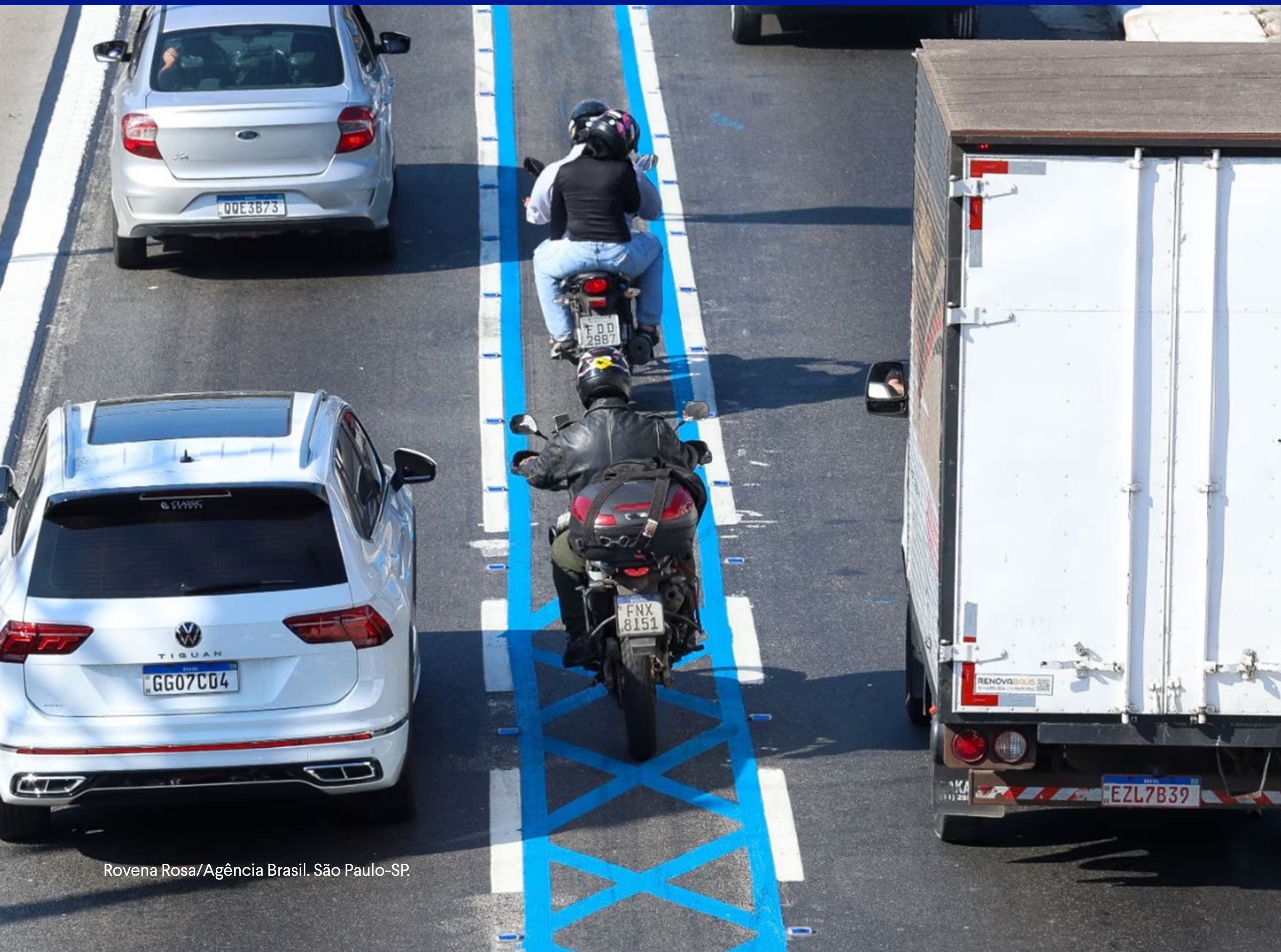
JANUARY 2026

The Blue Lane's Impact in São Paulo

Crashes, speed and motorcycle riders' perceptions



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Acknowledgments

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Introduction

This study assesses the effects of the Blue Lane on road safety. This exclusive lane assigned to motorcyclists on high-traffic roads was implemented as a pilot project in 2022 by the São Paulo City Government. It has become part of the municipality's road safety policy on an experimental basis.

Among its findings, the study points to an average increase of 100% to 120% in fatal crashes involving motorcyclists at intersections. At the same time, there has been no statistically significant decrease in crashes in general.

These results came about after five integrated steps: 1) standardizing and refining geospatial data on crashes by distinguishing intersections and block segments; 2) building a comparison group through statistical matching, based on road characteristics (level, width, traffic lights, enforcement, bus and bike lane infrastructure); 3) estimating the before-and-after effect by comparing intervention and control roads over time, together with sensitivity checks (difference-in-differences); 4) measuring speeds using drones and computer vision, stratifying traffic light proximity and spatial intervals between vehicles; and 5) conducting semi-structured interviews with motorcyclists to shed light on behavioral mechanisms.

Increased risk: data shows that the Blue Lane does not improve motorcyclists' safety

The study showed that, in specific contexts*, the average speed for motorcycles increased 24%, from 58.3 km/h to 72.2 km/h. On roads where the Blue Lane has been implemented, motorcyclists are much more likely to exceed speed limits.

This can be linked to a perceived greater sense of belonging and predictability in traffic since the Blue Lane has been implemented, according to motorcyclists. On the other hand, this sense may encourage risky behavior on the road.

Given these results, it is possible to conclude that the Blue Lane does not constitute a road safety measure. Therefore, the expansion and/or regulation of this type of intervention is not recommended.

If a decision is made to proceed with its implementation, active speed management (with average speed inspection), road redesign treatments in corridors, with special attention to intersections, as well as before-and-after monitoring with a comparison group are strongly recommended. It is important to note that speed management recommendations are independent of whether blue lanes are implemented, as they are effective in preventing injuries, especially to vulnerable users such as motorcyclists.

[1] On stretches far from traffic lights or with a spatial interval between vehicles greater than 20 m

Summary

1

Context

Blue Lane in perspective

With a growing motorcycle fleet, São Paulo introduces a measure, but impact studies are lacking

Over the last two decades, motorcycles have become one of the main means of urban transportation in Brazilian cities, taking on a growing mobility role due to their use in daily commutes and economic activities related to logistics and fast deliveries.

In Brazil, motorcycles account for 16.4% of commutes to work (IBGE, 2025). In the city of São Paulo, the number of registered motorcycles rose from just over 875,000 in 2010 to around 1.55 million in 2024 — a 78% increase. This growth rate is significantly higher than that of private cars, which in the same period saw a 25% increase to 6.4 million vehicles (SMUL, 2024).

The disproportionate increase may be related to motorcycles' lower purchase and maintenance costs, their greater convenience and mobility, and structural changes in the labor market. The expansion of digital delivery platforms and on-demand services may reshape mobility patterns and increase risk exposure for much of the urban population.

Number of motorcycles rose 78% in São Paulo, outpacing cars' 25% increase

As the number of motorcycles rose, motorcyclists became one of the most vulnerable groups on the road. Over the last decade, the percentage increase in casualties went from 32% in 2015 to 47% in 2024 (DETRAN-SP, 2025), indicating that São Paulo city is aligned with the national trend of relative growth in motorcycle deaths despite a global reduction in crashes (WHO, 2023).

In response to this trend, São Paulo has adopted several road safety policies and interventions targeted at this specific group, such as expanding exclusive motorcyclist waiting areas at traffic light intersections, with significant reductions in serious injuries (INSTITUTO CORDIAL, 2021). Other measures included banning motorcycles from sections of the Marginal Tietê and Marginal Pinheiros expressways (PMSP, 2019), implementing free training courses for motorcycle couriers (SMT, 2008), and reducing maximum speed limits (CET-SP, 2016; ANG et al., 2020; IGARASHI, 2024).

The Blue Lane measure was adopted on an experimental basis as part of these actions. It features road signs that seek to "reorganize road space and provide greater safety for motorcyclists and harmonious coexistence between modes of transport" (CET-SP, n.d.). It introduces a dedicated lane for motorcycles marked by blue lines between the leftmost two lanes in high-traffic urban areas.

The pilot project, implemented in 2022 on important roads such as Avenida 23 de Maio and Avenida dos Bandeirantes, quickly gained scale, growing from 34 km in length to 221 km in 2025. On an experimental basis and with approval from the National Traffic Secretariat, which is still discussing its regulation, the Blue Lane was incorporated into the 2025–2028 Target Program of the São Paulo City Hall (PMSP, 2025a).

The stated goal is to "double the length of exclusively dedicated lanes to motorcyclists," a proposal that has attracted the attention of other cities. Despite its rapid spread and visibility in public debate as a measure that could improve road safety, the Blue Lane still lacks independent and consistent evaluations that would allow an estimation of its real effects on the incidence of traffic injuries and risky motorcyclist behavior.

