

**CRITICAL POINT INDICATOR OF FATAL ACCIDENTS: A CONTRIBUTION TO
THE REDUCTION OF TRAFFIC DEATHS**

**INDICADOR DE PONTO CRÍTICO DE SINISTRO COM MORTE: UMA
CONTRIBUIÇÃO PARA A REDUÇÃO DE ÓBITOS NO TRÂNSITO**

**INDICADOR DE PUNTOS CRÍTICOS DE ACCIDENTES MORTALES: UNA
CONTRIBUCIÓN A LA REDUCCIÓN DE LAS MUERTES POR ACCIDENTES DE
TRÁFICO**

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ABSTRACT

Despite significant advances in road safety research, gaps remain in measuring and monitoring the factors that determine severe traffic crashes. This study proposes the Critical Point Indicator for Fatal Traffic Crashes (CPIF), a tool designed to identify and prioritize highway segments with the highest concentration of fatalities. More than 2.1 million crash records were analyzed from 2007 to 2024, involving 4.7 million people and resulting in 121,661 deaths on Brazilian federal highways. The research also compared trends across three groups of countries — the nine largest by area, nine South American nations, and 22 European countries — revealing an increase in fatalities since 2019 and conceptual divergences regarding the definition of “critical point” among national and international institutions. The results highlight distinct spatial and causal patterns that demand targeted engineering and policy responses. The CPIF is presented as a decision-support instrument to optimize public investments, guide localized interventions, and contribute to achieving the UN and Brazil’s PNATRANS goal of reducing road deaths by 50% by 2030.

Keywords: Road Safety. Crash Hotspots. Performance Indicators. Public Policies. Safe System Approach.

RESUMO

Apesar dos avanços em pesquisas sobre segurança viária, persistem lacunas na mensuração e no monitoramento dos fatores que determinam os sinistros graves. Este estudo propõe o Indicador de Ponto Crítico de Sinistro de Trânsito com Óbito (IPCO), instrumento destinado a identificar e priorizar segmentos rodoviários com maior concentração de mortes. Foram analisados 2,1 milhões de registros de sinistros ocorridos entre 2007 e 2024 em rodovias federais brasileiras, envolvendo 4,7 milhões de pessoas e resultando em 121.661 óbitos. O estudo também comparou tendências em três grupos de países — nove de maior extensão territorial, nove sul-americanos e 22 europeus — identificando aumento das fatalidades a partir de 2019 e divergências conceituais sobre “ponto crítico” entre instituições nacionais e internacionais. Os resultados evidenciam padrões espaciais e causais distintos que demandam abordagens específicas de engenharia e gestão pública. O IPCO é apresentado como ferramenta de apoio à decisão para otimizar

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investimentos, direcionar intervenções localizadas e contribuir para o alcance da meta da ONU e do PNATTRANS de reduzir em 50% as mortes no trânsito até 2030.

Palavras-chave: Segurança Viária. Pontos Críticos. Indicadores de Desempenho. Políticas Públicas. Sistemas Seguros.

RESUMEN

A pesar de los avances en las investigaciones sobre seguridad vial, aún existen vacíos en la medición y el monitoreo de los factores que determinan los siniestros graves. Este estudio propone el Indicador de Punto Crítico de Siniestro de Tráfico con Muerto (IPCO), una herramienta destinada a identificar y priorizar los tramos viales con mayor concentración de muertes. Se analizaron más de 2,1 millones de registros de siniestros ocurridos entre 2007 y 2024 en carreteras federales brasileñas, que involucraron a 4,7 millones de personas y resultaron en 121.661 fallecidos. El estudio también comparó las tendencias en tres grupos de países — nueve de mayor extensión territorial, nueve sudamericanos y 22 europeos — identificando un aumento de las fatalidades a partir de 2019 y divergencias conceptuales sobre el término “punto crítico” entre instituciones nacionales e internacionales. Los resultados evidencian patrones espaciales y causales diferenciados que exigen enfoques específicos de ingeniería y gestión pública. El IPCO se presenta como una herramienta de apoyo a la decisión para optimizar inversiones, orientar intervenciones localizadas y contribuir al cumplimiento del objetivo de la ONU y del PNATTRANS de reducir en un 50% las muertes en el tránsito hasta 2030.

Palabras clave: Seguridad Vial. Puntos Críticos. Indicadores de Desempeño. Políticas Públicas. Sistemas Seguros.

1 INTRODUCTION

Since the 1960s, the **World Health Organization (WHO)** has recognized traffic accidents as a global public health problem, as discussed in 1962 and later reaffirmed in **Resolution WHA27.58 (1974)**. In 2004, the *World Report on Road Traffic Injury Prevention* (WRI) consolidated evidence on the magnitude of the problem, leading the UN to institute **World Health Day dedicated to Road Safety**. Despite successive international initiatives, such as **Resolution No. 64/255 (2010)**, which inaugurated the *Decade of Action for Road Safety 2011–2020*, and **Resolution No. 74/299 (2020)**, which established a new target by 2030, the results are still insufficient. Road traffic accidents remain at unacceptable levels, with **1.19 million deaths and about 50 million injuries annually**, especially in developing countries.

In addition to the human impact, the **economic costs** are significant, ranging from **0.4% to 4.1% of GDP** in 31 countries analyzed (Wijnen & Stipdonk, 2017), which highlights the need for more targeted and sustainable interventions. Both in the resolutions and in subsequent global plans, the *Global Plan for the Decade of Action for Road Safety 2011–2020 and the Global Plan 2021–2030*, **safe road infrastructure** is recognized as an essential pillar, in line with the **Safe Systems approach**, which is based on the principle that human error is inevitable, but roads must be designed to absorb it without causing fatalities (UN, 2010; Wegman, 2017).

In view of this scenario, the present study proposes the creation of a **Traffic Accident Critical Point Indicator with Death (IPCO)** as a strategic tool to **prioritize road stretches with the highest concentration of deaths** and guide short and medium-term public policies. In the Brazilian context, this proposal supports the achievement of the goals of the **National Plan for the Reduction of Traffic Deaths and Injuries (PNATRANS)**, instituted by Law No. 13,614/2018, and contributes to the UN agenda of reducing traffic deaths by 50% by 2030.

The investigation was based on **open data on fatal accidents** from OECD countries, **South America, China, Russia and India**, and, in the Brazilian case, on records from the **Federal Highway Police (PRF)**, covering the period from **2007 to 2024**, totaling **2.1 million occurrences, 4.7 million people involved, 1.17 million minor injuries, 404 thousand serious injuries and 121,661 deaths**.

The article is structured in six parts: introduction; methodology; theoretical framework; empirical analysis of accidents on federal highways; proposal and rationale of the **IPCO**; and considerations, with implications and recommendations for public policies

2 METHODOLOGY

The research developed has a quantitative, descriptive and comparative character, aimed at identifying patterns of concentration of accidents with deaths on Brazilian federal highways and the proposition of a Critical Point Indicator of Traffic Accidents with Death (IPCO). The study adopts a reactive approach, based on empirical data already recorded, according to the classification of *Fletcher et al.* (2020), privileging the analysis of claims that actually occurred as a reference for the planning of corrective interventions.

2.1 DATA SOURCES

Public and official databases were used. At the international level, the bases of the Organization for Economic Cooperation and Development (OECD) were used, as well as national organizations of South American countries, China, Russia and India, allowing comparisons between three groups:

- a) the nine countries with the largest territorial extension;
- b) the nine countries of South America;
- c) twenty-two European countries.

