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Patterns of violent deaths associated with positive ethanol finding in Eastern Province, Saudi Arabia

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Abstract *Background:* The analysis of alcohol exemplifies the principal aim of forensic toxicology worldwide. Detection of ethanol in post-mortem cases is getting more important nowadays due to the upsurge in the number of ethanol related fatalities all over the world. Toxicological analysis is mandatory to diagnose, and interpret the presence and levels of alcohol in different post mortem samples. The difficulties in the interpretation of blood alcohol concentration (BAC) are more profound when the body shows signs of putrefaction and the measured BAC is low as sometimes it is false positive due to decomposition. *Objective:* To investigate ethanol related violent deaths, whether suicidal, homicidal or accidental fatalities with positive analytical results regarding ethanol since start of January 2012, till end of December 2014 in Eastern Province, Saudi Arabia. *Methods:* Ethanol related violent deaths whether suicidal, homicidal or, accidental fatalities over the period from the start of January 2012, till end of December 2014 in the Eastern region, Saudi Arabia were retrospectively investigated. *Results:* From a total 1376 cases examined in the Forensic Medical Authority, Eastern Province over the assigned three year period, only 94 ethanol positive fatalities were detected and were investigated retrospectively. Cases with positive ethanol results, were chiefly males between 21 and 30 years of age (28.8%). Accidental causes significantly predominated (47.9%) over suicidal and homicidal causes (28.8%, and 23.3%, respectively). Most of the cases were non-Saudi (73.3%), with prevalence of Indian nationality (47.8%). *Conclusion:* The precise statistical mortality database for ethanol related violent deaths may provide an enormous support for the effect of alcohol on aggressive behavior, human health and mortality. In the current study, ethanol positive deaths were 94 in total, with predominance of non-Saudi Indian males. Majority of the studied cases were between 21 and 30 years of age. Further international studies are recommended.

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1. Introduction

Ethanol (alcohol) is a widely known central nervous system depressant. It is the most frequently detected substance in many postmortem cases. Excessive intake of alcoholic beverages and drunkenness have constantly played a major role in serious accidents, trauma related deaths, drowning, suicide, and many other crimes of aggression as documented by police as well as accident and emergency department records.[1–5]

Furthermore, heavy drinking and alcohol-induced consciousness level impairment are frequent causal factors in road-traffic accidents as well as workplace and home violent mishaps.[6,7]

Alcohol comes on top of the list of psychoactive substances discovered in postmortem toxicological analysis worldwide, and the interpretation of (BAC) in such specimens represents a huge component of the workload at forensic toxicology laboratories.[4,6,7] Positive ethanol results depend on many sociomedical factors that might change among different countries. As a general rule, the postmortem BAC needs to be interpreted regarding whether the deceased had consumed ethanol and might have been drunk at the time of death or if this concentration exceeded some threshold limit. Such conclusions are often controversial and extreme caution during interpretation is required due to diverse postmortem artefacts.[8]

The identification of alcohol toxic effects has great sociomedical impacts due to the presence of BAC limits for driving in most countries that is liable to be punished by authorities.[9] Insurance claims might be canceled if the samples of the person involved in a fatal accident were confirmed to be above the legal limit for driving.

Determination of ethanol in postmortem specimens both qualitatively and quantitatively has become a fairly simple analytical method, where precisely accurate and specific results are nowadays achievable.[10] However, interpreting postmortem BAC results and reaching accurate conclusions about antemortem levels and the person's state of drunkenness and behavioral impairment degree at the time of death are so difficult.[11,12]

The body condition, the interval between death and autopsy, the environmental circumstances (temperature and humidity), and the type of specimens collected for analysis are vital factors to be considered. Sometimes alcohol might be formed after death by microbial activity and fermentation of glucose, which is a major dilemma if the dead body has undergone decomposition.[13,14]

Antisocial and criminal behavior is known to increase among alcoholics.[15] It is of great importance to note that measuring trends in alcoholics and alcohol-related violent problems is essentially challenging, and this relates to the unreliability of data in most alcohol related violent behaviors.[16]

2. Aim of the work

The aim of this study was to investigate the prevalence of alcohol influence in medico-legal autopsies in a three year period in Eastern Province, KSA.