Global research on dedicated motorcycle lanes is limited and focuses on Asian contexts, particularly Malaysia and India, where physically segregated motorcycle lanes prevail (SAINI et al., 2022). In Malaysia, one study reported a 74% reduction in casualties after the implementation of physically segregated motorcycle lanes (MANAN; NOORDIN, 2023); another observed that non-segregated roads were 1.45 times more likely to register fatal crashes (SARANI et al., 2021). Studies also point out that lane width influences driving behavior (HUSSAIN et al., 2011); and simulations have shown positive safety indicators in scenarios with exclusive lanes, including less frequent lane changes and fewer critical collision situations (AHMED et al., 2023).

These studies suggest that there are potential positive effects of physically segregating motorcycles, but they are not directly applicable to Brazil because they describe models that substantially differ from Brazil's approach, in which lanes are not separated from general traffic by barriers and are signified only by markings on the pavement. In addition, unprotected lanes such as the Blue Lane in São Paulo operate in high-traffic urban environments, where interaction between motorcycles and other vehicles remains intense.

In such cases, there is not enough evidence of a reduction in crashes - quite the opposite, as São Paulo's first experiment with motorcycle-only lanes, carried out in from 2006 to 2013, found an 87% increase in fatal crashes involving motorcyclists, despite the limitations of the evaluation. After the dedicated lanes were removed, there was a 36% reduction in this type of crash (CET-SP, 2014). In an international study, Alvin Poi et al. (2022) argue that these motorcycle lanes can actually increase the risk of collisions in settings with a high concentration of motorcyclists: "Simply providing non-exclusive lanes for motorcycles isn't enough and shouldn't be treated as the only way to reduce motorcycle accidents in urban areas."

The Blue Lane's effects seem to combine gains in the predictability of motorcyclists' trajectories with possible increases in speed, while amplifying risks at convergence points like road intersections and side accesses. A recent study says there is no "evidence that the Blue Lane has produced a statistically significant improvement in the road safety indicators analyzed" (COSTA et al., 2025), reinforcing the importance of further investigating the impacts of this type of motorcycle-dedicated lane.

There is a lack of scientific studies proving the Blue Lane's effectiveness in road safety

On the other hand, the São Paulo City Government has been emphasizing the initiative's safety benefits (PMSP, 2025b). Since 2022, the Traffic Engineering Company (CET-SP) has been publishing quarterly reports to monitor and track the Blue Lane's rollout, as required by Resolution 973 of the National Traffic Council (CONTRAN, 2022).

These documents playing an important oversight role, compiling operational information required by SENATRAN such as lanes' lengths and locations, traffic volumes and crash records. But they are not designed as impact assessments, for they lack a methodological framework that can establish causality between the Blue Lane and any changes in road safety indicators.

One of the main methodological flaws is the absence of an appropriate comparison group — an estimated scenario of what could have happened if the intervention had not taken place — which is a fundamental component of scientifically accurate impact assessments (TRB, 2023).

In addition, roads are not treated as complete analytical units. Only crashes that take place within the Blue Lane are considered "affected"; occurrences on the same road but outside of the lane are used as a basis for comparison. This approach disregards mutual influence, compromising the outcome's validity. Comparing "before and after" also fails to solve this problem, as it assumes that in the absence of intervention, past trends would carry over into the future, disregarding external factors such as seasonality, educational campaigns, inspections or traffic volume variations.

Another point of contention is that the pre- and post-intervention analysis are based on different data sources. Whereas the information for the period prior to the intervention comes from the Public Security Secretariat (SSP), the data for the period thereafter comes from the Traffic Engineering Company (CET). As those numbers are not comparable, this discrepancy compromises the results' integrity, undermining analytical reliability and accuracy regarding the Blue Lane's causative effects on road safety.

Faced with these identified gaps, it becomes clear that an approach that brings together multiple sources of consistent data is needed — one that incorporates not only robust quantitative methods, but also qualitative assessments that capture the perceptions of vulnerable users, whose views are often overlooked in technical and academic circles.

This is the purpose of the present study, which seeks to provide a more accurate and replicable assessment of the Blue Lane's effectiveness, helping to inform technical and regulatory decisions.

This research offers a precise and replicable methodology for evaluating the Blue Lane's impacts

The widespread implementation of the Blue Lane without consistent impact assessments adds risk to the formulation of data-based public policies. Given the possibility of its national regulation by the National Traffic Secretariat and the likely large-scale expansion of this type of intervention, it is essential to provide sound evidence on its effects on road safety and motorcyclists' risky behavior.

This project, run by the University of Sao Paulo, the Federal University of Ceara, and Instituto Cordia, with technical and financial support from Vital Strategies, aims to expand on earlier stidies through a mixed-methods research design that combines quantitative and qualitative approaches. The methodological framework seeks to produce scientific input for public policy decisions and for refining road safety strategies.

Physically segregated lanes in Malaysia. Source: Free Malaysia Today (FMT News).

2

Method

Mixed methods provide quantitiative and qualitative insights

Research analyses incidents, drone footage and interviews with motorcyclists

To assess the Blue Lane's effects on road safety and motorcyclist behavior in the city of São Paulo, this study takes a mixed-method approach.

The methodological structure incorporates three complementary avenues:

1) geo-referenced crash analysis, using causal inference models

2) traffic behavior observation, particularly speed, using aerial drone footage

3) courier motorcyclists' safety perceptions, through semi-structured interviews

By triangulating these components, the study seeks to capture objective dimensions of safety and traffic conditions, as well as more subjective aspects on road use and perceptions (Figure 1).

The strategy combines difference-in-differences (DiD) models to estimate the Blue Lane's average effects with field data collection (primary data) to qualify traffic behavior mechanisms. In addition, it relies on statistical procedures to establish a counterfactual scenario (control routes), and spatial standardization procedures to increase the reliability of traffic crash data. Thus, the overall study design aims to quasi-experimentally evaluate a real intervention in an urban context, a method typically employed when it is not possible to create an experimental comparison group.

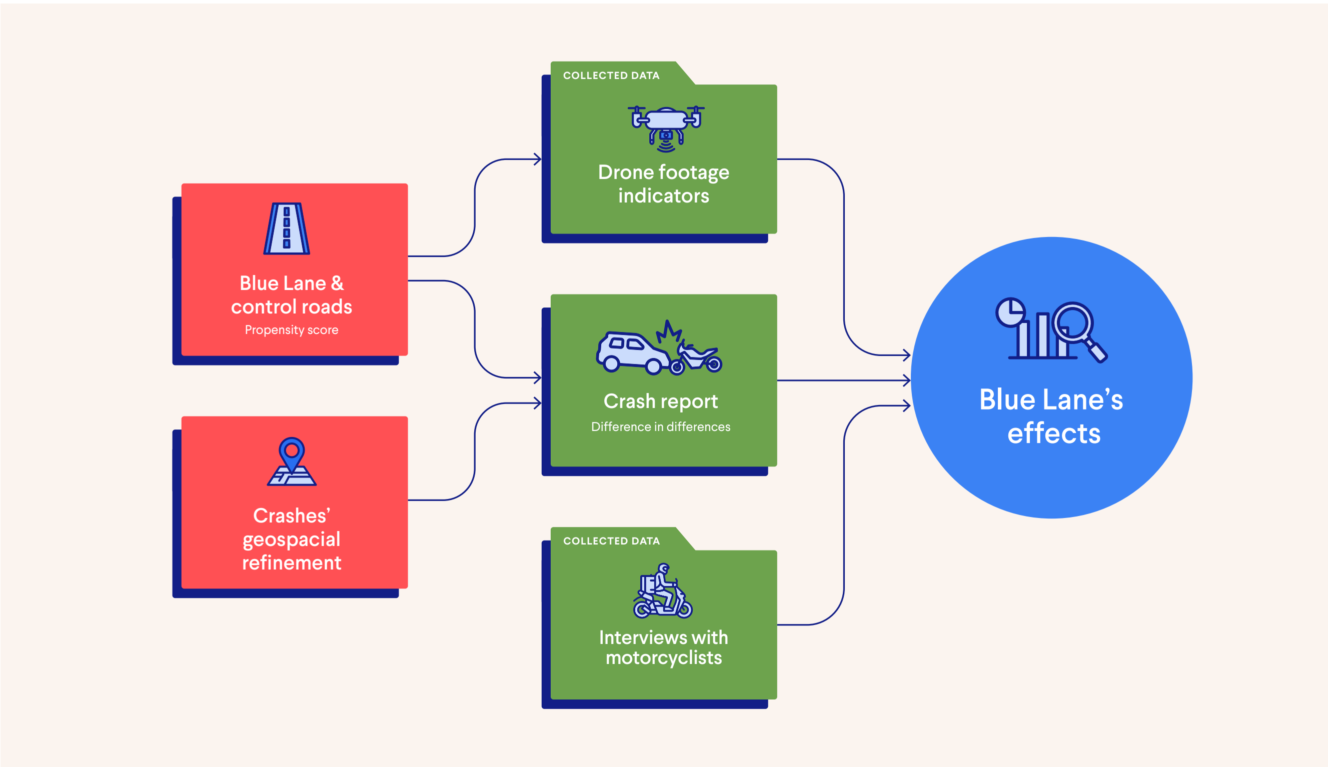

Figure 1: Blue Lane impact analysis methodology diagram. Source: Consórcio USP-UFC-Cordial

The Importance of a Comparison group

Measuring the impact of a road safety intervention goes beyond comparing figures from before and after its introduction. To correctly estimate the effects of a policy, researchers need to know what would have happened if the intervention had not been implemented. This prediction, known as the counterfactual, is the basis of any impact assessment. The more robust the methodology used to estimate this scenario, the more reliable the conclusions.

