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Association between alcohol consumption, marijuana use and road traffic injuries among commercial motorcycle riders: A population-based, case-control study in Dares Salaam, Tanzania

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ABSTRACT

Background: Alcohol consumption and psychoactive drug use are well-recognised risk factors for road traffic injuries (RTIs). Both types of use may impair and affect drivers' performance. Yet, there is limited literature on their contribution to RTIs among commercial motorcycle riders, particularly in low- and middle-income settings. This study aimed to determine the association between alcohol consumption, marijuana use and RTIs among commercial motorcycle riders in the city of Dar es Salaam, Tanzania.

Methods: We conducted a case-control study between July 2018 and March 2019. Cases (n = 164) were commercial motorcycle riders who had sustained an RTIs and attended at a hospital. Controls (n = 400) were commercial motorcycle riders who had not experienced an RTIs that led to hospital attendance during the past six months. Alcohol consumption was assessed using the Alcohol Use Disorder Identification (AUDIT) score, which classified participants as a non-drinker, normal drinker(1–7 scores) and risky drinker (scores ≥ 8). Marijuana use was assessed through self-reported use in the past year. We estimated odds ratios (ORs) using logistic regression adjusted for sociodemographic, driver-, and work-related factors.

Results: Risky drinking was associated with close to six times the odds of RTIs compared to non-drinkers (OR = 5.98, 95% CI: 3.25 – 11.0). The association remained significant even after adjusting for sociodemographic, driving and work-related factors (OR = 2.41, 95% CI: 1.01 – 5.76). The crude odds ratios of RTIs were significantly higher among users of marijuana than non-users (OR = 2.33, 95% CI: 1.38 – 3.95). However, the association did not remain statistically significant after adjusting for confounders (OR = 1.11, 95% CI = 0.49–2.48).

Conclusion: Our findings confirm increased odds of RTIs among commercial motorcycle riders with risky drinking behaviour even after taking sociodemographic, driving and work-related factors into account. Unlike alcohol consumption the relationship between marijuana use and RTIs among commercial motorcycle riders was unclear. Since motorcycle riders are more susceptible to the effect of alcohol due to higher demands of balance and coordination and because commercial motorcyclist riders, in particular, they spend a considerable amount of time on the road, our results underscore the importance of addressing hazardous alcohol consumption and marijuana use in future prevention strategies to enhance road safety.

1. Introduction

Road traffic injuries (RTIs) are among the leading causes of emergency care in many low- and middle-income countries (LMICs) (Adeloye et al., 2016). Currently, Africa has the world's highest road traffic fatality rates, with motorcyclists being disproportionately over-represented (World Health Organization, 2015). Also, RTIs among motorcyclists often go unreported (Abegaz et al., 2014; Constant and Lagarde, 2010) and consequently, the official statistics tend to be an underestimation of the true magnitude of the problem.

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Tanzania is one of the countries in Africa with a high burden of motorcycle-related RTIs. A study conducted at six public hospitals in Tanzania showed more than half of all injury-related admissions were due to motorcycle RTIs (Boniface et al., 2016). A large proportion of injured motorcyclists were commercial motorcycle riders (Bishop et al., 2018b). The high rate of road traffic crashes in this group was documented elsewhere in Tanzania (Nguyen et al., 2018) where, half of the riders reported to be involved in crashes and more than 80% experienced near-crash events within the past month before the interview (Nguyen et al., 2018).

Commercial motorcycle riders in Tanzania are mostly men with limited formal motorcycle training (Bishop et al., 2018b). A report by Bishop *et al.* showed that only 23% of commercial motorcycle riders had received formal motorcycle training (Bishop et al., 2018a). Furthermore, there is no standardised curriculum in Tanzania for training motorcycle riders, and when available, it is mostly theory-based as opposed to practical skills training (Bishop et al., 2018b; Bishop and Amos, 2015a).

Studies have shown that risky driving behaviours are common among commercial motorcycle riders (Falco et al., 2013; Mannering and Grodsky, 1995). Even though it is illegal to drive without a license in Tanzania (GoT, 1973), however, many commercial motorcycle riders tend to disobey the law (Bradbury, 2015). For example, a study found that only 29% of commercial motorcycle riders reported having a driving license (Bishop et al. (2018). . Additionally, profitability among riders depends on the number of trips they can complete during the working day, which incentivises commercial motorcycle riders to work for long hours and ride at higher speeds to maximise the number of trips (Bishop et al., 2018b; Bishop and Amos, 2015b; Nguyen et al., 2018). Regarding the use of protective safety measures, motorcycle helmet usage has been reported to be about 75% to 80%; however, the quality of helmets differs, and they are often not fastened correctly (Nguyen et al., 2018). Evidence suggests that helmet use is associated with reduction of mortality and the risk of head injuries among motorcycle riders (Gupta et al., 2018; Kuo et al., 2017).

