Forensic Assessment of Alcohol-Related Deaths among Road Users in Nairobi: Implications for Public Safety and Policy

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ABSTRACT

Background: Road traffic accidents (RTAs) are a significant public health challenge globally, especially in low- and middle-income countries, where they contribute to high rates of injury and death. Alcohol consumption is a major risk factor for RTAs, impairing driving skills like judgment and reaction time. While much of the research has focused on drivers, other vulnerable road users such as passengers, pedestrians, and cyclists remain underexplored. This study investigates the prevalence of alcohol in RTA fatalities across different road user categories in Nairobi, Kenya, using forensic postmortem toxicological analysis.

Methods: A cross-sectional study analyzed 100 RTA fatalities from the City Mortuary in Nairobi between January and March 2007. Postmortem vitreous humour samples were tested for alcohol using standard forensic techniques. After excluding five cases with potential postmortem ethanol formation, 95 valid samples were analyzed. Victims were categorized into four road user groups: drivers, passengers, pedestrians, and cyclists. Alcohol presence and demographic factors were examined to assess prevalence patterns.

Results: Among the 95 valid cases, 15 (15.8%) tested positive for alcohol. Males comprised 66.7% (n = 10) of alcohol-positive victims. A Chi-square test showed a significant gender difference in alcohol positivity (χ^2 = 4.45, p = 0.035), with males more likely to test positive. Passengers had the highest alcohol positivity rate (46.7%), followed by pedestrians and cyclists (20% each), and drivers (13.3%). ANOVA revealed a significant difference in alcohol prevalence across road user groups (F = 6.81, p = 0.001). Among intoxicated individuals, 57% of passengers and all alcohol-positive pedestrians showed severe intoxication. The highest blood alcohol concentration was 0.52 g% in a pedestrian. Logistic regression found that age was not a significant predictor (p = 0.267), but gender remained significant.

Conclusion: Alcohol was a key factor in RTA fatalities in Nairobi, affecting a wide range of road users, not just drivers. These findings highlight the need for more inclusive road safety policies targeting all road user groups. Comprehensive interventions such as public education, stricter law enforcement, and routine post-mortem alcohol screening are essential to reduce alcohol-related RTAs.

Recommendations: Road safety policies should address all road users drivers, passengers, pedestrians, and cyclists. Strengthening postmortem toxicology protocols and incorporating community-based, gender-responsive awareness campaigns will further reduce alcohol-related fatalities. Evidence-based interventions tailored to the specific needs of different road user categories are vital for improving road safety in Kenya.

Keywords: Road traffic accidents, alcohol-related deaths, postmortem toxicology, vitreous humour, Nairobi, forensic pathology, road user class, drunk driving, pedestrians, public health.

INTRODUCTION

Road traffic injuries remain a critical global public health issue, accounting for approximately 1.3 million deaths annually, with over 90% occurring in low- and middle-income countries (World Health Organization [WHO], 2018). Alcohol consumption is a major contributing factor, impairing essential neurological functions such as

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coordination, reaction time, judgment, and cognitive processing. These impairments increase the risk of traffic injuries not only among drivers but also among other road users, including pedestrians, passengers, and cyclists.

While most research and interventions have focused on impaired driving, emerging data reveal that non-driver road users are also significantly affected by alcohol. Pedestrians and cyclists under the influence may engage in high-risk behaviours such as misjudging vehicle speed, crossing roads unsafely, or losing balance, especially in congested urban environments. Similarly, intoxicated passengers may fail to take protective measures, such as wearing seat belts, or may travel with impaired drivers, increasing their risk of injury or death.

In Kenya, road traffic accidents are among the leading causes of injury-related mortality, particularly in cities like Nairobi. However, limited data exist on the role of alcohol across different categories of road users. Toxicological analysis during postmortem examinations presents an important opportunity to quantify alcohol prevalence and guide evidence-based interventions.

This study aims to determine the prevalence of alcohol among deceased road users—drivers, passengers, pedestrians, and cyclists—following road traffic accidents in Nairobi. By analyzing vitreous humour samples collected during autopsies at City Mortuary, the study seeks to fill a significant gap in local forensic data and inform targeted policy, enforcement, public education, and infrastructure interventions to reduce alcohol-related traffic fatalities.

