academicJournals

Vol. 10(31), pp. 3049-3055, 30 July, 2015
DOI: 10.5897/AJAR2015.10051
Article Number: 3F94A0654478
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Characterization of accidents involving tractors in Brazilian federal highways in the state of Minas Gerais

Deivielison Ximenes Siqueira Macedo*, Leonardo de Almeida Monteiro, Viviane Castro dos Santos, Carlos Alessandro Chioderoli and Daniel Albiero

Department of Agricultural Engineering, Federal University of Ceará Avenida Mister Hull, 2977 - Campus do Pici, Fortaleza – CE, 60356-001, Brazil.

Received 19 June, 2015; Accepted 21 July, 2015

Minas Gerais state has the largest road network within Brazil on which thousands of vehicles travel daily. Due the increasing in the number of tractors in Brazil, traffic incidents may have also increased. Therefore, the present work aimed to characterize accidents involving tractors in Minas Gerais federal highways through the following indicators, event type, crash causes, time of the day in which the episode occurred, drivers age, climatic conditions and the road the case happened by analyzing Traffic Accident Reports (TAR). The incidents' information was provided by the Federal Highway Police (FHP) through TAR questionnaires. The total data set in the present work is composed by 148 TAR forms in Minas Gerais State between January, 2008 and September, 2011. The results were submitted to the chi-square test at 95% probability. The events' profile indicates collision as the main crash type, lack of attention as the main cause and the time period that has the most occurrences was 09:00 to 11:59 time period. Additionally, the group aged 25 to 30 years old were involved in the highest number of episodes, in good climatic conditions and the Brazilian Federal road BR-381 had the most evidenced cases.

Key words: Highway safety, tractor accident, collisions, safety.

INTRODUCTION

Minas Gerais state has the largest road network within Brazil (Minas Gerais, 2014), on which thousands of vehicles travel daily. Due the increasing in the number of tractors in Brazil, they are usually observed on public roads, especially closer to either farms or rural areas. Ericson (2010) argues that on a road in Cambodia, from the total amount of vehicles, approximately, 9% are tractors. However, the increased number of agricultural machinery on public roads may have also increased traffic incidents.

Regarding farm machinery episodes, studies have shown that there are some circumstances which may increase traffic risks. Road conditions (Costello et al., 2003; Peek-ASA et al., 2007), increased tractors number (Lehtola et al., 1994), time of day (Glascock et al., 1995; Gerberich et al., 1996), changes in seasons (Gkritza et

*Corresponding author. E-mail: derilsiqueira@hotmail.com

al., 2010), alcohol consumption (Gassend et al., 2009) are commonly found in literature as the main traffic risks.

Traffic accident analysis is need due the fact it allows the recognition of the events' main reasons which led the author to provide the best way to solve the problems. However, in order to analyse road traffic episodes, a data set containing the occurrence main characteristics is required (Debiase et al., 2004). In Denmark, Jorgensen (2008) made an accidents' database throughout 20 years of various rural sectors and argues that in years that awareness campaigns about deaths related with tractors were carried out, the total death numbers decreased when compared to the years the campaign was not publicized.

Therefore, the present work aimed to characterize accidents involving tractors in Minas Gerais federal highways through the following indicators, event type, crash causes, time of the day in which the episode occurred, drivers age, climatic conditions and the road the case happened by analyzing Traffic Accident Reports (TAR).

MATERIALS AND METHODS

The study was conducted in the Laboratory of Agricultural Machinery Accident Research in partnership with the 16th Federal Highway Police (FHP) Superintendence in Fortaleza, Ceará State, Brazil.

The incidents' information was provided by the FHP through Traffic Accident Reports (TAR). The TAR form is filled by the FHP after a car crash and, subsequently uploaded on to the FHP database. The gathered information is available to all regional offices of the country.

Each report contains the following information, the location (highway) where the event happened, machinery type (dozers, wheel tractor or mixed tractor) and weather condition. Additionally, also contains information about the episode type and cause, dead numbers (fatalities), the time period within the day the case happened and information about the driver.

In order to determine the minimum number of TAR forms required for statistical analysis, the operational characteristics curves methodology was utilized (HINES et al., 2006), and it is expressed in the following equation:

$$d = \frac{|\mu - \mu o|}{\sigma} \quad (1)$$

Where, d = number of samples; μ = population mean; μo = sample mean, and σ = standard deviation.

From the obtained d value, is possible to find the minimum amount of TAR forms required in the operational characteristics curves graphic (Montgomery and Runger, 2013). In the present study case, the graph information shows the minimum reports amount is 15.

The total data set in the present work is composed by 148 TAR forms in Minas Gerais State between January, 2008 to September, 2011. The different accident types filled in the reports and contained in this study were as follows, rear collision, side collision, transverse collision, collision with a fixed object, possible damages, running over, runway excursion, rollover and fire. The different incident causes reported were as follows, lack of attention, mechanical failure, driver fell asleep, incompatible speed for the road, alcohol intake and the safe distance to the tractor was not kept. The time period within the day the crash occurred was subdivided in 8 classes each one having a 3 hours period and is presented in 0 to 24 h model. The classes are as follows, 00:00 - 02:59, 03:00 - 05:59, 06:00 - 08:59, 09:00 - 11:59, 12:00 - 14:59, 15:00 - 17:59, 18:00 - 20:59, 21:00 - 23:59.

