ROAD TRAFFIC CRASH TRENDS AT UNCONTROLLED LOCATIONS IN JAFFNA DISTRICT (2014–2024): A PRE-, DURING-, AND POST-COVID-19 PERSPECTIVE WITH EVIDENCE-BASED ENGINEERING COUNTERMEASURES

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ABSTRACT

Road traffic crashes remain a critical public health concern in Sri Lanka, with Jaffna District facing elevated risk driven by rapid post-conflict motorization and an ageing road network lacking adequate traffic control infrastructure. This study analyses 5,642 police-recorded crashes at uncontrolled locations in Jaffna District over a ten-year period (2014–2024), structured across three phases: Pre-COVID-19 (2014–2019), During COVID-19 (2020–2021), and Post-COVID-19 (2022–2024). A mixed methodology combining Equivalent Property Damage Only (EPDO) crash severity analysis, QGIS-based kernel density blackspot mapping, and systematic field intersection inventories were employed. A total of 3,398 crashes at uncontrolled locations were analyzed, and 22 blackspot junctions were confirmed across four priority road corridors: A009, AB016, AB018, and AB020. The pre-COVID-19 baseline annual EPDO averaged 2,223, declining to 1,725 during COVID-19, and partially recovering to 1,651 post-pandemic. The study found that 68.2% of crashes occurred at uncontrolled T-junctions and four-leg cross junctions, with angles, head-on, rear-end, sideswipe, and single-vehicle collisions accounting for over 85% of events. Field inventories revealed consistent deficiencies including absent road markings, insufficient sight distances, and no advance warning signs. Eight evidence-based engineering countermeasures are proposed — including stop sign packages for T-junction blackspots and mini roundabouts for four-leg junctions. International evidence indicates these measures could achieve a 40–75% reduction in fatal and serious injury crashes, supporting Sri Lanka's National Road Master Plan (2021–2030) and UN SDG 3.6.

Keywords: road traffic crashes, uncontrolled intersections, blackspot identification, COVID-19 impact, engineering countermeasures

1. INTRODUCTION

Road traffic crashes are a leading cause of mortality and disability globally, accounting for over 1.35 million deaths annually and disproportionately affecting low- and middle-income countries (LMICs), which bear more than 90% of road traffic mortality despite possessing less than 60% of the world's vehicle fleet (World Bank, 2023). In Sri Lanka, road crashes have escalated rapidly owing to increased motorization, inadequate infrastructure investment, and inconsistent enforcement of traffic regulations. Nationally, over 38,000 crashes are recorded annually, resulting in approximately 3,000 fatalities and 8,000 serious injuries (Asian Development Bank., 2018).

Jaffna District in the Northern Province presents a particularly acute road safety challenge. Post-conflict reconstruction from 2009 triggered rapid motorization, with vehicle ownership grew substantially between 2009 and 2016 (Munas and Bandara, 2018), while the existing road network remained largely unchanged in geometric design and traffic control provision. Figure 1 illustrates the location of Jaffna District within Sri Lanka and its road network context. Despite the recognized burden, no prior study has systematically identified crash patterns at uncontrolled locations across Jaffna's arterial road network. This study addresses this gap through a structured, data-driven investigation covering the decade 2014–2024.

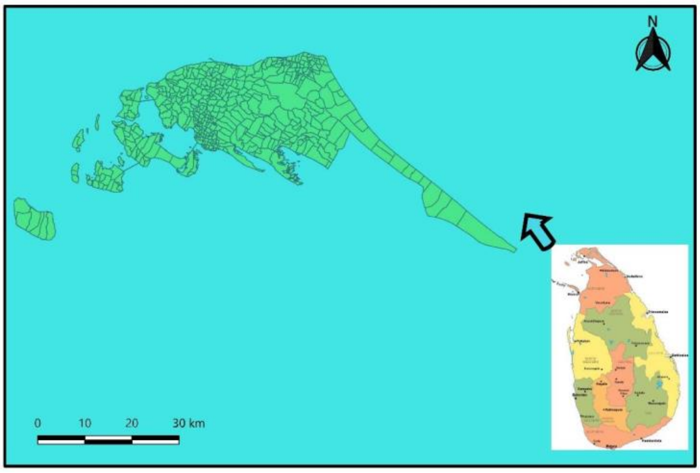

Figure 1. Study area: Jaffna District, Northern Province, Sri Lanka

2. LITERATURE REVIEW

Road traffic crashes at uncontrolled intersections represent a well-documented global safety challenge, particularly in LMICs. Satria et al. (2020) demonstrated that 90% of crash hot zones on Indonesian highways were concentrated at or near uncontrolled intersections with high adjacent land-use activity. Lin et al. (2022), in an analysis of 19,580 provincial road intersections in Taiwan, confirmed that proximity of schools, markets, and bus stops within 300m significantly increases crash frequency — findings directly consistent with conditions observed at Jaffna's blackspot junctions.