3. Methods

The data of alcohol related violent deaths ($N = 94$) whether suicidal, homicidal or accidental including fatal occupational injuries, accidental falls, fire related deaths, accidental drowning, and fatal alcohol poisoning using data from autopsy reports done in Department of Forensic Medicine, Eastern Province, Saudi Arabia over the period from the start of January 2012, till end of December 2014 were examined with respect to their demographic data and autopsy reports. Cadavers that had any apparent sign of putrefaction whether from external or internal examination, namely, greenish discolouration of abdomen and genitals, or abdominal distension, were categorized as cases with putrefaction and were excluded from the study. Diabetics or cases with proved infections in urine samples were excluded as well. Ethical requirements were fulfilled.

10–15 ml of peripheral blood – being the most reliable specimen for toxicological testing – was withdrawn from the femoral vein in the leg, the iliac vein, accessible from the body cavity during internal examination, or from the subclavian vein in the chest. 10–15 ml of urine was collected with a syringe, through a simple incision allowing visualization of the bladder. Vitreous was collected with a hypodermic syringe by inserting the needle into each eye. Comprehensive examination of the collected samples was done for all collected samples using the following protocol: Blood and urine samples of each subject were screened for ethanol and, drugs of abuse (Amphetamine, barbiturates, benzodiazepine, cannabis, cocaine, and opiates) using fluorescence polarization immunoassay (FPIA) principle on ARCHITECT system c4000, model i1000 SR by Abbott laboratories. Using gas chromatography – head space GC ultra-model K0C33B730000000, Milano, Italy, all samples were analyzed for all volatiles including ethanol. Extraction and analysis by gas chromatography–mass spectrometer GC–MS–QP2010, Shimadzu for weakly acidic and neutral drugs, is then performed. This includes acetaminophen, non-steroidal anti-inflammatory drugs, barbiturates, phenytoin, and Carbamazepine. Finally extraction and analysis was done by the same GC–MS for alkaloid and basic drugs, including most common centrally acting therapeutic drugs with the exception of those checked for weakly acidic and neutral extract. This includes antidepressants, stimulants, narcotics, antihistamines, decongestants, muscle relaxants, anticonvulsants, organic poisons, and antipsychotics. Finally analysis for detection of carbon monoxide, or other specific tests which would have to be specially requested or suggested by the circumstances of death might be done. Ethanol analysis was performed by a static headspace analysis.

3.1. Analysis of ethanol

As the limits for ethanol might be low, thus, a three-point calibration curve covering the ethanol concentration range between 0.01 mg/ dl and 10 mg/dl was constructed. Ethanol standards, quality control samples and internal standards (n-propanol, 10 mg/dl) were prepared in distilled water from HPLC grade solvents. A resolution mixture of ethanol, n-propanol, acetaldehyde, methanol and acetone were prepared in distilled water from HPLC grade solvents at a concentration of 100 mg/dl each.

3.2. Headspace procedure

The samples were placed in 20 ml headspace vials by adding 1.0 ml of samples, standards or quality control samples and

Table 1 Parameters of Head-space chromatography.

Parameter	Temperature
Initial temp	45 °C
Max Temp	350 °C
Ram 1 Initial temperature	90 °C
Inlet Temperature	230 °C
MS Transfer Line	250 °C
Ion source	220 °C
Syringe temperature	60 °C
Parameter	Time
Hold Time	00.00 min
Prep Run Timeout	99.00 min
Equilibrium Time	00.50 min
Ram 1 Hold Time	01.00 min
Prep Run Timeout	99.00 min
Equilibrium Time	00.50 min
Gas Saver Time	03.00 min
Parameter	Volume
Sample Volume	01.00 ml

1 ml of internal standard. The samples were sealed using crimp top vial caps with septa and were placed in the headspace rack. Operation parameters are given in Table 1.

3.3. Gas chromatography analysis

The quantitative analysis of ethanol and its separation from other low-molecular volatiles was done with a TRACE™ Ultra Gas Chromatograph.

3.4. Capillary gas chromatography/mass spectrometry analysis (GC/MS)

The quantitative analysis of ethanol and its separation from other low-molecular volatiles was done with a TRACE™ Ultra Gas Chromatograph. Injections were made in the split mode. The column temperature program was isothermal at 90 °C. Helium was used as the carrier gas. The injector and transfer line temperatures were 230 °C and the split ratio was 10:1 with each sample lot, a calibration curve, blank (distilled water) and quality control samples were run. The resolution mixture was first run in a scan mode in the mass range of 20–120 m/z to identify the compounds and subsequently the mixture was run in a SIM mode for the samples. The methods were linear in the concentration range used.

