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Road-user-specific patterns of police-reported road traffic injury outcomes in Rwanda, 2015–2024: A retrospective ecological study

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Research Article

Keywords: Road traffic injuries, Road-user categories, Injury severity, Vulnerable road users, Rwanda

Posted Date: November 23rd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11534637/v1

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Additional Declarations: No competing interests reported.

Abstract

Background

Road traffic injuries remain a major public health challenge, particularly among vulnerable road users. However, national evidence from Rwanda describing variations in police-reported injury outcomes by road-user category, injury severity, sex, crash location, and time remains limited.

Methods

We conducted a retrospective ecological study using aggregated Rwanda National Police data on road traffic injury outcomes recorded from January 2015 to August 2024. We described minor injuries, serious injuries, and crash-scene fatalities by road-user category, sex, crash location (Kigali versus outside Kigali), and time. Separate quasi-Poisson regression models examined associations between road-user category and reported injury counts, including interactions with crash location and adjusting for sex, season, and observation duration. Adjusted count ratios (aCRs) and 95% confidence intervals (CIs) were reported.

Results

Among 57,066 police-reported injury outcomes, 74.5% were minor injuries, 13.5% serious injuries, and 11.9% crash-scene fatalities. Motorcycles (37.7%), pedestrians (22.7%), and bicycles (15.7%) collectively accounted for 76.1% of reported outcomes. Although motorcycles contributed the largest number of reported outcomes, crash-scene fatalities represented a greater proportion of pedestrian-related outcomes (16.9%) than motorcycle-related outcomes (7.9%). Associations between road-user category and crash location differed significantly across all three severity-specific models (all $p < 0.001$). Compared with bicycles, motorcycles had higher adjusted serious injury counts in Kigali (aCR 5.18, 95% CI 3.47–7.75) and outside Kigali (aCR 1.92, 95% CI 1.49–2.48). Pedestrians also had higher adjusted serious injury counts in Kigali (aCR 2.60, 95% CI 1.68–4.01) and outside Kigali (aCR 1.49, 95% CI 1.14–1.95). Pedestrians accounted for more than half of female crash-scene fatalities in both geographic groups. Reported minor injuries increased markedly after 2020, while serious injuries generally declined.

Conclusions

Police-reported road traffic injury outcomes in Rwanda varied substantially by road-user category, injury severity, sex, crash location, and time. Geographic differences in adjusted road-user associations highlight the importance of context-specific road safety interventions, particularly for motorcyclists, pedestrians, and cyclists, alongside strengthened injury surveillance.

1. Background

Road traffic injuries (RTIs) remain a major public health challenge, contributing substantially to mortality, disability, and socioeconomic losses worldwide. The World Health Organization (WHO) estimated 1.19 million road traffic deaths globally in 2021, with motorcyclists, pedestrians, and cyclists accounting for a substantial proportion of these deaths [1]. These findings highlight the importance of examining injury outcomes across road-user categories rather than relying solely on aggregate road traffic injury statistics.

The burden is particularly pronounced in sub-Saharan Africa, where vulnerable road users account for a substantial share of road traffic injuries and fatalities. Studies from Cameroon, Ghana, Botswana, and elsewhere in sub-Saharan Africa have highlighted the substantial burden of road traffic injuries among vulnerable road users, particularly pedestrians, motorcyclists, and cyclists [2–5]. This variation underscores the need for context-specific evidence to characterize injury patterns and inform road safety interventions.

In Rwanda, previous police-based research identified road traffic crash hotspots along major roads and busy urban areas in Kigali, with motorcycles, pedestrians, and cyclists particularly associated with more severe crash outcomes [6]. Prehospital studies further identified motorcycle-related crashes as the predominant injury mechanism among adults and pedestrian injuries among children [7], while injury severity was associated with collision mechanisms, sex, alcohol use, and distance to healthcare facilities [8]. Rwanda has also implemented several road safety measures, including vehicle inspections, automated speed enforcement, impaired-driving enforcement, and public awareness campaigns [9–13].

Despite these contributions, evidence integrating national police-reported injury outcomes across road-user categories, injury severity, sex, crash location, and time remains limited. Examining both the contribution of road-user categories to reported injury counts and the distribution of injury severity within these categories may reveal important patterns obscured by aggregate statistics. However, differences in reported counts do not necessarily reflect differences in injury risk, which requires consideration of road-user exposure. A comprehensive characterization of reported injury outcomes can nevertheless help identify priorities for road safety surveillance and prevention.

This study aimed to (1) describe the distribution of police-reported road traffic injury outcomes by road-user category and severity; (2) examine variations in reported outcomes by sex, crash location, and time; and (3) assess associations between road-user category and reported injury counts, adjusting for sex, season, and crash location, while examining whether these associations differ between Kigali and areas outside Kigali.

2. Methods

2.1. Study setting, design, and data source

Rwanda is an East African country administratively divided into four provinces and the City of Kigali, comprising 30 districts. According to the 2022 Population and Housing Census, the country had a population of approximately 13.2 million [14]. Rwanda experiences distinct rainy and dry periods [15].

We conducted a retrospective ecological study using aggregated road traffic injury outcome data obtained from the Rwanda National Police (RNP), covering the period from January 2015 to August 2024. The dataset comprised monthly counts of reported road traffic injury outcomes, disaggregated by demographic characteristics, road-user category, geographic location, and injury severity. The unit of analysis was the aggregated monthly count rather than individual crashes or injured persons. Individual-level records, age information, and road-user exposure denominators were unavailable.

For this analysis, injury outcomes were categorized according to the operational classifications provided by the RNP Traffic and Road Safety Department, as follows:

- **Minor injury**: An injury requiring first aid or outpatient treatment without hospital admission, life-threatening complications, or permanent disability.
- **Serious injury**: An injury requiring hospitalization or specialized medical care because of its severity, including injuries potentially associated with long-term disability or life-threatening complications.
- **Crash-scene fatality**: A crash-related death recorded by the RNP at the crash scene. Deaths occurring subsequently during transport or following hospital admission were not captured.

2.2. Study variables

The variables included year, month, sex (female or male), injured road-user category, district, and injury severity. Injured road users were classified into eight categories: bicycles, lorries, minibuses/buses, motorcycles, pedestrians, private cars, trailers, and other road users.