The previous year's data is not a good basis for estimating what would have happened without the intervention. It dismisses other factors that may influence the outcome, such as changes in weather conditions, traffic flow variations, parallel road safety measures, or even changes in data collection procedures. In addition, there may be a natural fluctuation in the number of crashes, known in statistical terms as regression to the mean.

One way to obtain a good estimate is by using comparison groups. This approach makes it possible to isolate the intervention's effect, resulting in more reliable and useful assessments for road safety management. This is done, for example, in clinical trials for new vaccines. The experimental group receives the therapy, while a comparison group with similar characteristics does not. The differences between them reveal the actual effect of the medication. Similarly, when evaluating an action's impact on traffic, we need a group or model that serves as a reliable basis for comparison.

Choosing roads to compare

To identify a road network with similar characteristics to those assigned to the Blue Lane program, a group of road segments (codlogs) was selected that did not undergo intervention during the study period and had a similar profile to the Blue Lane roads. The selection process consisted of two complementary stages:

1. **Structural filter (perfect matching).** Only main roads and expressways longer than 2 km were selected, ensuring functional comparability between treated roads and potential control roads.
2. **Propensity score matching (PSM).** For the roads selected through the first filter, we estimated the probability of a segment receiving the Blue Lane, based on observations of the road environment, with a 1:1 matching (nearest neighbor), without replacement. The covariables included in the propensity score are: carriageway width, in meters; median strip presence (% extension); bicycle infrastructure (% extension); dedicated bus infrastructure (% extension); intersections per km of road; number of speed cameras per km of road; and traffic lights per km of road.

PSM: a tool for comparing pathways groups

Propensity score matching (PSM) is a statistical technique employed to form comparison groups between units that received an intervention and equivalent units that did not, identifying similar characteristics.

In public policies evaluation studies, working with comparison groups is essential to verify whether the observed results are a consequence of the performed intervention and not of other external factors.

For the Blue Lane study, PSM was used to find road pairs with similar characteristics to those that received the Blue Lane — width, number of intersections, bike lanes and bus lanes, and other factors. This made it possible to isolate the Blue Lane's implementation effect and assess its real implications for road safety, without confusing it with other changes or policies in progress.

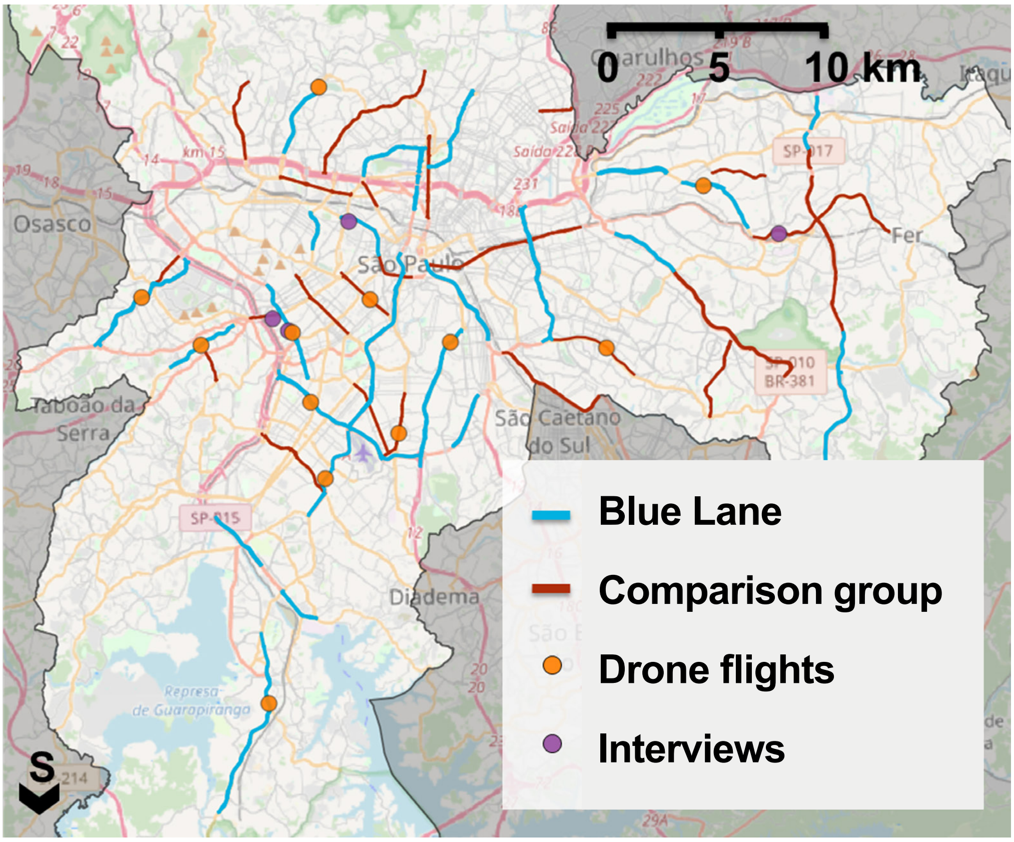

Figure 2: Spatial distribution of Blue Lane routes and drone filming collection points and interview locations with motorcycle delivery drivers in the city of São Paulo. Source: Consórcio USP-UFC-Cordial

Based on this categorization, we were able to come up with the final set of treated and control segments shown in Figure 2. This approach helped guide both the roads that received crash data analysis and those that were used as drone filming locations, ensuring coverage in both groups (treatment and control) and in different city areas.

The treatment group only includes roads where the Blue Lane was introduced between January 2022 and October 2024, making sure there were comparable time frames for "before" and "after" in the reviewed scenarios.

Further details on the methodological approach used can be found in Humberto et al. (2025a).

Crash data analysis isolates Blue Lane's impacts

Study of crash data from the observed roads employed a combination of analysis methods to isolate the impacts of the Blue Lane and identify its causal effects. To this end, the research design used propensity score matching (PSM) and difference-in--differences (DiD) statistical models.

PSM is applied to balance observable traits in the road environment across the Blue Lane and control roads to avoid confusion between the intervention and its expected effects, building on a sample of roads that are similar in hierarchy (arterial and VTR) and minimum length. Based on this paired data set, DiD estimates the average intervention effect from the before-and-after variations in the groups, seeking to control common shocks over time and unobserved fixed heterogeneities.

In doing so, it becomes possible to compare the behaviors in the two groups. If the data for both evolve similarly over time, this likely means that the Blue Lane intervention had no effect. However, if the number of crashes on Blue Lane roads behaves differently from that of the control roads, this indicates a possible impact of the intervention that deserves attention.

This strategy of combined PSM and DiD, which is recommended by previous studies for assessing transport policies through causal inference with observational data (SCHIFF et al., 2017), closely resembles the research design proposed by Costa et al. (2025) to evaluate the Blue Lane's effects on traffic crashes.

Time windows

Not all Blue Lane roads came into operation at the same time. Due to its phased rollout between January 2022 and October 2024 (approximately 212 km in length by the end of 2024), the main analysis in this study excludes the two months before and after the Blue Lane's implementation on each road. This reduces possible transient effects, adaptation and temporary noise, and verifies whether the results remain consistent regardless of the period or number of roads included.

To guarantee validity and robustness, additional estimates replicate the exercise leaving out one or two months, to see how stable the signals are and if the trends are plausible in the pre-intervention period. Interpretations also consider different coverage levels of the network that's been set up:

1. Until July 2024 (80% of the network), claims up to 12 months later
2. Until September 2024 (93% of the network), claims up to 10 months later
3. Until September 2024 (100% of the network), claims up to 9 months later

The analytical design finds a middle ground between the monitoring horizon and the network coverage: the longer the post-implementation window, the shorter the available road length (and vice versa). To address these sample composition biases, the results are analyzed by comparing time windows and Blue Lane coverage, while keeping the same propensity score matching protocol, spatial positioning of crashes and causal effect estimation.

All procedures were approved by the Biomedical Research Alliance of New York (Protocol 24-410-522) and by the Comitê de Ética em Pesquisa com Seres Humanos do Instituto de Psicologia da USP* (CAAE 82566224.8.0000.5561).

Further details on the methodological approach can be found in Humberto et al. (2025b).

Crashes are observed with geospatial refinement

The research took a territorial approach to roads, looking at structural elements (intersections/midblocks) as spatial units that are complementary to the segment (codlog), the same way Meyer and Gonçalves (2024) presents it. This technique was subsequently combined with assessment stratification based on the type of incident (fatal* and non-fatal** crashes) and whether motorcyclists were involved (with/without motorcyclists). This enables the identification of any heterogeneous effects relating to the Blue Lane and the prioritizing of complementary interventions.

This distinction assumes functional heterogeneity — while intersections concentrate flows and have greater potential for conflict, block sections involve acceleration, side maneuvers and crossings outside controlled points.

To measure these elements in an operational manner, intersection polygons were generated from the road network centerlines and dissolved buffers over road intersection points. The midblocks are composed by the resulting residual road network (Figure 3).

