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Alcohol in combination with illicit drugs among fatal injuries in Sao Paulo, Brazil: an epidemiological study on the association between acute substance use and injury

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Abstract

Injury deaths have a major impact on public health systems, particularly in the Latin American region; however, little is known about how different drugs, in combination or not with alcohol, interact with each injury type. We tested an epidemiological protocol for investigating alcohol and other drug acute use among fatally injured victims taking into account the injury context for all injury causes in Sao Paulo, Brazil. Blood alcohol and drug content were fully screened and confirmed following a probability sample selection of decedents (n=365) during 19 consecutive months (2014–2015). Drug concentrations, including benzodiazepines, cannabis, cocaine, and opioids were determined by gas chromatography-mass spectrometry (GC-MS) or liquid chromatography tandem mass spectrometry (LC-MS/MS). Toxicology data were interpreted in combination with injury context retrieved from police records regarding cause, place of injury, and victims' criminal history. More than half of all fatally injured victims studied were under the influence of at least one substance (55.3%). Alcohol was the leading substance consumed before a fatal injury event (30.1%), followed by cocaine (21.9%) and cannabis (14%). Illicit drug use (cocaine and cannabis) comprised more than two thirds of all drug-related deaths. Alcohol-positive deaths are over-represented among road traffic injuries, while drug-positive deaths are more prevalent among intentional injuries. Victims who had previous criminal convictions were significantly more likely to have used illicit drugs compared to those who did not have a criminal

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background. We estimated that one in every two fatal injuries in the city of Sao Paulo is associated with acute substance use by the victim. The health burden attributed to alcohol- and drug-related fatal injury events has reached significant higher levels in Latin American cities such as Sao Paulo compared globally.

Keywords

Alcohol; Deaths; Drugs; Epidemiology; Illicit; Injury

1. Introduction

The question of whether the use of psychoactive drugs other than alcohol is related to injury events has gained greater attention recently in the literature (1), particularly influenced by the fact that many jurisdictions in the world are now decriminalizing or even legalizing the recreational use of drugs such as cannabis (2,3). For instance, cannabis use has been reportedly increasing in emergency facilities, but data on fatal injuries and the effects of acute substance use on these deaths are still scant (4).

Injuries, both intentional and unintentional provoked by the acute exposure to physical trauma (5), compose a major portion of the burden of disease and health care costs (6,7). Although there seems to be a strong association between the acute combined use of substances (the so-called synergistic effect) and injuries (8), studies continue to demonstrate that alcohol plays a bigger role among road traffic and violence-related injuries compared to use of any other drug (9,10).

Post-mortem blood specimens collected on a population-representative basis offers the opportunity to study accurately the effect of the acute use of substances on fatal injury deaths (11). However, that is not always the case, especially in low- to middle-income countries where the lack of large-scale routine drug testing procedures among fatal trauma victims is commonplace.

As a consequence, there are either no epidemiological data at the population level for drugs commonly consumed (4), or there is a series of biases in the data available that inform policies despite the apparent lack of a clear definition of drug-related consequences. Furthermore, while systematic data collection on substance use among fatal injuries is encouraged by international organizations (4,12), very little has been done to understand the complex “context of drug use” (13) that might be linked to injuries (e.g. substances consumed in combination with criminal activities).

Given this, there is an important need to advance systems of data collection on substance use among injured victims, especially in the Latin American region, where both road traffic injuries (12) and interpersonal violence (14) have assumed epidemic proportions during the last half-century. Here, we report data retrieved from an epidemiological study on acute use of multiple substances associated with fatal injury events using the first representative sample of fatally injured victims from the largest city in Brazil.

2. Methods

2.1. Study design and sample selection

We followed a probabilistic sampling method using the city of Sao Paulo as the targeted population. Cases were fatally injured adult victims who had a sudden, unexpected, violent or otherwise non-natural cause of death (i.e. external causes of death) from the main forensic medical facilities that serve the entire city of Sao Paulo and its 96 regions (districts). Every cause of death meeting the parameters described above must undergo an autopsy procedure, with around 7,000 decedents autopsied each year in the city, mostly composed of homicides (26%) and traffic-related deaths (20%), followed by suicides (12%) (15).