For the purposes of this comparison of Brazil with the three groups of countries, national data published by the Mortality Information System (SIM), linked to the Ministry of Health, which consolidates deaths in all routes: federal, state, and municipal routes, were used.

For the purposes of the study on the IPCO, which was limited to records of accidents on federal highways in Brazil, open data from the National Department of Transport Infrastructure (DNIT) and the Federal Highway Police (PRF) were used. The PRF database of records of traffic accidents that occurred on federal highways between 2007 and 2024, totaled 2,122,326 occurrences, with 4.7 million people involved, 1.17 million minor injuries, 404 thousand serious injuries and 121,661 deaths at the event site.

2.2 SAMPLING AND SELECTION CRITERIA

For analysis purposes, the federal highways were segmented into 1-kilometer stretches, totaling 74,344 km evaluated. A critical point of accident with death was considered to be any segment of 1 km with the occurrence of at least one accident with death in the period studied. Of the 74,344 km, 36,494 km (49%) had at least one death. The final sample

was composed of the 100 segments with the highest concentration of deaths, defined based on the following criteria:

- d) registration of deaths in at least five years, of the last ten in the time series;
- e) exclusion of stretches that, in the last three years (2022–2024), did not record deaths, to avoid segments that have undergone recent interventions.

The selection guaranteed a confidence level of 95% and a margin of error of less than 2%, giving representativeness to the sample.

2.3 ANALYSIS PROCEDURES

The data were organized and tabulated in electronic spreadsheets, and analyses of **frequency, spatial distribution and temporal recurrence were performed**. For each critical segment, the following were identified:

- a) the number of claims;
- b) the total number of deaths;
- c) the type of claim;
- d) the predominant cause;
- e) the characteristics of the road (single, double or multiple lane).

Based on these variables, a matrix of fatality concentration was elaborated, which supported the identification of critical segments, in descending order, that is, from the one with the highest number of deaths to the one with the lowest per 1km segment.

2.4 LIMITATIONS AND ETHICAL CONSIDERATIONS

The study is based exclusively on **public secondary data**, without personal identification, in compliance with the ethical principles of confidentiality and anonymization. The main limitations stem from possible inconsistencies in registration between years and the absence of complementary variables, such as traffic volume and local socioeconomic characteristics. Even so, the method adopted is **replicable and scalable**, and can be applied by public managers at different administrative levels.

2.5 INTERNATIONAL COMPARATIVE PROCEDURES

For the purposes of global contextualization, a comparative analysis of traffic mortality trends was conducted in three groups of countries:

- a) the nine countries with the largest territorial extension (including Brazil, China, India, the United States, Russia, Australia, Canada, Argentina and Kazakhstan);
- b) nine South American countries with consolidated data with the OECD and national authorities; and
- c) twenty-two European countries, selected for the availability of consistent data, between 2012 and 2022.

The information was obtained from OECD databases, the World Bank and official national sources, standardized to allow the comparison of annual variations and identification of trends.

3 THEORETICAL FRAMEWORK

There are several terms or expressions in the literature to identify the concentration of traffic accidents, such as hotspot, darkspot, critical point, critical segment, critical stretch or red area. All these definitions have in common a high concentration of claims occurring in the same location. Locations with a high concentration of claims can be described as high risk, hazardous, hot spots, or black spots. It is in these places that better performance is required from drivers, and that, therefore, engineering interventions can reduce performance requirements, increasing the safety margin between driver performance and the demand for road performance, specifically in that location, resulting in a lower probability of an accident (Verkeersonveiligheid, 2003).

Normally, the definition of critical point has a single objective, which is to explain the reason for this concentration of events in the same point, region, highway segment, etc. According to Anderson (2009), the identification of critical points of traffic accidents is important for the appropriate policies of allocation of public resources in the search for improved safety. The analysis of critical points focuses on road segments or intersections and suggests dependence on the place where they occur, and may have one or several causes in common.

Erdogan et al. (2008), when studying 7,634 occurrences of accidents between 1996 and 2006, using the *GeoFigureic Information System* (GIS) platform, identified the concentration of accidents at crossroads of access to small cities, sharp curves and areas that became slippery during the rainy season. Among the causes are disobedience to signals, traffic light advances, improper overtaking, etcetera. For Shariff et al. (2018), they define *hotspot* as the place with the highest probability of an accident in relation to the surrounding

areas; in a study on the **Petani–Bukit Lanjan Expressway (Malaysia, 2011–2024)**, a hotspot *was considered* to be the stretch with **200 or more incidents up to 1,000 meters** in length.

In the Brazilian context, the concept of critical point has been addressed by several agencies since the 1970s and 1980s. The National Traffic Department (DENATRAN, 1982), currently the National Traffic Secretariat (SENATRAN) used the term black spots, classifying them according to different indices for accidents without victim, with victim and with death. The National Department of Highways (DNER), precursor of the DNIT, implemented safety programs financed by the World Bank between 1976 and 1994, including methodologies for identifying critical segments (IPR, 2004).

One of the most used methodologies to identify a critical segment is the Standard Severity Unit (UPS), used by DNIT and several Roads and Roads Departments (DERs). The methodology applies a severity index, where the accident without a victim has an index of 1 (one), with a victim of 5 (five) and with a death of 13 (thirteen).

The Federal Highway Police (PRF), on the other hand, has developed its own methodologies over the last decades. In 2010, the institution considered a critical stretch a 10 km segment with a high concentration of occurrences, applying weights of 1, 5 and 25 for accidents without victims, with victims and with deaths, respectively, according to studies by the Institute of Applied Economic Research (IPEA). In 2022, the PRF updated the model, aligning it with Resolution No. 798/2020 of the National Traffic Council (CONTRAN). This resolution, of a normative nature, is the only one of national scope on the subject, as it requires technical studies for the installation of speed meters based on the identification of critical sections of accidents. Article 6 of the rule defines a critical stretch as one that has a high number of accidents with deaths and injuries, covering a radius of up to 2,500 meters in rural areas and 500 meters in urban areas (CONTRAN, 2020). However, by leaving the quantification to the discretion of the local authority, the normative text results in heterogeneous standards among the bodies of the National Traffic System (SNT).

In addition to the regulatory framework, the National Plan for the Reduction of Traffic Deaths and Injuries (PNATRANS), instituted by Law No. 13,614/2018, which adopts six structuring pillars, stands out. Pillar 2 – Safe Roads provides for Action A2018, aimed at establishing procedures for identifying and treating critical points of claims, with three main products:

- a) Preparation of a technical manual for the identification and treatment of

these points;

- b) Training of technicians, designers and managers; and
- c) National program for the treatment of critical points (DENATRAN, 2018).

These initiatives reinforce the importance of territorial analysis and standardization of indicators to guide preventive interventions. However, there is a lack of a unified synthetic model that integrates the severity, temporal recurrence and spatial density of accidents, a gap that the present study seeks to fill through the proposal of the Critical Point Indicator for Traffic Accidents with Death (IPCO).

4 EMPIRICAL ANALYSIS OF ACCIDENTS ON FEDERAL HIGHWAYS

To identify the importance of identifying and treating critical points in reducing deaths in traffic accidents, the present investigation used an open database, especially that of accidents that occurred on federal highways, between 2007 and 2024, supplied by the PRF and the database of the National Road System (SNV). The objective is to identify the spatial distribution of deaths, understand the behavior of the types and causes of accidents and highlight the importance of identifying and treating critical points as an instrument to reduce traffic deaths.