Having defined each road element (intersection or block), they were associated with territorial layers, such as the presence of traffic lights, road hierarchy, bicycle and bus infrastructure, speed limits, electronic surveillance, etc. With the help of geoprocessing algorithms, variables such as median sidewalk and roadway width, number of lanes, number of approaches and block face length were also derived. A 10-meter buffer from the strict intersection design was considered.

* Fatal: Crashes with at least one fatality, with deaths occurring within 30 days of the incident.
** Non-fatal: Crashes with no fatalities, but with at least one injured victim.
Crashes involving only property damage were not considered in the analysis.

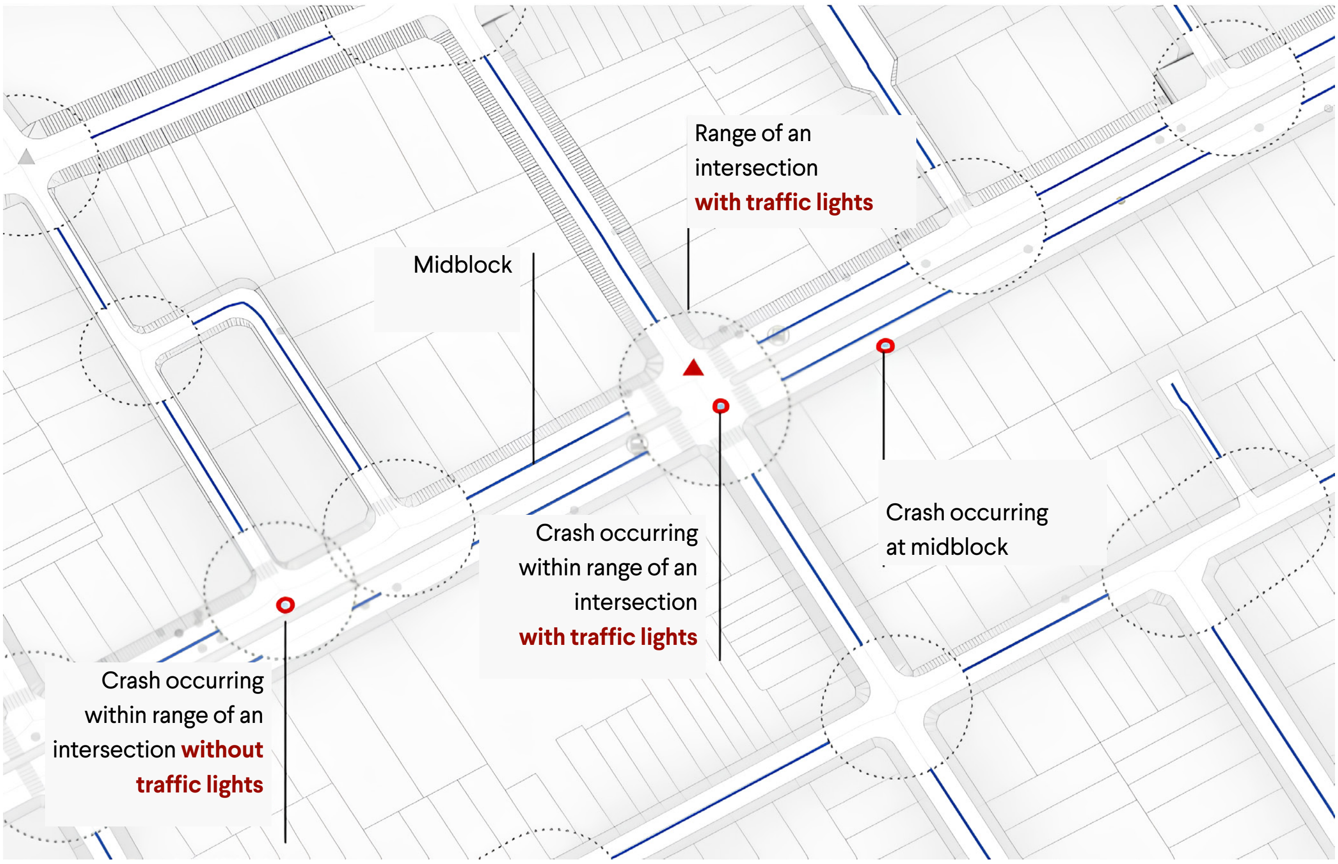

Figure 3: Breakdown of road structural elements in the middle of a block and at an intersection. Source: Instituto Cordial

This study used monthly traffic crash records provided by Infosiga/DETRAN-SP from January 2021 to July 2025, with standardized fields to ensure temporal comparability. As the analysis distinguishes between occurrences by road and road element (intersection/midblock), the geographic location of events is crucial. For this reason, a georeferencing assessment of the database was performed: in systematic samples, text addresses (street name and number/kilometer) were compared to the original coordinates in the record, highlighting possible discrepancies associated with generic addresses and vague descriptions, especially in nonfatal crashes.

As the primary position reference, the street was geocoded via Google Maps API, following technical guidance from the São Paulo State Traffic Department, in view of greater adherence to the analytical unit (segment/codlog).

Once geocoding was complete, crash locations were repositioned to reduce processing biases: from the lot's centroid to the lot's face and then to the block's outer boundary (road system edge). By doing so, we sought to mitigate possible associations with other locations, especially in large lots and corners. Records with insufficient or inconsistent addresses were excluded from any analysis that required granularity by road's structural element.

The goal was to recognize any inherent limitations associated with the data and mitigate potential spatial biases, providing a more reliable basis for estimating the intervention's effects on annual traffic injury and casualty rates, as measured per road length.

Further details on the methodology used can be found in Meyer et al. (2025).

Drones show traffic behavior on the Blue Lane

Drone footage was modeled and used to observe and measure the behavior of motorcyclists and other drivers on roads with and without blue lanes. The use of aerial cameras made it possible to track each vehicle along its route, identifying its position, type and speed.

With this data, it was possible to:

- Compare average speeds between roads with and without blue lanes
- • Check which conditions seem to impact motorcyclists' speed (for example, away from traffic lights or when there is more free space)
- Assess whether the Blue Lane's presence changes the way motorcyclists distribute themselves and interact with other vehicles

Based on the set of treated roads and their respective control roads, as defined by the PSM, only sections with a regulatory speed limit of 50 km/h were selected, with two sections being discarded due to their 60 km/h speed limit, since this could interfere with the comparative speed analysis. No before-and-after data collection was possible at the same locations, as the rapid expansion of implementations between November 2023 and January 2025 was carried out without prior schedule disclosure by the São Paulo City Hall.

Parameters and criteria: How the footage was captured

Time and space: filming took place in March and April 2025, from 6:30 a.m. to 9:00 a.m. (peak) and from 9:30 a.m. to 12:00 p.m. (off-peak), in steady weather conditions, with an altitude of between 30 and 35 meters. The camera was placed parallel to the road and positioned at a right angle to the traffic flow (Figure 4).

Device settings: during processing, stabilization was applied to reduce turbulence and minor height variations. Each video was recorded to a reference frame using keypoint detection (BRISK) and partial affine transformation (estimateAffinePartial2D). Then, the next steps were:

1. Detecting and classifying (Car, Motorcycle, Van, Bus, Truck, Bicycle, Pedestrian) using YOLOv10
2. Temporal tracking using StrongSORT for frame-by--frame association and unique ID
3. Trajectory reconstruction

Image capture: the detector was fine-tuned using images depicting the Blue Lane; the training/validation/testing set featured 1,769 images (70/15/15), with a good performance in the main classes (Cars, Motorcycles, Trucks and Buses). Figure 5 shows the computer model training results.

Figure 4: Video footage collection records from drone filming. Source: Consórcio USP-UFC-Cordial