Districts were grouped into Kigali and outside Kigali based on the recorded crash location, following consultation with the RNP regarding the operational relevance of this distinction for road safety planning. This classification did not represent the injured individual's place of residence. Seasons were classified into four categories based on calendar months: long rainy season (March–May), long dry season (June–August), short rainy season (September–December), and short dry season (January–February). These month-based categories were applied consistently throughout the analysis as operational seasonal classifications.

2.3. Statistical analysis

Descriptive analyses characterized the distribution of reported injury outcomes by road-user category, injury severity, crash location, sex, and time. Absolute counts and percentages were calculated using denominators appropriate to each comparison.

2.3.1. Road-user contribution to reported injury outcomes

For each injury-severity category, we calculated the number and proportion of reported outcomes attributable to each road-user category, using the total number of outcomes within that severity category as the denominator.

2.3.2. Injury-severity distribution within road-user categories

We calculated the proportions of minor injuries, serious injuries, and crash-scene fatalities within each road-user category, using the total number of reported outcomes in that road-user category as the denominator.

2.3.3. Geographic variation in reported injury outcomes

Geographic variation was examined by comparing the distribution of road-user categories and injury severity between Kigali and outside Kigali. Within each geographic group, we calculated road-user contributions to reported outcomes overall and by severity, as well as the severity distribution within each road-user category.

At the district level, we calculated the total number of reported injury outcomes and the proportions classified as minor injuries, serious injuries, and crash-scene fatalities, using the total number of reported outcomes within each district as the denominator. District-level totals and severity-specific proportions were visualized using choropleth maps, with districts classified into quartiles separately for each indicator. Proportions were interpreted alongside the corresponding total numbers of reported outcomes to account for potential instability in districts with small totals.

2.3.4. Temporal patterns in reported injury outcomes

Temporal patterns were assessed descriptively using annual counts of minor injuries, serious injuries, and crash-scene fatalities, stratified by road-user category. We also calculated the annual proportion contributed by each road-user category within each injury-severity category to examine changes in the composition of reported outcomes over time. Analyses focused on complete calendar years (2015–2023), with January–August 2024 presented separately to distinguish the incomplete observation period. No formal statistical tests for temporal trends were performed.

2.3.5. Sex-specific patterns in reported injury outcomes

Sex-specific patterns were examined using two complementary measures: the proportion of reported outcomes attributable to each road-user category within sex, injury-severity, and crash-location strata; and the female and male proportions within road-user category, injury-severity, and crash-location strata.

2.3.6. Multivariable modelling of reported injury counts

Separate log-link Poisson regression models were initially fitted for minor injuries, serious injuries, and crash-scene fatalities. For each severity category, reported counts were aggregated by road-user category, sex, crash location, and season. Overdispersion was assessed using the Pearson chi-square

statistic divided by the residual degrees of freedom [16]. Given evidence of overdispersion, quasi-Poisson generalized linear models were used for the primary analyses [17].

Models included road-user category, sex, crash location, and season as predictors. To account for unequal seasonal observation periods, the logarithm of the number of observed months in each seasonal category between January 2015 and August 2024 was included as an offset. The same season-specific offset was applied across road-user, sex, and crash-location strata within each season.

An interaction between road-user category and crash location was included to assess whether associations varied geographically, with its contribution evaluated using F-tests. Adjusted count ratios (aCRs) and 95% confidence intervals (CIs) were estimated, using bicycles, female sex, and the short dry season as reference categories. Road-user-specific aCRs were estimated separately for Kigali and outside Kigali. These estimates represent relative police-reported injury counts per observed month, rather than individual-level injury risk.

Negative binomial regression models were fitted as a sensitivity analysis using the same predictors, interaction terms, and offset to assess the sensitivity of adjusted associations to an alternative variance specification. All analyses were conducted using R statistical software (version 4.4.3) [18].

2.4. Data completeness and governance

Data were obtained from the Rwanda National Police under a confidential data-sharing arrangement and analyzed in aggregated, de-identified form. As individual-level records were unavailable, record-level missingness and the completeness of vehicle-type classifications in the original database could not be assessed.

2.5. Patient and public involvement

Patients and members of the public were not involved in the design, conduct, analysis, or reporting of this study.

3. Results

Between January 2015 and August 2024, a total of 57,066 police-reported road traffic injury outcomes were recorded in Rwanda. Minor injuries accounted for 42,542 (74.5%) outcomes, followed by serious injuries (7,709; 13.5%) and fatalities recorded at the crash scene (6,815; 11.9%).

3.1. Distribution of police-reported injury outcomes by road-user category

As shown in Fig. 1, motorcycles accounted for the largest share of police-reported injury outcomes (21,502; 37.7%), followed by pedestrians (12,973; 22.7%) and bicycles (8,982; 15.7%). Together, these three categories accounted for 76.1% of all reported outcomes. Private cars (9.6%), minibuses and

buses (8.0%), and lorries (5.3%) accounted for smaller proportions, while trailers (0.6%) and other road-user categories (0.2%) represented the smallest shares.

3.2. Injury severity distribution by road-user category

As illustrated in Fig. 2, minor injuries predominated across all categories, although their relative proportions varied. Motorcycles and minibuses/buses had the highest proportions of minor injuries (79.2% and 76.9%, respectively), compared with 69.2% among pedestrians and 74.0% among bicycles. The proportion of outcomes recorded as crash-scene fatalities was higher among pedestrians (16.9%) and bicycles (14.5%) than among motorcycles (7.9%). Lorries and trailers also had relatively high proportions of crash-scene fatalities (19.2% and 27.2%, respectively), although these categories accounted for fewer reported outcomes overall.

3.3. Geographic variation in reported injury outcomes by road-user category and severity

The distribution of reported injury outcomes by road-user category and severity differed between Kigali and areas outside Kigali, as shown in Fig. 3. Motorcycle-related crashes accounted for approximately half of minor (51.5%) and serious injuries (50.4%) in Kigali, compared with 25.1% and 28.9%, respectively, outside Kigali. They also accounted for the largest share of crash-scene fatalities in Kigali (37.8%), followed by pedestrian- (29.5%) and bicycle-related crashes (18.9%). Outside Kigali, pedestrian-related crashes accounted for the largest share of fatalities (33.0%), followed by motorcycle- (20.9%) and bicycle-related crashes (19.3%). Crashes involving private cars, minibuses and buses, and lorries contributed larger proportions of reported outcomes outside Kigali across all three severity categories.