All days and hours of the week were sampled in a similar proportion over a period of 19 months (from June 2014 to December 2015), generating a final sample representing all the causes of fatal injuries occurring during this period in the city (n=365). Blood was collected as soon as the body had arrived at the coroner's facility during the autopsy procedure. Victims who received 6 or more hours of medical treatment due to the injury event (or survived for the same period) prior to death were excluded. Blood specimens were obtained from the coronary sinus and/or the femoral vein, and kept refrigerated in Vacutainer® tubes containing sodium fluoride and ethylenediamine tetraacetic acid (EDTA).

The final sample was composed of a similar distribution of all fatal injuries registered in the city of Sao Paulo (15), demonstrating the population-based nature of this study's sample. We also minimized common biases in the investigation of substance use among deaths, such as avoiding using only victims who went through routine toxicological investigations (not all victims have postmortem blood analyzed for alcohol and drugs) or relying on non-standardized technical procedures for toxicology analysis in blood samples.

Patient identities were kept anonymous and strictly preserved throughout the project. Ethical procedures were approved by the Institutional Review Boards from both the Medical Legal Institute and the University of Sao Paulo Medical School (#096/14).

2.2. Toxicology data

Blood specimens from all victims included in the study were submitted to a comprehensive screening and subsequent confirmation (as required) of the positive cases for a variety of drugs and alcohol-related compounds. Blood alcohol concentration (BAC) was measured using headspace gas chromatography equipped with flame-ionization detection (HS-GC-FID) with a lower limit of quantification (LLQ) of 0.02% (w/v). Other drugs, including amphetamines, barbiturates, benzodiazepines, cannabis, cocaine, opioids/opiates (fentanyl, oxycodone, methadone, morphine, among others), and phencyclidine (PCP), were screened by enzyme-linked immunosorbent assay (ELISA) and confirmed/quantified as necessary by gas chromatography-mass spectrometry (GC-MS) or liquid chromatography tandem mass spectrometry (LC-MS/MS). The cutoffs used are detailed in Table 1.

Drug concentrations determined to be below the LLQ were reported if the signal to noise was greater than 3:1 (<LLQ). None of the specimens were confirmed positive for amphetamines or PCP. Confirmed positivity for barbiturates (0.5%) and opioids (3.3%) was

not considered for the purpose of our analysis, as these medications are commonly used in the emergency room (ER) for treatment of trauma. Although benzodiazepines (11.5%) could also be used in the ER, we kept the confirmed positives for this class of drugs among the positive results due to the great diversity of compounds found for this class of substances (Table 1).

Substance use was subsequently categorized into five general groups: any alcohol presence; at least one substance (positivity for alcohol and/or other drugs confirmed, except barbiturates and opioids); only alcohol (BAC positive but negative for any other drug use); only other drugs (BAC negative but positive for any other drug use); and two or more substances (positive for at least two different substances, including alcohol). Proportions for alcohol-positive and drug-positive cases are also reported together with other combinations, and refer to positivity for the respective groups of substances without mutually excluding concomitant use of other substances.

2.3. Sociodemographics, context of injury and criminal history

Medical records were reviewed throughout the data collection process and accessed more than once to ensure that conclusions about death investigations did not change during the study period (e.g. in the case of a revised death certificate issued by investigative authorities). Sociodemographic and injury context data were extracted at the time of the death investigation and checked by at least two different researchers after six months against a database maintained for forensic criminal investigation purposes.

Injuries were classified according to the cause of death (homicides, traffic-related, self-inflicted, falls, or poisoning, and all others) and the main weapon or method that caused the injury (e.g. firearms, sharp weapons, or motor vehicle, among others). Age, sex, and race (white or non-white) were obtained for each victim. Day, time and place of injury were also collected. The injury place was based on the description of the physical address where the injury occurred, with injuries happening in private properties classified as private settings, while those taking place in public roads or commercial properties (such as bars and groceries stores) classified as public settings.

A positive criminal background was considered when a victim had at least one previous criminal activity on file in the police records reviewed, including drug trafficking, theft, homicide perpetrators and violent behavior.