Table 3 Distribution of cases by Frequency of different Nationalities.

Nationality	Frequency	Percent
Saudi	26	27.7
Indian	44	46.8
Nepali	7	7.4
Pakistani	5	5.2
Bangladeshi	3	3.2
American	2	2.1
Yemeni	2	2.1
Chad	1	1.1
Omani	1	1.1
Sirilanki	1	1.1
Filipino	1	1.1
Lebanese	1	1.1
Total	94	100

Blood and urine samples were analyzed for ethyl glucuronide and ethyl sulfate (EtG and EtS) by Liquid Chromatography Tandem Mass Spectrometry using the methodology described by Helander et al.[17], and only cases with EtG levels $\geqslant 0.5$ μg/mL (positive cut-off for EtG), and EtS $\geqslant 0.1$ μg ng/mL (positive cut-off for EtS) were included in the study.

4. Statistical analysis

Data obtained have been tabulated and the results were analyzed statistically and expressed as mean ± SD. The percentage concentration of ethanol in all studied Samples, and demographic data of the investigated cases were submitted for statistical evaluation by SPSS program, version 22 and compared with similar studies.

5. Results

Ethanol positive deaths were 94 in total, 92 (97.8%) of the studied cases were males and, 2 (2.2%) were females. Blood alcohol concentrations (BACs) were detected by headspace gas chromatographic method in various samples. The alcohol-related fatalities were investigated as regards demographic data of the deceased and the frequency of co-occurrence of other substance of abuse or other chemicals or pharmaceuticals, as well as the mode and manner of death. As shown in Table 2, the males ($N = 92$, 97.8%) much

Table 2 Distribution of cases by gender, nationality and age group.

Age groups	Gender			Nationality		
	Male (%)	Female (%)	Total (%)	Saudi (%)	Non Saudi (%)	Total (%)
0–10	0 (0.0%)	0 (0%)	0 (0.0%)	0 (0%)	0 (0.0%)	0 (0.0%)
11–20	1 (1.1%)	0 (0.0%)	1 (1.1%)	0 (0.0%)	1 (1.1%)	1 (1.1%)
21–30	26 (27.7%)	1 (1.1%)	27 (28.8%)	11 (11.7%)	16 17.1%)	27 (28.8%)
31–40	26 (27.7%)	0 (0.0%)	26 (27.7%)	4 (4.3%)	22 (23.4%)	26 (27.7%)
41–50	22 (23.4%)	1 (1.1%)	23 (24.5%)	4 (4.3%)	19 20.2%)	23 24.5%)
51–60	9(9.5%)	0 (0.0%)	9 (9.5%)	3 (3.2%)	6 (6.3%)	9 (9.5%)
61–70	8 (8.4%)	0 (0.0%)	8 (8.4%)	3 (3.2%)	5 (5.2%)	8 (8.4%)
Total (%)	92 (97.8%)	2 (2.2%)	94 (100%)	26 27.7%)	69 73.3%)	94 (100%)

Table 4 Distribution of cases by nationalities versus toxicological results.

Nationality			Toxicological results		Total
			Ethanol with other drugs	Ethanol alone	
	Saudi	Count	8	18	26
		% of Total	8.5%	19.2%	27.7%
	Non Saudi	Count	58	10	68
		% of Total	61.7%	10.6%	72.3%
Total		Count	66	28	94
		% of Total	70.2%	29.8%	100.0%

Table 5 Detailed toxicological findings in investigated cases.

Toxicological findings	Positive results	Percentage
Ethanol alone	28	29.7
Ethanol + Codeine	17	18
Ethanol + Cannabis	14	14.9
Ethanol + Morphine	12	12.8
Ethanol + Amphetamine	4	4.2
Ethanol + Dextromethorphan	1	1.1
Ethanol + Chromium	1	1.1
Ethanol + Arsenic	2	2.1
Ethanol + Mercury	2	2.1
Ethanol + Hydrogen sulfide	1	1.1
Ethanol + Carbon monoxide	3	3.2
Ethanol + Acetone	1	1.1
Ethanol + Kerosene	1	1.1
Ethanol + Organophosphate Pesticides	2	2.1
Ethanol + Aluminum phosphide	1	1.1
Ethanol + Methanol	2	2.1
Ethanol + Sildenafil	1	1.1
Ethanol + Toluene	1	1.1
Total	94	100

Table 6 Distribution of cases by types of analyzed samples.