The distribution of injury severity within road-user categories also differed by crash location. As shown in Supplementary Figure S1, crash-scene fatalities represented a greater proportion of reported outcomes outside Kigali than in Kigali across most road-user categories. These differences were particularly pronounced among pedestrians (26.8% versus 7.3%), motorcycles (15.0% versus 4.3%), and bicycles (18.8% versus 8.3%). Similarly, serious injuries accounted for larger proportions of reported outcomes outside Kigali among motorcycles (20.7% versus 8.9%), pedestrians (18.2% versus 9.7%), and bicycles (14.7% versus 6.7%).

To further explore these geographical differences, district-level mapping revealed variation in the severity composition and total number of reported injury outcomes (Supplementary Figure S3). Districts within Kigali generally had higher proportions of minor injuries, whereas several districts outside Kigali, particularly in the Eastern Province, had higher proportions of serious injuries and crash-scene fatalities. In contrast, higher total reported outcome counts were observed in Kigali and in districts outside Kigali containing major urban centres, highlighting differences between the geographical distribution of reported outcomes and their severity composition.

3.4. Temporal trends in reported injury outcomes by road-user category and severity

Temporal patterns of police-reported injury outcomes varied by road-user category and injury severity, as illustrated in Fig. 4. Between 2015 and 2020, annual minor injury counts remained relatively stable across most road-user categories, followed by a marked increase from 2021 onward, particularly among motorcycles, bicycles, and pedestrians. Motorcycle-related minor injuries increased from approximately 750 in 2020 to 3,855 in 2023, while bicycle-related minor injuries increased from approximately 240 to 1,600 and pedestrian-related minor injuries from approximately 490 to 1,550 over the same period. In contrast, serious injury counts generally declined after 2020, while crash-scene fatalities showed comparatively smaller fluctuations without a corresponding increase. This divergence in reported injury severity patterns warrants cautious interpretation, as potential changes in reporting practices or injury severity classification over time could not be assessed using the available data.

Despite changes in absolute counts, the relative contributions of road-user categories to minor and serious injuries remained broadly consistent over time, as shown in Supplementary Figure S2. Motorcycles consistently accounted for the largest proportion of reported minor and serious injuries during 2015–2023, contributing approximately 35–44% and 31–39% of annual outcomes, respectively. In contrast, the composition of crash-scene fatalities showed greater variation. Pedestrians accounted for the largest share of fatalities during most years, while the contribution of bicycles increased from approximately 11% in 2015 to 25% in 2023, approaching that of motorcycles. Outcomes recorded during January–August 2024 are displayed separately in Fig. 4 and Supplementary Figure S2 to distinguish the partial reporting period from complete calendar years.

3.5. Sex-specific variation in reported injury outcomes by road-user category and crash location

The distribution of road-user categories differed by sex, injury severity, and crash location, as illustrated in Fig. 5. In Kigali, motorcycles accounted for the largest proportion of reported minor and serious injuries among both males and females, with consistently higher contributions among males. For serious injuries, motorcycles represented 52.6% of outcomes among males compared with 41.7% among females. In contrast, pedestrians accounted for a substantially larger share of crash-scene fatalities among females (54.6%) than males (24.9%), whereas motorcycles contributed the largest share among males (40.6%).

Outside Kigali, pedestrians remained the largest contributor to crash-scene fatalities among females (54.5%), compared with 28.9% among males. Motorcycles accounted for a larger proportion of serious injuries among males (30.7%) than females (20.9%), while pedestrians represented a larger share among females (35.4%) than males (19.4%). Across both locations, the contribution of bicycles to reported outcomes was generally greater among males, particularly for minor and serious injuries.

3.6. Associations between road-user categories and reported injury counts after adjustment for sex, crash location, and season

Consistent with the geographic differences observed in the descriptive analyses, three separate multivariable quasi-Poisson regression models, fitted for minor injuries, serious injuries, and crash-scene fatalities, identified significant interactions between road-user category and crash location (all $p < 0.001$), after adjusting for sex and season. Including interaction terms reduced overdispersion in each model, although residual overdispersion remained (Supplementary Table S2).

Adjusted count ratios (aCRs) are presented in Table 1. Compared with bicycle-related crashes, motorcycle-related crashes were associated with higher adjusted counts of minor injuries (aCR 3.98, 95% CI 3.04–5.21), serious injuries (aCR 5.18, 95% CI 3.47–7.75), and crash-scene fatalities (aCR 2.00, 95% CI 1.31–3.07) in Kigali. These associations were less pronounced outside Kigali, with corresponding aCRs of 1.31 (95% CI 0.97–1.77), 1.92 (95% CI 1.49–2.48), and 1.09 (95% CI 0.83–1.42). Pedestrian-related crashes were also associated with higher adjusted serious injury counts in Kigali (aCR 2.60, 95% CI 1.68–4.01) and outside Kigali (aCR 1.49, 95% CI 1.14–1.95). For crash-scene fatalities, the corresponding aCRs were 1.56 (95% CI 1.00–2.44) and 1.72 (95% CI 1.35–2.18), respectively.

Male sex was associated with higher adjusted reported counts of minor injuries (aCR 3.20, 95% CI 2.85–3.59), serious injuries (aCR 4.22, 95% CI 3.72–4.78), and crash-scene fatalities (aCR 5.26, 95% CI 4.52–6.12) compared with female sex. Seasonal associations were generally weaker, although minor injury counts were higher during the long dry season than during the short dry season (aCR 1.21, 95% CI 1.03–1.41).

Sensitivity analyses using negative binomial regression showed generally consistent directions of association with the primary quasi-Poisson models (Supplementary Table S3).