Studies have also indicated that alcohol consumption and psychoactive drug use are common among commercial motorcycle riders (Alti-Muazu and Aliyu, 2008; Nguyen et al., 2018; Mundenga et al., 2019). The consumption of alcohol, even in small doses is associated with an increased risk of being involved in a crashes and RTIs (Damacena et al., 2016; Keall et al., 2004). Alcohol intake affects judgment, slows down visual information processing and the ability to discriminate traffic signs, impairs psychomotor skills, and prolongs reaction time (Creaser et al., 2009; Ogden and Moskowitz, 2004). Moreover, the influence of alcohol has been shown to be a stronger risk factor for crashes among motorcycle riders than for other motorists (NHTSA, 2008). Epidemiological studies have reported lower mean Blood Alcohol Concentration (BAC) among motorcycle riders who were involved in road crashes relative to car drivers, evincing the need for greater physical coordination and balance when driving a motorcycle (Sun et al., 1998). Simulation experiments of alcohol's effect on driving show increased reaction time and errors for motorcycle riders compared to car drivers (Colburn et al., 1993). Other documented effects of alcohol include excessive or inappropriate speed, inattention, failure to navigate curves, and increased probability of running off the road (Kasantikul et al., 2005).

The risk of RTIs related to alcohol consumption is linked to both the amount and drinking pattern. Two studies conducted in sub-Saharan Africa found that alcohol consumption was associated with an increased risk of RTIs among commercial motorcycle riders (Owoaje et al., 2005; Tumwesigye et al., 2016). Studies have shown that motorcycle riders with a hazardous pattern of alcohol consumption are more likely to drink and drive (Freeman et al., 2020; Macinko et al., 2015; Staton et al., 2018). High-risk drinking has also been shown to be associated with other unsafe driving behaviours including the use of mobile phone while driving, speeding, not wearing a helmet and other protective gear (Bogstrand et al., 2015; Dos Santos et al., 2019; Heydari et al., 2016; Shyhalla, 2014; Wu et al., 2019). Risky drinkers have also been shown to be less compliant to traffic rules and road signs as well as driving without a driving license (Bogstrand et al., 2015; Dos Santos et al., 2019; Heydari et al., 2016; Shyhalla, 2014; Wu et al., 2019).

Recently, there has been increasing recognition of the effect of psychoactive drugs on RTIs (Ravera et al., 2011). The potential psychoactive drugs reported to be associated with the risk of RTIs are including marijuana/cannabis, amphetamines, cocaine, heroin and opiates (Alti-Muazu and Aliyu, 2008; Papalimperi et al., 2019). These substances impair driving performance by altering the perception of external stimuli, and consequently, their response to them (Movig et al., 2004). A cohort study conducted among trauma patients in Tanzania indicated that more than third of patients were tested positive for psychoactive drugs, and the most of the patients were motorcycle drivers (Mundenga et al., 2019). The most common psychoactive drugs detected among these trauma patients was marijuana (Mundenga et al., 2019). Moreover, the combination of psychoactive drugs and alcohol has been shown to compound the impairment and further increase the risk of RTIs (Kane et al., 2002; Marr, 1999).

Motorcycle riders who operate commercially are a distinct population in the traffic environment. They are exposed to a greater risk of road crashes and injuries as they spend more hours on the road and have different incentives for taking risks than other road users. There is limited evidence on the role of alcohol consumption and marijuana on RTIs among this group of riders in sub-Saharan Africa. Therefore, this study aimed to determine the association between alcohol consumption, marijuana use and RTIs among commercial motorcycle riders in the city of Dar es Salaam, taking into consideration sociodemographic, driver's and work-related factors.

2. Materials and methods

2.1. Study design and setting

A case-control study involving commercial motorcycle riders in Dar es Salaam was conducted from July 2018 to March 2019 using structured interviews. The city covers an area of 1590 square kilometers and is divided into five municipalities, with an estimated population of 5.7 million people (NBS, 2017). Men aged 15 to 39 years make up 25% of the city's total population (NBS, 2017). The main economic activities in the city are manufacturing, transportation, retail, and wholesale business. Public buses, commercial motorcycles ("Boda-bodas") and motorized three-wheelers ("Bajaji") are the most common means of transport in Dar es Salaam. According to the Police Crime and Traffic, Incidents Report in 2018, Dar es Salaam's city accounted for almost 40% of all road injuries in Tanzania (Inspector General of Police, 2017).

