Road Accident Rate Bogotá, Colombia, 2015- 2019

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Abstract

This text uses public data bases about Road Accident Rate Bogotá, Colombia, 2015- 2019. Using ANOVA categorical Regression we found the cyclical effect for injuries and fatalities, by: day of week, week of year, and Year. Also we found the incidence by sub urban division

Keywords
Road Accidents, Colombia, Public Policy, Personal Injuries, Homicides

1. Introduction

The risk of sinister in the provision of logistics services within the urban environment can be characterized for Bogotá at the level of urban area and time of day. The logistics services use motor vehicles to transport this cargo. The loss or impairment of the functionalities of motor vehicles affects the provision of the logistics service. In Bogotá, Colombia, the Municipal government has public databases with the registry of traffic accidents; information available for the period 2016 to 2019. This text describes the cyclicality of personal injuries, homicides due to motor vehicle traffic accidents. For this it uses the public information available; then an ANOVA model is implemented using as a factor the year, the week of the year, the day of the week; then the techniques of signal analysis are used: coherence and spectral power, wavelet analysis, for the identification of the identification of common patterns. In this way, methods are available to describe the evolution of the sector and to anticipate possible changes in the road accident rate. With the above, the homogeneity of behavior over time is identified.)

1.1 Objectives

Estimate the degree of identification of the annual, weekly, daily and location components in the road accident rate in Bogotá based on public information and using statistical techniques of personal injuries and deaths.

2. Literature Review

Given some of the models used are based on the retrieval of information from electronic traffic accident systems, it is questioned about the quality, certainty, adequacy and relevance of the information collected since it is partial and is frequently subject to the quality of the information from information collection systems since different actors in the road accident have contradictory contractual or personal legal interests and not always all the relevant information is available (Chung & Chang, 2015), (JI Ruiz & Herrera, 2016), (Vargas Castillo, 2013). Other analyzes discriminate the workload and discriminate the causal components of road accidents (SA Useche et al., 2018), social behaviors (Uribe Granja et al., 2013), (S. Useche et al., 2015) and psychological (J. Ruiz & López, 2010) or its physiological effects (DY et al., 2003). by component elements of the psychological profile (Norza Céspedes et al., 2014), (Riaño Garzón et al., 2017), (Uribe Granja et al., 2013), (Sojo Gómez, 2020), automotive flow modeling includes the implementation of descriptions that link engineering and physical sciences (Pérez et al., 2014).

The modeling of the traffic flow of Bogotá is important to discriminate the effects of vehicular activity such as pollution, noise and congestion, among others (Agudelo et al., 2020), for this city specific models have been developed for the estimation and prediction of specific transport systems for the city (Gómez & Bocarejo, 2015), (Zafra-Mejía et al., 2019) or for estimating the effect of vehicular accident (Wach & Unarski, 2007). The road accident rate in Bogotá has been studied using statistical grouping techniques (Bocarejo & Andes, 2011) including cars and motorcycles (Ospina-Mateus et al., 2021), (Gutierrez-Osorio & Pedraza, 2019), (Vargas et al. ., 2014), (Jimenez et al., 2015), as well as for the national territory (Ospina-Mateus et al., 2020). Detailed accident rate analysis

3. Methods

First the data was collected; then we proceed to the verification and standardization of information if necessary; Columns are then elaborated for the categorical variables associated with the date and time components. Later, ANOVA models are available with linear regressions of successive steps for categorical variables. there, compliance with the assumptions and the proportion of information explained for the total database and for the data grouped in daily records for both personal injuries and homicides are identified. Finally, it is concluded on: the adequacy of the models used as explained proportion, the hypothesis test of the utility of the model to explain the data and the explanatory variables.

4. Data Collection

Table 1 summarizes the 173,443 road accidents in Bogotá Colombia from 2016 to 2019. Based on the data provided by the Mayor's Office of the city, for the 20 localities or Minor Mayors into which Bogotá is divided. Table 2 summarizes the 81,715 injured by road accidents in Bogotá from 2015 to 2019. Based on data provided by the Mayor's Office of the city, for the 20 localities or Minor Mayors into which Bogotá is divided. Table 3 summarizes the 2,695 deaths from road accidents in Bogotá from 2015 to 2019. Table 4 summarizes the 1826 days of the registration of road accidents in Bogotá from 2015 to 2019. The 173,443 registrations are assigned in each of the 20 Minor Mayor's Offices and they are in the “Sum” column with the number of losses per location.