Table 1
Adjusted associations of road-user category, sex, and season with police-reported road traffic injury counts, allowing for interaction between road-user category and crash location, Rwanda, January 2015–August 2024.

group	Variable	Minor injuries aCR (95% CI)	Serious injuries aCR (95% CI)	Crash-scene fatalities aCR (95% CI)
Kigali	Bicycles	Reference	Reference	Reference
	Lorries	0.16 (0.08–0.30)	0.31 (0.15–0.66)	0.29 (0.14–0.60)
	Minibuses and buses	0.25 (0.15–0.43)	0.39 (0.19–0.78)	0.13 (0.05–0.36)
	Motorcycles	3.98 (3.04–5.21)	5.18 (3.47–7.75)	2.00 (1.31–3.07)
	Other road users	0.02 (0.00–0.11)	0.02 (0.00–0.26)	0.01 (0.00–0.28)
	Pedestrians	1.75 (1.30–2.37)	2.60 (1.68–4.01)	1.56 (1.00–2.44)
	Private cars	0.56 (0.38–0.84)	0.76 (0.44–1.33)	0.27 (0.13–0.57)
	Trailers	0.01 (0.00–0.13)	0.01 (0.00–0.35)	0.03 (0.00–0.23)
Outside Kigali	Bicycles	Reference	Reference	Reference
	Lorries	0.42 (0.27–0.63)	0.52 (0.36–0.74)	0.49 (0.35–0.69)
	Minibuses and buses	0.77 (0.55–1.09)	0.81 (0.59–1.10)	0.29 (0.19–0.44)
	Motorcycles	1.31 (0.97–1.77)	1.92 (1.49–2.48)	1.09 (0.83–1.42)
	Other road users	0.01 (0.00–0.10)	0.02 (0.01–0.09)	0.01 (0.00–0.07)
	Pedestrians	1.00 (0.72–1.37)	1.49 (1.14–1.95)	1.72 (1.35–2.18)
	Private cars	0.66 (0.46–0.94)	0.82 (0.61–1.12)	0.50 (0.36–0.70)
	Trailers	0.05 (0.02–0.15)	0.07 (0.03–0.15)	0.09 (0.05–0.18)
Sex	Female	Reference	Reference	Reference

group	Variable	Minor injuries aCR (95% CI)	Serious injuries aCR (95% CI)	Crash-scene fatalities aCR (95% CI)
	Male	3.20 (2.85–3.59)	4.22 (3.72–4.78)	5.26 (4.52–6.12)
Season	Short Dry Season	Reference	Reference	Reference
	Long Dry Season	1.21 (1.03–1.41)	0.97 (0.83–1.13)	1.16 (0.98–1.38)
	Long Rainy Season	1.05 (0.89–1.23)	0.97 (0.83–1.13)	0.96 (0.80–1.15)
	Short Rainy Season	1.08 (0.93–1.26)	1.01 (0.87–1.17)	1.06 (0.89–1.25)

Note

aCR, adjusted count ratio; CI, confidence interval. Estimates were derived from multivariable quasi-Poisson regression models including an interaction between road-user category and crash location, adjusted for sex, season, and observation duration. Road-user aCRs are presented separately for Kigali and outside Kigali, with bicycles as the reference category within each location. Female and short dry season served as reference categories for sex and season, respectively. Estimates reflect relative reported outcome counts rather than injury risk.

4. Discussion

This national analysis of police-reported road traffic injury outcomes in Rwanda from January 2015 to August 2024 identified substantial differences in reported injury patterns by road-user category, injury severity, crash location, sex, and time. Motorcycles, pedestrians, and bicycles accounted for most reported outcomes, although their contributions differed by injury severity. Motorcycles accounted for the largest overall number of reported outcomes, whereas pedestrians contributed the largest share of crash-scene fatalities. Geographic differences were also evident, with significant interactions between road-user category and crash location across all injury-severity models. Together, these findings highlight the importance of examining injury severity and road-user composition alongside overall injury counts to inform road safety priorities.

Road-user differences in reported injury outcomes

The prominent contribution of motorcycle-, pedestrian-, and bicycle-related crashes to reported injury outcomes broadly aligns with previous findings from Rwanda and other African settings [3, 5, 6, 19]. Earlier police-based research in Kigali identified associations between these road-user categories and more severe crash outcomes [6], while a prehospital study identified motorcycle-related crashes as the predominant injury mechanism among adults and pedestrian injuries as the most common among

children [7]. Although these studies differed in their populations, outcome definitions, and road-user classifications, they collectively highlight the importance of examining road-user-specific patterns when characterizing road traffic injuries.

An important finding was that road-user categories contributing the largest numbers of reported injuries did not necessarily have the highest proportions of fatal outcomes. Although motorcycles accounted for the largest overall number of reported outcomes, crash-scene fatalities represented a greater proportion of reported outcomes among pedestrians, cyclists, and heavy-vehicle users. This distinction highlights the importance of considering injury severity alongside overall reported counts when identifying road-user groups for targeted prevention efforts. A recent Rwanda prehospital study similarly reported greater injury severity in car-to-pedestrian and car-to-motorcycle collisions compared with car-only crashes[8]. While that study examined collision configurations and clinically assessed injury severity, it provides complementary context for the observed patterns.

The adjusted analyses further demonstrated differences in reported injury counts across road-user categories. Motorcycles had substantially higher adjusted reported counts than bicycles across all three severity categories in Kigali, particularly for serious injuries, whereas the corresponding associations were generally smaller outside Kigali. Pedestrians also had higher adjusted serious injury counts relative to bicycles in both geographic groups. These findings suggest that the relative contribution of different road-user categories varies by injury severity and geographic context. However, the associations reflect differences in reported counts rather than individual injury risks, because road-user exposure was unavailable.

The prominence of motorcycle-related crashes may reflect their role in transportation, exposure to mixed traffic, and limited physical protection [1, 19]. Similarly, outcomes involving pedestrians and cyclists may be influenced by vehicle speeds, interactions with motorized traffic, and inadequate infrastructure for walking and cycling [1, 20, 21]. Although these factors were not directly assessed in this study, they provide potential explanations for the observed patterns.

Geographic differences in reported injury outcomes

Geographic variation was another important finding. Motorcycles contributed a larger proportion of reported minor and serious injuries in Kigali, whereas serious injuries and crash-scene fatalities represented greater proportions of reported outcomes outside Kigali across several road-user categories. The significant interaction between road-user category and crash location in all three severity-specific regression models further demonstrated that adjusted road-user associations were not uniform across geographic settings.

Similar variations in road traffic injury patterns have been documented in other settings. A hospital-based study in Uganda identified differences in injury characteristics between urban and rural populations [22], while research on urban transport policies has highlighted the complex relationship between traffic congestion and road safety [23]. In Kigali, traffic density and congestion may be relevant

to the greater contribution of motorcycle-related minor injuries. Additionally, a prehospital study in Rwanda found an association between greater distance to healthcare facilities and increased injury severity [8]. Although these studies differ from ours in geographic classification, data sources, and outcome measures, they suggest that local traffic conditions, road environments, and access to care may influence injury patterns. However, these explanations remain hypothetical because the corresponding factors were not directly assessed in our study.