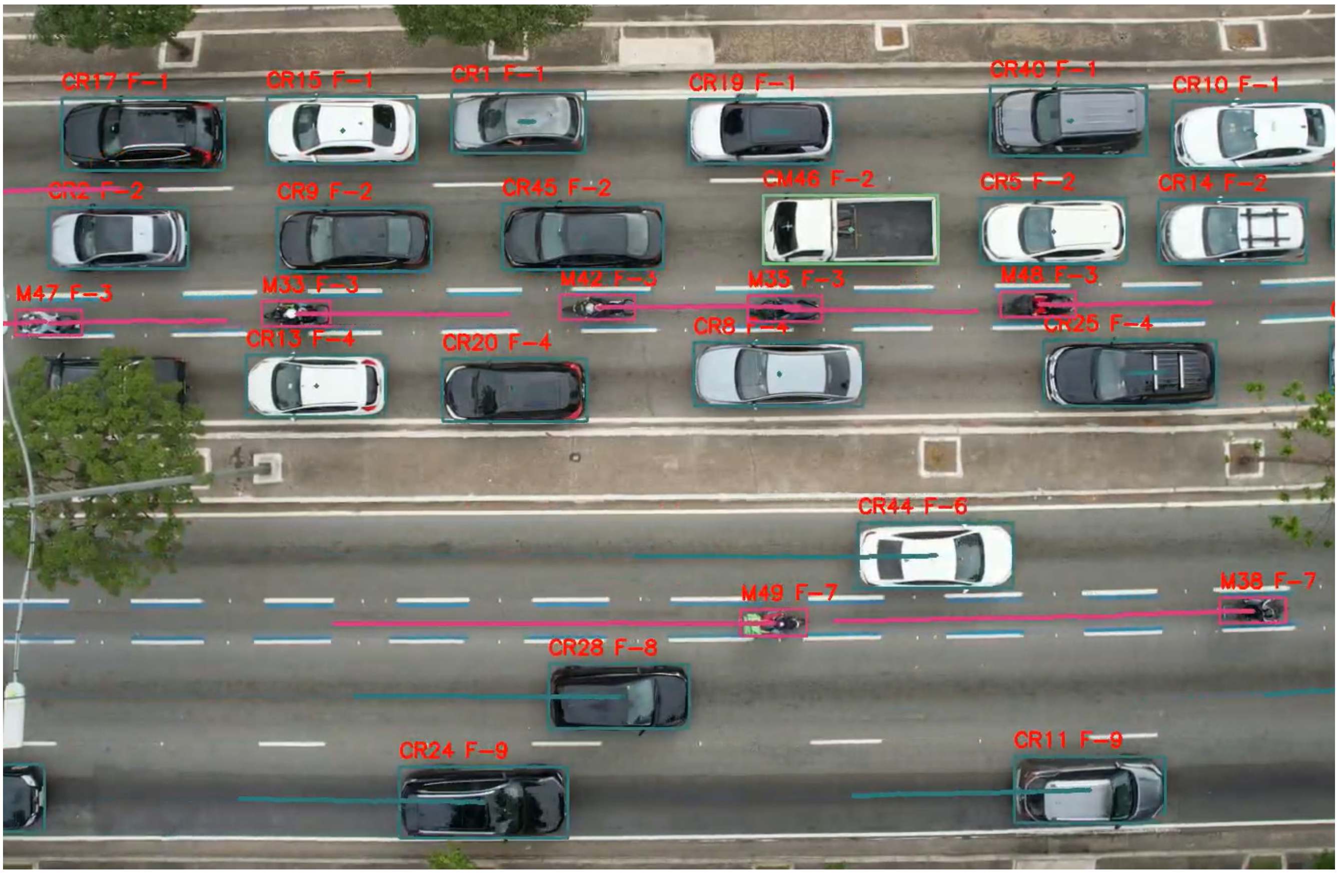

Figure 5: Results of detection, classification, and tracking with vehicle type characterization, unique identifier, and cross-frame association, highlighted by the “trail” of some moving vehicles. Source: Consórcio USP-UFC-Cordial

Data processing: pixel/frame trajectories were converted to meters/seconds using fiducial marks measured in the field, as well as footage frame rates (30 fps). To reduce noise, which is especially critical for motorcycles because of occlusions, a few algorithms were tested - moving average, Gaussian filter and Savitzky-Golay (0.5 s and 1.0 s windows).

Segment classification: to compare Blue Lane and non-Blue Lane segments, the “main corridor” was defined as the road space between lanes 1 and 2 (in the study scenario, plus the lane width designated to motorcyclists). To characterize effective use, a margin of 0.80 m along lane lines was considered and a minimum retention of 1.5 s within the corridor.

Setting criteria: two criteria were considered for traffic conditions and speed-relevant infrastructure (risk proxy):

1. Distance to traffic lights of up to 250 m (effects of downstream traffic light operation)
2. Leader-follower interaction effects between motorcyclists, as measured by the average distance between consecutive vehicles, or space gap (SG), as well as empirical thresholds to distinguish impeded vs. unimpeded cases

Data analysis: hypothesis tests were used to compare the average speed and proportions above 50 km/h, 60 km/h, 70 km/h and 80 km/h, supported by histograms

Further details on the methodology can be found in Oliveira et al. (2025).

Interviews with motorcycle delivery drivers

To learn what motorcyclists think of the Blue Lane and understand how the intervention impacts traffic behavior, the study set out to hear from them in person. The qualitative aspect involved conducting semi-structured interviews with motorcycle delivery drivers at delivery waiting points located in central and intermediate areas of São Paulo city.

Face-to-face interviews were conducted between November 2024 and February 2025, reaching a total of 57 participants. The target audience focused on motorcyclists who use the road for professional purposes, especially app-based delivery drivers and self-employed drivers (Figure 6). The script included open-ended questions regarding traffic experience, safety perception, interaction with cars and other motorcyclists, as well as specific questions about perceived changes in behavior and predictability after the Blue Lane implementation.

The average length of each interview was 25 minutes, and data collection was carried out with informed consent, confidentiality and anonymity. Transcripts were organized into spreadsheets, subjected to thematic content analysis according to previously defined categories and adjusted during exploratory reading. This included identifying meaning units, grouping them into thematic axes and quantifying mentions.

This approach seeks to extract recurring perception patterns, especially regarding perceived safety, flow, mutual respect and how well the Blue Lane fits with real-life traffic dynamics. The analysis highlighted differences between experienced and new riders and identified variations in use based on the type of delivery, which helped with interpreting the quantitative results.

Further details on the methodology can be found in Hadler et al. (2025).

Figure 6: Images from the semi-structured interviews with delivery riders. Source: USP-UFC-Cordial Consortium

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3

Traffic Crashes

Mixed methods point to a growth in crashes at intersections

Sample analysis showed, on average, a 100%–120% surge in fatal crashes involving motorcyclists at intersecting roads

According to the mixed methods assessment of the crash rate, the only consistent causal effect associated with the Blue Lane was an increase in fatal crashes at intersecting roads involving motorcyclists, which was statistically supported by the main samples. The analysis combined propensity score matching of roads, geospatial refinement of Infosiga records by road element (intersection and block) and statistical models of causal inference (difference-in-differences).

The analysis focused on the pre–post comparison between the treated and control roads excluding the two months surrounding implementation; further analysis with alternative windows serves to check robustness. Results are reported by severity (fatal/non-fatal), by motorcyclist involvement and by road element, with an 85% trust interval (p-value ≤ 0.15) used as the minimum significance criterion, aligned with the quality standards established by the Transportation Research Board through the CMF Clearinghouse (TRB, 2023).

Overall, there were no statistically significant reductions in crashes attributable to the Blue Lane. As for crashes with no motorcyclists involved, estimates hovered near zero and weren't significant across different time periods and road elements. In midblocks with motorcyclists, stats were mixed and mostly insignificant.

The most consistent pattern appears at intersections with motorcyclists and fatal crashes: there is a statistically significant increase over the main time frame (except for the two months surrounding implementation), with average effects ranging from 100% to 120%. Other results involving motorcyclists show estimated effects too insignificant within the adopted confidence interval (85%), making it impossible to support Blue Lane adoption as a road safety policy (Figure 7).

Two approaches were used to verify data reliability. First, variations in post-implementation time frames showed the same direction and statistical significance in fatal crashes involving motorcyclists at intersections, i.e., up to 9 months (100% implemented), 10 months (93%) and 12 months later (80%). Next, new estimates were made using less conservative time windows, i.e., only excluding the month around the intervention (instead of two months), thus maintaining the effect at intersections with motorcyclists and serving as a sensitivity check. In summary, the main sample provides the clearest evidence, and the additional exercises corroborate the core conclusion.

[2] Fatal crashes involving motorcyclists include any crash in which at least one of the fatal victims was a motorcyclist.

