ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue X October 2025

Alcohol Involvement in Fatal Road Traffic Accidents: A Forensic Toxicological Study of Drivers, Passengers, Pedestrians, and Cyclists in an Urban African Setting

Wangai Kiama, MMed (Path), FRC PATH (ECSA)

Department of Pathology, Egerton University, Egerton-Njoro, Kenya

DOI: https://dx.doi.org/10.51244/IJRSI.2025.1210000222

Received: 18 October 2025; Accepted: 28 October 2025; Published: 15 November 2025

SUMMARY

Background: Alcohol intoxication is a well-established risk factor in road traffic accidents (RTAs), yet its role among non-driving road users such as pedestrians, passengers, and cyclists remains underexplored. Postmortem toxicological analysis, particularly of vitreous humour, provides a reliable means of assessing alcohol levels at the time of death, provided contamination by fermentative microorganisms is ruled out.

Objective: This study aimed to determine the presence and quantify levels of exogenous ethanol in the vitreous humour of deceased RTA victims. It also sought to analyze the distribution of alcohol intoxication across different road user categories, assess the impact of microbial contamination on toxicological results, and identify demographic patterns among alcohol-positive fatalities.

Methods: A total of 100 vitreous humour samples were collected from confirmed RTA fatalities during medico-legal autopsies. Each sample underwent microbiological screening to detect contamination with fermentative bacteria or fungi. Forty-two samples (41.6%) were excluded due to microbial growth, particularly with organisms like Candida albicans, Proteus spp., and Staphylococcus aureus, which can produce ethanol postmortem. The remaining 15 uncontaminated samples were analyzed for ethanol concentration and classified according to forensic toxicology thresholds into light, moderate, heavy, very heavy, and stuporous levels of intoxication.

Results: Ethanol levels ranged from 0.04 g% to 0.52 g%. Passengers accounted for the largest proportion of alcohol-positive cases (46.7%), followed by pedestrians (20%), cyclists (20%), and drivers (13.3%). Heavy to very heavy intoxication levels were found predominantly among passengers, while all intoxicated pedestrians exhibited stuporous levels (>0.35 g%). Young adult males (aged 21–40 years) were disproportionately affected. The findings also underscore the necessity of excluding contaminated samples, as postmortem microbial fermentation poses a significant risk of false-positive ethanol detection.

Conclusion: Alcohol use was prevalent across all categories of road users, not limited to drivers. The presence of high ethanol levels in pedestrians, cyclists, and passengers highlights the need for a broader perspective in traffic safety strategies. Forensic screening of vitreous humour, combined with microbiological testing, is essential for accurate postmortem ethanol analysis.

Recommendations: To effectively reduce alcohol-related road traffic fatalities, a broader, inclusive strategy is essential. This study highlights the need to extend safety campaigns beyond drivers, targeting all road users—passengers, pedestrians, and cyclists—emphasizing that any alcohol use can impair judgment and increase risk. Forensic toxicology practices should include routine microbial screening and biochemical markers to ensure accurate postmortem ethanol analysis. Policies must address drink-walking and drink-cycling, while urban planning should improve nighttime safety. Targeted interventions for high-risk groups, especially young males, are critical. The message must shift from “don’t drink and drive” to “don’t be impaired in traffic—regardless of your role.”.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue X October 2025

Keywords: Vitreous humour, exogenous ethanol, road traffic accidents, postmortem toxicology, microbial contamination, forensic pathology, intoxication levels, non-driving road users

INTRODUCTION

Road traffic accidents (RTAs) remain a leading cause of death globally, accounting for over 1.3 million fatalities annually, with the highest burden in low- and middle-income countries (World Health Organization [WHO], 2018). Alcohol consumption, particularly ethanol, is among the most modifiable and prevalent risk factors for RTAs. As a central nervous system depressant, ethanol impairs judgment, coordination, and motor control—functions critical for safe road use (Jones et al., 1991; Stat Pearls, 2023).