Table 1. Road accident records in Bogotá, Colombia 2016 to 2019

Locality/ Year	2.015	2.016	2.017	2.018	2.019	Total
Antonio Nariño	640	667	703	807	614	3.431
Barrios Unidos	1.712	1.887	2.000	2.094	1.769	9.462
Bosa	1.317	1.528	1.634	1.954	1.841	8.274
Chapinero	1.946	2.423	2.006	2.148	2.102	10.625
Ciudad Bolívar	1.316	1.391	1.265	1.368	1.458	6.798
Engativá	3.255	3.494	3.587	3.925	3.366	17.627
Fontibón	2.287	2.794	2.818	2.986	2.998	13.883
Kennedy	3.391	4.010	4.112	4.003	3.935	19.451
La Candelaria	210	174	190	140	187	901
Los Mártires	1.029	1.183	1.281	1.266	1.143	5.902
Puente Aranda	2.208	2.413	2.415	2.462	2.585	12.083
Rafael Uribe	820	933	901	800	935	4.389
San Cristóbal	827	864	794	1.054	1.135	4.674
Santa Fe	750	971	1.087	1.156	1.079	5.043
Suba	3.227	3.343	3.073	3.179	2.874	15.696
Sumapaz	-	-	1	2	2	5
Teusaquillo	1.821	1.782	1.933	2.013	1.810	9.359
Tunjuelito	833	934	914	986	1.034	4.701
Usaquén	3.100	3.543	3.758	3.859	3.450	17.710
Usme	652	654	699	751	673	3.429
Total	31.341	34.988	35.171	36.953	34.990	173.443

Table 2. Number of Injured in Road Accidents in Bogotá, Colombia 2016 to 2019

Locality / Year	2.015	2.016	2.017	2.018	2.019	Total
Antonio Nariño	371	361	418	586	444	2.180
Barrios Unidos	655	651	553	914	709	3.482
Bosa	833	861	949	1.342	1.312	5.297
Chapinero	635	631	525	737	768	3.296
Ciudad Bolívar	946	886	854	1.006	1.225	4.917
Engativá	1.522	1.247	1.366	1.808	1.521	7.464
Fontibón	749	834	878	1.087	1.091	4.639
Kennedy	1.869	1.937	2.150	2.415	2.560	10.931
La Candelaria	68	65	70	72	116	391
Los Mártires	562	554	571	722	609	3.018
Puente Aranda	946	1.089	1.142	1.366	1.349	5.892
Rafael Uribe	569	600	587	679	673	3.108
San Cristóbal	609	565	605	802	903	3.484
Santa Fe	398	443	483	614	613	2.551
Suba	1.430	1.344	1.296	1.617	1.398	7.085
Sumapaz	-	-	-	2	3	5
Teusaquillo	716	619	632	878	746	3.591
Tunjuelito	532	581	531	618	813	3.075
Usaquén	926	893	948	1.111	1.119	4.997
Usme	465	360	464	526	497	2.312
Total	14.801	14.521	15.022	18.902	18.469	81.715

Table 3. Number of Deaths in Road Accidents in Bogotá, Colombia 2016 to 2019

Locality / Year	2.015	2.016	2.017	2.018	2.019	Total
Antonio Nariño	19	20	11	20	5	75
Barrios Unidos	17	23	25	20	13	98
Bosa	33	36	34	30	38	171
Chapinero	18	15	14	16	13	76
Ciudad Bolívar	46	39	42	34	33	194
Engativá	46	63	40	50	45	244
Fontibón	32	39	35	45	39	190
Kennedy	84	83	90	61	53	371
Los Mártires	23	20	17	17	14	91
Puente Aranda	40	42	37	37	42	198
Rafael Uribe	21	26	20	19	28	114
San Cristóbal	27	19	24	16	24	110
Santa Fe	20	17	11	9	22	79
Suba	45	44	46	35	43	213
Teusaquillo	15	17	22	23	18	95
Tunjuelito	16	27	26	22	20	111
Usaquén	17	36	27	33	26	139
Usme	18	22	19	29	25	113
Total	540	590	542	516	507	2.695