In the Sri Lankan context, Tharmarajah and Pasindu (2022) developed a Cumulative Safety Index for Jaffna's provincial road network, identifying sight distance deficiencies, access management failures, and absence of pedestrian facilities as dominant geometric safety variables, achieving an R^2 of 0.96 in predicting EPDO crash values. Renuraj et al. (2015) analysed Jaffna Police crash records for 2010–2013, identifying vehicle type and driver age as primary crash severity predictors. However, neither study produced a systematic blackspot inventory linking crash types to geometric conditions at individual uncontrolled junctions.

The COVID-19 pandemic has been recognized internationally as a natural experiment in road safety, enabling researchers to separate exposure effects from infrastructure effects. Road crashes data from Sri Lanka Police confirm a temporary reduction in road deaths from 3,097 in 2019 to 2,513 in 2021, before recovering toward pre-pandemic levels by 2022–2024. The Safe System approach — endorsed by the World Health Organization and World Bank (2024) — forms the overarching framework for countermeasure selection, recognizing that infrastructure must be designed to mitigate crash severity even when human error occurs.

3. METHOD

This study employed a mixed methodology integrating quantitative crash data analysis with systematic field investigation. The primary data source was police crash records (Form 297B) obtained from Jaffna District Police, covering 5,642 crashes between January 2014 and December 2024, stratified into three analytical periods: Pre-COVID-19 (2014–2019), During COVID-19 (2020–2021), and Post-COVID-19 (2022–2024).

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A subset of 3,398 crashes at uncontrolled locations was extracted for analysis. Crash severity was quantified using the EPDO method, applying weighted scores: fatal crashes (14.6), grievous injury (8.0), and non-grievous injury (1.4) (Tharmarajah and Pasindu, 2022). Pivot table analysis classified crashes by junction type, collision type, temporal context, and road corridor. Spatial blackspot mapping was conducted using QGIS with Kernel Density Estimation (KDE) and 200m buffer zones (bandwidth). KDE was performed with a search radius (bandwidth) of 200 m and a default quartic kernel in QGIS, consistent with the 200m spatial threshold used to aggregate co-located crashes into single blackspot clusters. Four high-priority corridors were selected based on EPDO rankings: A009, AB016, AB018, and AB020. Field road intersection inventories were then conducted at all 22 confirmed blackspot junctions, documenting lane geometry, sight distances, markings, signage, and adjacent land use.

4. RESULTS AND DISCUSSION

The pre-COVID-19 baseline (2014–2019) established a district annual average EPDO of 2,223 and 584 crashes. During COVID-19, these declined to 1,725 EPDO and 463 crashes — a 20.7% reduction attributable to mobility restrictions rather than infrastructure improvements. In the post-COVID-19 period, values partially recovered to 1,651 EPDO and 402 crashes annually (Figure 2), confirming that crash risk is strongly exposure-driven. The proportion of crashes at uncontrolled locations shifted from 68.2% pre-COVID, to 43.8% during COVID, and 49.8% post-COVID, demonstrating the persistent structural contribution of junction inadequacy.