4.1 DATABASE AND SCOPE OF ANALYSIS

2,122,326 accidents registered on federal highways were analyzed between 2007 and 2024, involving approximately 4.7 million people and resulting in 121,661 deaths on the spot. The base comprises a universe of 74,344 km of highways under federal jurisdiction, of which 7,530 km (10.1%) are double or multiple lanes and 66,814 km (89.9%) are single lanes. During the period of analysis, there were deaths recorded in 36,494 km, corresponding to 49% of the total length of the federal network. In all, there are about 1.7 million highways in Brazil, according to the National Transport Confederation (Cristaldo, 2017), with federal highways being the most strategic because they connect large cities, economic centers, states, geofunctional regions and border countries. It is on federal highways, which are responsible for registering accidents and the PRF, that just under 20% of deaths recorded in traffic accidents in Brazil are concentrated

In the set analyzed, 33,330 deaths (27%) occurred on roads with two or more lanes per direction and 88,331 (73%) on single-lane roads. This difference reflects infrastructure limitations and the role of duplication in mitigating the severity of claims.

4.2 IDENTIFICATION OF CRITICAL SEGMENTS

For the purposes of this investigation, a critical point is defined as the 1 km long segment with a record of at least one fatal accident in the analyzed period. The 74,344 segments were ranked by the sum of deaths, and the 100 most critical were selected, according to the following criteria:

- statistical reliability with a confidence level of 95% and a margin of error of less than 2%;
- exclusion of stretches that did not record deaths between 2022 and 2024, to avoid distortions due to recent interventions;
- prioritization of segments with temporal persistence, occurrence of deaths in at least five of the last ten years.

These segments correspond to the areas with the highest concentration of fatalities and, therefore, the greatest potential for corrective intervention.

4.3 SPATIAL DISTRIBUTION OF FATALITIES

Table 1 shows the concentration of deaths by extension of federal highways, considering the 10,000 km most critical. It is observed that, by concentrating efforts on only 2,000 km (2.6%) of the federal network, it would be possible to impact approximately 23% of deaths on federal highways, which represents approximately 4.4% of national traffic deaths (base 2023).

Table 1

Deaths in accidents on federal highways in the 10,000 most critical km (2007–2024)

Extensão (km)	Mortes entre 2007 e 2024 (acumulada)	Percentual (%) do total de Óbitos entre 2007 e 2024 (acumulada)	Percentual da extensão de rodovias federais* (%) (acumulada)	Média anual de mortos (acumulada)
100km	2928	2,41%	0,13%	163
500km	10287	8,46%	0,67%	572
1000km	17014	13,98%	1,35%	945
2000km	27571	22,66%	2,69%	1532
5000km	49712	40,86%	6,73%	2762
10000km	73661	60,55%	13,45%	4092

Source: author's organization (2025), based on data open to PRF and DNIT.

4.4 TYPES AND CAUSES OF CLAIMS

Table 2 summarizes the average types and causes of accidents in the 100 km most critical, revealing significant diversity. On average, each kilometer had nine types and ten different causes of accidents. This demonstrates that the determining factor is not the nature

of the event, but the place where it occurs, which reinforces the relevance of the proposed territorial approach.

Table 2

Average types and causes of accidents in the 100 km most critical on federal highways (2007–2024)

UF	AL	BA	CE	DF	ES	GO	MG	MT	PE	PI	PR	RJ	RS	SC	SP	Total
Segmentos de 1km analisados por UF (2)	1	1	7	1	4	5	11	1	7	3	5	21	2	4	27	100
Quantidade de sinistros registrados (3)	13	15	179	21	87	131	264	33	174	67	111	490	45	92	749	2471
Média de sinistros por segmento de 1km (4)	13	15	25	21	22	26	24	33	24	22	22	23	22	23	27	24
Média de tipos de sinistros por km (5)	8	7	9	10	10	9	9	9	9	11	9	9	8	11	9	9
Média de causas de sinistros por km (6)	8	7	10	9	10	11	9	14	11	9	10	10	10	11	12	10
Total Geral de mortes (7)	20	22	189	21	11	141	339	37	194	68	116	529	46	98	807	2727

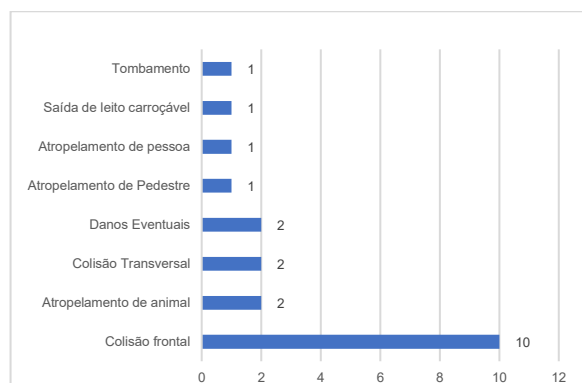
Source: author's organization (2025), based on open PRF data.

Figures 1 and 2 exemplify this diversity in the BR-316 segment, Km 255 (Alagoas-AL), with a predominance of frontal collisions, typical of single lanes. In Figures 3 and 4, referring to BR-381, Km 525 (Minas Gerais-MG), the deadliest point in the country, with 72 deaths in 18 years, there is a predominance of speeding (39 deaths), associated with accidents such as overturning, overturning and lane departure, which add up to 60 deaths.

In Figures 5 and 6, relating to BR-381 (São Paulo/SP, Km-83, 84, 85, 86 and 88), 153 deaths are identified, of which 98 were due to being run over, evidencing the high risk in densely populated urban areas. In this case, the incompatible speed stood out among the 16 causes identified.

Figure 1

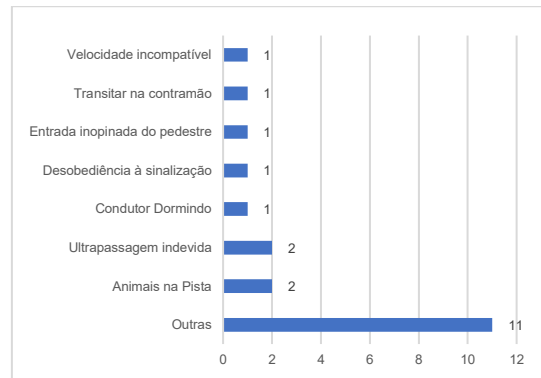
Deaths by type of accident on BR-316, Km-255, Alagoas/AL



Source: author's organization (2025), based on Abertis data from PRF.

Figure 2

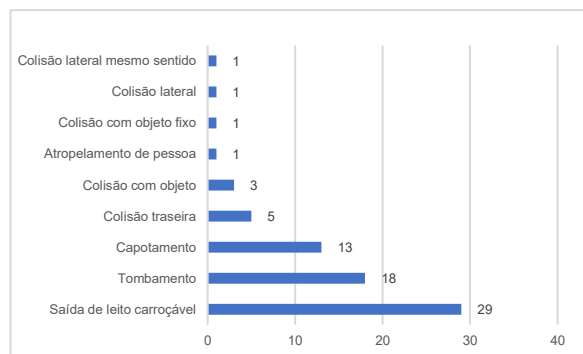
Deaths due to an accident on BR-316, Km-255, Alagoas/AL



Source: author's organization (2025), based on Abertis data from PRF.