While existing research and policies often focus on drivers, emerging evidence underscores the vulnerability of non-drivers—pedestrians, passengers, and cyclists—to alcohol-related harm. Intoxicated pedestrians may misjudge speed or visibility; cyclists may have impaired balance; and passengers may ride with unsafe drivers or fail to use seatbelts (D'Angelo et al., 2022). Despite this, most forensic studies have limited their analyses to drivers, neglecting the broader scope of alcohol's impact on road safety.

In sub-Saharan Africa, alcohol is believed to play a role in 20–50% of fatal RTAs, though underreporting and limited toxicological infrastructure obscure the true magnitude (Peden et al., 2004; Chalya et al., 2012). Moreover, postmortem interpretation of ethanol levels is complicated by factors such as microbial neoformation, specimen contamination, and ethanol redistribution, which can lead to misleading results if microbial screening is not performed (Pounder & Smith, 1995; Kaminska et al., 2023).

This study aims to quantify exogenous ethanol in the vitreous humour of deceased RTA victims using validated toxicological methods while incorporating microbial screening to exclude contaminated samples. By analyzing all categories of road users, this research addresses a critical gap in forensic literature and public health policy, promoting a comprehensive understanding of alcohol's role in road traffic fatalities within urban African contexts.

MATERIALS AND METHODS

This study employed a descriptive cross-sectional design to determine the presence and concentration of exogenous ethanol in the vitreous humor of deceased individuals involved in road traffic accidents (RTAs). Conducted over a three-month period from January to March 2007, the research was carried out at the City Mortuary in Nairobi, Kenya's largest mortuary. As the primary repository for RTA victims in the region, the facility provided a representative sample for forensic toxicological investigation (City Mortuary Records, 2006; Chief Government Pathologist, personal communication, 2006).

A convenient sample of 100 autopsies was selected based on an estimated 50% RTA-related death rate among 5,000 annual admissions. Inclusion criteria included all deceased individuals whose cause of death was definitively attributed to an RTA, including drivers, passengers, cyclists, and pedestrians. Exclusion criteria comprised bodies with no recoverable vitreous humor due to trauma and samples that showed microbial contamination during laboratory analysis.

Vitreous humor was collected using a sterile 18-gauge needle and 10 mL syringe, aspirating at least 2 mL from the lateral scleral canthus. Samples were stored in fluoride-containing bottles, sealed, refrigerated at –4°C, and transported in cooler boxes for analysis (Levine, 2006).

Quantitative ethanol analysis was conducted using Gas Liquid Chromatography (GLC) on a Varian 3700 Gas Chromatograph. Samples were prepared with an internal standard (n-propanol) and analyzed under controlled temperatures: injection at 100°C, column at 80°C, and detector at 140°C. Ethanol concentrations were expressed in g/L based on peak area ratios (Levine, 2006).

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue X October 2025

Microbiological screening was performed to detect fermentative organisms capable of postmortem ethanol production. Cultures were grown on Blood Agar, MacConkey Agar, Sabouraud Dextrose Agar, and Robertson's Cooked Meat Medium under both aerobic and anaerobic conditions (Murray et al., 2003).

Data were analyzed using SPSS. Descriptive statistics were presented in tables and charts, while Chi-square tests assessed associations between alcohol levels and demographic variables, with statistical significance set at $p < 0.05$.

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)

RESULTS

Socio-Demographic Data

A total of 100 road traffic accident (RTA) fatalities were examined during the study period. Of these, 70 were male (69.3%) and 30 were female (30.7%), indicating a male predominance in fatal RTA involvement. Age distribution revealed that the 21–30year age group was the most affected, accounting for 36 cases (35.6%), with 27 males (38.6%) and 9 females (29.0%). The 31–40year group followed with 30 cases (29.7%), comprising 22 males (31.4%) and 8 females (25.8%). The 41–50year group had 18 cases (18.8%), with a more balanced gender distribution. Notably, all eight fatalities in the >50 age group were male, while fewer cases were recorded in the ≤10 years (3 cases) and 11–20 years (5 cases) age groups.