Table 4. Number of records for 1,826 days of Road Accidents in Bogotá, Colombia 2016 to 2019

Locality/ Statistic	Sum	No zero	Max	Mean	Min	Std.	Prob	Curtosis	Assimetry	Spearman
Antonio Nariño	3.431	1.519	9	1,88	-	1,42	0,83	0,88	0,80	0,03
Barrios Unidos	9.462	1.781	16	5,18	-	2,81	0,98	(0,00)	0,46	0,06
Bosa	8.274	1.798	15	4,53	-	2,32	0,98	0,36	0,55	0,25
Chapinero	10.625	1.784	19	5,82	-	3,23	0,98	(0,05)	0,44	0,01
Ciudad Bolívar	6.798	1.777	13	3,72	-	1,99	0,97	0,43	0,56	0,06
Engativá	17.627	1.826	26	9,65	1	3,79	1,00	0,04	0,35	0,08
Fontibón	13.883	1.819	21	7,60	-	3,53	1,00	(0,15)	0,39	0,20
Kennedy	19.451	1.826	25	10,65	1	3,76	1,00	0,07	0,29	0,13
Los Mártires	5.902	1.711	13	3,23	-	2,03	0,94	0,63	0,71	0,08
Puente Aranda	12.083	1.817	19	6,62	-	3,01	1,00	(0,02)	0,36	0,12
Rafael Uribe	4.389	1.643	8	2,40	-	1,64	0,90	(0,13)	0,61	0,04
San Cristóbal	4.674	1.672	11	2,56	-	1,67	0,92	0,87	0,76	0,19
Santa Fe	5.043	1.634	10	2,76	-	1,87	0,89	0,31	0,67	0,18
Suba	15.696	1.824	21	8,60	-	3,34	1,00	0,16	0,36	(0,09)
Teusaquillo	9.359	1.789	17	5,13	-	2,73	0,98	0,12	0,50	0,04
Tunjuelito	4.701	1.664	10	2,57	-	1,66	0,91	0,35	0,63	0,11
Usaquén	17.710	1.820	28	9,70	-	4,26	1,00	(0,02)	0,27	0,10
Usme	3.429	1.537	8	1,88	-	1,37	0,84	0,26	0,66	0,05

The column "No zeros" includes the days with a record of no vial; the Max column contains the maximum number of loss records within a day in the civil calendar and similarly the “Mean” and “Min” columns. The column “Std. Dev” includes the standard deviation of the mean; The column “Prob” is the estimate by proportion of days with a record of loss; The coefficients of kurtosis, skewness and the Sperman correlation are also available for the daily loss record. The Sperman correlation coefficient is obtained between the accident records and the civil calendar date based on the daily records; Thus, values greater than 0.17 in absolute value are considered in correlation with time or with a trend; Therefore, a sustained increase in losses is only identified for Bosa, Fontibón, San Cristóbal and Santafé; in any case upward.

Table 5 has the coefficients of the linear regression with categorical variables for eight response variables: in each type of information the number of injured and the number of deaths; The four types of information are: the presence of the event, the number of records in the locality, the record by date and the number of accident events. The dichotomous variables are: The Year, DoY; The number of semen of the year, WoY, the day within the calendar month, DoM; and the day of the week DoW. Each of the localities or minor mayors had a categorical variable

Table 5. Linear Regression Coefficients for Categorical Variables in 8 Models of Road Accidents in Bogotá, Colombia 2016 to 2019