2.2. Study population

Cases were defined as commercial motorcycle riders who sustained an RTIs and attended at the selected study hospitals from July 2018 to March 2019. Typically, RTI victims tend to attend a nearby health care facilities to stabilize their emergency conditions such as bleeding, severe pain or breathing difficulties and sometimes are discharged or referred to a progressively higher-level health facility when further investigations are required. Our study included commercial motorcycle riders who sought care at a hospital. A total of 197 eligible cases were identified and approached, of which ten declined to participate, and 23 could not be reached for various reasons.

2.2.1. Control recruitment

Cases were identified and recruited from two tertiary hospitals of Muhimbili National Hospital (MNH) and Muhimbili Orthopedic Institute (MOI), and three main regional referral hospitals of Mwanayamala, Temeke, and Amana located in Dar es Salaam. These hospitals were purposefully selected because they are major public hospitals that provide care to RTI victims in Dar es Salaam. The three regional hospitals

represent the second-highest level of hospital care next to the tertiary hospitals, and the majority of RTIs victims with moderate and severe injuries would eventually end up at these hospitals. This approach ensured the capture of the majority of injured commercial motorcycle riders who sought hospital-level of care.

At the tertiary hospitals, cases were identified retrospectively from patient admission records at the Emergency Department (EMD) by a research assistant on a weekly basis. The information such as hospital registration number, name, phone number, date of the crash, and mechanism of injury that were recorded in the hospital patient registration system was extracted to assist tracing of commercial motorcycle riders who admitted due to RTIs at MNH and MOI wards. Once the cases were identified at the wards, they were informed about the study and, after informed consent, interviewed by our trained research assistant.

At the regional hospitals, cases were identified by a triage nurse at the outpatient/surgery department daily. The triage nurse then alerted our research assistant to interview without hindering or delaying the care or diagnostic services. Cases visiting during the weekend or nighttime were recorded in a logbook and invited for an interview the next day at the hospital.

Cases that were discharged before the interview could take place were tracked by phone number and then invited for an interview at the hospital when they came in for clinical check-up, at homes or at the parking stages. All the interviews were conducted face-to-face by trained research assistants and lasted approximately 40 min. A parking stage is a well-organized, precise location that registers and allows commercial motorcycle riders to park and wait for passengers. To avoid recall bias, we did not consider cases that could not be invited and interviewed within 14 days after the crash due to poor health conditions or other reasons.

2.2.2. Control recruitment

Controls were commercial motorcycle riders who reported no history of RTI that led to hospital attendance within the past six months. Recruitment of controls was done at 90 purposefully selected parking stages between December 2018 to March 2019. The parking stages were selected across the five municipalities of Dar es Salaam City Council and included parking stages located at the trunk and collector roads. There are variations in the size of parking stages: those located along the trunk roads have a large number of riders compared to those found in collector roads. This sampling approach was used to ensure that controls were representative of commercial motorcycle riders in the city. At the parking stages, all riders were approached, informed about the study and consented to participate in the study. We recruited about 20% of the riders at each parking stage. We assigned numbers (one for participation and the other for not) on a piece of paper and asked riders to choose a number. Compensation of a 1$ voucher was given to riders who participated. Of 413 eligible controls, 13 (3%) declined to participate for various reasons, ending up with a total of 400 controls. In total, our study population included 564 commercial motorcycle riders operating within the city of Dar es Salaam, aged 18 years and above (164 cases and 400 controls). The controls were interviewed face-to-face by trained research assistants. The interviews took place at parking stages and lasted approximately 40 min.

2.3. Sample size determination

The sample size was calculated using OpenEpi version 3.0 statistical software for unmatched case-control study (Dean et al., 2013). We aimed to detect an OR of at least 1.8 for being a case, with significant level ($Z\alpha = 1.96$), at 95% confidence interval, power of 80%, and a ratio of one case to two controls, assuming the prevalence of alcohol consumption among commercial motorcycle riders to be the same (22.2%) as that of males in the general population (Mbatia et al., 2009). A minimum sample size of $n = 495$ ($n = 165$ cases and $n = 330$ controls) was required. After adding 10% non-response rate, the total of 550 sample size was required.