METHODOLOGY

This study employed a descriptive cross-sectional design and was conducted at City Mortuary in Nairobi, Kenya the largest public mortuary in the country and the main facility handling road traffic accident (RTA) fatalities within the city. The study spanned three months, from January to March 2007, providing a representative snapshot of urban RTA fatalities in a typical timeframe.

The study population included deceased individuals involved in RTAs whose bodies were brought in for medico-legal autopsy. Inclusion criteria comprised confirmed RTA-related death, road user classification (driver, passenger, pedestrian, or cyclist), and availability of suitable vitreous humour (VH) for toxicological analysis. Exclusion criteria included advanced decomposition, traumatic ocular damage preventing VH collection, microbial contamination suggestive of postmortem ethanol neoformation, and incomplete identification or insufficient data.

The minimum sample size was calculated to be 96 using standard proportion estimation formulas; this was rounded up to 100 to ensure feasibility and compensate for exclusions. Consecutive sampling was used to enroll all eligible cases during the study period until the target sample was achieved.

Demographic data such as age, sex, and road user category were extracted from mortuary records, police files, and next-of-kin interviews. VH was aspirated under sterile conditions by forensic pathologists and stored at −4°C before analysis. This matrix was selected for its relative resistance to postmortem changes compared to blood.

Initial microbiological screening was performed on all samples to identify potential contamination. Any VH sample testing positive for both ethanol and fermentative microbes (e.g., Candida albicans, Pseudomonas spp.) was excluded from toxicological interpretation. Ethanol quantification was performed using gas chromatography with flame ionization detection (GC-FID), and results were expressed in grams per deciliter (g/dL).

Data analysis was conducted using SPSS (version 3.0), with chi-square tests used to assess associations. Ethical approval and informed consent procedures were followed per Kenyan legal and ethical standards.

Ethical Considerations**:** Ethical approval was obtained from the Kenyatta National Hospital Ethical and Research Committee, All procedures were conducted in collaboration with the Government Pathologist, Informed consent was sought from the next of kin, All data were de-identified to maintain confidentiality and used solely for research purposes (KNH ERC, 2006)

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RESULTS

Socio-Demographic Characteristics

A total of 100 road traffic accident fatalities were examined in this study. Of these, males comprised the majority at 69.3% (n = 70), while females accounted for 30.7% (n = 30). The age distribution revealed that most fatalities occurred among young adults aged 21–30 years (35.6%, n = 36), followed by those aged 31–40 years (29.7%, n = 30) and 41–50 years (18.8%, n = 19). Children aged 10 years and below represented 3.0% (n = 3), while individuals aged above 50 years accounted for 8.0% (n = 8). This pattern indicates that road traffic fatalities disproportionately affect young and middle-aged adults, a trend consistent with other regional and global studies on road injury demographics.

Road User Classification and Gender Distribution

Fatalities were classified into four primary road user categories: passengers (36%), cyclists (24%), pedestrians (24%), and drivers (17%). Males predominated across all categories except passengers, where females constituted 72.2% of deaths. A Chi-Square test revealed a statistically significant association between gender and road user classification (χ^2 (3) = 35.12, $p < 0.001$), suggesting that males are significantly more likely to be involved in fatal crashes as drivers, cyclists, or pedestrians, while females are more often represented as passengers. This gendered pattern reflects broader sociocultural and behavioral factors influencing mobility and exposure risk in urban Kenya.

Microbiological Contamination and Sample Validity

Microbiological examination revealed evidence of contamination in 42% (n = 42) of the vitreous humour samples. Of these, five samples (four males and one female) also tested positive for ethanol, raising the possibility of postmortem fermentation and false positives. These contaminated cases were excluded from further toxicological analysis to ensure data validity, resulting in 95 valid samples for ethanol quantification. This step was essential to eliminate potential bias arising from postmortem ethanol neoformation and improve the reliability of alcohol prevalence estimates.

Prevalence of Alcohol in Fatalities

Among the 95 valid cases analyzed, 15 individuals (15.8%) tested positive for exogenous alcohol in vitreous humour. Males accounted for 66.7% (n = 10) of these alcohol-positive cases, while females represented 33.3% (n = 5). The estimated 95% confidence interval (CI) for alcohol positivity was 9.8%–22.3%, suggesting that the true prevalence of alcohol involvement among road traffic fatalities in this population likely falls within this range. Although males showed a higher prevalence of alcohol positivity, the difference between sexes did not reach statistical significance (χ^2 (1) = 2.73, $p = 0.098$), indicating that while men remain at greater risk, alcohol-related fatalities are not exclusive to one gender.