2.4. Geospatial analysis

A geospatial analysis based on the postal code retrieved from each death scene was conducted to study the influence of alcohol and other drug use according to the reported place of the fatal injury. Death densities were calculated for each of the 96 districts based on the population rate for 2015 (per 100,000 population) (16). More than 85% (n=312) of the victims in our study had a place of death recorded and were successfully geocoded.

A map of the city of Sao Paulo divided into all the districts was used to input data on death densities by district according to drug and alcohol use positivity. A color gradient was used to illustrate death density rates across all districts of the city, with darker tones representing higher densities than lighter ones. The grouping of density rates across maps was reached using a Jerks algorithm, which makes an approximation of the intervals to the closest possible value of the median for each rate reported. MapInfo Professional software, version 10.0 was used.

Additionally, a ratio was created between mean death densities obtained for drug and alcohol positivity ($\rho_{\text{drug positivity}} / \rho_{\text{alcohol positivity}}$) grouped according to the main five regions of the municipality (West, East, North, Central and South). A region with a "drug problem ratio" (DPR) greater than 1 indicates a higher density of drug positivity compared to alcohol, whereas rate values less than 1 indicate the opposite.

2.5. Statistical analysis

Frequencies of positivity for the substances investigated and mean death densities are presented with 95% CIs. Odds ratios (ORs) with 95% CIs predicting the odds of a positive result according to each class of substance identified were adjusted by sex and age. Only predictor variables that presented missing values below 15% (varying from 6.3% for race to 14.5% for the place of injury) were included. For sex and age, only crude odds ratios (ORs) are reported. All analyses were conducted in STATA/IC statistical software version 13.1.

3. Results

3.1. Toxicology results

More than half of all deaths (55.3% CI95% 50.2–60.4) occurred while under the influence of at least one substance, including alcohol. Other drug use alone was higher than alcohol alone, and the combination of two or more drugs was present in one-eighth of all cases (12.9% CI95% 9.8–16.7). Alcohol was the most prevalent substance found, followed by cocaine, cannabis and benzodiazepines (Table 2).

Traffic-related casualties accounted for the highest proportion of alcohol-related deaths (42.9% CI95% 30.3–56.4 CI) and of all drug combinations (21.4% CI95% 12.4–34.5), while suicide cases accounted for the lowest proportion of victims positive for alcohol (13.6% CI95% 6.1–27.9) but a high proportion of benzodiazepine-related deaths (18.2% CI95% 9.1–33.0). Poisoning deaths presented the highest proportion of positivity for any substance use and also for other drug use alone, followed by homicides. Falls presented the highest proportion for alcohol use alone (26.9% CI95% 12.7–48.3) and for benzodiazepines (19.2% CI95% 7.7–40.4).

3.2. Bivariate analysis

Men were more likely to have used any substance (including alcohol) and drug combination than women, except for alcohol use alone. Younger victims were more likely to have used alcohol alone before the fatal injury, while victims over 30 years old were more likely to have used any substance, in combination or not with alcohol. Non-white victims were almost twice as likely to have used at least one substance compared to white victims. Traffic-related deaths and homicides presented a greater likelihood of victims combining two or more drugs compared to other injuries, while deaths resulting from poisoning presented a greater chance of involving the use of other drugs alone than all other injuries (Table 3).

Victims who had at least one previous criminal conviction were significantly more likely to have used any substance before the fatal injury event (particularly drug use alone or use of multiple drugs), compared to those who did not have a criminal background. On the other hand, those who had a criminal background were less likely to have used alcohol alone compared to those without a previous criminal conviction on file.

Moreover, deaths involving at least one substance, any alcohol presence or only alcohol were significantly more likely to occur during the night compared to other time periods. Those who used drugs, in combination or not with alcohol, were more likely to have been injured in a public setting than a private place, but this association was not significant when controlling for sex and age (Table 3).