2.4. Measurements of alcohol consumption and psychoactive drug use

The Alcohol Use Identification Test (AUDIT) was used to assess alcohol consumption. The AUDIT is a screening tool developed by the World Health Organization (WHO) for assessing alcohol consumption, drinking behaviour and alcohol-related problems (Saunders et al., 1993; Tsai et al., 2005). The first three questions in the AUDIT questionnaire are used to measure the frequency of alcohol consumption, the number of standard drinks containing alcohol on a typical day when drinking, and the frequency of heavy drinking (having six or more drinks on one occasion) (Babor et al., 2001). The next three questions covered: symptoms of alcohol dependence, impaired control due to over-drinking, increased salience due to drinking, and morning drinking. The last four questions focus on: harmful alcohol use, guilt after drinking, blackouts, and alcohol-related injuries associated with drinking. All ten items of AUDIT scores were summed up and classified into four categories: non-drinker (score 0), normal consumption (scores 1–7), risky drinker (scores 8–15) and possible alcohol dependence (scores 16 and above) (Fujii et al., 2016; Saunders et al., 1993). However, due to the small number of participants with AUDIT scores of 16 and above, the cut-off points of AUDIT scores were revised into three categories; non-drinker (score 0), normal consumption (AUDIT scores 1–7), and risky drinker (AUDIT scores $\geq$ 8). Missing values for AUDIT scores were imputed using means scores of individual with an assumption that the values were missing at random on less than two items of the scale. Psychoactive drug use was assessed by asking whether the participants had used any drugs in the past 12 months If they responded yes, there were follow-up question as about which psychoactive drug (s) they had used.

2.5. Variables

We collected demographic characteristics of the participants which included; age-group18-24, 25–29, 30–34, 35–48 years old; marital status: single, married and divorced or separated; and education level: none, primary and secondary and above.

2.5.1. Confounding variables

We also collected information on driver-related factors (ever possessed motorcycle driving license (yes/no), motorcycle driving experience categorized as $\leq$ six months,>six months and $\leq$ one year, >one year and $\leq$ 3 years,>three years) and risky driving behaviour. Risky driving behaviour was assessed using a validated motorcycle riding behaviour questionnaire that has been used in previous studies (Ivers et al., 2009; Sakashita et al., 2014). This is a 14-item aggregated rating scale with 5-point Likert-scale ranging from never (0) to very often (4). Several studies on unsafe driving behaviours have confirmed the accuracy and reliability of the tool in the field (Rothengatter and Vaya, 1996; Uttra et al., 2020).

The items included asking the participants: how often 1) do you drive with two or more passengers? 2) do you drive while listening to loud music? 3) do you drive about 60 km/hr. in a 50 km zone? 4) do you drive fast because your passenger demands it? 5) do you speed up if someone is trying to overtake? 6) do you take risks because it is fun driving that way 7) do you take risks because your passenger demands it? 8) do you make rude gestures at other drivers such as yelling, spitting? 9) do you do burnouts, roll out or skid just for fun? 10) do you honk your horn or flash your lights in anger at other drivers? 11) do you race or drag race just for the fun of it? 12) do you drive while talking on a mobile phone? 13) do you drive without a helmet? 14) do you drive while texting. The internal consistency of the questionnaire used in this study was examined using Cronbach alpha, which was 0.83. Then all scores of 14 items were summed up to give a total score. Missing values on each subject were filled using an imputation of the subject's mean score based on the

assumption of missing at random on less than three items. The scores of risky driving behaviours were classified into two categories based on the reference to the distribution of the scores of risky driving behaviour of the controls: those below the median score as "low-risk driving behaviour" and those above the median as "high-risk driving behaviour".

Furthermore, we collected information on work-related factors (number of working hours per day categorized using tertiles based on the reference of the distribution on the number of working hours per day of the of the controls; (5-≤13 h, 14 h and15–20 h; and average income earned per day using tertiles based on the reference of the distribution of the earnings of the controls in Tshs as low-income (6,000-≤13,000), moderate-income (13,000-≤18,000), and high-income (18,000–55,000). The missing information on the number of working hours and income earned per day was imputed using a mean total score of observed subjects in each group for cases and controls (Frick and Grabka, 2014; Hron et al., 2010)

2.6. Statistical analyses

Descriptive statistics, including frequencies and proportions, were used to summarize the data. Chi-square tests were used to compare sociodemographic, drivers-and work-related factors between cases and controls. Logistic regression analyses were performed to estimate the associations between alcohol consumption, marijuana use and RTIs. The analyses were, in different steps, adjusted for: i) sociodemographic factors; ii) driver-related factors; iii) work-related factors, and iv) fully adjusted model withall factors. The estimated effects were reported as OR with 95% confidence intervals. All statistical tests were two-sided, and a p-value < 0.05 was considered statistically significant. All data analyses were performed using Stata software 13 (Stata Corp.LP, College Station, United States of America).

2.7. Ethical consideration

The study received ethical approval from the Institutional Review Board at Muhimbili University of Health and Allied Sciences (Ref No. DA 282/298/01). A formal written informed consent in Swahili was used. The participants were assured of anonymity and that data collected would not be disclosed outside the research team.