Importantly, geographic classification was based on the location of reported crashes rather than injured individuals' residences. Areas outside Kigali also encompass diverse road environments and should not be interpreted as exclusively rural. Furthermore, the absence of population and traffic exposure denominators prevents direct comparisons of injury risk between geographic groups. Nevertheless, the observed heterogeneity underscores the importance of considering local road-user composition and injury patterns when developing road safety strategies.

Temporal changes in reported injury outcomes

The temporal analysis revealed contrasting trends across injury severity categories. Reported minor injuries increased markedly after 2020, particularly among motorcycles, bicycles, and pedestrians, while serious injuries generally declined and crash-scene fatalities showed comparatively smaller fluctuations. These divergent patterns suggest that changes in the recorded injury burden were not uniform across severity categories.

The reasons for these changes remain uncertain. Differences in traffic activity, transport use, enforcement, reporting completeness, or injury classification may have contributed to the observed trends. Previous studies documented changes in mobility and transportation in Rwanda during the COVID-19 pandemic [24, 25], providing context for interpreting patterns around 2020. However, the present study cannot establish whether the observed changes resulted from pandemic-related restrictions, subsequent mobility changes, road safety interventions, or surveillance practices.

The increasing contribution of bicycles to reported crash-scene fatalities over time is also noteworthy. Although the data cannot determine whether this reflects changes in cycling activity, traffic exposure, or safety conditions, the pattern suggests that cyclist safety deserves continued attention. More broadly, these findings demonstrate the value of monitoring injury outcomes separately by severity and maintaining consistent reporting practices over time.

Sex differences in reported injury outcomes

Males accounted for substantially more reported injuries and crash-scene fatalities than females, consistent with previous evidence from Rwanda and other settings [6, 26, 27]. This difference persisted after adjustment for road-user category, crash location, and season. However, sex-specific analyses revealed important differences in the distribution of road-user categories.

Pedestrians accounted for more than half of reported crash-scene fatalities among females in both Kigali and areas outside Kigali, compared with considerably smaller proportions among males. Female outcomes were also more concentrated among pedestrians and minibus/bus users, whereas motorcycles and bicycles contributed larger shares of reported outcomes among males.

These patterns may reflect differences in transport participation and mobility. Previous research has described greater reliance on walking and public transportation among women in some settings [28–30]. Nevertheless, the present study did not measure transport exposure or travel behaviour, and the findings cannot establish whether the observed differences reflect variation in injury risk or transport use. The findings therefore highlight the importance of considering road-user composition alongside overall sex differences when interpreting reported injury patterns.

Implications for road safety policy and practice

These findings can inform road-user-specific and geographically targeted road safety interventions in Rwanda. The substantial contribution of motorcycle-, pedestrian-, and bicycle-related crashes highlights the need to address the distinct safety challenges associated with these road-user categories. Evidence-informed measures include promoting helmet use and safe riding practices, strengthening speed management and traffic law enforcement, and improving pedestrian and cycling infrastructure through safe crossings, sidewalks, and traffic-calming measures [1, 20, 21, 31, 32]. Although the effectiveness of these interventions was not evaluated in this study, they represent potential priorities for road traffic injury prevention.

The geographic heterogeneity in reported injury patterns suggests that intervention priorities should be informed by local conditions rather than applied uniformly. In particular, the greater proportion of serious and fatal outcomes outside Kigali warrants further assessment of road infrastructure, emergency response capacity, and access to trauma care. This is consistent with evidence from Rwanda linking greater distances to healthcare facilities with increased injury severity among patients attended by prehospital emergency services [8]. Similarly, the substantial contribution of pedestrian-related fatalities among females highlights the need to investigate sex-specific travel patterns, pedestrian exposure, and mobility needs to inform inclusive road safety interventions.

Strengthening road traffic injury surveillance is also essential. A systematic review of police–hospital data linkage studies demonstrated the value of integrating multiple data sources to improve the completeness and utility of road traffic injury surveillance [33]. In Rwanda, improved linkage between police records, emergency medical services, and health-facility data could facilitate more complete ascertainment of injury severity and deaths occurring after the crash scene. Consistent with WHO guidance on strengthening road traffic mortality data systems [34], such efforts would benefit from coordinated data collection across relevant sectors. Collecting information on road-user exposure, crash circumstances, vehicle characteristics, and safety behaviours would further support exposure-adjusted risk assessments and evaluation of road safety interventions.

Strengths and limitations

A major strength of this study is its use of nationally collected police-reported road traffic injury data spanning nearly ten years. By examining outcomes across road-user categories, injury severity, sex, crash location, and time, the study provides a detailed characterization of injury patterns that may be obscured by analyses of aggregate counts alone. The multivariable analysis further examined geographic heterogeneity in adjusted road-user associations while accounting for sex, season, and observation duration.

Several limitations should be acknowledged. First, reliance on routinely collected police data may have introduced underreporting, incomplete documentation, and misclassification. Previous studies have documented discrepancies between police and hospital records, with reporting completeness varying across road-user categories [33, 35]. As only aggregated data were available, record-level missingness, completeness of road-user classification, and potential differences in reporting across categories could not be assessed. Furthermore, police-recorded injury severity could not be independently validated against clinical records, and crash-scene fatalities excluded deaths occurring during transport or after hospital admission.

Second, the aggregated nature of the data limited the examination of individual characteristics and crash circumstances. Age was unavailable for analysis alongside road-user categories, preventing age-specific comparisons and adjustment for age. Other potentially relevant factors, including helmet use, alcohol consumption, vehicle speed, road conditions, and transport exposure, were also unavailable.

Third, the absence of reliable road-user exposure denominators prevented estimation of exposure-adjusted injury rates or individual-level injury risks. Although the regression models accounted for observation duration, they did not explicitly adjust for secular year-to-year changes in reported counts. Substantial residual overdispersion, particularly in the minor injury quasi-Poisson model, also warrants caution. Negative binomial sensitivity analyses showed generally consistent directions for the principal motorcycle and pedestrian associations, although the magnitude of some estimates differed appreciably, particularly for pedestrians, indicating sensitivity to model specification.