	Presence/ Locality		**Registers/ Locality**		**Date / Locality**		**Event**	
P Valor	**Injury**	**Dead**	**Injury**	**Dead**	**Injury**	**Dead**	**Injury**	**Dead**
F AA	0,000	0,152			0,000	0,037	0,000	0,001
F AS	0,000	0,091			0,003	0,259	0,000	0,562
F MD	0,442	0,332			0,283	0,394	0,388	0,537
F SD	0,000	0,405			0,137	0,399	0,000	0,066
Antonio Nariño	0,000	0,352	0,000	0,197	0,000	0,014		
Barrios Unidos	0,001	0,242	0,027	0,791	0,000	0,021		
Bosa	0,006	0,119	0,000	0,093	0,000	0,483		
Chapinero	0,009	0,077	0,007	0,840	0,000	0,044		
Ciudad Bolívar	0,190	0,933	0,000	0,002	0,000	0,141		
Engativá			0,000	0,836	0,000	0,442		
Fontibón	0,867	0,435	0,029	0,177	0,000	0,056		
Kennedy			0,000	0,001	0,000	0,032		
La Candelaria	0,000	0,570	0,090	0,985	0,012	0,526		
Los Mártires	0,006	0,502	0,001	0,345	0,000	0,010		
Puente Aranda	0,640	0,915	0,000	0,519	0,000	0,048		
Rafael Uribe	0,363	0,916	0,001	0,270	0,007	0,070		
San Cristóbal	0,025	0,231	0,000	0,038	0,000	0,002		
Santa Fe	0,000	0,393	0,000	0,056	0,000	0,066		
Suba	0,350	0,334	0,001	0,502	0,065	0,420		
Sumapaz	0,643	0,962	0,042	0,898	0,061	0,752		
Teusaquillo	0,727	0,775	0,002	0,825	0,121	0,851		
Tunjuelito	0,000	0,212	0,000	0,937	0,000	0,641		
Usaquén	0,006	0,538	0,149	0,151	0,408	0,487		
Usme	0,002	0,152	0,000	0,749	0,006	0,625		
CLASS							0	0
LOCALITY							1,1E-292	6,06E-27
DESIGN_PLACE							0	0,1619
F DH							1,55E159	2,68E-87

5. Results and Discussion

5.1 Numerical Results

Table 6 and table 7 contain the coefficients for the number of wounded and dead obtained by linear regression using categorical variables for the variables of: Town or City Hall, with their names; a coefficient for the year, D YY; the coefficient for the day of the week, DoW; and the day of the month, DoM and for the week of the year, WoY. Only statistically significant variables are included with internal values at p <0.05 (*), p <0.01 (**), p <0.005 (***) and p <0.001 (****). Subsequently, the following table displays similar results for the week of the year. Finding a behavior with a higher level of detail in terms of the number of explanatory variables for the injured than for the dead.

Table 6. Linear Regression Coefficients of the Road Claims model in Bogotá, Colombia 2016 to 2019

	Injury			Dead		
	B	Pr > |t|	Sig	B	Pr > |t|	Sig
Antonio Nariño	3,286	0,000	****	0,076	0,352	
Barrios Unidos	5,867	0,001	****	0,232	0,242	
Bosa	5,927	0,006	**	-0,383	0,119	
Chapinero	4,792	0,009	**	0,368	0,077	
La Candelaria	2,013	0,000	****	0,036	0,570	
Los Mártires	3,065	0,006	**	-0,086	0,502	
San Cristóbal	2,148	0,025	*	0,130	0,231	
Santa Fe	3,875	0,000	****	-0,087	0,393	
Tunjuelito	3,578	0,000	****	0,134	0,212	
Usaquén	13,095	0,006	**	-0,330	0,538	
Usme	2,314	0,002	***	-0,119	0,152	
Intercepción	-24,822	0,005	**	0,000	0,000	***
D YY-2015	-9,015	0,000	****	0,073	0,434	
D YY-2016	-10,850	0,000	****	0,219	0,018	*
D YY-2017	-9,185	0,000	****	0,096	0,304	
D DoW-1	8,399	0,000	****	-0,008	0,941	
D DoW-2	11,063	0,000	****	0,083	0,471	
D DoW-3	8,904	0,000	****	0,136	0,237	
D DoW-4	9,298	0,000	****	0,107	0,350	
D DoW-5	11,859	0,000	****	0,190	0,097	
D DoW-6	9,720	0,000	****	0,189	0,096	
D DoM-27	-1,740	0,473		-0,578	0,036	*
D DoM-29	-0,590	0,807		-0,553	0,044	*
D WoY-5	7,607	0,015	*	0,622	0,080	
D WoY-6	10,259	0,002	***	0,356	0,339	
D WoY-7	11,959	0,000	***	0,305	0,421	
D WoY-8	11,342	0,001	***	-0,025	0,947	
D WoY-9	11,394	0,000	***	0,886	0,015	*
D WoY-10	12,887	0,000	***	0,041	0,911	
D WoY-11	12,507	0,000	***	0,191	0,614	