3. Results

3.1. Characteristics of study participants

The cases were comparatively younger than the controls, with a mean age of 27.8 and 29.5 years, respectively (Table 1). More than half (55.3%) of the cases were single, while 59.3% of the controls were married. The cases had a lower level of education and less driving experience compared to the controls. About 39.0% of the cases and 35.5% of the controls reported never having possessed a motorcycle driving license. Regarding the work-related factors, the cases reported working more hours per day compared to the controls. More than half of the cases reported earning a higher daily income compared to 18% among the controls. Nearly 82% of cases reported high risky driving behaviour compared to controls (57.5%).

3.1.1. Distribution of alcohol consumption and marijuana use

A higher proportion of cases reported consumption of alcohol in the past year compared to controls ($p < 0.001$). Compared to controls, cases more often reported consuming alcohol two or more times in a week, and engaged in heavy drinking and consumed more alcohol in the past year ($p < 0.001$). Cases (14%) were 3.5 times more likely to report risky drinking compared to controls (4%). Regarding psychoactive drug use, marijuana was the only drug reported among the study participants. Marijuana use in the past year was higher among cases (18.3%) compared to controls (8.8%) ($p = 0.01$). Overall, 15.3% of cases and 7.3% of controls reported having both consumed alcohol and used marijuana in the past year ($p < 0.001$) (Table 2).

Table 1
Comparison of sociodemographic, driver-and work-related characteristics of cases and controls (N = 564).

Characteristics	*Cases* *n = 164, n (%)*	*Controls* *n = 400, n (%)*	*P-value*[δ]
Sociodemographic factors			
Age groups, years			<0.001
18–24	56 (34.2)	66 (16.5)	
25–29	54 (32.9)	178 (44.5)	
30–34	34 (20.7)	93 (23.3)	
35–48	20 (12.2)	60 (15.0)	
Missing	0(0)	3 (0.8)	
Highest education level			<0.001
None	30 (18.3)	66 (16.5)	
Primary	109 (66.5)	161 (40.3)	
Secondary and above	25 (15.2)	163 (40.8)	
Missing	0 (0)	10 (2.5)	
Marital status			<0.001
Married	73 (44.5)	237 (59.3)	
Single/Divorced/Separated	91 (55.5)	161 (40.3)	
Missing	0 (0)	2 (0.5)	
Driver-related factors			
Ever possessed a motorcycle driving license			0.01
No	64 (39.0)	143 (35.6)	
Yes	100 (61.0)	256 (64.0)	
Missing	0 (0)	1 (0.3)	
Motorcycle driving experience duration			<0.001
≤ 6 months	15 (9.2)	6 (1.5)	
>6 months-≤1year	26 (15.9)	17 (4.3)	
>1–3 years	39 (23.8)	107 (26.8)	
≥3 year	84 (51.2)	264 (66.5)	
Missing	0 (0)	6 (1.5)	
Risky driving behaviour			<0.001
Low	30(18.3)	173(43.5	
High	134(81.7)	226(57.5)	
Work-related factors			
Number of hours worked per day			0.02
≤13	49 (32.0)	172 (43.1)	
14	39 (25.5)	103 (25.825)	
15–20	65 (42.5)	124 (31.1)	
Missing	11 (6.7)	1 (0.3)	
Average income per day (Tshs)			<0.001
Low (6,000 - ≤13,000)	11 (6.6)	157 (39.3)	
Moderate (13,000-≤18,000)	140(23.0)	131 (32.8)	
High (>18,000 – 55,000)	114 (69.5)	105(26.3)	
Missing	16 (9.8)	7 (1.8)	

[δ]P-value for the chi-square. The chi-square calculations did not include the missing categories.

3.1.2. Association between alcohol consumption, marijuana use and RTIs

In Table 3, we present the association between alcohol consumption, marijuana use and RTIs. The results show that the odds of RTIs were close to six times higher among risky drinkers compared to non-drinkers in the crude model (OR = 5.98, 95% CI: 3.25 – 11.00). The odds of RTIs among risky drinkers were between 4 and 5 times higher after adjusting for each of the confounding factors,i.e. sociodemographic, driver's- and work-related factors separately (Table 3). Following adjustment for all factors the odds for RTIs among risky drinkers reduced but remained statistically significant (OR = 2.41, 95% CI: 1.01 – 5.76), (Table 3). The estimated crude odds ratio of RTIs was two times higher among those who reported the use of marijuana in the past year compared to those who did not (crude OR = 2.33, 95% CI: 1.38 – 3.95). Adjusted for risky driving behaviour, the odds of RTIs among commercial motorcycle riders who reported the use of marijuana in the past year decreased (OR = 1.77, 95% CI 1.01–3.11). The association between reported marijuana use and RTIs was not sustained in the fully adjusted model (OR = 1.11,

Table 2
Distribution of alcohol consumption and marijuana use among cases and controls (N = 564).