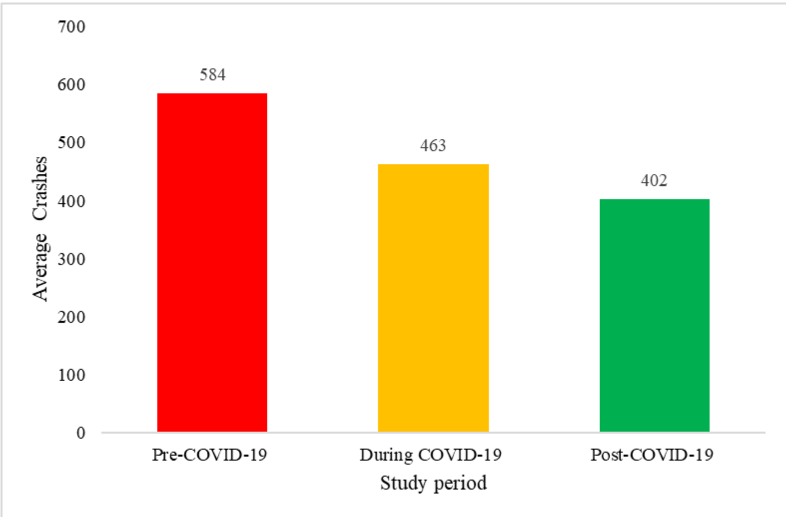

Figure 2. Average annual crash frequency by study period (Pre-COVID-19, During COVID-19, Post-COVID-19)

Police-reported crash data, while the most comprehensive source available for this study, are known to underrepresent minor and property-damage-only crashes—particularly those involving motorcycles and pedestrians—meaning the true crash burden in Jaffna District, and the relative ranking of blackspots by severity, may be underestimated.

QGIS crash distribution mapping (Figure 3) confirmed that crashes are heavily concentrated along the four priority arterial corridors rather than distributed uniformly across the district. The spatial clustering along A009, AB016, AB018, and AB020 is consistent with the EPDO corridor rankings and validates the corridor-selection methodology.

As shown in Fig. 4, EPDO-based corridor ranking identified A009 as highest-priority (37 pre-COVID crashes, EPDO 393), followed by AB016 (29 crashes, EPDO 162), AB020 (23 crashes, EPDO 167), and AB018 (13 crashes, EPDO 235). Blackspot mapping confirmed 22 junctions across the four corridors: 12 T-junctions and ten four-leg cross junctions, all completely uncontrolled. Field inventories at all 22 sites documented consistent deficiencies: two-lane roads of 3.0–6.0 m width, no centre median, no pavement markings, no advance warning signs, and high adjacent roadside activity (schools, markets, bus stops) within 50 metres.

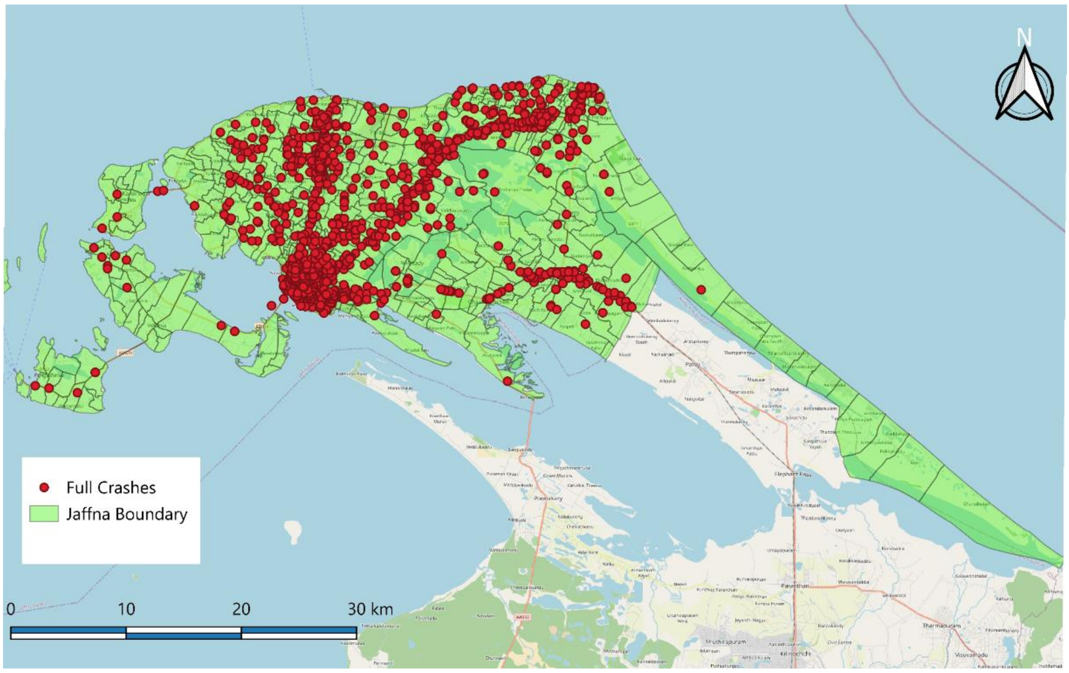

Figure 3. QGIS spatial distribution of all recorded crashes, Jaffna District (2014–2024)