Sample type	Number	Ethanol concentration (Mean ± SD)
Blood	90	146.15 ± 132.2
Urine	50	178.12 ± 175
Vitreous	11	137.50 ± 124.5

prevailed over females ($N = 2$, 2.1%), and the non-Saudi nationals ($N = 69$, 73.3%) prevailed over Saudi cases ($N = 26$, 27.7%).

The highest incidence of cases ($N = 27$, 28.8%) was detected among victims in the age group (21–30 years), followed by age group (31–40 years), with a total number of 26 (27.7%).

As seen in Table 3, the highest incidence of cases was among Indians ($N = 44$, 46.8%), followed by Saudis ($N = 26$, 27.7%). As regards toxicological findings, 28 (29.7%) of the studied cases revealed only ethanol in their analytical results, and the rest of the cases (66, 70.3%) showed multiple findings as shown in Tables 4 and 5. Cannabis ($N = 14$, 14.9%) was the highest substance of abuse detected in samples together with ethanol, followed by morphine ($N = 12$, 12.8%) as shown in Table 5. As shown in Table 6, blood sample was collected in 90 of the studied cases, followed by urine ($N = 48$), while vitreous humor samples were analyzed in only 11 cases.

Table 7 Distribution of cases as regards ethanol levels in the different studied samples:

Ethanol level	Blood samples		Urine samples		Vitreous samples	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
< 30	6	6.6%	1	2%	1	9.1%
31–80	34	37.8%	11	22%	5	45.4%
81–160	21	23.3%	12	24%	3	27.3%
161–240	14	15.6%	16	32%	1	9.1%
> 241	15	16.7%	10	20%	1	9.1%
Total	90	100.0%	50	100.0%	11	100.0%

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Table 8 Correlation coefficient of variable blood, urinary and vitreous ethanol concentration in the studied postmortem biological samples.

Sample type		Blood	Urine	Vitreous
Blood	Pearson correlation	1	0.856**	0.709*
	Sig. (2-tailed)	0.000	0.000	0.014
	N	90	50	11
Urine	Pearson Correlation	0.856**	1	0.860**
	Sig. (2-tailed)	0.000	0.000	0.006
	N	50	50	8
Vitreous	Pearson Correlation	0.709*	0.860**	1
	Sig. (2-tailed)	0.014	0.006	0.000
	N	11	8	11

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 9 Distribution of studied cases by cause of death versus manners of death.

Cause of death		Manner of death			Total
		Accidental	Suicidal	Homicidal	
Hanging	Count	0	23	0	23
	% of Total	0.0%	24.4%	0.0%	24.4%
Falling from Height	Count	0	1	0	1
	% of Total	0.0%	1.1%	0.0%	1.1%
Firearm Injury	Count	0	1	11	12
	% of Total	0.0%	1.1%	11.7%	12.8%
Stab wound	Count	2	1	6	9
	% of Total	2.1%	1.1%	6.4%	9.6%
Contusion	Count	1	0	0	1
	% of Total	1.1%	0.0%	0.0%	1.1%
Cut throat	Count	0	1	0	1
	% of Total	0.0%	1.1%	0.0%	1.1%
Drowning	Count	7	0	0	7
	% of Total	7.4%	0.0%	0.0%	7.4%
RTA	Count	15	0	0	15
	% of Total	16%	0.0%	0.0%	16%
Head Injury	Count	2	0	2	4
	% of Total	2.1%	0.0%	2.1%	4.2%
Co poisoning	Count	15	0	0	15
	% of Total	16%	0%	0%	16%
Burn	Count	2	0	0	2
	% of Total	2.1%	0.0%	0.0%	2.1%
Traumatic asphyxia	Count	1	0	0	1
	% of Total	1.1%	0.0%	0.0%	1.1%
Strangulation	Count	0	0	3	3
	% of Total	0.0%	0.0%	3.1%	3.1%
Total	Count	45	27	22	94
	% of Total	47.9%	28.8%	23.3%	100%

Table 7 demonstrates that 23.3% ($N = 21$) of the cases had BACs in the range 81–160 mg/dl, while for the urine samples 16 of the urine samples (32%) were in the alcohol range of 161–240 mg/dl while in the Vitreous samples 5 (45.4%) of the studied 11 samples were in the range of 31 –80 mg/dl. Statistical analysis of the results in Table 8, indicate that a high coefficient of correlation was ascertained between alcohol concentration in vitreous humor and blood and also between alcohol concentration in vitreous humor and urine. Pearson's correlation coefficient for vitreous humor was 0.709 with blood