Measures	*Cases (n = 164), n (%)*	*Control, (n = 400), n (%)*	*P-value*[δ]
Ever used alcohol in the past year			<0.001
No	105 (64.0)	320 (80.0)	
Yes	59 (36.0)	76 (19.0)	
Missing	0 (0.0)	4 (1.0)	
Frequency of drinking an alcoholic drink			<0.001
Never	105 (64.0)	320 (80.0)	
Once or less in a month	16 (9.8)	38 (9.6)	
2–4 times in a month	20 (12.2)	22 (5.6)	
2–3 times in a week	19 (11.6)	11 (2.8)	
4 or more in a week	4 (2.4)	5 (1.3)	
Missing	0 (0)	4 (1.0)	
Number of drinks containing alcohol on a typical day			<0.001
None	105 (64.0)	326 (81.5)	
1 or 2	40 (24.4)	56(14.0)	
3 or 4	17 (10.4)	17(4.3)	
5 or 6	2 (1.2)	1(0.2)	
Frequency of having six or more drinks on one occasion			<0.001
Never	119 (72.6)	355 (88.8)	
Less than a month	24 (14.6)	39 (9.8)	
Every month	15 (9.2)	5 (1.3)	
Every week	6 (3.7)	1 (0.3)	
AUDIT score categories			<0.001
Non-drinker	105 (64.0)	323 (80.8)	
Normal consumption	24 (14.6)	59 (14.8)	
Risky drinker	23 (14.0)	16 (4.0)	
Possible alcohol dependence	12 (7.3)	2 (0.5)	
Use of marijuana in the past year			0.001
No	134 (81.7)	365 (91.2)	
Yes	39 (18.3)	35 (8.8)	
Alcohol or marijuana use* in the past year			<0.001
Not used	105 (64.0)	320 (80.0)	
Either used alcohol or marijuana	34 (20.7)	47 (11.8)	
Used alcohol and marijuana	25 (15.3)	29 (7.3)	
Missing	0 (0)	1 (0.7)	

*Use of psychoactive drugs was asked for and marijuana was the only drug reported, AUDIT: Alcohol Use Disorder Identification tool, [δ]P-value for the chi-square.

95% CI: 0.49–2.48).

4. Discussion

This study adds to the existing evidence that there is an increased risk of RTIs among commercial motorcyclist riders who report alcohol consumption in sub-Saharan Africa (Owoaje et al., 2005; Tumwesigye et al., 2016). Our analysis showed an almost six times increased odds of RTIs among commercial motorcyclist riders who reported risky drinking compared to non-drinkers. The effect decreased to 2.41 times when adjusted for sociodemographic characteristics, work-related factors and risky driving. The decreased effect of alcohol consumption in the fully adjusted model indicates that some of the effect may be due to other risk factors of RTIs

Unlike the increased risk of RTIs among riders with risky drinking behaviour, the odds of RTIs was non-significant among commercial motorcycle riders reporting normal alcohol consumption compared to non-drinkers. Furthermore, our findings showed that alcohol consumption in the past year was not significantly associated with the risk of RTIs. This could probably be explained by the fact that alcohol consumption in the past year is a less sensitive measure as it includes both riders who reported normal alcohol consumption and those who fall into the risky drinker category.

Evidence from other studies suggested that alcohol consumption and marijuana use are directly or indirectly associated with other risky driving behaviours. In this study we also noted high prevalence of risky driving behaviour in both cases and controls. As motorcycle use is becoming an increasingly important means of transportation in Tanzania (Bishop et al., 2018b; Sumner et al., 2014), the high prevalence of risky driving behaviour is particularly concerning.

Our study shows that most cases were younger, unmarried, and had a lower level of education. These findings are consistent with other studies that have shown an association with increased motorcycle RTIs and sociodemographic factors, notably young age, male sex, and low education level (Lin and Kraus, 2009; Xiong et al., 2016).

Only six out of ten motorcycle riders are reported to have ever possessed motorcycle driver's license even though possession of license is mandatory in Tanzania (GoT, 1973). The low proportion of license possession may reflect a low level of enforcement of traffic-related safetyregulations. Approximately two-thirds of study participants reported working for>13 h a day, suggesting a higher number of working hours in this group of riders.