3.3. Geospatial findings

Geospatial analysis revealed a disproportionate distribution of injury deaths across districts of the city (Figure 1a). Alcohol-positive cases showed a greater distribution of high death density areas across districts of the city compared to drug-positive cases (Figure 1b–1c). This scenario was further confirmed by the disproportional distribution of only alcohol-positive cases compared to only drug-positives, with the high death density areas concentrated more in the central and peripheral regions of the city in the latter (Figure 1d–1e).

DPR ratios were calculated for the main five regions of the city, with the central and north regions showing a greater concentration of drug-related deaths compared to alcohol-related deaths, whereas in the south and west a similar distribution between drug-related and alcohol-related deaths was observed. In the east zone of the city, alcohol-related deaths were more predominant than drug-related deaths (Table 4).

4. Discussion

Intentional and unintentional injuries are influenced by a multitude of contributing factors, both at the individual-level (e.g. risk-taking behavior, substance use, etc.) and at the community-level (e.g. permeated violence, availability of safety strategies, etc.) that together shape each individual’s risk of injuries (13,17,18). Substance use is one of the main individual factors contributing to injuries (18–20), with findings here showing that one in every two decedents were found to be under the influence of at least one substance before an injury death.

To our knowledge, this study is the first to document the prevalence of acute use of alcohol and drugs using the recommended toxicological confirmation procedures in blood (21) in a representative population-based sample of all fatal injuries from the Latin American region. The prevalence of one third of victims under the influence of alcohol observed here was within the range among injured victims observed worldwide (19,22,23), but the prevalence of other drugs, mainly cocaine and cannabis, which represented together more than two-thirds of all of the other substances found, are among the highest reported elsewhere (19,24,25).

Also worrisome is the high level observed of the proportion of alcohol-related road traffic deaths (43%) compared to all countries that have available estimates of road traffic deaths attributable to alcohol (12). Additionally, suicide-related deaths appear to be more strongly associated with other drug use than alcohol. Similar findings were reported in a study comparing the use of different substances between motor vehicle crash decedents and suicides in New Mexico, USA, where the use of multiple substances, particularly cocaine, was found to be more prevalent among suicide deaths than motor vehicle collisions (26).

Very little data on substance use, particularly for drugs other than alcohol, are available for monitoring systems on injury deaths among low- to middle-income countries (27), but international research in high-income countries has addressed this issue since the 1970's, with the creation of national systems on drug surveillance (4,28). Enforcement strategies unifying different data sources have been shown to be effective in guiding preventive actions in other cities around the world (7,29,30). In low- to middle-income countries, particularly Brazil, research on this issue continues to gain momentum, but the political instability and the lack of long-term funding limits the integration between research and health services on injuries (31).

The findings presented here indicate that alcohol is the lead substance consumed before a fatal injury event, followed by cocaine and cannabis. Poly-drug use is also frequent, especially the combination of alcohol with illicit drugs. Moreover, road traffic deaths have a stronger association with alcohol use compared to other causes of death, while other drug use seems to be more related to intentional injuries (homicides and suicides).

Furthermore, social differences, past criminal activity and time period of events seem to play a key role in the current distribution of substance-related injuries resulting in death. For instance, the use of illicit drugs (mostly cocaine and cannabis) interacts differently with race and previous criminal involvement of decedents compared to alcohol use. Earlier evidence supports the differential role of alcohol and other drug use among diverse ethnic groups sustaining both non-fatal (32) and fatal injuries (33), suggesting that the social context where substance-related injuries occur differ significantly according to the substance used and the victim's social background, including past criminal activities as found in the current study.

Also, by observing the distribution of substance-related deaths in a visual map of the city, it was possible to identify important regions of the city that differ in relation to socio-economic characteristics and the prevalence of each substance class in these regions. For example, a greater proportion of socially disadvantaged groups has been found to be positively associated with higher incidence of alcohol- and drug-related health problems such as injuries (34).

The data presented here suggest that alcohol-related injuries are broadly spread among the districts in the city of Sao Paulo, whereas drug-related deaths seem to be more concentrated in the central and peripheral regions of the city. This could be related to the differential population distribution and levels of consumption of these substances observed in the areas studied, demanding further attention from researchers and local enforcement authorities in order to explore the associations revealed by combining geospatial information with epidemiological health data.

