Road Safety and its Effect on the Accident Rate in Santiago De Cali (2005 To March 2023)

Dainer Orlando Cruz Chate*

Transit Services Program Consortium - PST Consortium, Colombia.

*Corresponding Author
Dainer Orlando Cruz Chate, Transit Services Program Consortium - PST Consortium, Colombia.

Citation: Chate, D. O. C. (2024). Road Safety and its Effect on the Accident Rate in Santiago De Cali (2005 To March 2023). I*nt J Nanotechnol Nanomed, 9*(1), 01-07.

Abstract

Objective
Examines the impact between road prevention and accidents (According to article 2 of the National Traffic Code Law 769 of 2002, a traffic accident is defined as: a generally involuntary event, generated by at least one moving vehicle, which causes damage to people and property involved in it and also affects the normal circulation of vehicles that move along the road or roads included in the place or within the area of influence of the event) in Cali, specifically, analyzing the influence of sanctions for violations of traffic regulations on the occurrence of road accidents with victims.

Methods
The effects produced by the sanctions for infractions to traffic regulations in drivers, men and women, taking into account their ages, on their road accident rate where they were victims when driving on the roads of Santiago de Cali were analyzed. The effect generated by lifeguard cameras (SAST - Automatic, semi-automatic systems and other technological means for the detection of infringements, regulated by Law 1843 of July 14, 2017) on road accidents was also analyzed.

Results
The number of summonses imputed to the driver affects the number of accidents with an approximate increase of 2.07%. Young drivers increase their risk of being a victim of a road accident by 470.68%, while older drivers reduce their risk by almost 100%. Male drivers are 0.9% more likely to be victims of road accidents than women. Drivers penalized through lifeguard cameras represent an effect towards the decrease of 1.07% of being involved as a victim of a road accident.

Conclusions
The road prevention actions carried out by the Special District of Santiago de Cali, through the imposition of subpoenas for violation of traffic signals are related to the number of road accidents in which drivers are implicated as victims, especially those sanctions originating from life-saving cameras (SAST mechanisms). Such a relationship has been generating a positive impact in the reduction of road events, as well as in the risks of drivers being injured or killed when avoiding good conduct. Drivers between the ages of 20 and 45 are the most prone to road risks with injury or death and, furthermore, more than half of them were involved in road accidents without having registered any preventive sanction.

Keywords: Road Safety, Accident, Sast Mechanism, Automotive Diagnostic Center, World Health Organization (WHO).

1. Introduction

Road safety turns out to be a topic of great importance in all cities of the world, since traffic accidents represent one of the main causes of preventable injuries and deaths. According to the Report on the global situation of road safety issued by the World Health Organization (WHO), every year, more than 1.2 million people die as a result of traffic accidents and no less than another 50 Millions suffer injuries. More than 84% of deaths occur in low- and middle-income countries [1, 2]. According to the National Road Safety Observatory, more than 7,000 people lost their lives in traffic accidents during 2021, the highest number reported in the last 10 years [3]. According to the Cali Mobility Secretariat, during 2022 the rate of deaths from traffic accidents in Cali was 13.6 per 100,000 inhabitants, slightly below the national average of 15.6 per 100,000 inhabitants and, so far in the year 2023, motorcyclists, pedestrians and cyclists continue to be the main victims of traffic

accidents in the city [4]. In Santiago de Cali, road accidents continue to be a constant concern due to the high number of accidents and victims that are registered on its roads, especially when more than 780,258 vehicles circulate through its streets (Figure obtained from the RUNT as of July 2022), In Santiago de Cali, the accident means that there are the same number of drivers mobilizing, which is equivalent to a third of the Cali population. It should be noted that the decision not to involve drivers who were involved in road accidents where only damage to vehicles occurred and no victims were reported, is based on Law 2251 of July 14, 2022, article 143 Material Damage, in where the damages caused by road accidents are transferred to the Civil Process and, therefore, should not be dealt with by the Traffic authorities Road traffic dentality continues to be a constant concern due to the high number of accidents and victims that occur on its roads, especially, when more than 780,258 vehicles circulate through its streets. From there, it was decided to focus the study on those accidents where victims are injured or killed, because it is an epidemiological issue of public health. and that can still be attended by the transit authorities [5]. In this study, it was proposed to examine the relationship between road prevention and the accident rate in the city, specifically, analyzing the influence of sanctions for violations of traffic regulations, especially those imputed by life-saving cameras, in the occurrence of road accidents. With victims during the period 2005 to March 2023. The relationship between the number of road accidents in which drivers (men and women) are involved as victims, the incidence of their age and the number of subpoenas imputed as sanctions, especially those sanctioned through SAST mechanisms, was evaluated.