Our findings are consistent with findings from a previous study on risk factors for RTIs among commercial motorcyclists in Uganda by Tumwesigye *et al.* ,which showed that alcohol consumption was associated with increased risk of RTIs among commercial motorcycle riders (Tumwesigye et al., 2016),

The measurement we have used,the AUDIT is an indirect measure of alcohol consumption which does not measure the effects of the actual intake of alcohol consumption, i.e. level of intoxication at the time of RTIs; instead, it measures the frequency and amount of alcohol consumption to predict the pattern of alcohol use and disorder and hence its influence on the driving ability, directly or indirectly through other mechanisms. Also, studies have shown that drivers with hazardous alcohol consumption are more likely to drink and drive (Freeman et al., 2020; Macinko et al., 2015; Staton et al., 2018)

Previous studies have reported that alcohol intake negatively affects attention and increases the likelihood of sensory and motor dysfunction such as loss of balance and increase in reaction time (Lin and Kraus, 2009; Ogden and Moskowitz, 2004; Woratanarat et al., 2009). Since balance and coordination are important for motorcycle riders, both novice and experienced motorcycle riders are more susceptible to the effect of alcohol consumption than other motor vehicle drivers (Mannering and Grodsky, 1995; Rudin-Brown et al., 2013). In addition to the impairment of driving performance, alcohol consumption has been shown to be associated with other risky driving behaviours such as speeding, failure to use a helmet, and not having a motorcycle driving license (Bogstrand et al., 2015; Dos Santos et al., 2019; Heydari et al., 2016; Shyhalla, 2014). Moreover, high alcohol consumption has been reported to be associated with non-compliance with traffic rules such as violating the traffic lights, carrying two or more passengers and using cellphones while driving (Heydari et al., 2016). Our findings show that, even after considering risky driving behaviour, risky drinking was still associated with higher odds of RTIs, emphasizing the need to develop interventions to reduce risky alcohol consumption among these riders.

Another important finding revelead that there was a doubling odds of RTIs among riders who reported marijuana use compared to non-users. Congruent to the observation obtained in a longitudinal study of a cohort of motor vehicle drivers in New Zealand (Sewell et al., 2009), which showed that statistically significant association disappeared after controlling for risky driving behaviour, driving licensure and driving experience. Studies have suggested that increased risk of RTIs observed with marijuana use might appear to reflect the characteristics of drivers who are often young men and prone to engage in risk-taking behaviour (Brien and Gormley, 2016; Fergusson and Horwood, 2001). In addition, the studies which have found an association have observed it among drivers who reported to have driven while under the influence of marijuana but not with merely the use (Sewell et al., 2009). Cognitive

Table 3
Association between alcohol consumption, marijuana use and RTIs, crude and adjusted for sociodemographic, driver- and work-related factors (OR and 95% confidence intervals (95% CI), N = 564).

Variables	Crude model	Adjusted for sociodemographic	Adjusted for Driver-related factors[b]		Adjusted for work-related factors	Fully adjusted[d]
			Driving license, driving experience	Risky driving behaviour		
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Ever used of alcohol in the past year						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	2.39 (1.60–3.59)	2.12 (1.37–3.27)	2.12 (1.39–3.26)	1.92 (1.25–2.93)	2.04 (1.28–3.26)	1.38 (0.77–2.47)
AUDIT score categories						
Non-drinker	Ref	Ref	Ref	Ref	Ref	Ref
Normal consumption	1.25 (0.74–2.11)	1.10 (0.63–1.94)	1.22 (0.71–2.10)	1.18 (0.69–2.03)	1.11 (0.6 2–2.02)	0.96 (0.47–1.97)
Risky drinker †	5.98 (3.25–11.00)	5.40 (2.80–10.30)	4.90 (2.59–9.29)	4.03 (2.12–7.67)	4.97 (2.45–10.09)	2.41 (1.01–5.76)
Use of marijuana in the past year						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	2.33 (1.38–3.95)	1.90 (1.08–3.34)	1.74 (0.98–3.04)	1.77 (1.01–3.11)	2.23 (1.20 – 4.14)	1.11 (0.49–2.48)

Notes: AUDIT Alcohol Use Disorder Identification tool, [a]Sociodemographics include age, marital status and the highest level of education. [b]Driver-related factors include i) possession at any time of a motorcycle driving license and riding experience ii) risky driving behaviour. [c]Work-related factors include the number of working hours per day and driver's earnings per day. †Risky drinker here includes risky drinkers and drivers with alcohol dependence. [d]The fully adjusted model includes sociodemographic, driver- and work-related factors

studies have reported a plausible biological mechanism of impaired driving performance among marijuana users (Sewell et al., 2009). However, there has been inconsistent evidence on whether marijuana use increases the incidence of a crash and subsequent injuries in epidemiological and experimental studies (Sewell et al., 2009). It has been suggested that the mechanism through which marijuana use does not increase crash risk despite neurophysiologic impairments is that marijuana users tend to overestimate their impairment and consequently employ compensatory strategies (Ramaekers et al., 2009; Sewell et al., 2009). Furthermore, driving and simulation studies have revealed that drivers who use marijuana/cannabis tend to decrease their speed, attempts fewer overtakes, and increase their following distance (Smiley, 1998; Downey et al., 2013).