Figure 3

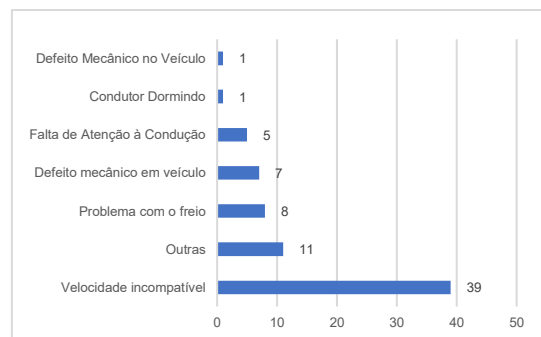
Deaths by type of accident on BR-381, Km-525, Minas Gerais/MG



Source: author's organization (2025), based on Abertis data from PRF.

Figure 4

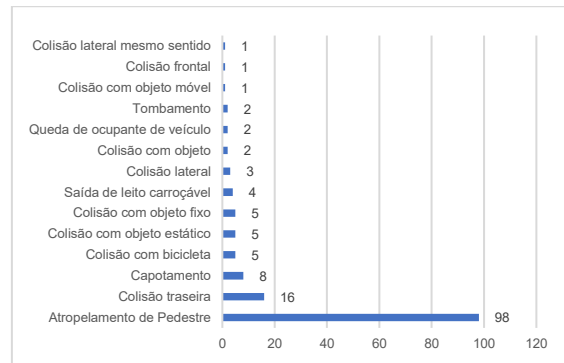
Deaths due to an accident on BR-381, Km-525, Minas Gerais/MG



Source: author's organization (2025), based on Abertis data from PRF.

Figure 5

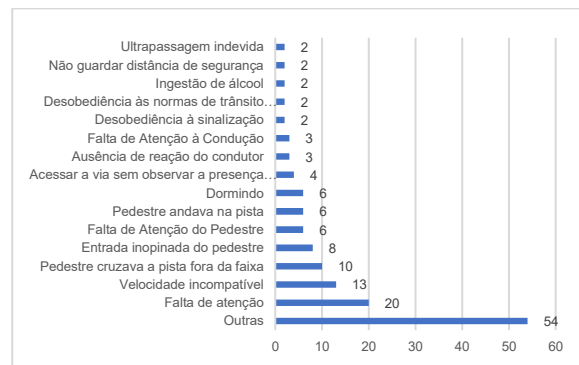
Deaths by type of accident on BR-381, Kms (83, 84, 85, 86 and 88), São Paulo/SP



Source: author's organization (2025), based on Abertis data from PRF.

Figure 6

Deaths due to accidents on BR-381, Kms (83, 84, 85, 86 and 88), São Paulo/SP



Source: author's organization (2025), based on Abertis data from PRF.

The importance of this analysis lies precisely in the identification of the predominant types and causes at each critical point, making it possible to guide specific measures of engineering, inspection or traffic education according to local characteristics.

In the segment of BR-316, Km 255 (Alagoas), for example, the records of frontal collisions indicate the need for stricter actions to combat improper overtaking, with intensification of face-to-face inspection and use of electronic control technologies. In addition, it is recommended to adapt the infrastructure, with the implementation of third lanes to reduce exposure to risk during overtaking maneuvers.

In urban segments of BR-381 (São Paulo, Kms 83, 84, 85, 86 and 88), where pedestrians are run over, priority measures include the construction of footbridges, the installation or expansion of speed bumps and the realization of educational campaigns with the local community.

These examples demonstrate how the IPCO can work as an alert and prioritization instrument, allowing public managers to quickly identify the most critical locations and adopt targeted and cost-effective interventions, aligned with the Safe Systems approach.

4.5 RELATIONSHIP BETWEEN CRITICAL POINTS OF CLAIMS AND FATALITIES

The comparative analysis between the 100 critical points of claims with deaths and the 100 critical points of general claims (Table 3) shows that the two sets do not overlap entirely. While in the 100 points of general claims there is, on average, one death for every 76 claims, in the 100 critical points of claims with death there is more than one death per claim.

Illustrative example: the BR-101/RJ point, Km 322 recorded 2,852 accidents and 14 deaths, occupying only the 678th position among the points of highest lethality, that is, it is the 678th most lethal kilometer, of the more than 73 thousand federal highways, while the BR-381/MG point, Km 525, with 72 deaths, occupies the 552nd position when the criterion is the total number of accidents.

Table 3

Comparison between the 100 most critical points of general claims and death claims (2007–2024)

Pontos críticos	Quantidade de pontos críticos	Quantidade de sinistros	Quantidade de sinistros com mortes	Quantidade de mortes	Comparativos
Pontos críticos de sinistros com mortes	100 (os 100 pontos críticos com mais mortes entre 2007 e 2024)	2.471	2.471	2.726	- A cada 1(um) sinistro, ocorre 1,1 óbitos. - Em 76 sinistros ocorre em média, mais de 83 óbitos.
Pontos críticos de sinistros (incluindo os sinistros com mortes)	100 (os 100 pontos críticos com mais sinistros entre 2007 e 2024)	140.704	1.753	1.839	- A cada 76 sinistros ocorre um óbito.

Source: author, 2025.

These results converge with the conclusions of Pianezzer et al. (2020), who identified five groups of claims, three of which were high-risk (with a higher concentration of deaths) and two low-risk (predominance of victimless claims). Thus, the places with the highest lethality are, in fact, the most critical for road safety policies.

4.6 DISCUSSION OF THE RESULTS

The findings demonstrate that the distribution of fatalities in the Brazilian highway system is highly concentrated, and that prioritizing interventions in a few critical kilometers

can have a disproportionately positive impact on the reduction of deaths. In addition, it was observed that the diversity of causes and types of claims at the same point reinforces the need for interdisciplinary analyses, which combine engineering, inspection and education, precisely the tripod of road safety, established in §10 of article 144 of the Federal Constitution of Brazil.

These results also corroborate the international literature on *hotspots* (VERKEERSONVEILIGHEID, 2003; ERDOGAN et al., 2008; SHARIFF et al., 2018), which emphasizes the role of physical space as a central variable for risk mitigation.

5 PROPOSAL AND RATIONALE FOR THE CRITICAL POINT INDICATOR FOR TRAFFIC ACCIDENTS WITH DEATH (IPCO)

5.1 THE SECURE SYSTEMS APPROACH

The Safe Systems approach, initiated in Sweden in the late 1990s, according to the *World Resources Institute* (WRI, 2020) and Ferrier et al. (2017), gave rise to the Vision Zero program, later adopted in several countries. The central principle is that human errors are inevitable, and therefore roads must be able to absorb them, reducing the severity of claims.

According to Fletcher et al. (2020), insurance systems prioritize the prevention of serious claims through proactive and reactive actions. The reactive approach, based on the identification and treatment of hotspots based on historical data, remains the most widely used worldwide. The proactive approach, on the other hand, seeks to anticipate risks before the occurrence of claims, through safety audits and urban planning.

In the present study, we opted for the reactive approach, as it is understood that Brazil still faces gaps in the identification and treatment of critical points, and that this approach offers greater economic and operational viability, in addition to allowing rapid responses based on empirical evidence.

5.2 INSTITUTIONAL DIAGNOSIS AND GOVERNANCE CHALLENGES

International experience shows that the treatment of critical points is an essential component of road safety programs. The Court of Auditors of the European Union (ECA-EU, 2024) audited 13 infrastructure projects financed between 2018 and 2023, totaling €242 million in investments in Spain, Slovakia, Romania and Lithuania, and identified conceptual divergences on "tipping point" between member states. This methodological heterogeneity reinforces the need for standardization of criticality indicators, as shown in Table 4.