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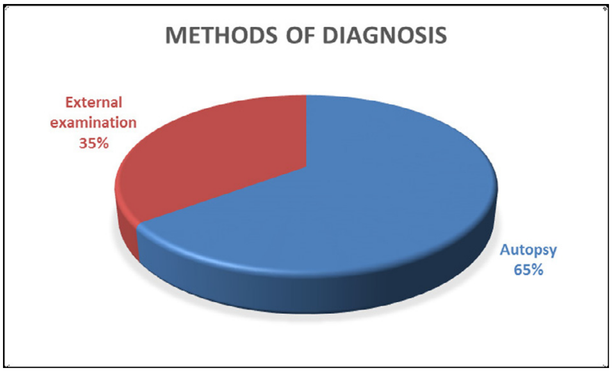

Figure 1 Methods of diagnosis in investigated cases.

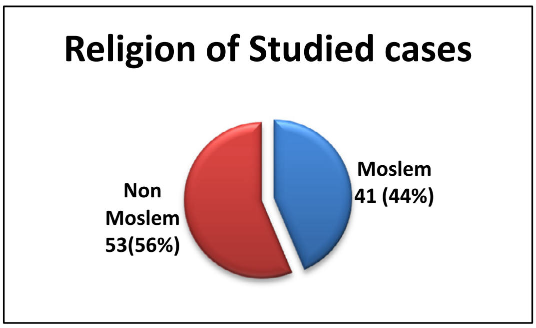

Figure 2 Religion of studied cases.

and 0.860 with urine. The results demonstrated that all the fluids tested against vitreous humor significantly correlated with P (associated probability for the used correlation tests) at the 0.01, as well as at the 0.005 levels.

Hanging ($N = 23$, 24.4%) among suicidal cases showed the highest incidence among studied cases as seen in Table 9, followed by firearm injuries among homicidal cases ($N = 11$, 11.7%). Autopsy was performed in 65% of the cases, while external examination with toxicological sample collection was performed in 35% of the cases as shown in Fig. 1. Non Moslem cases 53 (56%), exceeded Moslem cases 41 (44%) as shown in Fig. 2, while most of the cases were unemployed 58 (62%) as seen in Fig. 3.

6. Discussion

The detection of toxic substances -in particular ethanol- plays a significant role in any forensic investigations. It is essential to reveal whether or not the deceased was under the influence of ethanol at the very moment of an accident or criminal offence. Gas chromatography offers the forensic toxicologist the most extensively used approach for determining alcohol levels in blood, or other body fluids.[18,19]

Postmortem toxicology testing is a vital part of the forensic autopsy. Intentional violent drug-related deaths are a major percentage of any forensic pathologist or medical examiner's workload. Centres for Disease Control and Prevention (CDC) considered poisoning, including ethanol, prescription and illicit drugs, as the second leading cause of injury death (CDC).[20]

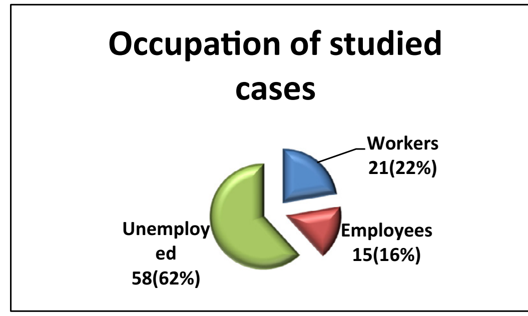

Figure 3 Occupation of studied cases.

Usually, investigation of deaths includes investigation of the death or crime scene noting the presence and types of all drugs, reviewing medical records, performing autopsy examination, followed by testing of collected post-mortem fluids and tissues for qualitative and quantitative analysis of drugs and chemicals. Less frequently, an external examination of the body with collection of post-mortem samples for toxicology testing instead of a complete autopsy is performed.[21,22] Toxicology test results are interpreted in conjunction with autopsy findings and circumstantial evidences of the death scene,[21] In accordance with this fact, autopsy was performed in 65% of the cases in our study while external examination with toxicological sample collection was performed in only 35% of the investigated cases.