Microbiological Quality Control and Exclusion of Samples

To ensure accuracy in postmortem alcohol analysis, microbiological screening of all 100 vitreous humor samples was conducted. Forty-two samples (41.6%) were contaminated, with five testing positive for ethanol and subsequently excluded due to the risk of postmortem ethanol neoformation. Common organisms included Proteus spp., E. coli, Staphylococcus aureus, and Candida albicans. Dual-organism contamination was most frequent (47.6%). Exclusion of ethanol-positive samples with fermentative organisms was essential to maintain the validity of toxicological interpretations.

Identification of Microorganisms and Implications for Postmortem Ethanol Formation

Microbial contamination posed a significant threat to accurate ethanol detection. Organisms with potential for postmortem ethanol production included: Gram-negative bacteria: Proteus spp. (9 cases), Pseudomonas spp. (8), E. coli (4), Gram-positive bacteria: Staphylococcus aureus (14), Streptococcus spp. (α and β hemolytic), Fungi: Candida albicans (21 cases), Aspergillus spp. (6, but non-fermentative)

These findings reinforce the importance of excluding ethanol-positive samples with fermentative organisms to avoid false positives.

Blood Alcohol Concentrations in Valid Samples (n = 15)

After excluding samples with microbial contamination, 15 valid cases remained with confirmed exogenous ethanol in vitreous humour. The ethanol concentrations ranged from 0.04 g% to 0.52 g%, and intoxication levels were classified as light, moderate, heavy, very heavy, and stuporous based on standard forensic toxicology thresholds. The distribution of alcohol levels across road user classes (passengers, pedestrians, drivers, and cyclists) and intoxication categories is presented below with corresponding percentages.

Light Intoxication (0.01–0.05 g%) – 2 cases (13.3%)

To ensure accurate postmortem alcohol interpretation, microbiological screening was performed on all 100 vitreous humor samples. Forty-two samples (41.6%) showed microbial contamination, with five also testing

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue X October 2025

positive for ethanol and thus excluded due to the risk of postmortem neoformation. Identified organisms included Proteus spp., E. coli, Staphylococcus aureus, and Candida albicans. Dual-organism growth was most common (47.6%). Excluding contaminated, ethanol-positive samples was critical for ensuring valid forensic toxicological conclusions.

Moderate Intoxication (0.06–0.20 g%) – 2 cases (13.3%)

Two cases (13.3% of alcohol-positive individuals) exhibited moderate intoxication (0.06–0.20 g%), including one driver and one cyclist, each representing 6.7%. Blood alcohol levels in this range impair motor skills, attention, and reaction times. For the driver, moderate intoxication compromises vehicle control, increasing crash risk. For the cyclist, it affects balance and situational awareness, heightening vulnerability on the road. These findings underscore the significant risks posed by moderate alcohol consumption among active road users.

Heavy to Very Heavy Intoxication (0.21–0.35 g%) – 7 cases (46.7%)

Five individuals (33.3%) were classified as heavily intoxicated (0.25–0.30 g%), with four being passengers. No drivers or cyclists were represented in this group, possibly due to underrepresentation or rapid death post-incident. Two others (13.3%) were very heavily intoxicated (>0.30–0.35 g%), comprising one driver and one passenger, both exhibiting severe cognitive and motor impairment. Combined, these categories accounted for nearly half (46.6%) of all valid alcohol-positive cases. The predominance of passengers (five out of seven) suggests a concerning trend of heavy alcohol use among non-drivers, highlighting the need for public health interventions targeting all road users, not just drivers.

Stuporous Intoxication (>0.35 g%) – 4 cases (26.7%)

Four individuals (26.7%) exhibited stuporous intoxication levels (>0.35 g%), including three pedestrians and one cyclist. At this severity, extreme central nervous system depression impairs consciousness, coordination, and judgment. Such profound intoxication renders safe road navigation nearly impossible, especially for non-motorized users. These findings highlight the significant risk alcohol poses to all road users—not just drivers—and emphasize the urgent need for inclusive public health strategies addressing alcohol-related risks among pedestrians, cyclists, and other vulnerable groups.