Table 4

Concepts of critical point in countries audited by the ECA-EUFor: author's organization (2025), based on data from the European Court of Auditors (ECA-EU, 2024)

Estado Membro	Estratégia/Definição
Lituânia	Pontos críticos são segmentos com quatro ou mais sinistros registrados no ano anterior; Os pontos críticos devem ser identificados para o público que circula no local, com recomendações aos condutores.
Espanha	Ponto crítico (definição 01) – é o grau de periculosidade, considerando a quantidade de sinistros ocorridos anteriormente, extensão do segmento e volume de tráfego por faixa de horário. Ponto crítico (definição 02) – Número absoluto de sinistros.
Romênia	Ponto crítico é um segmento que tem uma taxa de sinistro superior à média registrada. Embora esteja revogada, até que se apresenta uma nova metodologia.
Eslováquia	Ponto crítico é um segmento de 1km com cinco ou mais sinistros registrados no ano anterior.

A similar situation occurs in Brazil. The Federal Court of Accounts (TCU), through Ruling No. 275/2016, pointed out that only 7 of the 337 audited construction contracts dealt with the correction of critical segments, revealing low institutional prioritization. The Office of the Comptroller General of the Union (CGU, 2022) reinforced this finding by identifying weaknesses in the indicators of the National Highway Improvement Plan (PNMR), especially in the management of critical segments, which received only 1.5% of the R\$ 14.6 billion invested between 2020 and 2021.

All three audit programs have in common the analysis of the importance of investments in critical points, although they have highlighted some difficulties, including low investment, the lack of a unified concept in the case of the EU, and non-standardized indicators in the Brazilian context.

5.3 EMPIRICAL EVIDENCE OF SUCCESS

Latin American experiences reinforce the effectiveness of the Secure Systems approach. In Buenos Aires, a 33% reduction in deaths was observed between 2015 and 2019, after the adoption of integrated engineering and inspection measures (Santos et al., 2020). In Brazil, Avenida M'Boi Mirim, in São Paulo, recorded reductions of 80% in deaths and 72.7% in injuries between 2016 and 2017, after integrated engineering, inspection, and education interventions (São Paulo Road Plan, 2019). These results show that the identification of priority stretches is an effective strategy and rapid implementation.

5.4 INTERNATIONAL COMPARATIVE ANALYSIS OF DEATHS DUE TO TRAFFIC ACCIDENTS (2012–2022)

5.4.1 Nine countries with the largest land area

Table 5

Deaths in traffic accidents in the 9 (nine) largest countries in area

Countries	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2012-2022
Argentina	5074	5209	5279	0	5550	5611	5493	4898	3513	4481	4567	2.7%	1.3%	100%	-	1.1%	2.1%	10.8%	28.3%	27.6%	1.9%	-10%
Australia	1299	1185	1151	1205	1295	1223	1135	1187	1097	1116	1188	8.8%	2.9%	4.7%	7.5%	5.6%	7.2%	4.6%	7.6%	1.7%	6.5%	8.5%
Brazil	44812	42266	43780	38651	37345	35375	32655	31945	32716	33813	33894	5.7%	3.6%	11.7%	3.4%	5.3%	7.7%	2.2%	2.4%	3.4%	0.2%	-24%
Kazakhstan	2279	2323	2401	2549	2390	2086	2096	2094	1997	0	0	1.9%	3.4%	6.2%	6.2%	12.7%	0.5%	0.1%	4.6%	-	-	-
Canada	2075	1951	1841	1887	1900	1861	1939	1756	1746	1768	1934	6.0%	5.6%	2.5%	0.7%	2.1%	4.2%	9.4%	0.6%	1.3%	9.4%	6.8%
China	59997	58539	58523	58022	63093	63772	63194	62763	61703	62218	60676	2.4%	0.0%	0.9%	8.7%	1.1%	0.9%	0.7%	1.7%	0.8%	2.5%	1.1%
USA	33782	32893	32744	35484	37806	37473	36835	36355	39007	42939	42795	2.6%	0.5%	8.4%	6.5%	0.9%	1.7%	1.3%	7.3%	10.1%	0.3%	26.7%
India	138258	137572	139671	146133	150785	147913	157593	158984	138383	153972	168491	0.5%	1.5%	4.6%	3.2%	1.9%	6.5%	0.9%	13.0%	11.3%	9.4%	21.9%
Russia	27991	27025	26958	23114	20308	19088	18214	16981	16152	14874	14172	3.5%	0.2%	14.3%	12%	6.0%	4.6%	6.8%	4.9%	7.9%	4.7%	50% OFF
Total	315567	308963	312348	307045	320472	314402	319154	316963	296314	315181	327717	2.1%	1.1%	1.7%	4.4%	1.9%	1.5%	0.7%	6.5%	6.4%	4.0%	20% OFF

Source: author's organization (2025), based on OECD and country data.

- Two periods are distinguished: (i) 2012–2019, with a slowdown in the fall and, in some cases, an increase (China, USA, and India with more deaths in 2019 vs. 2012); (ii) 2020–2022, with a resumption of deaths in 2021 compared to 2020 in eight countries (exception: Russia).
- Between 2022 and 2021, only three countries reduced deaths: Russia, China, and the USA; six increased — Brazil had the smallest increase (+0.2%), while Canada recorded the highest increase (+9.4%).
- In the full 2012–2022 cycle, Russia showed a continuous reduction in all ten periods; Brazil, China and the USA reduced in six periods; Australia and Canada in five; Argentina in four; India and Kazakhstan in three.
- Comparing 2012 vs. 2022, five countries reduced (especially Russia, Brazil, Argentina, Australia, and Canada) and three increased (USA, India, and China).

5.4.2 Nine South American countries

Table 6 shows higher volatility and worse relative performance:

Table 6

Deaths in traffic accidents in 9 (nine) South American countries

Countries	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022
Argentina	5074	5209	5279	0	5550	5611	5493	4898	3513	4481	4567	3%	1%	-100%	-	1%	-2%	-11%	-28%	28%	2%
Brazil	44812	42266	43780	38651	37345	35375	32655	31945	32716	33813	33894	-6%	4%	-12%	-3%	-5%	-8%	-2%	3%	0.2%	
Bolivia						1226	1140	1201	1022	1325	1467	-	-	-	-	-	-7%	5%	-15%	30%	11%
Chile	1979	2103	2116	2136	2178	1925	1955	1973	1794	2052	2137	6%	1%	1%	2%	-12%	2%	1%	-9%	14%	4%
Colombia	5320	5757	6118	6406	6936	6505	6629	6577	5447	7238	8030	8%	6%	5%	8%	-6%	2%	-1%	-17%	33%	11%
Ecuador	2242	2277	2322	2138	1967	2153	2151	2180	1591	2131	2202	2%	2%	-8%	-8%	9%	0%	1%	-27%	34%	3%
Paraguay	1165	1191	1118	1157	1202	1198	1162	1292	1146	1396	1026	2%	-6%	3%	4%	0%	-3%	11%	-11%	22%	-27%
Peru	3209	3110	2798	2965	2696	2826	3244	3110	2159	3032	3328	-3%	-10%	6%	-9%	5%	15%	-4%	-31%	40%	10%
Uruguay	510	567	538	506	446	470	528	422	391	434	431	11%	-5%	-6%	-12%	5%	12%	-20%	-7%	11%	-1%
Total	64311	62480	64069	53959	58320	57289	54957	53598	49779	55902	57082	-3%	3%	-16%	8%	-2%	-4%	-2%	-7%	12%	2%

Source: author's organization (2025), based on OECD and country data.