Blood is the usual specimen provided for ethanol analysis. The site from which post-mortem blood is obtained is important. The preferred site is the femoral vein.[22,23] Vitreous is a colorless, clear and gel-like fluid surrounded by the vitreous membrane. No blood vessels come in direct contact to the vitreous, which is not accessible for contamination by microorganisms and its high water content makes measured ethanol levels equivalent to blood levels.[24] Similar to vitreous, urine is resistant to post-mortem bacterial contamination, and post-mortem alcohol production in urine only occurs when it contains large amounts of glucose as in diabetics, or there has been a bacterial or fungal urinary tract infection ante-mortem.[24,25] The inclusion of the EtS biomarker, in conjunction with EtG, eliminates the potential for false positive or negative results as it is not vulnerable to the *Escherichia coli* bacteria by creation or degradation. EtS has proven to be a more robust and reliable biomarker of ethanol exposure that is quickly replacing EtG as the gold standard for alcohol consumption.[17]

Suicide is one of the commonest leading causes of death worldwide. Many have considered suicide to be an innately violent act. Except for few neurobiological researches much of the investigation on the interrelationship of suicide and violence has focused on personality traits and psychiatric abnormalities related to self-reported harm and aggression, and it is terrifying to account for alcohol abuse in surveys of the possible role of ethanol in violence ending in suicide or homicide.[26,27]

The present study revealed that 28.8% of the cases were between the ages of 21 and 30, which was similar to other relevant studies, with male predominance (97.8%), who are mostly unemployed (62%).[28–31] In Dammam, Eastern Province, Saudi Arabia, there is prevalence of immigrant workers

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from Southeast Asia, mainly Indians, which explains the higher incidence of ethanol related Indian victims (47.8%). Saudi ethanol related fatalities were less than Indians, where this may be explained by the effect of religion and the good relations between family members throughout the country.[32] This might explain as well the low percentage of homicidal deaths, in the current research (23.3%) compared to a higher frequency of homicidal deaths reported by the other researchers.[33,34]

The frequency of firearm-related deaths in our study was found to be 12.8%, and it was the most common manner of death among the homicidal group as in accordance with other studies.[35] Consistent with our results hanging was found to be the chief manner of suicide as in many other countries, including Japan[36], India[37] and, Germany[38] and it is the second-leading suicide method following intoxication in India.[37]

In line with other studies, ethanol was solely detected in only 29.7% of the cases, while in 70.3% of the cases alcohol was detected together with other drugs.[39–41] The actual underlying cause of death in these cases is not ethanol or drug alone but the additive central nervous system depression with concurrent use of both of them can lead to fatal overdose and death. This finding is in accordance with other studies stating that drugs use with alcohol is usually associated with lethal poisoning.[42]

The unavailability of blood samples required for toxicological analysis or even contaminated samples, mandated the necessity to find alternate samples, such as vitreous humor for ethanol analysis. The correlations between alcohol concentrations in blood, urine, and vitreous samples in our work proved to be suitable alternative samples with correlated results as seen in many other studies.[43–46]

7. Conclusions

The detection and quantification of ethanol in the body for the purpose of determining its influence on human behavior is of crucial importance. Ethanol positive deaths were 94 in total, 92 (97.8%) of the studied cases were males between 21 and 30 years of age (28.8%). Accidental causes significantly predominated (47.9%) over other causes. Most of the cases were non-Saudi (73.3%), with prevalence of Indian nationality (47.8%). Further studies are recommended.

The precise statistical mortality database for ethanol related violent deaths may provide an enormous support for the effect of alcohol on aggressive behavior, human health and mortality. Excessive alcohol use is attributed to a variety of fatal health outcomes and it is critical to examine demographically which groups are most affected. Such data will help to better tailor prevention efforts accordingly. Our findings call for an instant mandatory regular testing program to check ethanol concentration in all post-mortem samples collected from violent related fatalities.

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Ethical approval

Necessary ethical approval was obtained from the institute ethics committee.

Conflict of interest

None declared.