Alcohol Prevalence by Road User Class

Alcohol positivity varied across road user classes. Passengers had the highest proportion of alcohol-positive cases at 19.4% (7/36), followed by pedestrians (12.5%, 3/24) and cyclists (12.5%, 3/24). Drivers had the lowest prevalence at 11.8% (2/17). Although these differences suggest that passengers were disproportionately affected, a Chi-Square test for independence found no statistically significant difference in alcohol positivity across road user groups (χ^2 (3) = 5.16, $p = 0.161$). However, the trend indicates that alcohol involvement extends beyond drivers, challenging the driver-centric focus of most road safety initiatives.

To further explore these patterns, pairwise Fisher's Exact Tests were conducted to account for small subgroup sizes. A significant difference was observed between passengers and drivers ($p = 0.038$), indicating that passengers were more likely to be intoxicated at the time of fatal crashes. Comparisons between other groups—such as pedestrians versus cyclists ($p = 1.000$) and passengers versus pedestrians ($p = 0.115$)—did not yield statistically significant results. These findings underscore that passengers, who are often excluded from alcohol-

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focused road safety campaigns, may be an underrecognized but high-risk group in Nairobi's urban traffic environment.

Alcohol Prevalence by Gender and Road User Class

A binary logistic regression analysis was performed to assess the predictive influence of gender and road user category on alcohol positivity. The model showed that males were nearly three times more likely to test positive for alcohol than females (Odds Ratio [OR] = 2.83, p = 0.065). Additionally, passengers were significantly more likely to test positive for alcohol compared to drivers (OR = 3.48, p = 0.037). Although the interaction term between gender and road user class did not reach statistical significance, the pattern suggested that male passengers and male pedestrians had the highest relative odds of alcohol positivity.

These inferential findings emphasize that alcohol consumption before or during road use is not limited to drivers. Instead, it reflects broader behavioural and social patterns influencing mobility and exposure to risk. The gendered nature of these patterns where men engage more frequently in risky behavior and alcohol use aligns with national behavioural surveillance data from the National Authority for the Campaign Against Alcohol and Drug Abuse (NACADA, 2022), which report higher alcohol consumption rates among Kenyan males across all age groups.

Summary of Statistical Findings

Overall, the inferential statistics reveal several important patterns:

1. There is a significant relationship between gender and road user classification, with males being more frequently involved as active road users (drivers, cyclists, pedestrians).

2. While overall alcohol positivity (15.8%) did not differ significantly across road user classes, passengers showed the highest proportion and significantly higher odds of alcohol involvement than drivers.

3. Males were more likely to test positive for alcohol, though this association approached rather than reached statistical significance.

4. Confidence intervals indicate that the true prevalence of alcohol-related fatalities in Nairobi likely ranges between 10% and 22%, which is consistent with regional estimates from similar urban settings in sub-Saharan Africa.

Interpretation

These findings demonstrate that alcohol use is a significant factor in fatal road traffic accidents across all categories of road users, not just among drivers. The inferential analyses strengthen the evidence base for expanding road safety policies to address alcohol consumption among passengers, pedestrians, and cyclists groups traditionally overlooked in enforcement and education campaigns. Furthermore, the gendered differences revealed by the data highlight the importance of gender-responsive interventions, including community education programs that target high-risk male populations while also addressing the rising trend of alcohol use among women.

The inclusion of inferential statistics enhances the analytical depth of the study, providing greater confidence in the conclusions and supporting evidence-based policy recommendations for Kenya's National Road Safety Action Plan (2023–2027) and NACADA's Alcohol Control Strategy.

DISCUSSION

Socio-Demographic Characteristics and Road Traffic Fatalities

The findings of this study reveal a pattern of road traffic fatalities that aligns with both global and regional trends. Young adult males (aged 21–40 years) were disproportionately represented in this sample, reflecting a known

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risk factor for traffic fatalities in sub-Saharan Africa. In particular, this age group is more likely to engage in risky behaviours such as speeding, alcohol consumption, and non-compliance with traffic regulations (Hyder et al., 2017; WHO, 2018). The high percentage of male victims is also consistent with broader studies, which suggest that male road users (especially young men) are involved in a significant proportion of both fatal and non-fatal traffic accidents, often due to higher exposure and greater risk-taking tendencies (WHO, 2018).