2. Method
2.1. Source of Information
The Secretariat of Mobility of Santiago de Cali, has a large amount of information related to the records of traffic accidents and the records of subpoenas that are imposed on the alleged offenders of traffic regulations, from the year 2000 to the date of continuous and permanent way. Through the Inter-Administrative Contract (CI) signed between the Mayor's Office of Cali and the Valle Automotive Diagnostic Center (CDAV), the latter is in charge of the records of the Police Reports for Traffic Accidents (IPAT- Regulated by Resolution 0011268 of December 6, 2012) and traffic violations. The Transit Services Program Consortium (PST), as a strategic ally of CDAV, provides all the technical and technological infrastructure to comply with the commitment established in the CI. The PST, as sub-responsible for the records of the actions carried out by the transit agents on the road, records each of the IPATs and Comparendos on a daily basis. Based on this primary source, this study of drivers was carried out where the causal relationship of preventive measures on their generated effect on accidents with victims since 2005 was analyzed. The data that support the findings of this study are available from Valle Automotive Diagnostic Center - Transit Services Program Consortium but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Cali Mobility Secretariat.

2.2. Population
The population object of the study were the drivers of vehicles that were involved in traffic accidents as victims (according to what was recorded in the IPAT) and, in turn, who reported or not reporting traffic violations (according to what was reported) registered in the IPAT).

2.3. Application of the Statistical Model
The Poisson Regression Model (MRP) was applied to the data under study [6- 12]. Given the characteristics of the study and the embedded variables, the application of the MRP was taken as the ideal reference (it is a type of generalized linear model in which the response variable has a Poisson distribution) as it is the most appropriate in studies of variables of count (Cameron and Trivedi, 1998; Winkelman, 2000). It is a model that is especially applicable to model non-negative integer count data (number of times a certain random phenomenon occurs).
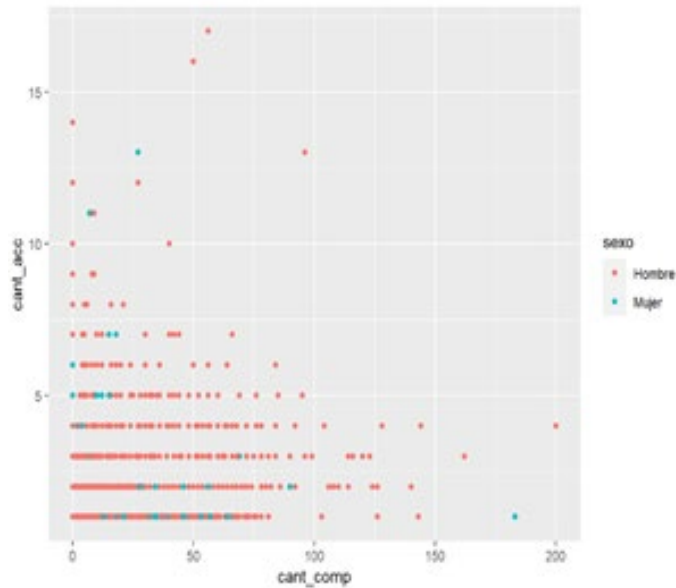
2.4. Analysis
To evaluate the causality or incidence of preventive measures on the materialization of the risk of road accidents, a univariate analysis was carried out, which reviewed the behavior patterns that allowed the construction and application of a Poisson regression statistical model (MRP), which was initially estimated without taking life-saving cameras into account, a second model was calculated including them, and a third model was estimated taking into account the youth and aging of drivers. Coefficients with a p value less than 0.05 were considered significant and those with a p value less than 0.1 were considered significant. The model with the lowest value for the Akaike criterion (AIC) was considered the best model.

3. Results
The results of the number of accidents in which the drivers (men and women) were involved compared to the number of defendants are presented in Figure 1. It can be said that the number of subpoenas imposed compared to the number of road accidents in which drivers are involved, seems to present an inverse relationship.

The results regarding the number of accidents with respect to the number of defendants and age are presented in Figure 2. Note that in the representation of each one of the points, the highest concentration of those with blue and green color tones, and the mesh is located in the zone of greatest volume in the variables represented in each one of the axes, this is, between the ages of 20 to 40 years.