The greatest advantage of our newly developed method is the use of blood specimens for estimating recent drug use in all causes of fatal injuries. This strategy applied together with the proper selection of victims to avoid common biases in death investigations, appears to work better than applying continuous resources in generating prevalence data based only on routine investigations, particularly in the case of injury deaths for which current drug testing rates are low (28).

Nonetheless, associations reported here should not be mistakenly taken as directly causal between variables, as substance use was measured only at the moment when the acute event occurred. Perpetrators and others involved in the injury events who were not fatally injured were also not included in the study; therefore, the results most likely under estimate the role of substance use in fatal injury events.

In conclusion, this study aimed to gather the most detailed evidence on substance use among all cause of fatal injuries using a cross-sectional design based on a representative sample from the largest city in Brazil. We estimated that one in every two fatal injuries in the city of Sao Paulo is associated with acute substance use by the victim. Moreover, preventive and enforcement strategies to reduce substance-related injuries should be tailored according to each substance class, type of injury and the primary setting where the injury event usually occurs. This issue is particularly relevant for countries such as Brazil, where illicit drug markets are on the rise and new public health approaches for the growing burden of injuries are urgently required.

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Highlights

- One in every two fatal injuries in the city of Sao Paulo is associated with acute substance use by the victim
- Alcohol-positive deaths are over-represented among road traffic injuries, while drug-positive deaths are more prevalent among intentional injuries
- The association between acute substance use and injury varies significantly according to different drug classes, victim's social background and the spatial distribution of injury events

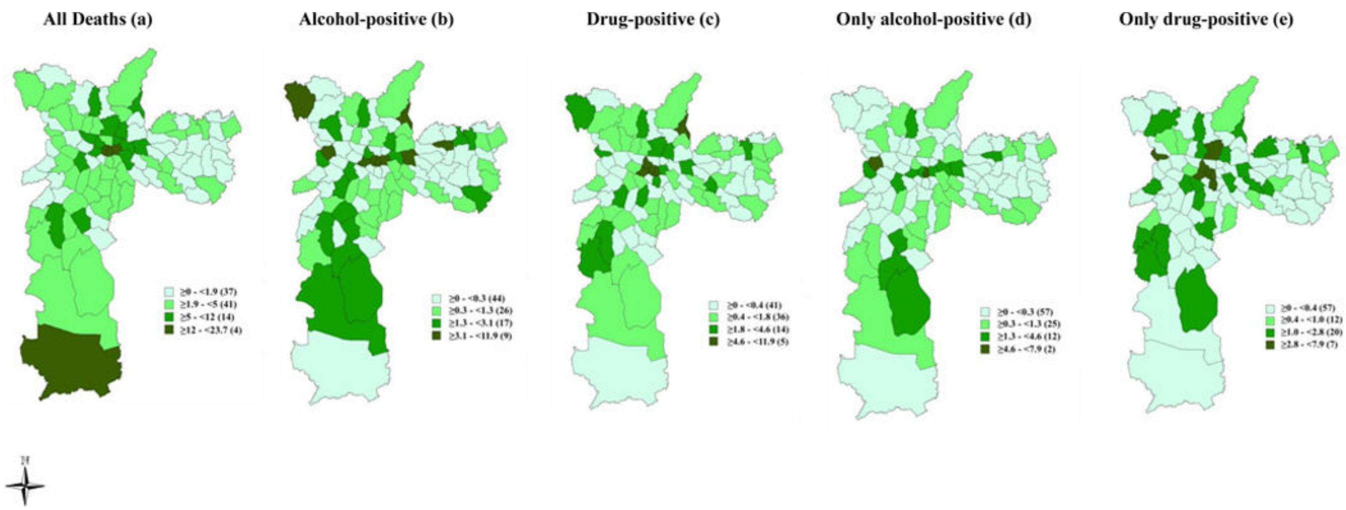

Figure 1.
Death density rates according to each substance positivity group distributed into the 96 districts of Sao Paulo.

*Rate levels shown are approximated to the first decimal digit.

Table 1.

Lower limit of detection (LLD) for substances screened in post-mortem whole blood specimens followed by confirmatory lower limit of quantification (LLQ).