Table 6. Linear Regression Coefficients by Week of Year Road model in Bogotá, Colombia 2016 to 2019

	Injury	Dead	Injury	Dead	Injury	Dead
	B	Pr > |t|	Sig	B	Pr > |t|	Sig
D WoY-12	10,387	0,002	***	0,330	0,378	
D WoY-13	7,306	0,021	*	0,268	0,454	
D WoY-14	9,298	0,004	***	0,272	0,451	
D WoY-15	11,321	0,001	***	0,059	0,875	
D WoY-16	7,051	0,035	*	0,403	0,287	
D WoY-17	7,878	0,015	*	0,729	0,047	*
D WoY-18	12,878	0,000	***	0,432	0,229	
D WoY-19	11,813	0,000	***	0,447	0,232	
D WoY-20	7,733	0,021	*	0,500	0,187	
D WoY-21	11,879	0,000	***	0,452	0,225	
D WoY-22	12,182	0,000	***	0,591	0,097	
D WoY-23	12,154	0,000	***	0,611	0,096	
D WoY-24	7,292	0,029	*	0,388	0,305	
D WoY-25	8,809	0,008	**	0,279	0,459	
D WoY-26	8,390	0,008	**	0,487	0,178	
D WoY-27	10,700	0,001	***	0,496	0,172	
D WoY-28	9,656	0,004	***	0,326	0,387	
D WoY-29	8,286	0,013	*	0,358	0,345	
D WoY-30	10,058	0,002	***	0,466	0,205	
D WoY-31	10,457	0,001	***	0,392	0,270	
D WoY-32	11,170	0,001	***	0,236	0,527	
D WoY-33	9,998	0,003	***	0,474	0,211	
D WoY-34	7,468	0,023	*	0,163	0,661	
D WoY-35	15,048	0,000	***	0,469	0,189	
D WoY-36	13,468	0,000	***	0,426	0,243	
D WoY-37	11,904	0,000	***	0,241	0,524	
D WoY-38	10,379	0,002	***	0,113	0,765	
D WoY-39	12,135	0,000	***	0,715	0,050	
D WoY-40	14,491	0,000	***	-0,007	0,985	
D WoY-41	12,513	0,000	***	0,706	0,060	
D WoY-42	10,021	0,003	***	0,334	0,380	
D WoY-44	13,644	0,000	***	0,697	0,050	
D WoY-45	7,380	0,023	*	0,103	0,780	
D WoY-46	7,037	0,035	*	0,473	0,212	
D WoY-47	6,885	0,037	*	0,300	0,424	
D WoY-48	10,976	0,001	***	-0,059	0,871	
D WoY-49	13,326	0,000	***	0,365	0,318	
D WoY-50	10,788	0,001	***	0,706	0,063	

5.2 Graphical Results

The evolution for the number of registrations, the number of wounded and the number of deaths is presented in Figure 1 and in Figure 2. The dotted line has on the right scale the coefficient for the number of deaths according to the week of the anus. Coefficients directly associated with the previous sections of Table 6 and Table 7.