Prevalence and Impact of Alcohol Intoxication Across Road User Categories

The study revealed a significant prevalence of alcohol intoxication among all categories of road users involved in fatal road traffic accidents, highlighting that alcohol-related risks extend beyond just drivers. Among the 15 confirmed cases of exogenous alcohol detected in vitreous humour, passengers constituted the largest group (46.7%). Many exhibited heavy or very heavy levels of intoxication, suggesting substantial cognitive and motor impairment at the time of the incident. This finding underscores the vulnerability of intoxicated passengers, who may engage in risky behavior or fail to take safety precautions, such as wearing seatbelts.

Pedestrians accounted for 20% of the positive cases, all within the stuporous intoxication category (>0.35 g%). Such extreme impairment significantly compromises a pedestrian's ability to navigate safely, assess hazards, or respond to traffic. Cyclists, also comprising 20%, displayed a range of intoxication from light to stuporous an alarming trend given their dependence on balance, coordination, and environmental awareness for safe riding.

Although only 13.3% of the alcohol-positive cases were drivers, the levels of intoxication observed moderate and very heavy underscore the continued need for strict drink-driving enforcement. The detection of severe intoxication among non-driving road users emphasizes that alcohol use in traffic environments poses dangers regardless of the role of the individual.

These findings call for a shift in public health and policy focus. Prevention efforts must be broadened to include not only drivers but also pedestrians, cyclists, and passengers. Holistic strategies, inclusive of education, legislation, and infrastructure improvements, are essential to reduce alcohol-related road traffic fatalities effectively.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue X October 2025

DISCUSSION

Socio-Demographic Patterns of Fatalities

The male predominance (69.3%) observed in this study is consistent with both regional and global data, which highlight that men are disproportionately represented in fatal road traffic accidents. This trend is commonly linked to increased exposure to road environments, higher rates of vehicle ownership, and greater propensity for risk-taking behaviours such as speeding and drink-driving among males (WHO, 2018; Kiama, 2022). The majority of fatalities occurred in the 21–30 and 31–40-year age groups, aligning with patterns seen globally, as young adults are typically more mobile and more likely to engage in high-risk travel—especially in contexts involving alcohol consumption (Wongchanapai et al., 2008). The absence of females in the >50 age group may reflect social dynamics, where older women are less likely to be on the road late at night or in high-risk scenarios. Although more males were recorded, the lack of a statistically significant association between age and sex ($p = 0.267$) suggests similar vulnerability across genders within age groups.

Microbial Contamination and Sample Validity

The observed 41.6% microbial contamination rate in vitreous humour samples highlights the significant challenge of accurately interpreting postmortem ethanol levels. Microbial translocation during decomposition, particularly by organisms like Proteus spp., Pseudomonas spp., and Candida albicans, can lead to neoformation of ethanol, resulting in false-positive findings (Boumba et al., 2008; Petković et al., 2005). The exclusion of five ethanol-positive, contaminated samples was essential to maintain data integrity. As emphasized by Stojan et al. (2003), ethanol detection in the presence of fermentative organisms requires cautious interpretation unless supported by confirmatory markers. Routine microbiological screening is thus critical for reliable postmortem toxicology.

Microbial Findings and Implications for Forensic Interpretation

The detection of fermentative microorganisms in numerous samples reinforces concerns about postmortem ethanol artefacts. Candida albicans, identified in 21 cases, is a well-known ethanol producer under anaerobic conditions (Boumba et al., 2008). Similarly, Proteus and Pseudomonas species have been associated with false-positive ethanol results, particularly in decomposing bodies (Stojan et al., 2003). Petković et al. (2005) demonstrated that such organisms can generate detectable ethanol levels within 48 hours under typical mortuary conditions. Excluding contaminated samples from final analysis, as done in this study, enhances the reliability and forensic credibility of the remaining 15 ethanol-positive cases.