Finally, geographic comparisons reflected reported crash locations rather than injured individuals' residences, while district-level summaries may obscure localized variation. Changes in reporting practices and injury classification over time, together with the partial observation period in 2024, may also have influenced temporal comparisons

5. Conclusions

Police-reported road traffic injury outcomes in Rwanda varied substantially by road-user category, injury severity, sex, crash location, and time. Motorcycles accounted for the largest overall number of reported outcomes, whereas pedestrians contributed the largest share of crash-scene fatalities. Geographic heterogeneity in adjusted road-user associations and the substantial contribution of pedestrians to

female fatal outcomes further highlight the importance of context-specific prevention strategies. These findings support targeted motorcycle, pedestrian, and cyclist safety interventions, geographically responsive road safety planning, and strengthened injury surveillance to guide future prevention efforts.

Abbreviations

RTC
road traffic crash
RTI
road traffic injury
RNP
Rwanda National Police
aCR
adjusted count ratio
CI
confidence interval
RNEC
Rwanda National Research Ethics Committee.

Declarations

Ethical approval and consent to participate

Ethical approval was obtained from the Rwanda National Research Ethics Committee (RNEC861/2025). The study involved secondary analysis of aggregated, de-identified data obtained from the Rwanda National Police, with no direct interaction with human participants. The study was conducted in accordance with relevant national ethical guidelines and regulations. As no individuals were recruited or directly involved in the study, informed consent to participate was not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Declaration of Generative AI and AI-Assisted Technologies in the Manuscript Preparation Process

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) to assist with language editing, improving clarity and readability, and refining the presentation of the manuscript. The authors reviewed and edited the AI-assisted content and take full responsibility for the final content of the published article.

Funding

This research was funded by the NIHR (NIHR133314) using UK international development funding from the UK Government to support global health research. The views expressed are those of the authors and not necessarily those of the NIHR or the UK Government.

Author Contribution

GB contributed to the methodology, data curation, formal analysis, interpretation of findings, and drafting and revision of the manuscript. ET, BTA, ErT, AGB, and VM contributed to the interpretation of findings and critical review and editing of the manuscript. JCB contributed to the interpretation of findings, critical review and editing of the manuscript, and funding acquisition. AB provided supervision and contributed to the interpretation of findings, critical review and editing of the manuscript, and funding acquisition. All authors reviewed and approved the final manuscript.

Acknowledgement

The authors thank the Rwanda National Police, Traffic and Road Safety Department, for supporting access to the study data.

Data Availability

The data supporting the findings of this study are not publicly available due to the terms of the data-sharing agreement with the Rwanda National Police. Data may be made available upon reasonable request, subject to permission from the Rwanda National Police.

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Figures

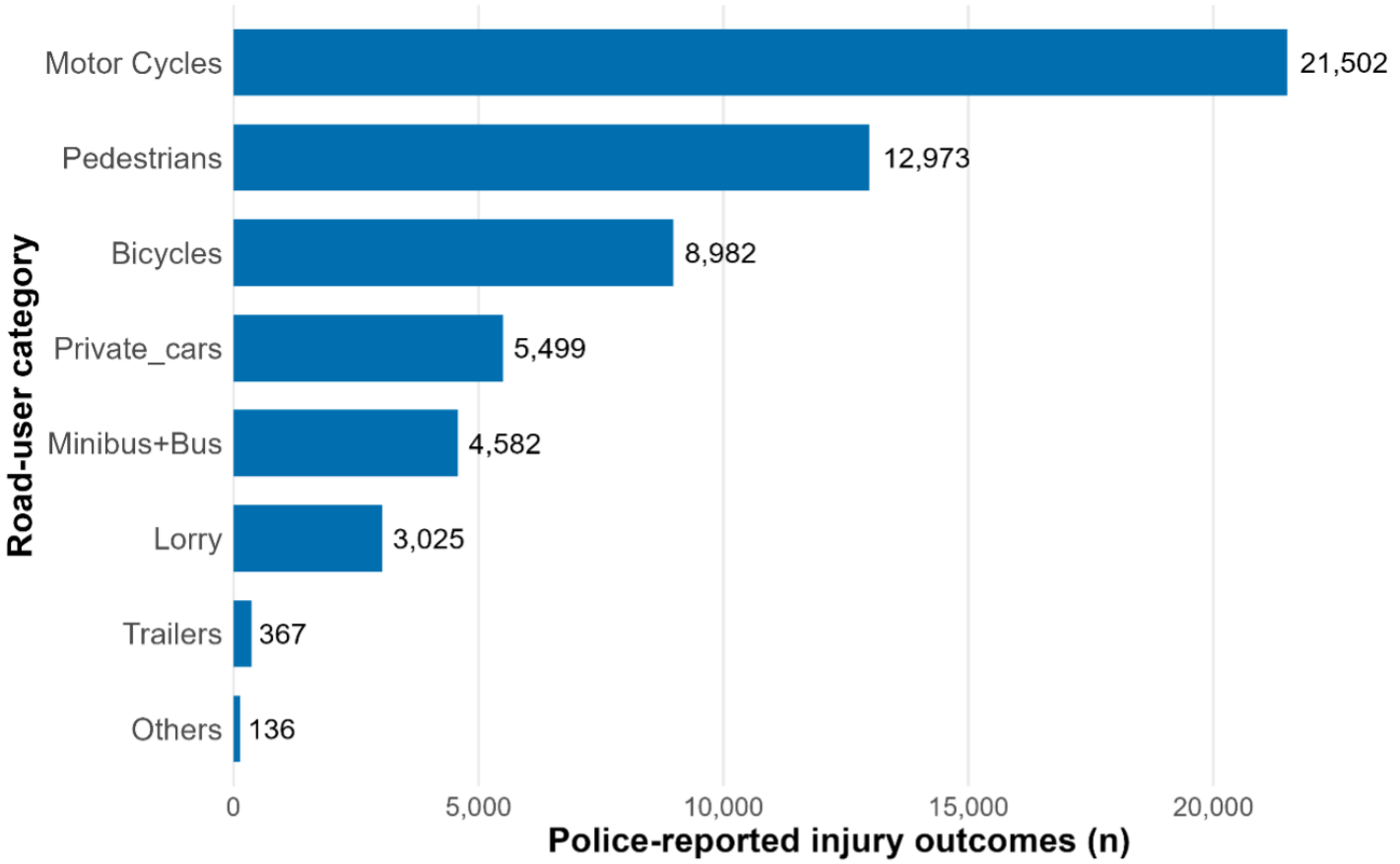

Figure 1

Distribution of police-reported road traffic injury outcomes by road-user category in Rwanda, January 2015–August 2024. Bars represent the total number of reported minor injuries, serious injuries, and crash-scene fatalities combined (N = 57,066). Counts are not adjusted for road-user exposure.

