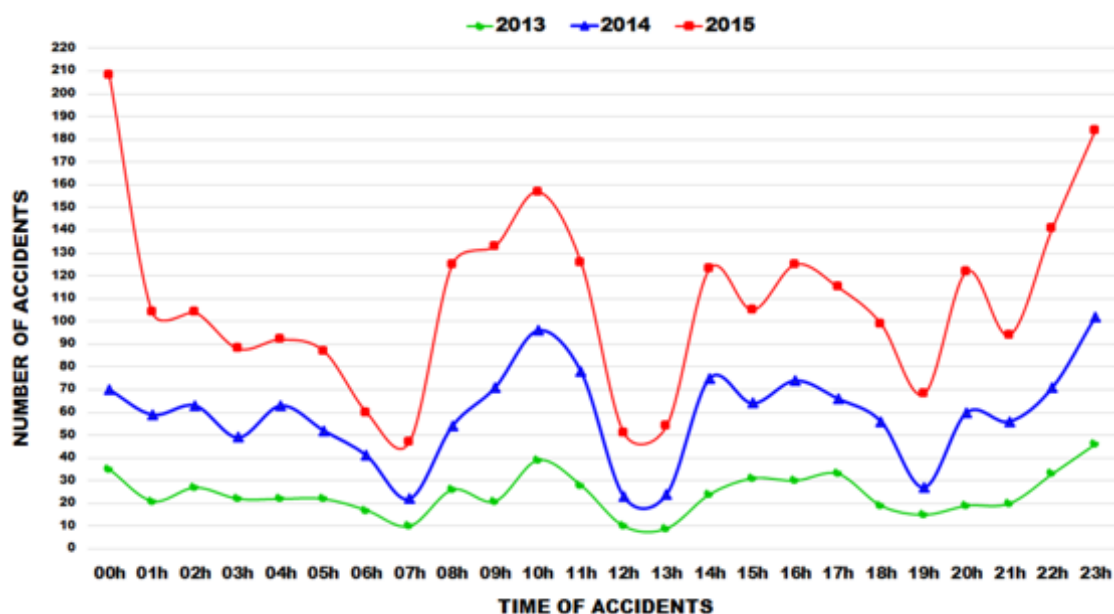


Figure 1. Traffic accidents ($N = 3,045$) recorded at Politec according to the time of the incident in the police report.

4. Discussion

Depending on BAC levels, numerous neuromotor alterations can be perceived. Even at low doses, the attention is decreased; there is euphoria, a false perception of speed and difficulty in discerning light intensity²².

Ethanol is absorbed into the blood stream at different rates by different individuals. Those rates can be observed in the circadian rhythm of each person^{23,24} according to consumers' gender and age group^{25,26}, bodily water available²⁷, genetic and ethnic features^{28,29} and associated ingestion of ethanol and food^{30,31}. Each of those factors is considered to affect ethanol absorption and metabolism.

Several countries have established legal limits for drivers BAC, while some even have lowered their values under the Brazilian limit of 0.6 mg/L³². In countries such as Poland and Sweden, BAC limit is 0.2 mg/L, in Japan and Russia, the limit is 0.3 mg/L^{33,34}. In Portugal, Peru, Australia, France, Finland, Bulgaria, Hungary, Spain, Scotland, Italy, South Africa, Belgium, Denmark, Germany and Turkey it is equal to or below 0.5 mg/L^{33,34,35}.

In Canada, Romania, England, Jamaica, Kenya, Paraguay and Singapore the allowed BAC is 0.8 mg/L, while in the USA, 0 to 0.2 mg/L is an acceptable BAC level for people under 21 years old, varying between states from 0.1 to 0.5 mg/L. In the USA BAC levels are usually used for criminal purposes or license suspension^{33,34}.

The new Brazilian Traffic Code (CTB) establishes penalties referring to crimes committed while driving automobiles¹⁴.

There are countries that have established low BAC limits ($\leq 0.6\%$), such as Chile, Colombia and Mexico³⁴. Random employment of breathalyzer also varies in different countries. Costa Rica, for example, utilizes this resource frequently, whereas Bolivia uses it sporadically⁹.

The number of victims related in the results found in this study meet the trend found in other studies performed in different Brazilian cities, where male victims predominated³⁶⁻³⁹.

The male gender was the most representative in this study, with age ranging from 21 to 30. Other authors³⁹⁻⁴¹ have found similar results in their studies, where victims were predominantly young and male.

The conservation of the mortality and hospitalization rates as well as the rising number of deaths involving traffic accidents suggest Brazil's strategy and

policies to tackle the problem are not working⁴². Researchers indicate that Brazil is still in an initial stage of awareness of driving under the effects of alcohol as a public health issue. The few existing statistics point towards a concerning behavioral condition^{41,43,44}.

Other authors confirm that these individuals tend to show a risky behavior that could potentially cause accidents due to the socio-cultural profile and aggressiveness in traffic^{36,38,39,45,46}.

The report organized by the WHO, depicting highway safety, ranks the Brazilian states according to the number of deaths by traffic accidents in 2015, and presents Mato Grosso state in 14th place (83%). São Paulo state leads the ranking in absolute numbers of deaths in Brazil. In the Midwest region, a reduction of 13.1% was observed in 2015 in comparison to the previous year. Nevertheless, in terms of number of deaths per 100 thousand inhabitants, Midwest region was the most violent, with a rate of 26.6%¹¹. These findings were also reported by Malta⁴¹, who showed that the Midwest region had a higher index in ethanol consumption and driving.