References

1. Clark JC. Sudden death in the chronic alcoholic. *Forensic Sci. Int.* 1988;**36**:105–11.
2. Hansen AU, Simonsen J. The manner and cause of death in a forensic series of chronic alcoholics. *Forensic Sci. Int.* 1991;**49**:171–8.
3. Bilban M, Skibin L. Presence of alcohol in suicide victims. *Forensic Sci. Int.* 2005;**147**(Suppl):9–12.
4. Johansson A, Holmgren P, Ahlner J. Fatal intoxications in a Swedish forensic autopsy material during 1992–2002. *Forensic Sci. Int.* 2004;**143**:53–9.
5. Borges G, Cherpitel CJ, MacDonald S, et al. A case-crossover study of acute alcohol use and suicide attempt. *J. Stud. Alcohol* 2004;**65**:708–14.
6. Perola M, Vuori E, Penttila A. Abuse of alcohol in sudden out-of hospital deaths in Finland. *Alcohol Clin. Exp. Res.* 1994;**18**:255–60.
7. Girasek DC, Gielen AC, Smith GS. Alcohol's contribution to fatal injuries: a report on public perceptions. *Ann. Emergency Med.* 2002;**39**:622–30.
8. Flanagan RJ, Connally G. Interpretation of analytical toxicology results in life and at postmortem. *Toxicol. Rev.* 2005;**24**:51–62.
9. Jones AW. Medicolegal alcohol determinations – breath or blood alcohol concentrations? *Forensic Sci. Rev.* 2000;**12**:23–47.
10. Tagliaro F, Lubli G, Ghielmi S, et al. Chromatographic methods for blood alcohol determination. *J. Chromatogr.* 1992;**580**:161–90.
11. Kalant H. Interpretation of post-mortem ethanol concentrations. *Aerosp. Med.* 1968;**39**:633–7.
12. Ziavrou K, Boumba VA, Vougiouklakis TG. Insights into the origin of postmortem ethanol. *Int. J. Toxicol.* 2005;**24**:69–77.
13. O'Neal CL, Poklis A. Postmortem production of ethanol and factors that influence interpretation: a critical review. *Am. J. Forensic Med. Pathol.* 1996;**17**:8–20.
14. Corry JEL. A review. Possible sources of ethanol ante- and postmortem: its relationship to the biochemistry and microbiology of decomposition. *J. Appl. Bacteriol.* 1978;**44**:1–56.
15. Conner KR, Duberstein PR, Conwell Y. Domestic violence, separation, and suicide in young men with early onset alcoholism: re-analyses of Murphy's data. *Suicide Life Threat. Behav.* 2000;**30**:354–9.
16. Conner Kenneth R, Cox Christopher, Duberstein Paul R, Tian Paul A, Nisbet Paul A, Conwell Yeates. Violence, alcohol, and completed suicide: a case-control study. *Am. J. Psychiatry* 2001;**158**(10):1701–5.
17. Helander A, Böttcher M, Fehr C, et al. Detection times for urinary ethyl glucuronide and ethyl sulphate in heavy drinkers during alcohol detoxification. *Alcohol Alcohol.* 2009;**44**:55–61.
18. Ernesto Bernal. Determination of volatile substances in forensic samples by static headspace gas chromatography. In: Salih Bekir, editor. *Gas Chromatography in Plant Science, Wine Technology, Toxicology and Some Specific Applications*, 10. p. 197–224, ISBN: 978-953-51-0127-7.
19. Chaturvedi AK, Smith DR, Soper JW, Canfield DV, Winnery JE. Characteristics and toxicological processing of post-mortem pilot specimens from fatal civil aviation accidents, CAMI report: August, 2002. US Department of Transportation, FAA; 2002.
20. Jiaquan Xu MD, Kenneth D, Kochanek MA. Deaths: final data for 2007*CDC: National Division of Vital Statistics*, vol. 58, No. 19; pp. 1–136.
21. McLemore Jerri, Schwilke Eugene, Shanks Kevin, Klein Dennis. The Effects of Acquisition of Blood Specimens on Drug Levels and the Effects of Transportation Conditions on Degradation of

Drugs, Final Technical Report. National Institute of Justice; 2013. p. 1–53.