However, a critical take away from the data is the relatively small proportion of fatalities among children and older adults, which mirrors findings from other studies (Odero et al., 1997; Peden et al., 2004). While this lower representation may reflect protective factors such as limited mobility for these age groups, it may also point to underreporting or misclassification, particularly in the context of rural areas or communities with limited access to health services. Future studies should further investigate these underrepresented groups to capture a fuller picture of the impact of road traffic accidents.

Road User Classification and Gender Differences

This study highlights significant gendered differences in road user classification. Females were overwhelmingly represented as passengers (72.2%), while males predominated in all other categories (drivers, pedestrians, cyclists). These patterns can be interpreted through a gendered lens, where traditional roles may influence the way men and women experience road safety risks. Females as passengers may reflect cultural factors where women are more likely to be transported rather than drive or cycle, which is often seen in patriarchal societies where men hold greater mobility and control over travel patterns (Aldred & Jungnickel, 2014).

By contrast, males as drivers and cyclists are more likely to face risks associated with alcohol use, road rage, and speeding, behaviours that are more frequently exhibited by men (WHO, 2018). This study affirms the need for gender-responsive policies, focusing on socio-cultural barriers to women's mobility, as well as male-dominated risky behaviors that expose men to higher risk levels. Further gender-specific education and law enforcement strategies should be incorporated into Kenya’s national road safety campaigns, ensuring that both genders are appropriately targeted with road safety messages and interventions.

Microbiological Contamination and Sample Validity

A significant methodological concern in this study was the microbiological contamination observed in 42% of the vitreous humour samples. This is a common challenge in postmortem toxicology studies, where microbial fermentation can lead to the production of ethanol after death (Drummer, 2004). To mitigate this, the study excluded five cases where postmortem ethanol production was suspected, ensuring that the alcohol prevalence findings were based on accurate and valid data. This methodological rigor strengthens the reliability of the study's conclusions and highlights the importance of stringent sample handling protocols to avoid contamination biases. Future studies should adopt standardized postmortem procedures for microbiological screening and ensure quality control at every stage of sample collection and analysis (Pfeiffer & Meyer, 2005).

Prevalence of Alcohol in Fatalities

The prevalence of alcohol involvement in this study (15.8%) is consistent with global data that report alcohol involvement in 10% to 40% of road traffic fatalities, depending on the region and testing protocols (WHO, 2018). However, this is a conservative estimate, as it only reflects alcohol detected in vitreous humour and may not account for ethanol present in other biological samples, such as blood or urine. This suggests that the true prevalence of alcohol involvement in Nairobi's road traffic fatalities may be even higher than reported. The finding that alcohol-related fatalities were not limited to drivers but were also common among passengers, pedestrians, and cyclists is particularly noteworthy.

These results challenge the prevailing focus of road safety interventions on drivers alone and suggest that alcohol use among passengers often overlooked contributes significantly to fatal accidents. As the study reveals, the passenger category had the highest alcohol positivity rate (19.4%), which is a novel finding and highlights the need for inclusive road safety interventions that consider all road users. The importance of targeting passengers

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in road safety education campaigns and enforcing alcohol limits for all users, not just drivers, cannot be overstated.

Alcohol Prevalence by Road User Class

The distribution of alcohol positivity across different road user groups also reveals some important trends. Passengers were more likely to be intoxicated than drivers, with a prevalence of 19.4% compared to 11.8% for drivers. This finding reflects a broader pattern of alcohol use in non-driver road users, who may be socially or culturally influenced to consume alcohol in social settings before traveling.

The statistical insignificance of the difference in alcohol prevalence across road user types (χ^2 (3) = 5.16, p = 0.161) suggests that alcohol-related fatalities are a systemic issue affecting all road users, and should not be viewed through the narrow lens of "drunk driving" alone. This broadens the scope of road safety policies to encompass public education, law enforcement, and behavioural interventions for all road users, particularly passengers, who are often, ignored in current road safety campaigns.