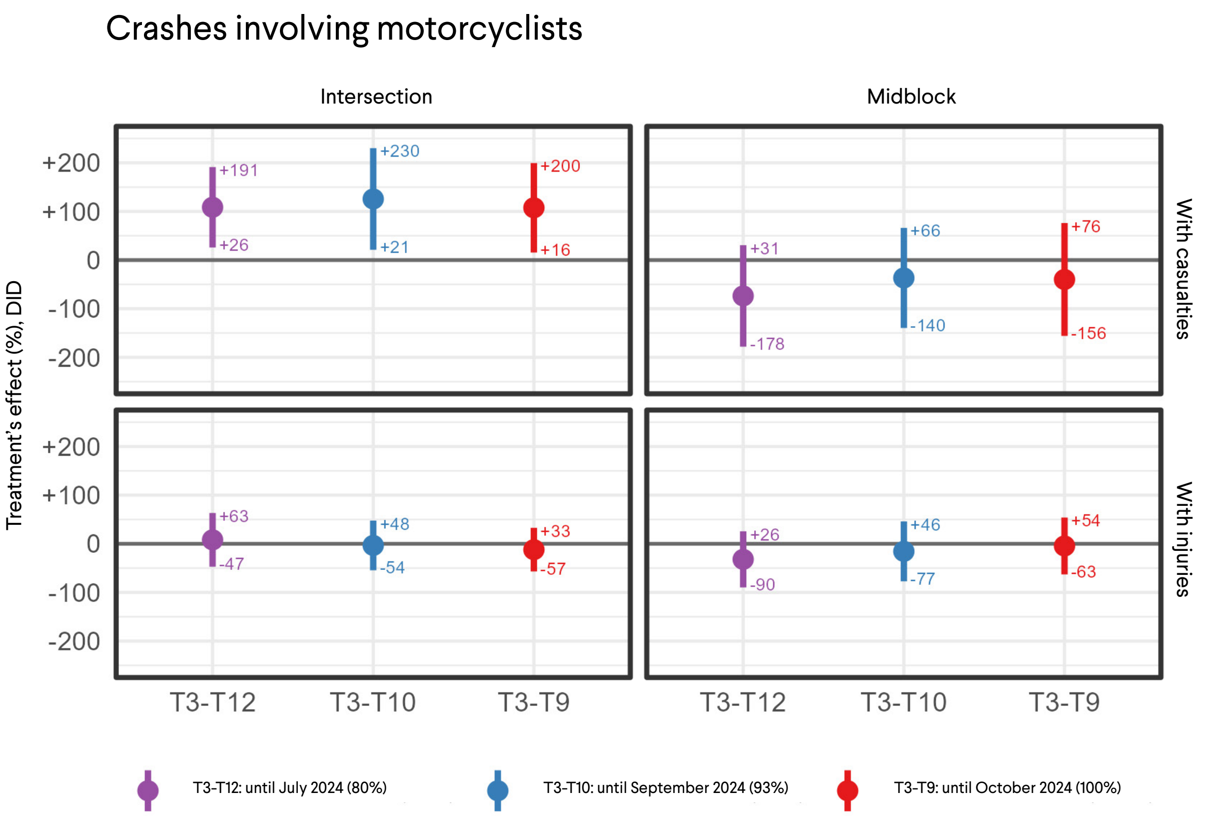

Figure 7: Difference-in-differences variables applied to crashes involving motorcyclists and their statistical confidence interval (85%), by crash location and severity. Source: Consórcio USP-UFC-Cordial. nça estatística (85%), por tipo de localização e gravidade do sinistro.

Potential risk mitigation measures

These results demonstrate that the Blue Lane does not constitute a road safety measure. From an operational standpoint, it highlights that other measures should be considered to potentially mitigate said effects at intersections:

1. Strengthen and maintain road markings in approach and crossing areas
2. Clearer transitions for motorcycle lane entrances and exits
3. Speed management by average speed, as well as focused monitoring on critical points with fixed and handheld devices

In addition, continued geospatial refinement and structural monitoring (midblock/intersection) are recommended to track the effects while the Blue Lane remains experimental.

Rovena Rosa/Agência Brasil. São Paulo-SP

4

Speed

Drones reveal reckless behavior by motorcyclists

Image analytics show significant increase in speed on roads with the Blue Lane

Consistently, data from drone-captured trajectories show an increase in motorcycles' speed on roads with the Blue Lane. This amplifies the likelihood of crashes and adds to the risk of severe outcomes in the event of a collision.

This is true for all covered sections. It becomes more intense in stretches with no traffic lights, where there's less disruption from stops and traffic tends to flow more freely.

To arrive at this analysis, this investigation sought to ensure comparability: Results were stratified by spatial interval (distance to the most immediately preceding vehicle during video recording) and vicinity to traffic lights, distinguishing between nearby (up to 250 m downstream) and distant sections. Larger spatial intervals indicate a lower effect of leader–follower interaction and greater freedom to choose driving speed.

In distant sections, the Blue Lane seems to shift the speed distribution to higher levels, both in average values as well as probability of exceeding speed limits of 50 km/h, 60 km/h, 70 km/h and 80 km/h. Near traffic lights, the increase is less substantial and concentrates on intermediate lanes, accompanying the formation and dissipation of queues.

Combining the spacing between vehicles (spatial interval) and their distance from traffic lights helps to separate the infrastructure effects from those of demand and control. With reduced spatial intervals, pack behavior is what makes speed variability grow. As the space increases, riders enjoy a greater sense of choice and the Blue Lane can be linked to higher speeds. For this reason, the main analysis considered unimpeded motorcyclists (spatial interval ≥ 20 m), to avoid confusion between behaviors attributed to the Blue Lane and those attributed to group dynamics.

Speed profile

Considering sites with unimpeded motorcyclists and located within 250 m of signalized intersections, the average speed rises from 53.4 km/h on control roads to 57.9 km/h on Blue Lane roads (Figure 8), pointing to a 4.5 km/h (8.4%) increase, with statistical significance (α=5%). For sites with unimpeded motorcyclists and located more than 250 m from traffic lights, the average speed jumps from 58.3 km/h on control roads to 72.2 km/h on Blue Lane roads, an increase of 13.9 km/h (23.8%), with statistical significance (α=5%) (Figure 9).

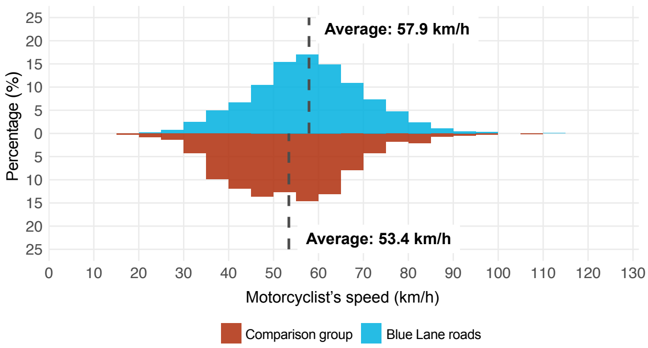

Figure 8: Speed histograms of unimpeded motorcyclists near traffic lights, on control roads, and on Blue Lane roads. Source: Consórcio USP-UFC-Cordial.

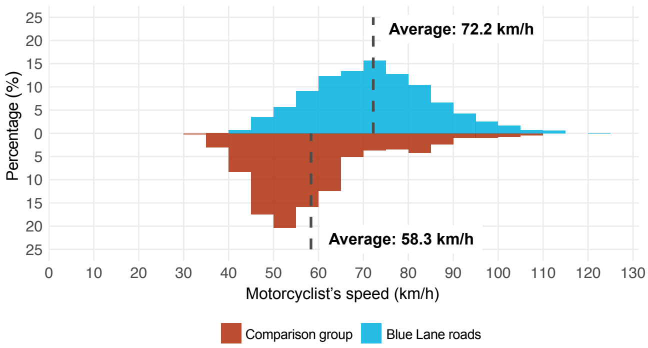

Figure 9: Speed histograms of unimpeded motorcyclists away from traffic lights, on control roads, and on Blue Lane roads. Source: Consórcio USP-UFC-Cordial.

A cumulative speed distribution (Figure 10) confirms the shift in speed range in the Blue Lane scenario.

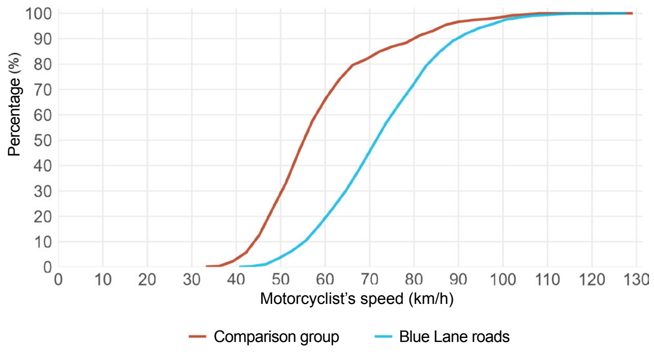

Figure 10: Speed histograms of unimpeded motorcyclists in areas far from traffic lights, on control roads and on Blue Lane roads. Source: Consórcio USP-UFC-Cordial.

Well over established limits speeds

An increase in speeding beyond the established limit was also observed on roads with Blue Lanes when compared to the control roads, with the exception of speeds above 80 km/h (Table 1).

Outside the vicinity of traffic lights, speeding also goes up at all established levels (Table 2). These results show that, outside the traffic light radius, the Blue Lane is linked to even higher speeds and a greater chance of crossing critical levels.

Table 1: Share of unimpeded motorcyclists (spatial interval ≥ 20 m) surrounding traffic lights that exceed established speed thresholds, on control roads and on designated roads (Blue Lane).

Speed thresholds	Control roads (N = 749)	Blue Lane	Difference (p-value)
› 50 km/h	57.9%	74.6%	+16.6 (‹0.001)
› 60 km/h	30.7%	42.1%	+11.4 (‹0.001)
› 70 km/h	9.7%	16.4%	+6.6 (‹0.001)
› 80 km/h	3.7%	4.3%	+0.6 (0.24)

Table 2: Share of unimpeded motorcyclists outside the traffic lights radius that exceed speed thresholds, on control roads and on designated roads (Blue Lane)..

Speed thresholds	Control roads (N = 749)	Blue Lane	Difference (p-value)
› 50 km/h	70.9%	95.9%	+25.0 (‹0.001)
› 60 km/h	34.6%	81.1%	+46.5 (‹0.001)
› 70 km/h	17.1%	55.4%	+38.3 (‹0.001)
› 80 km/h	10.0%	26.9%	+16.9 (‹0.001)

Variation in speeds across space: traffic light surroundings vs. away sections

Near traffic lights (73% of observations), speeding grows as the space between two vehicles widens, although dispersion is greater at short intervals due to queue formation and dissipation (Figure 11). Away from traffic lights, where there is less interference from cyclical stops and a greater chance of free-flowing traffic, the distinction between the two scenarios becomes clearer (Figure 12).