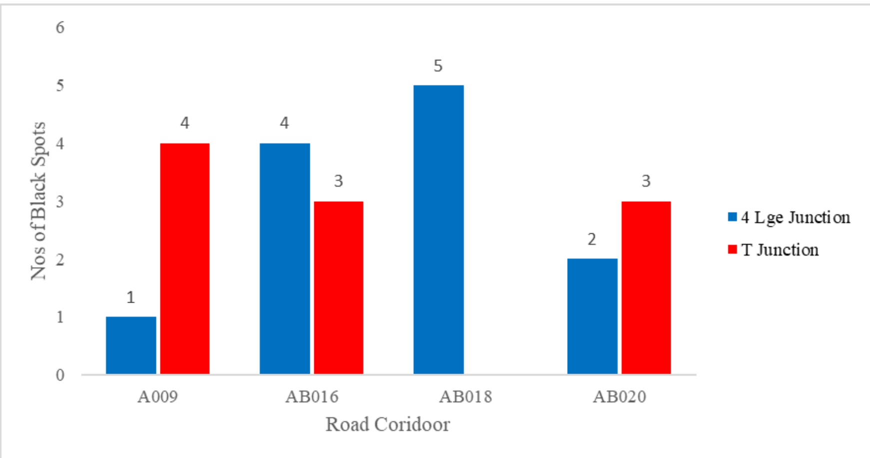

Figure 4. Blackspot count by road corridor and junction type (QGIS analysis; 22 blackspots total)

Eight engineering countermeasures were proposed across three implementation phases. For the 12 T-junction blackspots, stop sign installation packages, comprising a stop sign, white stop bar, advance warning sign, and retroreflective delineation, are recommended, projected to reduce angle collisions by 35–45% and injuries by 26% (FHWA, 2008). For the ten four-leg junction blackspots, mini roundabouts of 15–25 m outer diameter are proposed at LKR 500,000–800,000 per junction, eliminating head-on conflict points and reducing fatal and serious injury crashes by 40–90%.

The COVID-19 period confirmed as a natural experiment that crash risk at these junctions is geometry-driven: even with 20.7% fewer crashes during the pandemic, approximately half of

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all remaining crashes still occur at structurally deficient uncontrolled junctions. This shift may also reflect a change in traffic composition during the pandemic: mobility restrictions disproportionately curtailed routine motorcycle and three-wheeler trips associated with school and workplace commuting — the dominant users of minor-road uncontrolled junctions — while permitting essential travel by car and goods vehicles on better-controlled arterial corridors. If so, the reduced uncontrolled-junction crash share during COVID-19 may partly reflect this compositional shift in addition to the overall reduction in traffic volume; disaggregating crash data by vehicle type across the three periods would help confirm this mechanism. Post-pandemic recovery to near pre-COVID levels without any infrastructure change validates that engineering intervention, not traffic management alone, is required for lasting safety improvements. The total estimated budget for all eight countermeasures across 22 junctions ranges from LKR 17.9–21.9 million over 36 months, modest relative to the 3% of GDP estimated annual cost of road crashes in Sri Lanka (OECD/ITF, 2023).

5. CONCLUSION

While prior studies have examined road safety in Jaffna District at the level of provincial road segments (Tharmarajah and Pasindu, 2022) or specific corridors such as the A9 (Munas and Bandara, 2018), this study provides the first junction-level blackspot inventory specifically for uncontrolled locations in Jaffna District, combining a decade-long crash dataset (2014–2024) spanning pre-, during-, and post-COVID-19 phases with field-based geometric inventories and site-specific, costed engineering countermeasures for each of 22 confirmed blackspots. The finding that 68.2% of all pre-COVID crashes occurred at completely uncontrolled junctions represents a first-order infrastructure failure directly addressable through engineering intervention. Twenty-two blackspot junctions were identified across four priority corridors, and eight evidence-based countermeasures were proposed and costed, collectively projected to achieve a 40–75% reduction in fatal and serious injury crashes. The proposed interventions are practical, budget-consistent, and aligned with Sri Lanka's National Road Master Plan (2021–2030) and United Nations Sustainable Development Goal 3.6. Future research should incorporate traffic count and speed data at blackspot junctions and develop locally calibrated EPDO weighting for the Northern Province context.

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