Patterns of Intoxication Across Road Users

Light and Moderate Intoxication

Light intoxication (13.3%) was observed in a passenger and a cyclist—road users often neglected in safety discourse. Even at low BAC levels (0.01–0.05 g%), alcohol can impair coordination and judgment, increasing accident risk in complex traffic settings (Stojan et al., 2003). Cyclists are particularly susceptible due to their reliance on balance and agility, while impaired passengers may contribute to in-vehicle distractions. Moderate intoxication (0.06–0.20 g%) was recorded in one driver and one cyclist, a range known to impair reaction time and decision-making (WHO, 2018), thereby elevating crash risk significantly, particularly when operating or navigating roadways (Kiama, 2022).

Heavy and Very Heavy Intoxication

Heavy (0.21–0.30 g%) and very heavy intoxication (>0.30–0.35 g%) levels accounted for nearly half of the valid alcohol-positive cases. Most of these were among passengers (5 out of 7), revealing a significant trend of high alcohol consumption among non-driving road users. Although not in control of vehicles, heavily intoxicated passengers may contribute to dangerous situations through distraction, failure to use seatbelts, or inability to assist the driver (Wongchanapai et al., 2008).

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue X October 2025

One very heavily intoxicated case involved a driver, which is particularly concerning. At such high BAC levels, drivers exhibit severe motor and cognitive dysfunction, which can lead to catastrophic consequences for themselves and others on the road (Kiama, 2022).

Stuporous Intoxication

Four individuals (26.7%) were in the stuporous category (>0.35 g%), including three pedestrians and one cyclist. These individuals were likely to have been in a state of near-unconsciousness, severely compromising their ability to navigate traffic environments. Such levels of intoxication have been associated with high fatality risk in non-motorised road users, who may stumble into traffic or misjudge vehicle speeds and distances (Boumba et al., 2008).

The overrepresentation of pedestrians in this category points to a critical and often ignored public health risk: alcohol-impaired walking. In several studies from Sub-Saharan Africa, intoxicated pedestrians were shown to have disproportionately high fatality rates, particularly at night and near entertainment venues (Kiama, 2022).

Road User Class and Alcohol Positivity

Passengers represented the largest proportion (46.7%) of alcohol-positive cases, indicating significant intoxication among non-driving vehicle occupants. This challenges the traditional focus on "drink-driving" and highlights the broader impact of alcohol on in-vehicle safety and decision-making. Pedestrians and cyclists each accounted for 20% of positive cases, often with high levels of intoxication, emphasizing their heightened vulnerability in traffic—particularly in urban settings with inadequate infrastructure (Wongchanapai et al., 2008). Though fewer in number (13.3%), intoxicated drivers posed significant risk, consistent with studies showing that even a small proportion of drunk drivers can contribute disproportionately to traffic fatalities (Petković et al., 2005).

Contextual Interpretation and Study Limitations

This study adds to the growing body of forensic literature emphasizing that alcohol use is not restricted to drivers and that intoxication among pedestrians, cyclists, and passengers is a serious risk factor in fatal RTAs (Boumba et al., 2008; Kiama, 2022).

However, the study's limitations include the small sample size (n=15), limited timeframe, and absence of multi-fluid comparisons (e.g., blood and urine) to corroborate vitreous humour results. Additionally, crash scene data such as time of death, lighting conditions, or vehicular speed were not available, limiting interpretation of contextual factors.

Despite these constraints, the microbiological screening and rigorous exclusion of contaminated samples enhance the reliability of the findings.

Implications for Policy and Forensic Practice

This study calls for a multifaceted approach to alcohol-related road safety. Public health messaging must expand beyond drivers to include all road users particularly pedestrians, cyclists, and passengers. In countries with high informal transport usage, drunk passengers may play a more significant role in crash causation than previously assumed (Kiama, 2022).

From a forensic perspective, the study demonstrates the critical importance of microbial screening and the need for broader adoption of confirmatory markers to distinguish endogenous from exogenous ethanol. Routine implementation of these techniques will improve the validity of medicolegal interpretations and support judicial outcomes based on sound science (Boumba et al., 2008).