Moreover, in studies that reported driving impairment, marijuana use was associated with impairment of automatic driving functions of which drivers could not compensate for, and the risk of which increased with increasing doses (Ramaekers et al., 2009). On the other hand, other psychoactive drugs such as opiates, stimulants inhalant, and zopiclone have been associated with a higher risk of RTIs (Elvik, 2013; Gudaji and Dankishiya, 2016). At both the individual and societal level, alcohol consumption and psychoactive drug use represent a severe threat to road traffic safety (Lin and Kraus, 2009; WHO, 2015; Staton et al., 2018). Studies have shown that the effects of alcohol consumption increase in dose-related fashion and are more pronounced with complex integrative functions, which is the opposite pattern from that seen for marijuana use (Sewell et al., 2009). Combining marijuana with alcohol might eliminate the ability to use coping strategies effectively, leading to impairment at lower doses than when either drug is used alone (Kane et al., 2002; Sewell et al., 2009). Our study showed that it is not uncommon among commercial motorcyclists to consume alcohol and use marijuana; 15% of cases and 7.3% of controls reported using both alcohol and marijuana in the past year. However, we did estimate an effect for this combination as data could not differentiate between combined use of alcohol and marijuana at the same time from using them at separate occasions.

A notable limitation of our study was that data were self-reported and subject to social desirability bias(Latkin et al., 2017). Globally, injured victims tend to underreport socially sensitive issues such as alcohol consumption and psychoactive drug use (Hoonpongsimanont et al., 2019), and a similar observation was documented in Tanzania (Mundenga et al., 2019). The frequency of self-reported marijuana use among the cases in our study was lower (18.3%) than what was observed in a cross-sectional survey among trauma patients at the national hospital in Tanzania (36.1%) (Mundenga et al., 2019). The disparities between the findings of our study and this survey could be attributed to the difference in the measurement used. In the trauma patients survey, the psychoactive drug use, including marijuana use, was measured through urine analysis, which is more reliable as compared to self-reports. Also, self-reported measurements may suffer from specific drawbacks due to the way the respondents choose to reply, the answers may be exaggerated or the respondents may be too embarrassed to report a certain behaviours. To address this bias our study following recommendations from previous studies, in particular by guaranteeing anonymity among respondents, clearly defining their roles and the purpose of the data collection and prefacing of questions (Latkin C.A, 2017). Our study included only the commercial motorcycle riders who could be interviewed within 14 days from the date of the RTIs so as to minimize recall biases. The psychoactive drug use was measured using a blunt measure, which asked the participants if they had used any psychoactive drug in the past year and this might have hindered the detection of an association with RTIs. Additionally, this study may lack the statistical power to detect a potential association between marijuana use and RTIs, considering confounders. In spite of these limitations, the strength of our study lies in the ability to use population-based controls rather than hospital-based controls. Population-based controls are preferred due to their representativeness of the source population as compared with control selected from hospital- which may share similar essential exposures with cases and hence leading to overmatching (Ruano-Ravina et al., 2008). Additionally, we have used a validated AUDIT questionnaire, which has been pre-tested in Tanzania among trauma patients and has shown an acceptable validity and reliability (Vissoci et al., 2018). Face-to-face structured questionnaire were used in data collection, which provides an advantage of making clarifications of difficult questions if needed and ideal in population with low literacy. A further strength is that our study was able to adjust for risky driving behaviour as well as important work-related factors, which has been shown to be common among commercial motorcyclists (Nguyen et al., 2018).

5. Conclusion

In conclusion, these results confirm that commercial motorcyclists with risky drinking behaviour have a considerably higher risk of RTIs than non-drinkers. This remained true after adjustment for sociodemographic, drivers and work-related factors. Unlike alcohol consumption, our findings suggested that the relationship between marijuana use and risk of RTIs among commercial motorcycle riders was unclear. In consideration of commercial motorcycle riders being more susceptible to the effect of alcohol and spend considerable amount of time on riding, the findings underscore the importance to address hazardous alcohol consumption and marijuana use in future injury prevention strategies to enhance road safety.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Author contributions

FF coordinated the design of the study project, data collection, analysis, and drafted the manuscript. GK participated in study design, data collection,development of the manuscript. MH participated in the development of study design, assisted and supervised the data analysis, drafting of the manuscript, editing, and proofreading. JM contributed in design of study, data analysis, interpretation of the results and comments on the manuscript. CM contributed in study design, supervision of data collection, data analysis and interpretation review of the manuscript.

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