- In 2021 vs. 2020, all nine countries increased deaths (first year after the pandemic was declared).
- In 2022 vs. 2021, seven countries increased; Uruguay and Paraguay differed with a reduction. Brazil recorded the lowest increase in the group (+0.2%); Bolivia and Colombia (+11%) and Peru (+10%) had the highest.
- In the cut of the ten periods, Brazil and Uruguay reduced in six; Peru in five; Argentina and Paraguay in four; Ecuador and Colombia in three; Bolivia and Chile in two (Bolivia with analysis hampered by data gaps).

5.4.3 Twenty-two European countries (and Brazil as a reference)

Table 7 indicates relatively better performance, but with the same post-2019 inflection:

Table 7

Deaths in traffic accidents in 22 (twenty-two) countries in Europe and Brazil

Countries	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022
Austria	531	455	430	479	432	414	409	416	344	362	370	-14,31 %	-5,49%	11,40%	-9,81%	-4,17%	-1,21%	1,71%	17,31 %	5,2%	2,21%
Belgium	827	764	745	762	670	609	604	644	499	516	540	-7,62%	-2,49%	2,28%	12,07 %	-9,10%	-0,82%	6,62%	22,52 %	3,4%	4,65%
Brazil	44812	42266	43780	38651	37345	35375	32655	31945	32716	33813	33894	-5,68%	3,58%	-11,72%	-3,38%	-5,28%	-7,69%	-2,17%	2,41%	3,3%	0,24%
Czech Republic	742	654	688	734	611	577	658	617	517	531	527	11,86 %	5,20%	6,69%	16,76 %	-5,56%	14,04 %	-6,23%	16,21 %	2,7%	-0,75%
Denmark	167	191	182	178	211	175	171	199	163	130	154	14,37 %	-4,71%	-2,20%	18,54 %	17,06 %	-2,29%	16,37 %	18,09 %	20,2 %	18,46 %
Finland	255	258	229	270	258	238	239	211	223	225	189	1,18%	11,24 %	17,90%	-4,44%	-7,75%	0,42%	-11,7%	5,69%	0,9%	-16,0%
France	3653	3268	3384	3461	3477	3448	3248	3244	2541	2944	3267	10,54 %	3,55%	2,28%	0,46%	-0,83%	-5,80%	-0,12%	21,67 %	15,9 %	10,97 %

Germany	3600	3339	3377	3459	3206	3180	3275	3046	2719	2562	2788	-7,25%	1,14%	2,43%	-7,31%	-0,81%	2,99%	-6,99%	-	10,74%	-5,8%	8,82%
Greece	988	879	795	793	824	731	700	688	584	624	641	11,03%	-9,56%	-0,25%	3,91%	11,29%	-4,24%	-1,71%	-	15,12%	6,8%	2,72%
Hungary	605	591	626	644	607	625	633	602	460	544	535	-2,31%	5,92%	2,88%	-5,75%	2,97%	1,28%	-4,90%	-	23,59%	18,3%	-1,65%
Iceland	9	15	4	16	18	16	18	6	8	9	9	66,67%	73,33%	300,00%	12,50%	11,11%	12,50%	-66,7%	-	33,33%	12,5%	0,00%
Ireland	163	188	192	162	182	154	134	140	146	136	155	15,34%	2,13%	-	12,35%	-	-	4,48%	-	4,29%	-6,8%	13,97%
Italy	3753	3401	3381	3428	3283	3378	3334	3173	2395	2875	3159	-9,38%	-0,59%	1,39%	-4,23%	2,89%	-1,30%	-4,83%	-	24,52%	20,1%	9,88%
Lithuania	301	258	267	239	188	191	173	186	175	148	120	14,29%	3,49%	-	21,34%	1,60%	-9,42%	7,51%	-	15,4%	-	-18,9%
Luxembourg	34	45	35	36	32	25	36	22	26	24	36	32,35%	22,22%	2,86%	11,11%	21,88%	44,00%	-38,9%	-	18,18%	-7,7%	50,00%
Holland	650	570	570	621	629	613	678	661	610	582	745	12,31%	0,00%	8,95%	1,29%	-2,54%	10,60%	-2,51%	-	-7,72%	-4,6%	28,01%
Norway	145	187	147	117	135	106	108	108	93	80	116	28,97%	21,39%	20,41%	15,38%	21,48%	1,89%	0,00%	-	13,89%	14,0%	45,00%
Poland	3571	3357	3202	2938	3026	2831	2862	2909	2491	2245	1896	-5,99%	-4,62%	-8,24%	3,00%	-6,44%	1,10%	1,64%	-	14,37%	-9,9%	-15,5%
Portugal	718	637	638	593	563	602	700	688	536	561	618	11,28%	0,16%	-7,05%	-5,06%	6,93%	16,28%	-1,71%	-	22,09%	4,7%	10,16%
Spain	1903	1680	1688	1689	1810	1830	1806	1755	1370	1533	1759	11,72%	0,48%	0,06%	7,16%	1,10%	-1,31%	-2,82%	-	21,94%	11,9%	14,74%
Sweden	285	260	270	259	270	252	324	221	204	210	227	-8,77%	3,85%	-4,07%	4,25%	-6,67%	28,57%	-31,8%	-	-7,69%	2,9%	8,1%
Switzerland	339	269	243	253	216	230	233	187	227	200	241	20,65%	-9,67%	4,12%	14,62%	6,48%	1,30%	-19,7%	-	21,4%	11,9%	20,5%
Total	6805 1	6353 2	6487 3	5978 2	5799 3	5560 0	5299 8	5166 8	4904 7	5085 4	5198 6	-6,64%	2,11%	-7,85%	-2,99%	-4,13%	-4,68%	-2,51%	-	-5,07%	3,7%	2,23%

Source: author's organization (2025), based on OECD and country data.

- 2021 vs. 2020: 12 of the 22 countries increased deaths.
- 2022 vs. 2021: 16 of the 22 countries increased deaths; 9 were discharged in both intervals.
- Brazil was included only for comparative reference, reinforcing the trajectory analogous to the European one, but with a slightly more intense recovery trend in 2021–2022.

5.4.4 Comparative synthesis and implications

- Common pattern: deceleration of reductions at the end of the decade and resumption from 2019 (post-pandemic, economic recovery, change in mobility patterns).

- Order of performance: Europe (best performer) > largest countries (average performer) > South America (performance below the other two groups of countries).
- Brazil: evolution similar to the global pattern, with the lowest increase between 2021–2022 (+0.2%) among the countries that grew in Table 5; Still, trend reversal since 2019.

The convergence of these results — resumption of deaths in different geographies and income levels — reinforces the need for standardized criticality metrics, capable of locating stretches where lethality is concentrated and prioritizing engineering, inspection, and education interventions. It is in this context that the Critical Point of Death Claim (IPCO) Indicator is inserted, presented below (Section 5.5), which measures the lethal density per kilometer adjusted for temporal recidivism, allowing operational ranking and alignment with the UN/PNATRANS goals.