Source: self made.

Figure 1: Number of driver accidents vs Number of defendants bystanders (2005 to May 2023).
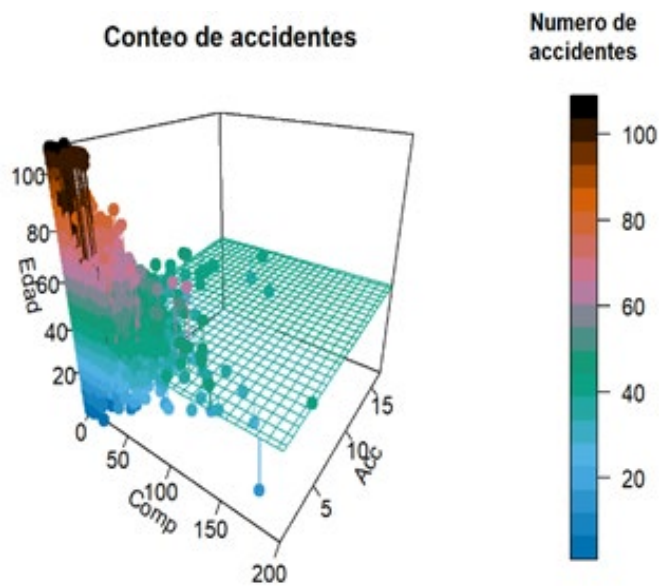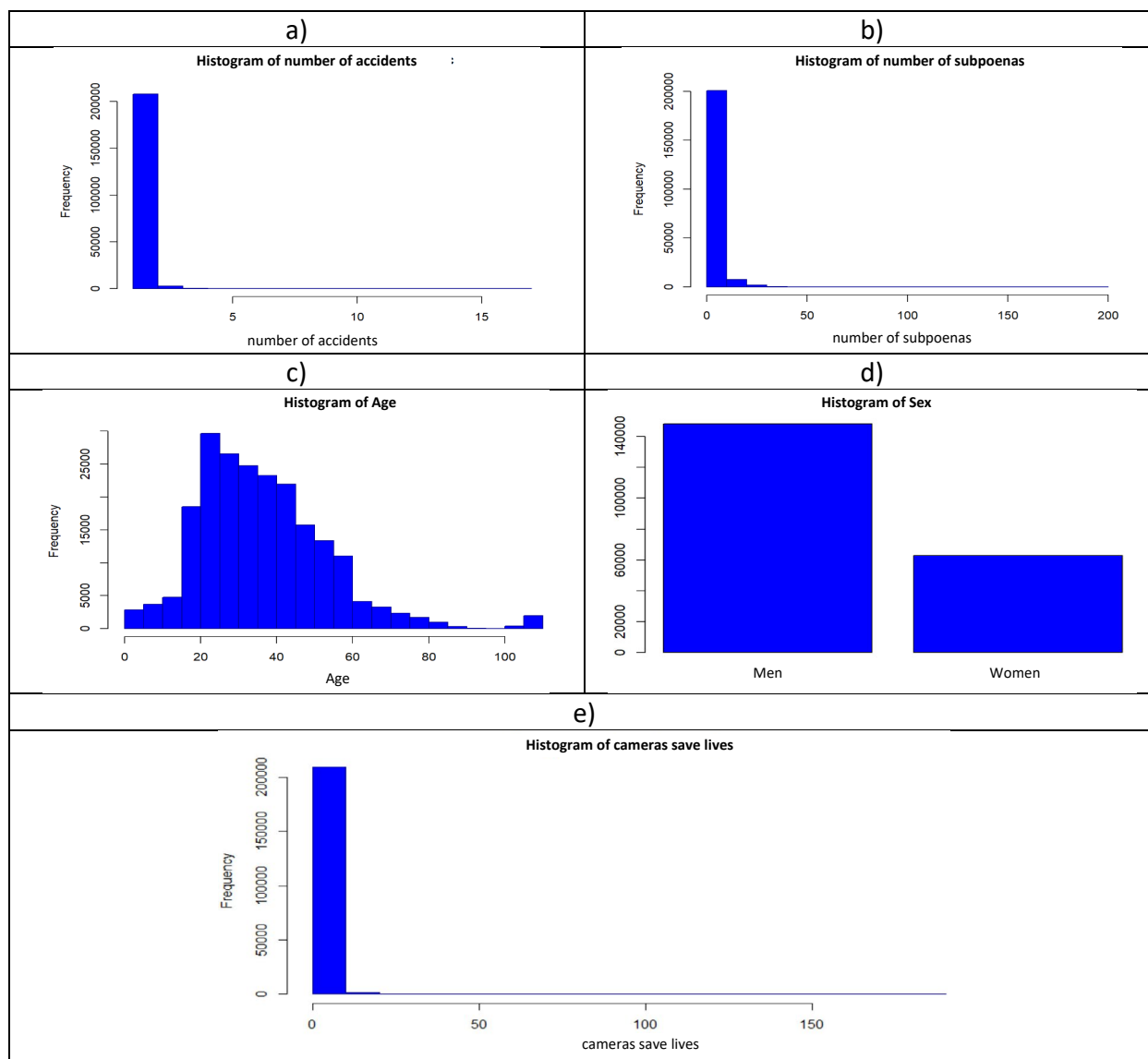