CONCLUSION

This study underscores the significant contribution of alcohol to fatal road traffic accidents, affecting not only drivers but also passengers, pedestrians, and cyclists. Among 15 valid vitreous humour samples with confirmed exogenous alcohol, varying intoxication levels were observed, with passengers comprising the largest group,

many being heavily intoxicated. Pedestrians and cyclists also showed high alcohol levels, highlighting their vulnerability. A 41.6% microbial contamination rate emphasized the need for routine microbiological screening. Young adult males were most affected. These findings support a comprehensive, multi-user approach to alcohol-related road safety interventions, informed by accurate postmortem forensic toxicology.

RECOMMENDATIONS

To effectively reduce alcohol-related road traffic fatalities, a broader, inclusive strategy is essential. This study highlights the need to extend safety campaigns beyond drivers, targeting all road users—passengers, pedestrians, and cyclists—emphasizing that any alcohol use can impair judgment and increase risk. Forensic toxicology practices should include routine microbial screening and biochemical markers to ensure accurate postmortem ethanol analysis. Policies must address drink-walking and drink-cycling, while urban planning should improve nighttime safety. Targeted interventions for high-risk groups, especially young males, are critical. The message must shift from “don’t drink and drive” to “don’t be impaired in traffic—regardless of your role.”

REFERENCES

1. World Health Organization (WHO). (2018). Global Status Report on Road Safety.
2. Jones, A. W., & Holmgren, A. (1991). Alcohol effects on psychomotor performance.
3. StatPearls. (2023). Ethanol Toxicity. National Center for Biotechnology Information.
4. D’Angelo, C., Sethi, D., & Passmore, J. (2022). Gender differences in alcohol-related injury.
5. Peden, M., et al. (2004). World Report on Road Traffic Injury Prevention.
6. Chalya, P. L., et al. (2012). Trauma admissions in a regional referral hospital in Tanzania.
7. MSD Manual. (2023). Alcohol Use and Intoxication.
8. Identification & Management of Acute Alcohol Intoxication (2022). NICE Guidelines.
9. Pope, E., & Henssge, C. (1995). Interpretation of postmortem blood alcohol levels.
10. Pounder, D. J., & Smith, D. J. (1995). Postmortem ethanol diffusion and artefacts.
11. Kaminska, K., et al. (2023). Microbial neoformation of ethanol in forensic samples.
12. City Mortuary Records. (2006). Annual Report on Body Admissions. Nairobi, Kenya: City Mortuary Archives.
13. Kenya National Police Service. (2005). Standing Orders on Procedures for Police Investigations and Autopsies. Nairobi, Kenya: Government Press.
14. Levine, B. (2006). Principles of Forensic Toxicology (3rd ed.). Washington, DC: American Association for Clinical Chemistry Press.
15. Murray, P. R., Baron, E. J., Jorgensen, J. H., Pfaller, M. A., & Yolken, R. H. (2003). Manual of Clinical Microbiology (8th ed.). Washington, DC: ASM Press.
16. Saferstein, R. (2006). Forensic Science: From the Crime Scene to the Crime Lab (2nd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.
17. Boumba, V. A., Ziavrou, K. S., & Vougiouklakis, T. (2008). Postmortem alcohol production: A brief review of the literature and a case report. Forensic Science International, 174(2-3), 133–136.
18. Kiama, P. W. (2022). Postmortem evaluation of alcohol in road traffic fatalities in Nairobi. Journal of Physical and Applied Sciences, 4(1), 112–124.
19. Petković, M., Simic, M., & Vujic, D. (2005). Postmortem production of ethanol in different tissues
20. under controlled conditions. Journal of Forensic Sciences, 50(4), 837–840.
21. Stojan, M., Petković, M., & Simic, M. (2003). The role of microorganisms in postmortem ethanol production. Journal of Medical Biochemistry, 22(2), 45–52.
22. Wongchanapai, W., Suwanlert, S., & Sukonpan, K. (2008). Postmortem blood alcohol stability under different storage conditions. Siriraj Medical Journal, 60(3), 160–164.
23. World Health Organization. (2018). Global status report on road safety 2018. Geneva: WHO Press.