5.5 THEORETICAL FOUNDATION OF THE IPCO

The formulation of the Critical Point Indicator for Traffic Accidents with Death (IPCO) is based on three theoretical axes:

a) the need for standardized measurement to enable results-based management. According to Holló and Eksler (2010): *"you cannot manage what you cannot measure"*. Kevin, quoted by Holló and Eksler, previously stated that *"if you can't measure it, you can't improve it"*;

b) Wegman's (2017) emphasis on *the go fishing where the fish are strategy*, that is, concentrating efforts where there is greater density of data and occurrences;

c) the recognition by Mononen and Leviäkangas (2016) that performance indicators are essential instruments to reduce knowledge gaps and measure institutional advances.

The literature on Road Safety Performance Indicators (RSPI), according to Hakkert, Gitelman and Vis (2007) and Yannis et al. (2013), distinguishes behavioral indicators (speed, use of belts, alcohol) from structural indicators (infrastructure and management). The IPCO falls into this second category, seeking to quantify the spatial and temporal risk of fatalities.

5.6 CONSTRUCTION AND APPLICABILITY OF THE IPCO

The conception of the IPCO considered essential variables:

- Segment length (L), expressed in kilometers;
- Number of fatalities (ΣS_m);

- Temporal frequency (R_t) — number of years with death records;

The proposed formula is:

$$IPCO = \frac{(\sum S_m \times R_t)}{L} \quad (1)$$

The indicator is dimensionless and always shows values greater than zero.

Considering the empirical distribution of fatalities, the following criticality classification is suggested:

- $IPCO \geq X$ severe critical $\rightarrow$ (those that concentrate 50% of deaths);
- $Z \leq IPCO < X$ moderate critical $\rightarrow$ (those that concentrate between 20% and 49% of deaths);
- $IPCO < Z \rightarrow$ mild critical (those that concentrate below 20% of deaths).
- It is suggested that the R_t remain between 5 and 10 years, as very long periods may not portray the current situation.

The X and Z values will depend on the period of analysis (R_t) and the extension (L). For rural areas, the length of the segment (L) is usually larger than urban areas. In urban areas, critical intersections can be identified, where the extension (L) does not exceed 200 meters (0.2 km).

Regarding the temporal frequency (R_t), it is important to note that historical series should be 5 (five) years, accepting up to three years, to avoid the use of very short periods, and not to generate errors from a statistical phenomenon known as regression to the mean (DER/SP, 2023).

For the purpose of defining priority points for intervention, the segments that have $IPCO \geq X$ should receive immediate attention (engineering works, inspection and educational measures), as they can positively impact the goal proposed by the UN and PNATTRANS.

The simplicity of the calculation favors its replication by state and municipal agencies, as it depends only on open data from RENAEST and its own databases, supplied with claims records. This characteristic responds to the warning of Tesic et al. (2018) that excessively complex indicators are not very applicable in countries with incomplete or divergent databases.

5.7 CONCEPTUAL SYNTHESIS AND INTEGRATION WITH PUBLIC POLICIES

The absence of a standardized indicator for critical points was confirmed in the analysis of 12 road safety and urban mobility plans of Brazilian capitals and state agencies (Table 5). In practically all of them, the reactive approach prevails, and the UPS methodology is the one with the greatest coverage among the documents analyzed.

Table 5

Mobility or road safety plans that address critical points (capitals and public agencies)

Órgão	Metodologia e Estratégias realizadas em relação a pontos críticos
Departamento de Infraestrutura Nacional de Transportes – DNIT	1) O DNIT emprega a metodologia Unidade Padrão de Severidade – UPS, com pesos diferentes para sinistros sem vítima, com vítima e com óbito, segundo Pena, C. Mori, F. Otto, G. e Tani, V. (2009) ; 2) A metodologia UPS é a mais comumente utilizada pelos diversos órgãos, que tem no DNIT a referência em estudos de infraestrutura viária; 3) A Resolução No 10 de 2023 do DNIT, estabeleceu procedimentos para identificação e procedimentos para eliminação de pontos críticos.
Polícia Rodoviária Federal – PRF	1) A PRF instituiu o indicador de ponto crítico em 2022, com seguinte descrição: o indicador “Ponto Crítico” no âmbito da PRF, se refere a uma extensão de rodovia federal que não ultrapasse 500m em vias de zonas urbanas e 2.500m em vias de zona rural, e que possua alta concentração ¹ de sinistros graves ² , e que possua fator de infraestrutura viária contribuinte para a ocorrência dos sinistros; 2) A série histórica de análise deve contemplar três anos, e considerar apenas os sinistros graves, aqueles com feridos graves ou mortos.
Departamento de Estradas e Rodagem – DER/SP	1) O Manual de Segurança Viária do DER/SP, adota a UPS para identificar a severidade dos segmentos. De uma forma geral utiliza a metodologia adotada pelo DNIT, onde os sinistros sem vítima valem 1 ponto, com vítima 5 pontos e com morto, 13 pontos.
Município de São Paulo/SP	1) O município adota um Plano de Segurança Viária do município de São Paulo de 2019; 2) Intervenções em pontos críticos de travessia de pedestre é uma das sete estratégias para reduzir mortes no trânsito; 3) A metodologia utilizada para identificar segmentos críticos de mortes de pedestres leva em consideração a Unidade Padrão de Severidade-UPS; 4) A UPS = DM + 4VF + 6PF + 13FAT, onde DM se refere a sinistros com danos materiais, VF a sinistros com vítimas feridas, PF a sinistros com pedestre feridos e FAT se refere a sinistro com vítima fatal; 5) O ranking de severidade é adotado dividindo-se a UPS/extensão da via; 6) Já a UPS de uma forma geral utiliza a metodologia adotada pelo DNIT, onde os sinistros sem vítima vale 1 ponto, com vítima 5 pontos e com morto, 13 pontos.
CET-RIO/RJ	1) O município do Rio de Janeiro adota um agrupamento de sinistros em um raio de 25m, como ponto crítico; 2) É levado em consideração além da quantidade de sinistros, a quantidade de pessoas feridas, mortas, envolvimento de pedestres e ciclistas; 3) A Unidade Padrão de Severidade - UPS é a metodologia utilizada pela CET-RIO para ranquear pontos críticos.
Empresa de Transportes e Trânsito de Belo Horizonte/MG	1) A Política de Segurança no Trânsito de Belo Horizonte (2016), apresenta uma análise das vias com maior frequência de sinistros, tanto considerando dados absolutos como sinistros por quilômetro
Município de Fortaleza/CE	1) Informações extraídas do relatório de segurança viária de Fortaleza em 2019; O município de fortaleza também utiliza a Unidade Padrão de Severidade para ranquear os pontos críticos; A Autarquia Municipal de Trânsito – AMT realiza levantamentos periódicos sobre pontos críticos.
Secretaria de Mobilidade de Recife/PE	1) Informações coletadas na Minuta do Programa de Segurança Viária para Recife, 2024-2030. Observar-se-á que a única metodologia identificada no plano foi a GDCl; Ação 132 - Desenvolver o monitoramento sistemático com caracterização do segurança viária a partir da metodologia para definição de pontos e trechos críticos, considerando a severidade dos sinistros e, quando possível, o nível de exposição; Ação 413 - Criar procedimento para Inspeção e tratamento sistemático de segurança viária em trechos e pontos críticos baseado em dados; A416 - Definir e implementar procedimentos para avaliar os projetos de mobilidade a partir de métricas (antes e depois), usando como referência a metodologia da Global <i>Designing Cities Initiative</i> (GDCl).
Secretaria Municipal de Mobilidade Urbana – STTU, Natal/RN	1) As informações foram extraídas no Plano Diretor de Mobilidade de Natal de 2022; 2) O plano realiza um diagnóstico com várias análises quantitativas e qualitativas, apresenta diretrizes de educação para o no trânsito e elenca a necessidade de elaborar um Plano de Segurança Viária (Implantação de um Plano de Segurança Viária, que esteja alinhado à abordagem de Sistemas Seguros e à Agenda 2030 da ONU, sobretudo com a ODS 11 (Cidades e Comunidades Sustentáveis); 3) Apresenta diversos indicadores, bem elaborados, entre os quais o Indicador 2: Percentual de interseções semaforizadas ou satisfatoriamente tratadas com <i>traffic calming</i> para garantir a travessia segura de pedestres (em relação ao total de interseções das vias arteriais). Objetivo: Melhorar constantemente o grau de segurança para pedestres nas interseções das vias arteriais e pontos críticos na ocorrência de sinistros.
Secretaria Municipal de Mobilidade Urbana – SMMU Empresa Pública de Transporte e Circulação – EPTC (Porto Alegre/RS)	1) O plano para década prevê no pilar engenharia a identificação e tratamento de pontos críticos de sinistros, ou seja, aqueles locais concentradores dessas ocorrências; 2) Os pontos críticos são definidos em um ano, com previsão de adoção das medidas corretivas no ano seguinte; 3) Os pontos críticos foram segmentados, levando-se em consideração o tipo de veículo envolvido e de sinistro.
Prefeitura municipal de Florianópolis/SC.	1) O Plano de Mobilidade Urbano de Florianópolis (2016) menciona em poucas partes do documento a redução de sinistros, mas não trata na identificação e tratamento de pontos críticos; 2) EM 2021, o plano passou por uma revisão, muito embora não foi possível acessar por problemas de download da página. Na revisão foi adotado o termo Plano de Mobilidade Urbana Sustentável – PLAMUS.
Secretaria de Mobilidade – SEMOB (Distrito Federal)	1) Foi consultado o Plano de Mobilidade Ativa - PMA do Distrito Federal de 2020, onde se verifica um esforço para identificação de pontos críticos de sinistros envolvendo pedestres e direcionamento de fiscalização
Prefeitura Municipal de Campo Grande/MS.	1) Campo Grande, capital do Mato Grosso, no Plano Diretor de Mobilidade Urbana (2024), caderno 14, estabelece a necessidade de desenvolvimento de um programa específico para identificação e tratamentos de pontos críticos, com ações de engenharia, reforço ou adequação da fiscalização eletrônica e com agentes de trânsito; 2) Apesar do plano dispor de uma tabela com indicadores propostos, não figura qualquer um que se assemelhe ao que se propõe no presente artigo.
Prefeitura Municipal de Manaus/AM.	1) O Plano de Mobilidade Urbana de Manaus de 2015, menciona discretamente a necessidade de realizar verificações constantes nos locais de maior periculosidade, sem contanto mencionar como identificar esses locais (metodologia utilizada).
Secretaria Municipal de Segurança e Mobilidade Urbana de Palmas/TO	1) O Plano de Mobilidade de Palmas/TO, “Mobilize-se”, lançado em 2024, possui alguns cadernos (produtos) entre os quais um de indicadores, não constando, porém, um indicador de ponto crítico ou algo nesse sentido; 2) O produto 6 do plano (Diagnóstico da infraestrutura e da segurança viária), aponta análise reativa com base no histórico de sinistros e feridos, destacando a necessidade de tratar essas localidades.