Source: self made.

Figure 2: Number of Driver Accidents Vs Number of Defendants and Age (2005 to May 2023).

3.1. Univariate Analysis

In figure 3, each of the variables involved is presented, representing the individual behavior patterns of: a) the number of road accidents with victims, b) the number of tickets imposed on drivers, c) the age of the drivers, d) Sex and e) the number of subpoenas imposed through SAST mechanisms.

Source: self made.

Figure 3: Graphic Representation of Each of the Variables Included in the Analysis.

The number of victims of traffic accidents in figure 3 a) shows a high frequency of drivers involved in an accident, when its range goes from 1 to 17. The Number of subordinates charged in figure 3 b) shows a high concentration of drivers without subsidiaries imputed and its range oscillates between 0 and 200. The majority of drivers immersed as victims of traffic accidents are between the ages of 15 and 45, figure 3 c). As presented in graph 3 d), there is an imbalance between men (more likely to be victims of road accidents) and women (less likely to be victims of road accidents). The Number of subpoenas charged in figure 3 e), since they represent a differential part of the total number of subpoenas, it presents a high concentration of drivers without imputation of subpoenas and its range oscillates between 0 and 183.

3.2. Mrp Analysis

Table 1 shows the results obtained for the coefficients obtained by the adjustment through the MRP with the response variable number of road accidents with injuries and the independent variables. In all the models it is observed that the coefficients of the variables age and Sex are significant at 0.01. For this study, Age and Sex were included in the modeling, as they are considered contributing factors in explaining their effects on driver accident rates. The ratio between the residuals and the degrees of freedom in all models was greater than 0.05, indicating that the data is not scattered. MRP 2 was selected for the adjustment of the data due to its lower dispersion and lower AIC value.

Variables Explicativas	MRP Inicial			MRP 1			MRP 2		
	Coeficiente	Error estándar	Valor p	Coeficiente	Error estándar	Valor p	Coeficiente	Error estándar	Valor p
intercept	0.0659058	0.0052177	2e-16 ***	0.0601627	0.0052343	2e-16 ***	0.068960490	2.659e-03	2e-16 ***
Number of Appearances	0.0171438	0.0002653	2e-16 ***	0.0209335	0.0003474	2e-16 ***	0.020650197	3.497e-04	2e-16 ***
Age	0.0002211	0.0001215	0.068719 .	0.0002305	0.0001216	0.0579 .	1.741651604	9.699e-01	0.0726 .
Age^2	NA	NA	NA	NA	NA	NA	-10.337789243	9.922e-01	2e-16 ***
SexWoman	-0.0168132	0.0045919	0.000251 ***	-0.0089943	0.0046214	0.0516 .	-0.009008744	4.622e-03	0.0513 .
Sast	NA	NA	NA	-0.0107959	0.0007213	2e-16	-0.010709749	7.245e-04	2e-16 ***
AIC	456249			456003			455893		
Residual deviance	19595			19347			19235		
gl	211088			211087			211086		
RD/gl	0.0982858 > 0.05			0.0916542 > 0.05			0.091124 > 0.05		
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1; NA: 'No Aplica'									
Edad^2: quadratic effect introduced for the explanation of conductor aging.									
Source: self made.									

Table 1. Comparison of the estimates obtained from the MRPs adjusted to the data.

SexMuTable 2 summarizes the findings of the MRP 2 model adjusted for each of the drivers, according to the logarithmic transformation to which the observations were submitted, expressed in exact termsjer.