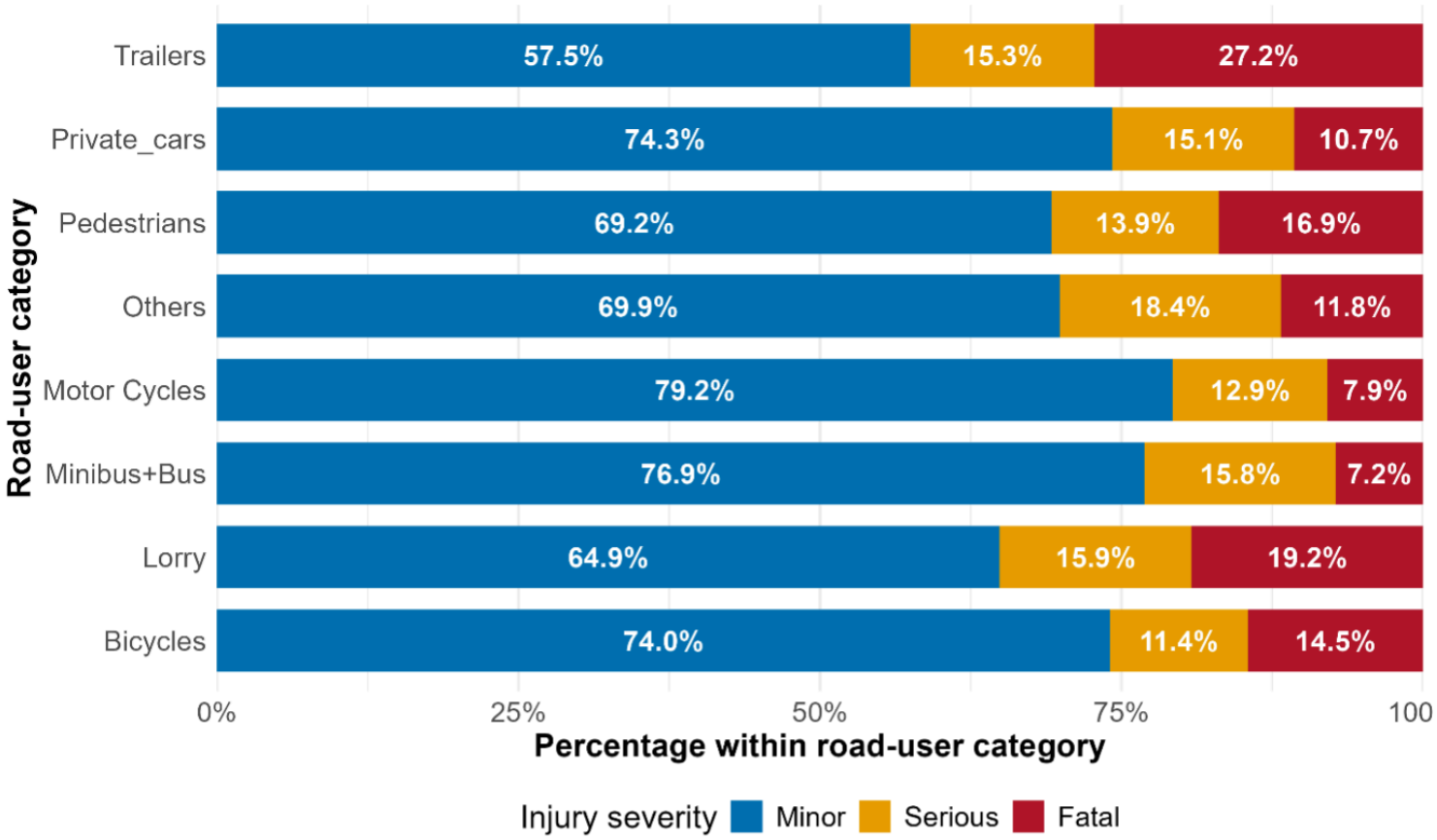

Figure 2

Distribution of police-reported road traffic injury outcomes by injury severity within road-user categories in Rwanda, January 2015–August 2024. Percentages were calculated using the total number of reported outcomes within each road-user category as the denominator.

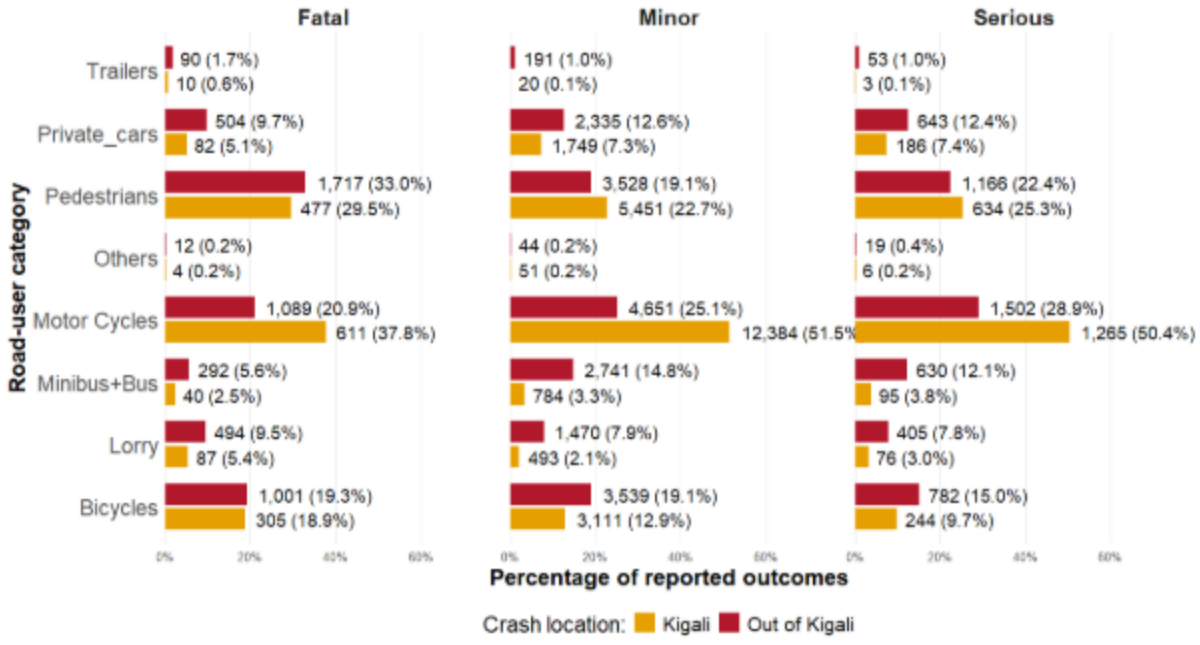

Figure 3

Distribution of police-reported road traffic injury outcomes by vehicle-type category and injury severity in Kigali and outside Kigali, Rwanda, January 2015–August 2024. Percentages were calculated separately within each crash-location group and injury severity category.