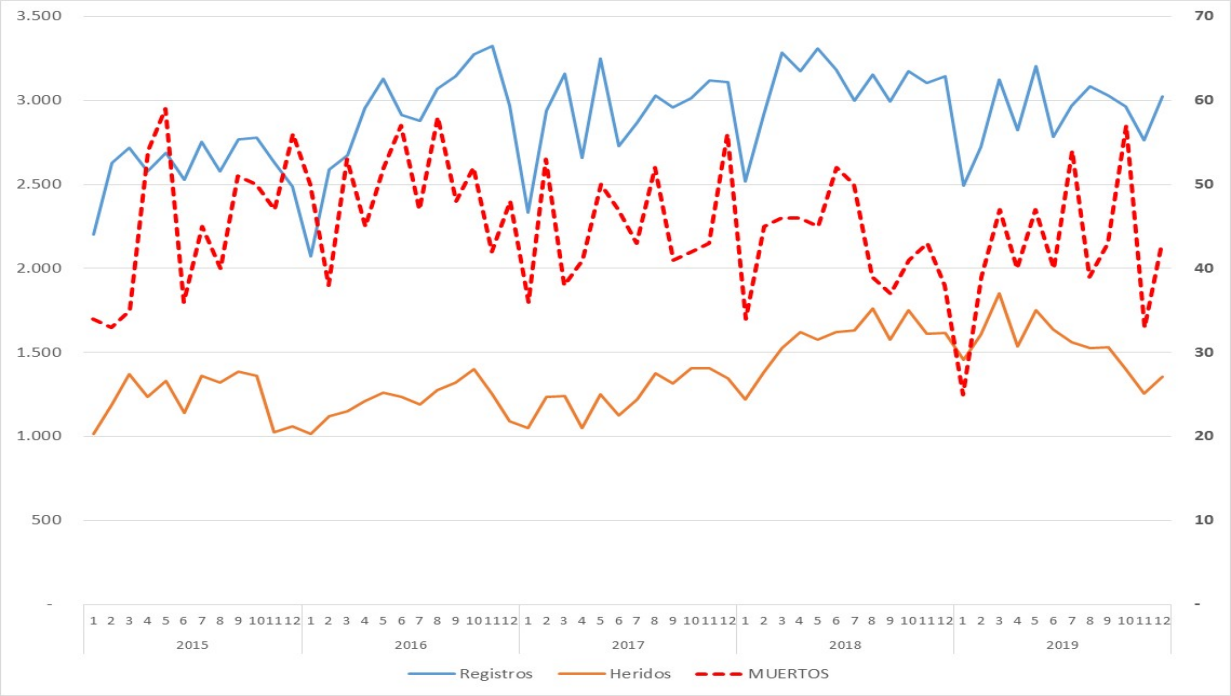

Figure 1. Monthly Accidents on the Bogota Roads. 2017 to 2019

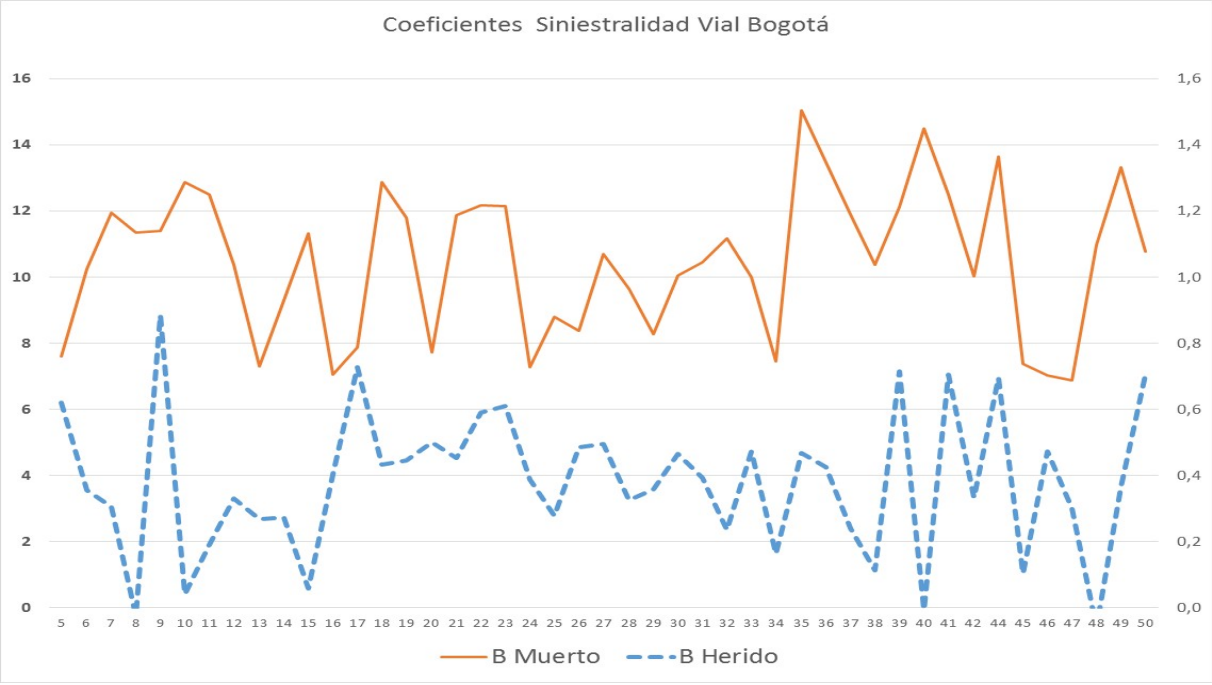

Figure 2. Weekly Statistical Coefficients of the Monthly Accident Rate on the Bogotá Roads. 2016 to 2019

5.3 Proposed Improvements

Signal analysis, spectral decomposition techniques could be used to identify the behaviors and regularities underlying homicides in road accidents such as the Granger causality equations or the Signal Engineering Wavelets.

5.4 Validation

The following table contains for 8 different variables summarizes the amount of information represented and the contrast of assumptions for linear statistical models with categorical variables. Row Y specifies the name of the output variable. T is the frequency of the records used daily summaries or the database, X are the variables included. DF are the degrees of freedom used, R^2 is the proportion of information as a percentage explained by the specific model, R^2 Adj. It is the R^2 corrected for the degrees of freedom and the variables used, DW is the Durbin Watson statistic used to identify the serial correlation between the data used. The lower part has the modeled sum of squares, Model, the sum of squares of the Error, Error, these being the two components of the total sum of squares corrected by the mean, Total C. From these data the statistic is obtained F and the probability of F as a statistic for the acceptance or rejection of the hypothesis of the non-existence or the existence of the model.

For the 8 synthesized models, it is found which 7 are statistically significant based on the p (F) statistic. All of them are statistically significant except for the dead model obtained per day. In any case, the data do not show a first-order serial correlation, thus fulfilling the assumption of independence between the data recording, since its DW statistics are all close to 2. The models for the injured in the daily record obtains