Explanatory Variables	Linear change in the number of victims in road accidents	Value p	Exact change in the number of victims in road accidents (e^i)	IC 95%
Accident rate in the period	0.068960490	p<0.001	1.0713939	(1.0658223, 1.0769879)
Number of Appearances	0.020650197	p<0.001	1.0208649	(1.0201618, 1.0215611)
young drivers (Age)	1.741651604	p=0.1	5.7067610	(0.8514035, 38.1385954)
Aged Drivers (Age^2)	-10.337789243	p<0.001	0.0000324	(0.0000046, 0.0002253)
Women victims in accidents	-0.009008744	p=0.1	0.9910317	(0.9820898, 1.0000442)
Number of Sanctions through Lifeguard Cameras (Sast)	-0.010709749	p<0.001	0.9893474	(0.9879342, 0.9907439)
Source: self made.				

Table 2. Summary of the exact estimates of the MRP2.

3.3. Effects on the Accident Rate

When considering that the imposition of subpoenas as a preventive measure against the occurrence of accident events, where the protection of the physical integrity of drivers prevailed, in contrast, it was determined that an increase in an imposed subpoena is associated with an approximate increase of 2.07% in the number of accidents, if the other conditions remain constant, It was expected that this relationship would be inverse, but apparently the strong correlation between the accident rate with the imputation of sanctions through subpoenas (0.358) and the accident rate with age (0.013) mean that accidents with victims are concentrated among the youngest, the results that corroborate this fact, according to the contrast of age, determined that an increase of one year in the age of a young driver is associated with an approximate increase of 470.68% in the number of accidents, keeping the other conditions constant, while , aging (a squared increase in age) reduces by almost 100% the probability that drivers will become victims involved in traffic accidents, other things being equal; in the contrast of sex, men were more prone to road accidents than women in 99.10% and 0.90% respectively when maintaining constant conditions; In contrast to lifeguard cameras, it is reported that the imposition of subpoenas with this mechanism reduces the risk of road accidents by 1.07%, under constant conditions.

4. Discussion

The intention of this study was to determine the relationship between road safety and the accident rate in the city of Cali. Based on data recorded at the Cali Mobility Secretariat, for a considerably

long period of more than 211,000 observations from drivers. The introduction of cameras saves lives, based on Colombian legislation since 2002 with Law 769 in its article 5, which was later modified by article 22 of Law 1383 of 2010, gained very high relevance in the prevention of road accidents.

A UK study based on 34 intersections found that sites with more than 4.7 injury crashes per year in the "after" period experienced a statistically significant 48% reduction, while sites with fewer experienced a non-significant reduction. Increase of 5.3%. A study in the United States, with 102 intersections, found a 15.5% reduction in total accidents, for example, an 84% reduction in accidents at a right angle (90º) significant to 1%, a 31% reduction in "rear – end" rear-end accident - (at 5%) and a 52% increase in accidents involving front vehicles turning in the opposite direction.

In Cali, 20 life-saving camera sites were implemented in 2012, 20 in 2013, in April 2021 all points were vandalized in their entirety, as of November 2022 it was possible to reestablish activities in 14 sites with the installation of the cameras saves lives and it was possible to continue with prevention through this mechanism. In a study carried out in Cali at 40 points of life-saving cameras, it shows that there was a 32% decrease in the number of accidents between 2012 and 2013. It should be noted that in studies carried out in the United Kingdom, in the United States and the one carried out in 40 sites in Cali, include accidents with damages, with damages being the ones that present the most frequency compared to those of victims, so the comparison of those results with the current study becomes a bit complex, but they can be useful reference. With the results of this study calibrated through MRP, they were reduced by 1.07% (approximately 528 accidents with victims were avoided in the period evaluated) in Cali, due to the effect of the prevention exercised by the life-saving cameras.

5. Conclusions
Linear models are recognized as the main techniques for calibrating Poisson-type road safety models where the fixed distribution of errors of all drivers who are victims of road accidents in the study period are assumed. However, the frequency of road accidents is influenced by many factors that vary, some of which are the age of the drivers and the number of sanctions for violations of traffic regulations, especially those that come from life-saving cameras.
This study exposes how the implementation of mechanisms such as cameras save lives have a very positive effect in reducing the risk of being victims of road accidents in drivers who travel the roads of Santiago de Cali. Particular attention should be paid to younger drivers, who are more prone to the risk of being involved in road accidents.