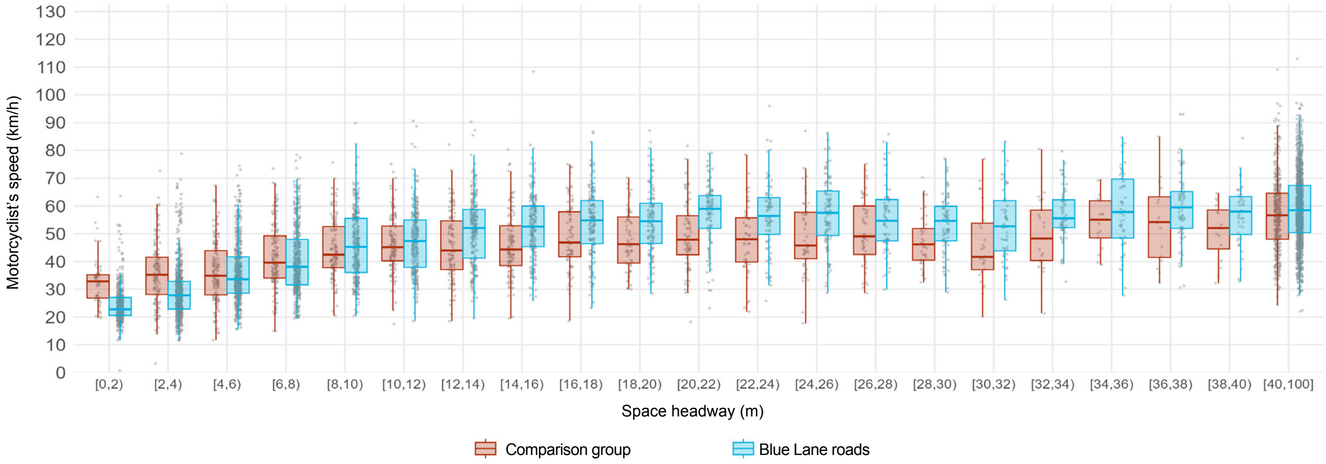

Figure 11: Motorcycle speed distribution by spatial range and surrounding traffic lights, for control roads and Blue Lane roads. Source: Consórcio USP-UFC-Cordial.

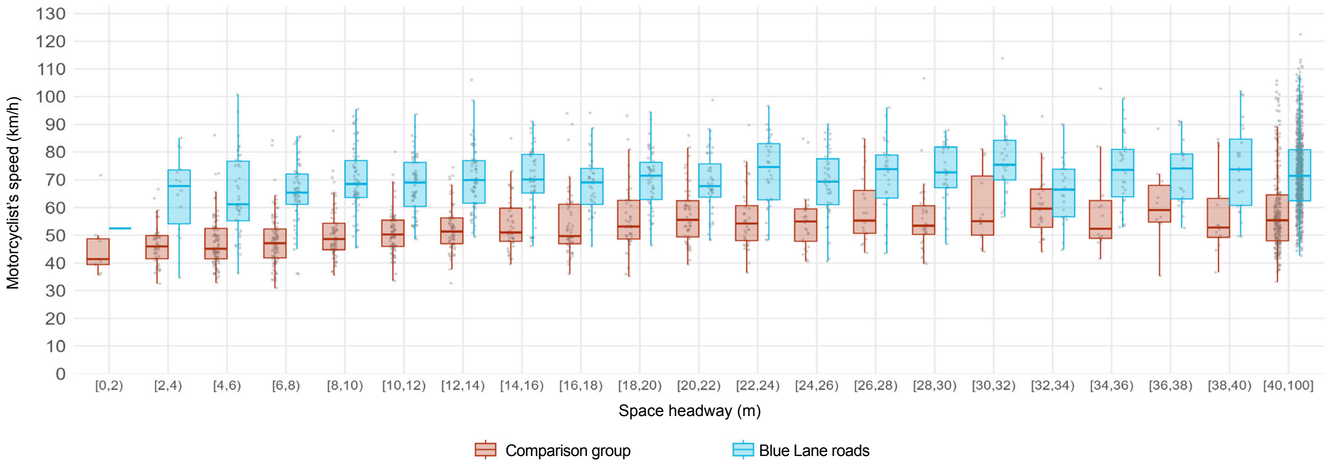

Figure 12: Motorcycle speed distribution by spatial range and away from traffic lights, for control roads and Blue Lane roads. Source: Consórcio USP-UFC-Cordial.

Potential risk mitigation measures

The Blue Lane yields mixed results when it comes to risk behaviors. Having a motorcycle-only lane appears to organize traffic flow and reduce side uncertainties. However, under free-flow conditions, it systematically increases speeds, raising the likelihood of crashes and increasing exposure to severe outcomes when conflicts occur.

Therefore, practical recommendations should focus on areas outside the influence of traffic lights:

1. Standardize Blue Lane entrances and exits
2. Reinforce speed limit signage
3. Target inspections to sections with a higher probability of speeding with a higher probability of speeding, also considering inspections for average speed

This data paves the way for a variety of additional metrics on risky behavior besides speed and space between vehicles: Lane-change frequency, time interval between vehicles and time-to--collision can be derived from the trajectories. These will be explored in future work to deepen the assessment of operational safety in different scenarios of Blue Lane usage.

5

Perception

Motorcyclists' accounts point to ambivalence

Interviewees mention a greater sense of safety, but also an impetus to take risks

Thematic analysis of motorcycle delivery drivers' interviews reveals an underlying tension: the Blue Lane offers a sense of safety and respect, but also fosters unsafe behaviors, such as speeding and risky maneuvers.

To identify these perceptions, the research established four axes: physical visibility, traffic behavior, sense of belonging and working conditions (Figure 13). Survey questions were linked to infrastructure features, road interaction dynamics and working environment conditions.

Respondents agree on the benefits of improved traffic flow predictability and the potential to reduce surprises when changing lanes. However, issues related to the continuity of signage remain.

Working conditions appear across the board as a factor that pushes the scheme to its limits, affecting driving patterns even when infrastructure improves legibility.

The four identified axes create a force system: in general, physical visibility and belonging tend to reduce uncertainty and conflict, while traffic behavior and work pressures can reintroduce risk through speeding, overtaking and poor decision-making under heavy traffic conditions.

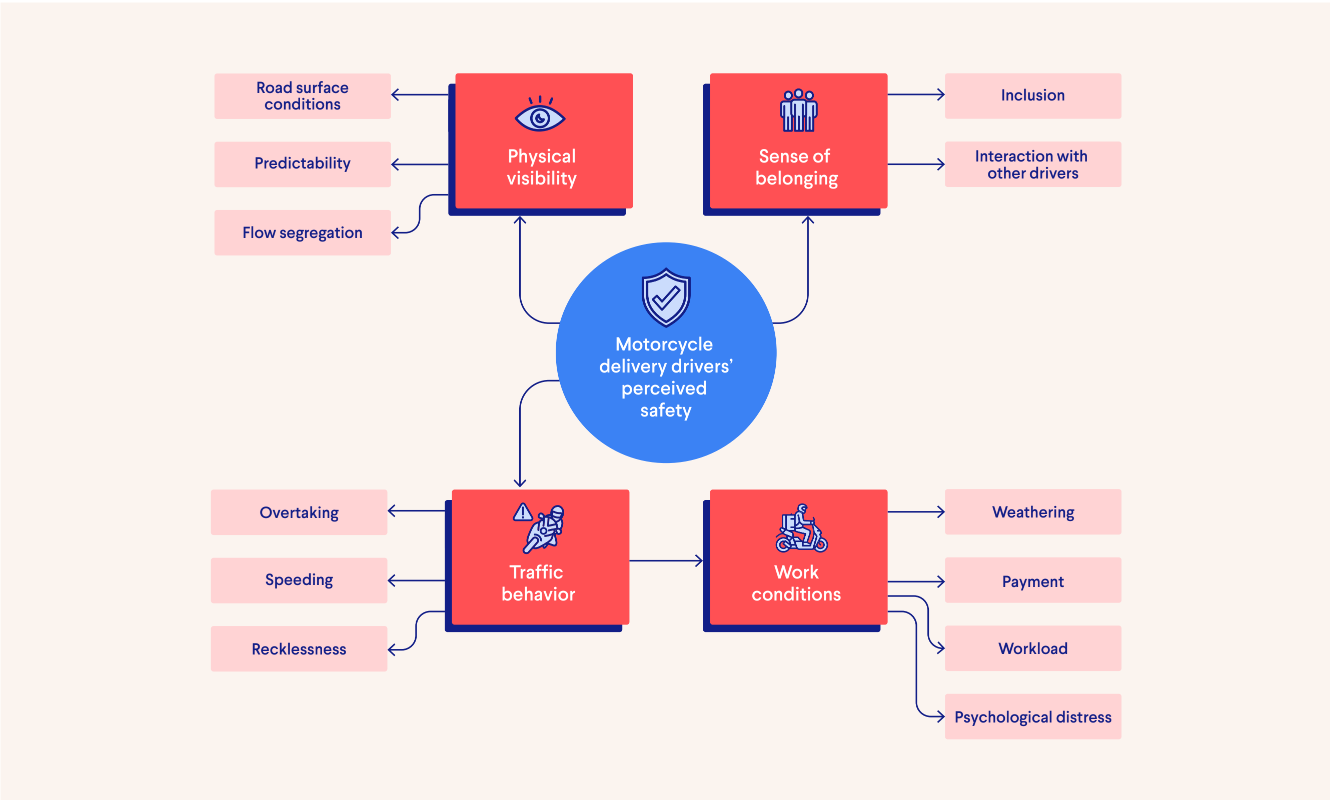

Figure 13: Diagram illustrating delivery motorcyclists' perception of safety. Source: Consórcio USP-UFC-Cordial.