Source: author (2025).

The IPCO proposes to fill this gap by offering a uniform criticality metric that can be integrated into PNATRANS and Road Safety and Mobility Plans of states and municipalities. In this way, the indicator is consolidated as a strategic tool for public management, allowing the planning of prioritized interventions.

6 CONSIDERATIONS

Even fifteen years after the first United Nations (UN) resolution establishing the Decade of Action for Road Safety 2011–2020, the goal of reducing traffic deaths by 50% has not yet been achieved. The analysis of three groups of countries, those with the largest territorial extension, the South American and the European, revealed a similar behavior: a slowdown in the reduction of deaths at the end of the last decade and a resumption of growth from 2019 onwards. This sample covers approximately 60% of the world's population, giving global representativeness to the results. Brazil has a similar trajectory, with a continuous increase since 2019. Despite this, among the countries analyzed, it had the second lowest growth percentage (+0.2%) between 2021 and 2022, behind only Iceland, a country with the smallest demographic and vehicular scale.

The main plans analyzed, Global Plans 2011–2020 and 2021–2030 (UN), PNATRANS (SENATRAN, 2024) and the European Road Safety Plan, converge on the improvement of infrastructure and the adoption of the Safe Systems approach. According to Fletcher et al. (2020) and the *World Resources Institute* (WRI, 2020), this approach seeks to eliminate serious claims, recognizing that human errors are inevitable and that roads must be designed to absorb them without causing fatalities.

In Brazil, the analysis of 15 mobility and road safety plans revealed that almost all of them mention the need to identify and treat critical points. However, there is still a lack of uniformity regarding the definition criteria, the historical series used and the radius of coverage of the stretches (which varied between 25 m and 2,500 m). Although PNATRANS mentions the term *critical point* in its strategic actions, and Contran Resolution No. 798/2020 establishes distance parameters, there is still no standardized criticality methodology or indicator, resulting in significant methodological differences between the federal, state, and municipal spheres, resulting in losses in the evaluation of the critical point treatment policy. For example, it is not possible to know the measures adopted with the respective costs, and the results obtained later after implementation.

This gap is reinforced by the control agencies, which warn of the need to prioritize investments in places with a higher concentration of claims. The Federal Court of Accounts (TCU) and the Office of the Comptroller General of the Union (CGU) highlighted, in recent reports, that only 1.5% of the resources allocated to the maintenance of federal highways (2020–2021) were applied to the treatment of critical segments. Similarly, the Court of Auditors of the European Union (TCE-EU, 2024) pointed out divergent concepts of critical points between countries, recommended methodological standardization and expansion of resources for the correction of high-risk stretches.

Based on the analysis of 2,122,326 accidents that occurred on Brazilian federal highways between 2007 and 2024, involving 4.7 million people, 1.17 million minor injuries, 404 thousand serious injuries, and 121,661 deaths, a sample was separated with 100 points with the most death records in the last 18 years, each 1 km long, totaling 2,471 accidents and 2,726 deaths. On average, each point presented nine types and ten different causes of accidents, showing that the common factor is not the type of event, but the location, which confirms the conclusions of Anderson (2009) and Erdogan et al. (2008) about the territorial relevance in the concentration of fatalities. In summary, the research showed:

- a) absence of a standardized national indicator for critical point;
- b) significant spatial concentration of fatal claims within a few kilometers;
- c) institutional fragility in budget prioritization and in the integration of road safety plans.

In view of this diagnosis, the article proposed the Critical Point Indicator for Traffic Accidents with Death (IPCO) as an instrument of public management and decision support, integrating severity, temporal recurrence and spatial density. The IPCO represents a contribution to road safety and seeks to fill the gaps identified in current policies and programs, contributing to the fulfillment of the UN and PNATTRANS goal of reducing traffic deaths by 50% by 2030.

The investigation did not address, however, correlations between critical points and socioeconomic, demographic or vehicle typology factors, which constitutes a limitation and, at the same time, an opportunity for future research. Complementary studies may associate the IPCO with indicators of exposure, logistics cost and territorial vulnerability, expanding its application in integrated transport planning and road safety.

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