22. Can İsmail Özgür, Özkara1 Erdem, Salaçin Serpil, Gümüştekin Mukaddes. Importance of sampling sites for postmortem evaluation of ethyl alcohol. *J. Forensic Res*. 2012;**3**(7):3–7.
23. Kugelberg FC, Jones AW. Interpreting results of ethanol analysis in post-mortem specimens: a review of the literature. *Forensic Sci. Int*. 2007;**165**:10–29.
24. Moriya F, Hashimoto Y, Furmiya J, Nishioka S. Effects of perimortem physical factors associated with death on exogenous ethanol concentrations in number of the cases cardiac blood. *Legal Med*. 2005;**7**:213–6.
25. McIntyre Iain M. Identification of a post-mortem redistribution factor (F) for forensic toxicology. *J. Anal. Sci. Technol*. 2014;**5**(24):1–3.
26. International Center for Alcohol Policies (ICAP), . *Guidance for first responders in violent situations involving alcohol*, 2007, Retrieved April 24, 2008, from <www.icap.org>.
27. Cherpitel CJ, Ye Y, Bond J. Attributable risk of injury associated with alcohol use: cross national data from the emergency room collaborative alcohol analysis project. *Am. J. Public Health* 2005;**95**:266–72.
28. Hingson Ralph W, Heeren Timothy, Zakocs Ronda C, Kopstein Henry, Wechsler Henry. Magnitude of alcohol-related mortality and morbidity among U.S. college students ages 18–24. *J. Stud. Alcohol* 2002;**63**:136–44.
29. Bellis MA, Hughes K. Comprehensive strategies to prevent alcohol-related violence. *IPC Rev*. 2008;**2**:137–68.
30. World Health Organization, 2015. Media centre factsheets. Alcohol. <http://www.who.int/mediacentre/factsheets/fs349/en>. Updated January 2015.
31. Stahre Mandy, Simon Michele. Alcohol-related deaths and hospitalizations by race, gender, and age in California. *Open Epidemiol. J*. 2010;**3**:3–15.
32. Madadin Mohammed, Mahmoud Amany, Asowayigh Kholoud, Alfaraidy Maram. Suicide deaths in Dammam, Kingdom of Saudi Arabia: retrospective study. *Egypt. J. Forensic Sci*. 2013;**3**:39–43.
33. Hilal A, Cekin N, Gulmen MK, Ozdemir MH, Karanfil R. Homicide in Adana, Turkey. A 5-year review. *Am. J. Forensic Med. Pathol*. 2005;**26**:141.
34. Gill JR, Cattiness C. Sharp injury fatalities in New York City. *J. Forensic Sci*. 2002;**47**:554–7.
35. Tuusov Jana, Lang Katrin, Väli Marika, Pärna Kersti, et al. Prevalence of alcohol-related pathologies at autopsy: estonian forensic study of alcohol and premature death. *Addiction* 2014;**7**:1–9.
36. Ojima T, Nakamura Y, Dateless R. Comparative study about methods of suicide between Japan and the United States. *J Epidemiol*. 2004;**19**(9):823–9.
37. Joseph A, Abrajam S, Muliyil JP, Prasad J, Minz S, Abraham VJ, et al. Evaluation of suicide rates in rural India using verbal autopsies, 1994–1999. *BMJ* 2003;**326**(7399):1121–2.
38. Suicidal methods Wiesner G. A comparison between East and West Germany epidemiological, forensic and sociomedical aspects. *Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz* 2004;**47**(11):1095–106.
39. Maryam Akhgari, Farzaneh Jokar, Afshar Etemadi Aleagha. Drug related deaths in Tehran, Iran: toxicological, death and crime scene investigations. *Iran. J. Toxicol*. 2011;**5**(1, 2):402–9.
40. Karlovsek MZ. Illegal drugs-related fatalities in Slovenia. *Forensic Sci. Int*. 2004;**146**(Suppl. 1, 2):S71–5.
41. Carson HJ. Classes of drugs and their prevalence in multiple drug intoxication in suicides and accidents. *Legal Med*. 2008;**10**(2):92–5.
42. Koski A, Ojanper I, Vuori E. Interaction of alcohol and drugs in fatal poisonings. *Hum. Exp. Toxicol*. 2003;**22**(5):281–7.
43. De Martinis BS, de Paula CM, Braga A, Moreira HT, Martin CC. Alcohol distribution in different Postmortem body fluids. *Hum. Exp. Toxicol*. Feb 2006;**25**(2):93–7.
44. Pawe Papierz, Jarosaw Berent, Leszek Markuszewski, Stefan Szram. A comparative study of the ethyl alcohol concentration in vitreous humor in relation to ethyl alcohol concentration in blood and urine. *Prob. Forensic Sci*. 2004;**LVIII**:34–44.
45. Jones AW. Alcohol – postmortem. In: Siegel J, Knupfer G, Saukko P, editors. *Encyclopaedia of Forensic Sciences*. London: Academic Press; 2000. p. 112–26.
46. Pelissier-Alicot A, Gaulier J, Champsaur P, Marquet P. Mechanisms underlying postmortem redistribution of drugs: a review. *J. Anal. Toxicol*. 2003;**27**:533–44.