Physical visibility

Most accounts emphasize how traffic flow became more organized and predictable. A fair number of respondents see the Blue Lane as something that “materializes” the corridor where motorcycles travel, making it easier for other road users to be aware of them. This appears to be associated with greater attention on the part of drivers, including a change in habits (checking the rearview mirror, signaling in advance), which tends to reduce interactions and uncertainties from motorcyclists’ point of view.

“[...] When changing [lanes], they [the driver] are already getting into the habit of looking in the rearview mirror, signaling... What used to be the problem? They would just pull out of nowhere, without signaling." (White male, 36 years old, Iguatemi Shopping Mall)

Other testimonials reinforce that signage removes the need to create an “imaginary” corridor, reducing risky maneuvers in high-density situations:

“Because it's signaled, so the driver on the other side can see it better. Also the space thing, because we don't have to try so hard to make a lane between the cars—an imaginary one, let's say.” (Mixed-race man, 22, Itaquera Shopping Mall).

Traffic behavior

Traffic behavior reveals a duality: in one sense, lanes are perceived as a means of reducing uncertainty; yet, there is a practical interpretation that they open a continuous, free path to travel faster, especially when pressed for time. One interviewee summarizes:

“We drive pretty fast. When you get on the [Blue] Lane, you can race along.” (Mixed-race male, 27, Eldorado Shopping Mall).

There are also mentions of overtaking within the corridor, quick changes out of the lane and immediate returns: strategies that suggest increased fluidity at the cost of greater exposure to collision with adjacent traffic. In addition, there is a recurring diagnosis of widespread recklessness, with expectations of greater enforcement as a containment mechanism:

“I believe recklessness is one of the biggest causes of accidents. [...] People don’t respect the rules.” (Mixed-race man, 41, Mogi Shopping Mall).

On another note, there are references to situational responses when a motorcycle proceeds at a slower speed: “When people hold back too much, we cut to the other side and get ahead of them. End of story.” (Black man, 37 years old, Hub Santa Cecília). These excerpts reinforce that the lane reconfigures, but does not eliminate, coordination dilemmas between users.

Sense of belonging

This topic touches on the symbolic and social dimensions of recognizing motorcycles as a legitimate part of traffic. Many interviewees say they feel more respected now that there's a designated space for them, which boosts their sense of belonging and reduces everyday conflicts.

“Because cars respect motorcycles more, right? In our lane... We're riding only in our lane; it brings more safety.” (Black woman, 34, Shopping Metrô Itaquera)

“It's because cars respect us more, you know? When they see the lanes, they respect us. When there's no lane, no one respects us.” (Mixed-race man, 27, Shopping Eldorado).

In contrast, when there are no lanes, some describe an environment of dispute and the need to improvise a corridor, with greater tension: “Other than that [the Blue Lane], they don’t respect us. You are forced to keep swerving, turning or honking [...].” (Black man, 47 years old, Itaquera Shopping Mall).

The statement “the lane is ours. The lane has to be ours” (Mixed-race man, 27 years old, Eldorado Shopping Mall) sums up this symbolic appropriation.

Working conditions

Working conditions act as a backdrop that influences risk decisions and safety perceptions. Respondents associate targets, deadlines and variable pay with the need to maintain high speeds and not waste time, which pushes them toward making riskier choices under certain circumstances. They also report physical and psychological exhaustion resulting from long hours, bad weather and sometimes hostile interactions at delivery points:

> "Because you never know what you're going to be carrying. [...] Psychologically, you have to deal with so much. You almost die, there's rain, sun, all of that. [...]" (Brown man, 32 years old, Santa Cecília Hub)
>
> "I leave home at 9:30 a.m. and arrive at 11:30 p.m." (White man, 22 years old, Eldorado Shopping Mall).

This contextual component, external to the infrastructure, seems to act as a vector for risk intensification, potentially canceling out the gains in predictability and legibility provided by the Blue Lane.

Potential risk mitigation measures

From the standpoint of motorcyclists' safety perceptions, the Blue Lane offers gains in visibility and belonging that favor coordination among users. However, it does not cover risk structural dimensions that appear to be associated with working conditions. In terms of public policy, the reports suggest three directions:

1. Maintain and improve physical legibility (continuity of signage and standardization of transitions/conversions)
2. Monitor and regulate behavior through enforcement and education tools, focusing on overtaking and speeding within the corridor
3. Coordinate labor policies and support for delivery workers to mitigate pressures that spill over into traffic risk

6

Conclusion

Blue Lanes are not a road safety measure

Rise in fatal crashes at intersections and motorcyclists' speed points to greater risk

This study's quantitative and qualitative results paint a clear picture. Analysis of traffic crash data using the PSM + DiD strategy, with geospatial refinement by intersections and block segments, identified, on average, an **increase in fatal crashes involving motorcyclists at intersections, with effects in the range of 100% to 120%**, and statistical significance in line with international literature. In block segments, the signals are heterogeneous and not significant.

In addition, looking at other types of crashes, such as non-fatal incidents or those not involving motorcyclists, **no statistically significant reductions in crashes associated with the Blue Lane's introduction were seen**, a finding that remains consistent with the results of Costa et al. (2025). Sensitivity tests by time horizon support the robustness of this finding at intersections.

Drone results show that when there is greater operational freedom (away from traffic lights and with a minimum distance of 20 meters between vehicles), **speed distributions shift to higher levels in the Blue Lane scenario**, with average motorcycle speeds rising from 58.3 km/h on control roads to 72.2 km/h on Blue Lane roads, an increase of 13.9 km/h. Likewise, the probability of speeding is significantly higher on Blue Lane roads, with 55.4% of motorcyclists riding above 60 km/h, compared to 17.1% on control roads.

Interviews with delivery motorcyclists help explain this behavior: **although the Blue Lane improves predictability, visibility and sense of belonging, it is perceived as a "free route", encouraging speeding and risky overtaking, especially under work pressure.**

In summary, the infrastructure seems to organize the flow, but it also increases speed levels when traffic is flowing more freely and roadblocks are cleared, a combination that can lead to more severe conflicts, particularly at intersections.

Considering this evidence, **the Blue Lane does not constitute a road safety policy.** The consistent identified effect is instead adverse: there is a rise in fatal crashes at intersections involving motorcyclists. It is, therefore, not recommended to regulate or expand the Blue Lane based on current conditions.

If implementation proceeds on an experimental basis, it should be gradual and subject to a before-and-after evaluation protocol, with a minimum six-month baseline, control routes defined by propensity score, estimated effects by difference-in-differences and crash identification by road structural element (midblock/intersection).

It would be advisable to study which intersection improvements could bring safety benefits. As this is a new type of signage, no clear evidence exists indicating that possible corrections and adjustments will affect safety enhancement.

Given this context, we suggest evaluating the standardization of approaches and transitions, continuity and legibility of signage and the use of materials with better grip. To discourage speeding in free-flowing sections, an integrated package is recommended that combines targeted handheld radar, average speed enforcement and surface texturing at critical approaches, in alignment with the Safe Systems approach.

As for this study's limitations and next steps, the observation period for some of the analyzed roads has been too short, which may reduce the accuracy of fine-grained data by gravity and location (structural element), making the results prone to fluctuation.

Furthermore, the data can only be generalized to the context of São Paulo. In a scenario in which the Blue Lane remains in operation and/or proceeds to expansion, we recommend expanding the sample size, standardizing before-and-after drone collections by corridor, strengthening Infosiga/DETRAN-SP quality routines with clear rules for repositioning by road structural element, and exploring complementary sources to monitor vehicle speeds and routes, such as telemetry or aggregated GPS records. We also suggest maintaining methodological triangulation based on qualitative and quantitative data, in addition to indicating p-values and confidence intervals for statistical tests.

In conclusion, the Blue Lane produces notable gains in visibility and belonging. However, given the conditions, no evidence exists of a reduction in crashes, and it may lead to increased speeds in scenarios with fewer traffic restrictions, with signs of worsening conditions for motorcyclists at intersections. Speed gains, even if moderate, raise both the probability and severity of crashes, reinforcing the need for active speed management as a central pillar of road safety.

There is no one-size-fits-all solution: cities that want to reduce crashes have a set of proven effective measures at their disposal, which include not only speed management aspects (reviewing speed limits, redesigning roads to prevent excessive speed, among others) and consistent monitoring, but also prioritizing active modes and public transportation, which can be implemented regardless of the Blue Lane.

At the same time, it is critical to consider the declining use of public transportation in recent years: reduced demand shifts travel to individual modes, increasing risk exposure and putting pressure on the road system. Therefore, it is advisable that any continued implementation of the policy be conditional on overall safety criteria. Interventions should ensure the existence of protected structures for other vulnerable users (pedestrians and cyclists), as well as including average and spot speed monitoring and data governance that can support causal assessments. Policies that restore public transport's appeal and prioritize active modes are also essential to structurally reduce exposure and risk in urban traffic.

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