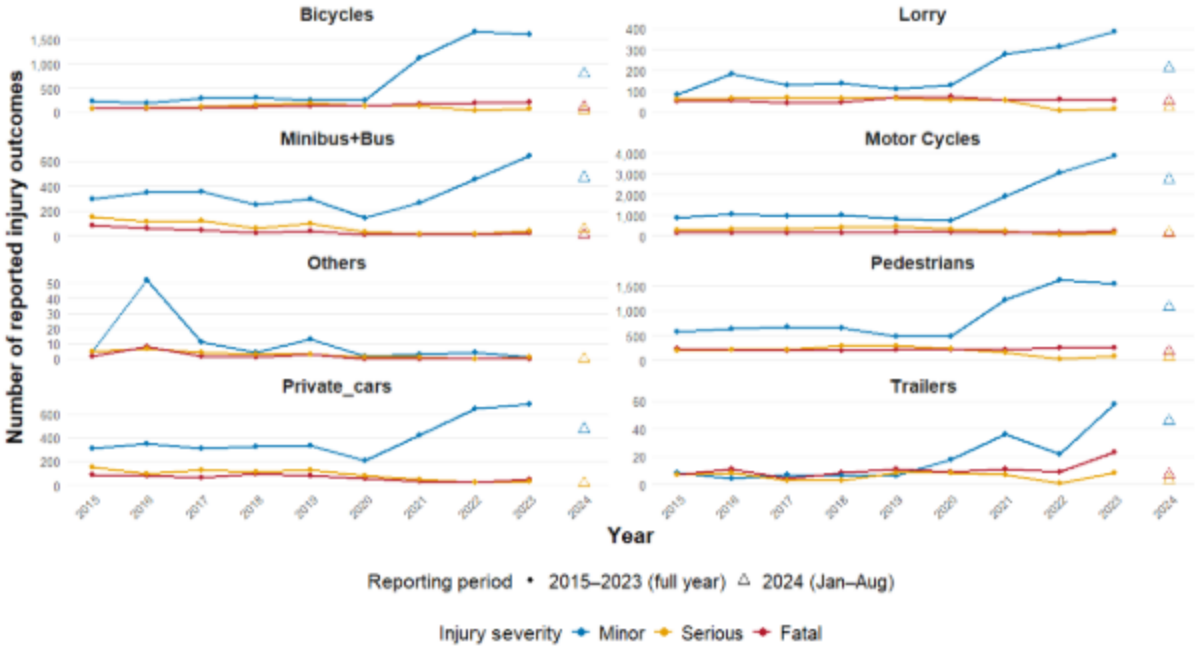

Figure 4

Annual trends in police-reported road traffic injury outcomes by road-user category and injury severity in Rwanda, January 2015–August 2024. Lines represent annual counts for complete calendar years (2015–2023), while separate triangular markers represent counts recorded during January–August 2024.

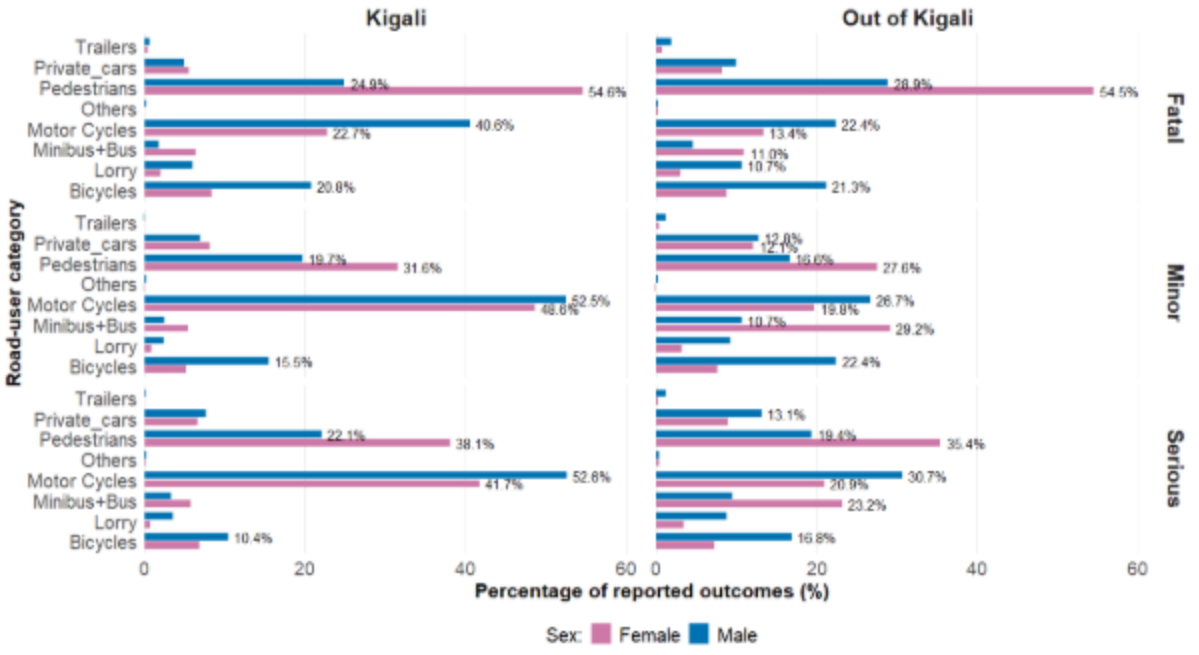

Figure 5

Distribution of police-reported road traffic injury outcomes by road-user category, sex, injury severity, and crash location in Rwanda, January 2015–August 2024. Percentages represent the proportion of reported outcomes attributed to each road-user category, calculated separately within each combination of sex, injury severity, and crash location. For visual clarity, percentage labels are displayed only for values ≥10%; all categories are represented in the bars.

Supplementary Files

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