According to Mato Grosso State Department of Traffic (DETRAN), in 2015, 67.9% of the licensed drivers in the state were male⁴⁶.

According to Bastos⁴⁷ behavior theories have generated hypotheses as to why teenagers and young adults are more likely to be involved in traffic accidents and acts of violence. Inexperience, search for emotion, pleasure in appreciating risky situations, impulsiveness and alcohol or drug abuse are factors that could be associated to a higher incidence of traffic accidents in this group.

It is worth noting the strong stimulus towards alcohol consumption through massive advertising aimed mainly at the younger individuals, acknowledged by the own industry²². The strong rise in alcohol consumption represents a serious challenge for the implementation of actions that focus on reducing traffic accident and urban violence morbimortality indexes^{22,48}.

In 2010, the WHO approved, in a text signed by 193 countries, the restriction of beer advertising as a strategic solution to decreasing violence in traffic. WHO data show that alcohol is the causative agent of 4% of deaths worldwide, killing more people than AIDS and tuberculosis²². The younger audience, especially of the male gender, represents the bigger portion of the victims. The data presented obey the 10th ICD (International Classification of Diseases)⁴⁹.

In this article Twenty-three counties in Mato Grosso State appeared in the BAC exam records analyzed, being five cities considered the highest accident caused by alcohol consumption. A research performed in the Brazilian state of Santa Catarina by Fey⁵⁰ showed that traffic accidents with victims occurred mostly on Sundays and Saturdays, respectively. In Mato Grosso, the findings were similar, with highest indexes on Sundays 648 (21.3%), Saturdays 521 (17.1%) and Mondays 483 (15.9%), respectively (Table 01). Contrastingly, Biffe³⁹ reported that in São Paulo, accidents peaked on Thursdays, Fridays, Saturdays and Sundays, respectively.

In Mato Grosso State, the Traffic Department reported that, in the last five years, Saturday was the day in which most traffic accidents occurred⁴⁶.

Since the number of traffic accidents involving alcohol is highest during the weekends, we might assume that in this period, alcohol consumption is greater, which is compatible with the culture of alcohol consumption in recreational and social situations^{51,52} (Table 1).

The considerable number of cases reported on Monday could be explained by the way in which sample collection is performed. The samples collected on Monday are possibly also composed from accidents that occurred on Sunday, since Brazilian legislation states that the autopsy must be performed at least six hours after death, except when signs of death are deemed to be obvious. On a technical point of view, it is recommended that autopsies be performed during the day under natural light⁵³.

Kugelberg and Jones⁵⁴ say that BAC levels are usually used as evidence in civil and criminal cases. Dubowski⁵⁵ clarifies that alcohol concentration in blood or exhaled air constitutes the most objective indicator of the compromise in driving abilities related to alcohol consumption.

In all cases studied, autopsies were performed in the first 24 hours after death, avoiding the effects of putrefaction and liver metabolism. Kugelberg and Jones⁵⁴ state that there is no significant alteration in bodily alcohol concentration after death until the beginning of the biological decomposition state, in contrast to what Lemos⁵⁶ reported when analyzing alcohol concentration in blood, breath, urine, saliva and vitreous humor.

Strategies aimed towards decreasing driving under alcohol use, such as license suspension, coercive actions, breathalyzer use by law enforcement and lowering of maximum speed limit, have effectively decreased the number of fatal

victims in 62%, according to the Brazilian Association of Traffic Medicine (ABRAMET). Intense informational and inspectional efforts to reduce drivers' alcohol consumption by the highway police may also be effective measures to prevent traffic accidents involving alcohol^{57,58}.

The observations pertinent to young drivers, in direct comparison; allows us to inquire that this information shows a greater impact in engaging in an accident at night than in the morning, even with the excess risk that is considerably greater during the day (Fig.01). The results presented in this study are in agreement with the records found by researchers in Sweden⁵⁹ and researchers in Canada⁶⁰, explaining that exposure to these peak times is mainly related to the fatigue of vehicle drivers offering men twice the risk during the dawn. The results of this study are consistent with records found by Rice⁶¹ who stated in her records that driving at night, using alcohol, being young and adolescent, and being male were considered factors for the high rates of auto accidents in California/USA.

5. Conclusions

The results presented in this study show the relevance of the involvement of ethanol in traffic accidents with fatal victims. We observed a higher frequency of young males, between 21 and 30 years old, with accidents happening mostly on weekends and during the night.

This information demonstrates the influence of the current lifestyle and recreational social activities that, oftentimes, stimulate alcohol abuse. It was also observed that individuals residing in the counties of Primavera do Leste and Cuiabá are more likely to be involved in traffic accidents with alcohol consumption per 100 thousand inhabitants compared to other counties in the state.

The present study contributes to statistical analyses on individuals most likely to be involved in traffic accidents due to alcohol consumption, but also to subsidize improvement in public policies aimed towards the awareness of damages associated with driving and alcohol use. This study also provides information to health and public safety professional by identifying the population group most likely to be involved in these kinds of accidents, consequently aiding in the planning of preventive and interceptive actions.

Conflict of Interest

All authors declared that there is no conflict of interest.

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