These findings suggest the importance of strengthening road prevention measures and promoting greater awareness and compliance with traffic regulations in Santiago de Cali.

In the first place, it is necessary to focus efforts on the implementation of more effective strategies to control and monitor compliance with traffic regulations. Although there are sanctions for infractions, the results indicate that their current application is not being sufficient to reduce road accidents. It is important to consider the possibility of intensifying awareness campaigns, improving the mechanisms for detecting infractions and increasing the visibility and presence of the authorities on the roads.

In addition, greater attention should be paid to the specific risk factors that may be influencing road accidents. For example, young drivers may require driver training and education programs more focused on their needs and awareness of the dangers and consequences of risky behavior behind the wheel. Likewise, it is important to analyze in depth the gender differences in road accidents and develop strategies that address the specific factors that can influence driving behaviors.

The implementation of lifesaving cameras or SAST mechanisms has shown to have a positive impact on accident prevention. These devices can automatically detect and penalize traffic violations, which can lead to increased deterrence and awareness among drivers. It is advisable to continue promoting the use of these mechanisms and evaluate their expansion to more areas of the Special District.

In addition to the aforementioned measures, it is essential to adopt a comprehensive approach to road safety that involves all relevant stakeholders. This includes transit authorities, drivers, pedestrians, cyclists, motorcyclists, and the community in general. Some actions that may be considered are:
• Vial Education: Promote continuous and effective educational campaigns that promote knowledge and awareness about traffic regulations, the risks associated with reckless behavior and the consequences of traffic accidents. These campaigns can target different age groups and focus on specific issues, such as the use of seat belts, the prohibition of driving under the influence of alcohol and drugs, respecting speed limits and the proper use of devices. of security vial.
• Safe Road Infrastructure: Improving road infrastructure is essential to prevent accidents. This involves building and maintaining safe streets and highways, implementing proper signage, creating safe spaces for pedestrians and cyclists, and designing intersections and junctions that minimize collision risks. In addition, periodic road safety evaluations must be carried out and corrective measures taken in areas identified as critical points.
• Application and Enforcement of Traffic Regulations: It is essential to strengthen the application of traffic regulations in a fair and equitable manner. This implies the increase of traffic controls, the implementation of violation detection technologies, the imposition of effective and proportional sanctions to the violations, and the promotion of responsible behaviors among the publics conductores.
• Promotion of Sustainable Mobility Alternatives: Promoting the use of alternative and sustainable means of transport, such as public transport, cycling and walking, can reduce the number of vehicles on the roads and, therefore, decrease the risks of accidents. This

implies improving the quality and accessibility of public transport, developing adequate infrastructure for bicycles and promoting urban planning oriented towards sustainable mobility.

• Monitoring and Analysis of Accident Data: It is essential to collect, monitor and analyze accurate and up-to-date data on traffic accidents. This will make it possible to identify patterns, trends and areas of increased risk, which in turn will help to target prevention strategies and resource allocation effectivelytiva.

In summary, road safety is a constant challenge that requires the collaboration and commitment of all the actors involved. Through the implementation of comprehensive measures, such as road safety education, infrastructure improvement, application of traffic regulations, promotion of sustainable mobility alternatives, and data analysis, it is possible to reduce road accidents in Santiago de Cali. However, it is important to highlight that road safety is not only the responsibility of the authorities, but also of drivers and the community in general. We must all assume an active commitment to promoting safe behavior on the roads and respecting traffic regulations.

It is essential that the authorities continue working on the implementation and strengthening of road prevention policies and programs. This implies a constant supervision of the roads, the improvement of signaling, the continuous training of traffic agents and the establishment of alliances with educational institutions and civil organizations to promote road safety. Likewise, it is necessary to periodically evaluate the strategies implemented and carry out impact studies to measure the effectiveness of road prevention measures. This will allow you to adjust actions and focus resources more efficiently.

In short, road prevention plays a crucial role in reducing road accidents in Santiago de Cali. The results of the Poisson regression model highlight the importance of addressing factors such as penalties for moving violations, driver gender, and use of restraint devices. However, road safety must go beyond these variables and comprehensively address education, infrastructure, compliance with regulations and the promotion of safe and sustainable mobility. With a joint approach and constant dedication, it is possible to achieve significant improvements in road safety and protect the lives of citizens on the roads of Santiago de Cali.

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