Screening cut offs		Confirmatory cut offs	
Drug Class	**Screening LLD (ng/ml)**	**Compounds**	**Confirmatory LLQ (ng/ml)**
Alcohol[a]	0.01% (w/v)		
		Ethanol[a]	0.02% (w/v)
Amphetamines	50		
		d-Amphetamine	20
		d-Methamphetamine	50
		MDMA	50
		MDA	20
Phencyclidine (PCP)	10		
		Phencyclidine	10
Cocaine	20		
		Cocaine	50
		Benzoylecognine	20
		Cocaethylene	20
Cannabinoids (THC)[b]	5		
		THC-OH	1
		Cannabidiol	1
		THC-COOH	5
		Cannabinol	1
		THC	1
Benzodiazepines (Temazepam)[b]	20		
		Alprazolam	5
		Diazepam	5
		Midazolam	5
		Nordiazepam	5
		Desalkyflurezepam	5
		Chlordiazepoxide	0.05
		Temazepam	5
Barbiturates (Secobarbital)	20		
		Phenobarbital	50
Opiates and Opioids	20		
		Methadone	50
		Morphine	50
		Fentanyl	2.5

Screening cut offs		Confirmatory cut offs	
Drug Class	**Screening LLD (ng/ml)**	**Compounds**	**Confirmatory LLQ (ng/ml)**
		Oxycodone	50
		Hydrocodone	10

[a]Ethanol screened and confirmed by Headspace GC-FID. Values are in percent weight/volume

[b]LC-MS/MS technique applied for confirmation. All other confirmatory procedures were done by GC-MS, unless otherwise noted.

Table 2.

Substance use confirmed among decedents by cause of injury.

	All injuries % (95% CI)	Traffic-related % (95% CI)	Homicides % (95% CI)	Suicides % (95% CI)	Falls % (95% CI)	Poisoning % (95% CI)	All others % (95% CI)
n	**365**	**56**	**104**	**44**	**26**	**21**	**114**
General positivity							
At least one	55.3 (50.2–60.4)	57.1 (43.6–69.7)	59.6 (49.8–68.7)	34.1 (21.3–49.7)	50.0 (30.5–69.5)	81.0 (56.4–93.3)	55.3 (45.9–64.2)
Only alcohol	17.3 (13.7–21.5)	21.4 (12.4–34.5)	14.4 (8.8–22.7)	9.1 (3.3–22.6)	26.9 (12.7–48.3)	9.5 (2.1–34.0)	20.2 (13.7–28.7)
Only drugs	25.2 (21.0–29.9)	14.3 (7.1–26.5)	25.0 (17.5–34.4)	20.5 (10.7–35.5)	15.4 (5.5–36.3)	61.9 (38.3–80.9)	28.1 (20.5–37.1)
Two or more	12.9 (9.8–16.7)	21.4 (12.4–34.5)	20.2 (13.5–29.2)	4.5 (1.1–17.3)	7.7 (1.7–28.1)	9.5 (2.1–34.0)	7.0 (3.5–13.5)
Specific positivity							
Alcohol	30.1 (25.6–35.1)	42.9 (30.3–56.4)	34.6 (26.0–44.4)	13.6 (6.1–27.9)	34.6 (18.2–55.7)	19.0 (6.7–43.6)	27.2 (19.7–36.2)
Cocaine	21.9 (18.0–26.5)	21.4 (12.4–34.5)	30.8 (22.5–40.4)	9.1 (3.3–22.6)	3.8 (0.5–25.4)	42.9 (22.6–65.8)	19.3 (13.0–27.7)
Cannabis	14.0 (10.8–17.9)	19.6 (11.0–32.6)	19.2 (12.7–28.1)	2.3 (0.3–15.5)	0	28.6 (12.5–52.9)	11.4 (6.7–18.8)
Benzodiazepines	11.5 (8.6–15.2)	7.1 (2.6–18.0)	7.7 (3.8–14.8)	18.2 (9.1–33.0)	19.2 (7.7–40.4)	14.3 (4.2–38.7)	12.3 (7.4–19.8)
Alcohol + ocaine	8.8 (6.3–12.2)	12.5 (5.9–24.4)	16.3 (10.3–24.9)	2.3 (0.3–15.5)	0	9.5 (2.1–34.0)	4.4 (1.8–10.2)
Alcohol + annabis	4.1 (2.5–6.7)	12.5 (5.9–24.4)	2.8 (0.9–8.7)	2.3 (0.3–15.5)	0	9.5 (2.1–34.0)	1.8 (0.4–6.9)
Alcohol + Benzodiazepines	3.3 (1.9–5.7)	1.8 (0.2–12.3)	5.8 (2.6–12.4)	2.3 (0.3–15.5)	7.7 (1.7–28.1)	0	1.8 (0.4–6.9)