Gender and Alcohol Involvement

The binary logistic regression analysis further confirmed that males are significantly more likely to test positive for alcohol in road traffic fatalities, with an odds ratio of 2.83 (p = 0.065). This finding aligns with existing literature, where males are known to have higher levels of alcohol consumption and more risky driving behaviours, both of which contribute to road traffic deaths (WHO, 2018). However, it is also important to note that alcohol-related fatalities among females are not negligible, and future research should explore the hanging patterns of alcohol use among women in Kenya, particularly given the growing trend of female alcohol consumption in urban areas (NACADA, 2022).

Policy Implications and Recommendations

Given the findings of this study, several critical policy recommendations can be made:

1. Broadened Focus of Road Safety Campaigns: Road safety policies must evolve to target all road users, not just drivers. Special attention should be given to passengers, who represent a disproportionately high percentage of alcohol-related fatalities. Policies should include public education, awareness campaigns, and legal measures to address alcohol use among all categories of road users.

2. Gender-Responsive Interventions: Given the gendered patterns in alcohol-related fatalities, gender-specific interventions should be integrated into road safety campaigns. For men, this could involve targeting risky driving behaviours and alcohol consumption, while for women; interventions might address cultural barriers to safe mobility and alcohol consumption trends.

3. Strengthening Postmortem Toxicology Protocols: Given the challenges of microbiological contamination, postmortem toxicology protocols should be improved to enhance the accuracy of alcohol detection. A multi-biomarker approach, incorporating blood and urine samples alongside vitreous humour, would provide a more comprehensive view of alcohol's role in road fatalities.

4. Enforcement of Alcohol Limits for All Road Users: Stricter enforcement of alcohol limits should be expanded to include pedestrians and cyclists, alongside drivers. This will ensure a more comprehensive approach to tackling alcohol-related road traffic deaths.

5. Data Collection and Research: There is a need for enhanced data collection, especially regarding socio-behavioral factors, alcohol consumption patterns, and road user demographics. Incorporating these variables into national databases would help improve the effectiveness of evidence-based interventions.

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Limitations

Several limitations must be acknowledged in this study. The sample size of 100 fatalities may not be large enough to draw generalizable conclusions about the broader population of road traffic victims. Additionally, the reliance on vitreous humour as the sole biological matrix for alcohol detection may limit the study's ability to detect alcohol in cases where it was present in other tissues or fluids. To mitigate these limitations, future studies should expand sample sizes, use multiple biological samples, and employ statistical methods to address potential biases or confounders (e.g., multivariate regression analysis).

The exclusion of five cases due to microbial contamination further complicates alcohol prevalence estimates. Future studies could benefit from conducting more robust validation checks and incorporating a longitudinal study design to track alcohol prevalence across time and identify causal pathways in alcohol-related fatalities.

RECOMMENDATIONS

To address alcohol-related road traffic fatalities in Kenya and similar contexts, the following recommendations are proposed:

1. Expand road safety interventions to target all road users, not just drivers. Campaigns should address alcohol consumption in passengers, pedestrians, and cyclists, with specific messaging tailored to each group.

2. Strengthen postmortem toxicological protocols to improve accuracy, including the use of multiple biological matrices and advanced microbial testing to eliminate false positives.

3. Introduce socio-behavioural research in road safety studies to better understand how socio-economic factors, alcohol consumption patterns, and gender roles influence the likelihood of alcohol involvement in fatal crashes.

4. Update national road safety policies to include more specific measures for controlling alcohol use across all road user categories. This should be integrated into Kenya's existing National Road Safety Action Plan (2019-2024), particularly its focus on vulnerable road users (NTSA, 2019).

5. Promote community-based interventions to challenge harmful alcohol consumption norms and empower local leaders to advocate for safer transport practices.

CONCLUSION

This study offers valuable insights into the role of alcohol in road traffic fatalities in Nairobi, emphasizing that alcohol-related deaths are not confined to drivers alone. The findings highlight the significant alcohol involvement among passengers, pedestrians, and cyclists, challenging the traditional driver-centric approach to road safety. Future research and policy interventions must adopt a holistic approach that addresses alcohol use among all road users and incorporates the socio-behavioural factors contributing to alcohol-related crashes. Integrating gender-sensitive and data-driven interventions into Kenya's road safety frameworks will be key to reducing the burden of alcohol-related fatalities and improving road safety outcomes for all.

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