values of R^2 between 0.36; 0.43 and 0.52. The models for the deaths based on daily records show 0.01, 0.03 and 0.07, so the statistical models, although significant in some cases, explain little of the variation in the data. For the models based on the records of the database, it is obtained that 0.00 is explained for the dead and 0.12 for the wounded.

Table 7. P Values Linear Regression of the Road Claims model in Bogotá, Colombia 2016 to 2019

Y	Dead	Injury	Dead	Injury	Dead	Injury	Dead	Injury
t	Daily	Daily	Daily	Daily	Daily	Daily	Record	Record
X	Record/ Locality	Record/ Locality	If/ Locality	If/ Locality	Record/ Locality	Record/ Locality		
K	Q	Q	K	K	Q	Q	K	K
T			1	1	1	1	1	1
DF	1.805,00	1.805,00	1.715,00	1.715,00	1.450,00	1.450,00	173326	173289
R^2	0,04	0,43	0,07	0,40	0,26	0,62	0,00	0,12
R^2 Adj.	0,03	0,43	0,01	0,36	0,07	0,52	0,00	0,12
Model	105,91	148.345,7	200,20	136.338,0	737,07	211.983,6	12,56	19.770
Error	2.751,53	194.183,9	2.657,24	206.191,5	2.120,37	130.545,9	2.808,56	145.440
Total c.	2.857,44	342.529,6	2.857,44	342.529,6	2.857,44	342.529,6	2.821,12	165.210
F	3,47	68,95	1,17	10,31	1,34	6,28	6,68	154
P(F)	3,18E-07	2,20E-205	1,10E-01	1,55E-123	9,67E-05	3,87E-144	8,46E-98	0,00E+00

6. Conclusion

Statistical models are available for those injured by road accidents associated with the date of the civil calendar and the Minor Mayor's Office; such models explain between 36% to 63% of the information. There are no statistical models in the practical or empirical sense, although there are from the statistical point of view for the deaths due to road accidents associated with the date of the civil calendar and the Minor Mayor's Office; such models explain between 0% and 3% of the information. There is no homogeneity in the homicide event in a road accident. Other models could be used such as acoustic or electronic signal analysis to capture frequencies and periods of common occurrence.

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