Table 3.

Substance use according to each substance positivity group by sociodemographic and contextual characteristics (n=365).

	All victims % (95% CI)	At least one OR[a] (95% CI)	Any alcohol OR[a] (95% CI)	Only alcohol OR[a] (95% CI)	Only drugs OR[a] (95% CI)	Two or more OR[a] (95% CI)
Sex						
Men	82.2 (77.9–85.8)	3.2 (1.8–5.6) *	2.4 (1.2–4.8) *	1.6 (0.7–3.5)	2.1 (1.0–4.3) *	3.6 (1.1–11.8) *
Women	17.8 (14.2–22.1)	1.0	1.0	1.0	1.0	1.0
Age						
30 or less	37.0 (31.9–42.5)	0.5 (0.3–0.8) *	1.0 (0.6–1.7)	2.3 (1.2–4.4) *	0.4 (0.2–0.7) *	0.4 (0.2–0.8) *
More than 30	63.0 (57.5–68.1)	1.0	1.0	1.0	1.0	1.0
Race						
Non-white	49.7 (44.4–55.0)	1.7 (1.1–2.7) *	1.4 (0.9–2.4)	1.7 (0.9–3.2)	1.4 (0.8–2.3)	1.0 (0.5–1.9)
White	50.3 (45.0–55.6)	1.0	1.0	1.0	1.0	1.0
Injury type						
Traffic-related	50.3 (45.0–55.6)	0.8 (0.4–1.6)	2.1 (1.0–4.2)	1.3 (0.6–2.9)	0.3 (0.1–0.7) *	3.7 (1.2–11.7) *
Homicides	28.5 (24.1–33.4)	0.8 (0.5–1.6)	1.4 (0.7–2.7)	0.7 (0.3–1.5)	0.6 (0.3–1.1)	3.6 (1.2–10.3) *
Self-inflicted	12.1 (9.1–15.8)	0.4 (0.2–0.9) *	0.5 (0.2–1.3)	0.4 (0.1–1.4)	0.6 (0.2–1.4)	0.9 (0.2–4.9)
Falls	7.1 (4.9–10.3)	0.9 (0.4–2.2)	1.5 (0.6–3.8)	1.2 (0.4–3.3)	0.5 (0.2–1.7)	1.9 (0.3–10.5)
Poisoning	5.8 (3.8–8.7)	2.9 (0.8–9.6)	0.7 (0.2–2.4)	0.6 (0.1–2.9)	2.8 (1.0–8.1) *	1.4 (0.2–7.8)
All others	31.2 (26.7–36.2)	1.0	1.0	1.0	1.0	1.0
Method of death						
Motor vehicle	15.9 (12.5–20.0)	1.0 (0.5–1.9)	1.8 (0.9–3.5)	1.3 (0.6–2.8)	0.4 (0.2–1.1)	2.3 (0.8–6.3)
Firearms	22.7 (18.7–27.3)	0.8 (0.4–1.5)	1.0 (0.5–1.9)	0.4 (0.2–1.1)	0.8 (0.4–1.6)	2.4 (0.9–6.1)
Sharp weapons	6.3 (4.2–9.3)	1.7 (0.6–4.7)	1.8 (0.7–4.7)	1.7 (0.6–5.1)	1.0 (0.3–3.1)	1.4 (0.3–7.0)
Falls	9.3 (6.7–12.8)	0.9 (0.4–2.1)	1.2 (0.5–2.7)	1.2 (0.5–3.0)	0.8 (0.3–2.1)	0.9 (0.2–4.5)
Poisoning	6.9 (4.7–10.0)	2.9 (1.1–8.1) *	0.5 (0.2–1.7)	0.5 (0.1–2.3)	4.0 (1.6–10.4) *	0.8 (0.2–4.2)
All others	38.9 (34.0–44.0)	1.0	1.0	1.0	1.0	1.0
Criminal background						

	All victims % (95% CI)	At least one OR[a] (95% CI)	Any alcohol OR[a] (95% CI)	Only alcohol OR[a] (95% CI)	Only drugs OR[a] (95% CI)	Two or more OR[a] (95% CI)
No	84.1 (79.6–87.7)	3.0 (1.4–6.3)*	1.3 (0.6–2.5)	0.2 (0.1–0.8)*	2.4 (1.2–4.7)*	4.0 (1.8–9.0)*
Yes	15.9 (12.3–20.4)	1.0	1.0	1.0	1.0	1.0
Injury place						
Private	35.1 (30.0–40.5)	0.9 (0.5–1.4)	0.9 (0.5–1.5)	1.1 (0.6–2.0)	1.0 (0.5–1.8)	0.7 (0.3–1.5)
Public	64.9 (59.5–70.0)	1.0	1.0	1.0	1.0	1.0
Death time						
Night	23.0 (19.0–27.6)	2.8 (1.3–6.1)*	5.2 (2.1–12.9)*	6.0 (2.0–18.2)*	0.6 (0.3–1.4)	2.4 (0.6–9.1)
Evening	37.5 (32.7–42.6)	1.5 (0.7–2.9)	2.5 (1.1–5.8)*	2.3 (0.8–6.5)	0.7 (0.3–1.5)	2.1 (0.5–7.8)
Afternoon	21.9 (18.0–26.5)	0.9 (0.4–2.0)	1.1 (0.4–2.8)	0.5 (0.1–2.1)	0.9 (0.4–2.0)	1.9 (0.5–7.8)
Morning	17.6 (14.0–21.8)	1.0	1.0	1.0	1.0	1.0
Death day						
Weekend	26.0 (21.8–30.8)	1.5 (0.9–2.5)	1.7 (1.0–2.8)	1.5 (0.8–2.7)	0.9 (0.5–1.7)	1.6 (0.8–3.4)
Weekday	74.0 (69.2–78.2)	1.0	1.0	1.0	1.0	1.0

[a] For sex and age, only crude ORs are presented. All other regressions included sex and age as covariates.

* P-value≤0.05.

Table 4.

Mean death densities rates according to each substance positivity group and drug problem ratio (DPR = ρ drug positivity / ρ alcohol positivity) estimates among major regions in the city of Sao Paulo, Brazil.

Regions	All deaths Mean (95% CI)	Alcohol-positive Mean (95% CI)	Drug-positive Mean (95% CI)	Only alcohol Mean (95% CI)	Only drugs Mean (95% CI)	DPR I (Fig 1b–1c)	DPR II (Fig 1d–1e)
Central	9.07 (3.73–14.41)	2.89 (0.09–5.71)	3.26 (0.60–5.93)	1.56 (−0.20–3.33)	2.09 (0.23–3.96)	1.13	1.34
North	3.96 (1.69–6.23)	1.05 (0.04–2.06)	1.63 (0.14–3.13)	0.29 (−0.05–0.64)	0.88 (−0.01–1.78)	1.55	3.03
East	1.99 (1.30–2.68)	0.71 (0.37–1.06)	0.60 (0.34–0.87)	0.45 (0.19–0.70)	0.37 (0.15–0.58)	0.85	0.82
South	3.22 (2.29–4.16)	0.75 (0.47–1.04)	0.76 (0.44–1.01)	0.42 (0.20–0.65)	0.44 (0.18–0.70)	1.01	1.05
West	2.65 (1.69–3.60)	1.05 (0.36–1.73)	1.06 (0.44–1.69)	0.63 (0.07–1.19)	0.65 (0.15–1.15)	1.01	1.03