Regarding to the operator's age, the first class of operator's age is between 0 and 19 years old. Subsequent classes have a 5-year-period starting at the age 20 and finishing at the age 60. The last class is above 60 years old. For climatic conditions analysis, the indicators are good (open sky), medium (cloudy) and bad (rain) environments. Concerning to event location, Brazilian federal highways are named as follows, firstly there is the BR prefix followed by three numbers. In Minas Gerais state, highways that had episodes reported were: BR-381, BR-262, BR-116, BR-153, BR-040, BR-365, BR-050, BR-135, BR-251, BR-267, BR-459, BR-354, BR-356, BR-452, BR-146, BR-460 and BR-474.

The results were submitted to a nonparametric statistical analysis by frequency distribution. The chi-square adherence test is used to find out which classes have significant difference between its indicators (Equation 2).

$$\chi^2 = \Sigma\left[\frac{(|Fo - Fe|)^2}{Fe}\right] \quad (2)$$

χ^2 = Qui-square calculated; Fo = Observed frequency, and Fe = expected frequency.

The observed frequency relates to the number of registered occurrences. The expected frequency relates to the estimated value considering the total number of both accidents and indicators. The freedom degree corresponds to the total indicators' number minus one. Consequently, the observed value was compared with the expected tabulated value. When the observed value is higher than the tabulated value means there is significant difference.

RESULTS AND DISCUSSION

The chi-square adherence test (Table 1) made it possible to check which classes had significant difference between its indicators.

All the indicators were statistically significant at 95% probability which means incidents are not occurring randomly and all the cited classes may contribute for the event occurrence (Table 1). The reports have no information whether car drivers or tractor drivers caused the crash, therefore, either the car driver was the responsible or the tractor operator was the responsible or both car and tractor drivers were responsible.

By analyzing the cases, the most frequent episode type was collisions, all together (rear, side, and transverse collision as well as collision with a fixed object) they account for 75.68% of total accidents. Rear collision (28.28%), side collision (22.9%) and transverse collision (15.54%) were the most evidenced incident types (Figure 1).

Literature recognizes collisions as a serious problem and authors argue is the main type of tractor occurences on public roads in rural areas of India (Kumar et al., 1998), in Portugal (Justino, 2009) and the United States (Gkritza et al., 2010). This could be explained by the speed difference between both domestic cars and tractors on roads. For instance, the rear collision occurs

Table 1. Chi-square adherence test for accident indicators.

Indicators	χ^2 Cal	χ^2 Tab
Type	144.85*	16.92
Cause	134.55*	11.07
Highway	187.41*	26.29
Age group	20.18*	18.31
Time of day	69.73*	14,06
Weather conditions	157.39*	5.99

X^2 tab: chi-square tabulated 5%; X^2 cal: chi-square calculated; * ($p<0.05$); ^{NS} (not significant).

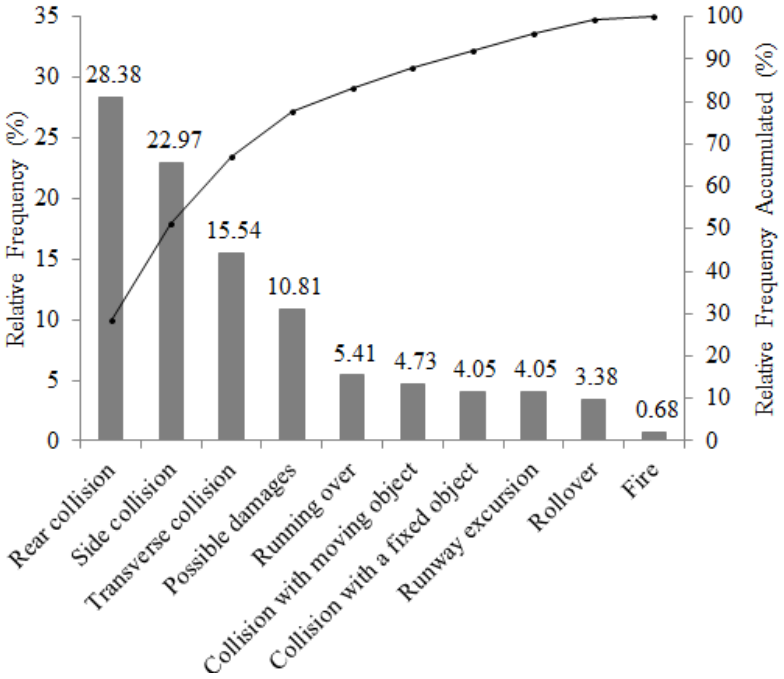

Figure 1. Crash types and their frequencies occurred on federal highways in Minas Gerais.

when a vehicle collides with the rear of the tractor, these cases can be associated with either a low speed tractor or drivers' lack of attention or the unfamiliarity of drivers with tractors on public roads. Welch (2006) states that rear collision occurs because the driver does not see the tractor and has no sufficient time to avoid the encounter.

Regarding to events' causes, the main reported cause was lack of attention (61.36%), followed by mechanical failure (18.18%) (Figure 2).

Schlosser et al. (2002) and Bunn et al. (2005) have also verified lack of attention as the main cause of accidents involving tractors. The lack of attention is usually attributed to human error, therefore the operator needs to have a special attention in order to reduce the general amount of incidents (Fernandes et al., 2011).

Concerning to the age of the injured, the group aged 25-30 years old suffered the highest number of crashes (16.18%), followed by the 35-39 group (13.24%) and the 45-49 set (12.5%) (Figure 3). The group with the most occurrences has less than 30 years old, mostly young workers having either a few experiences or no experience at all. On this account, their susceptible to accidents was higher. The results differ from Kumar and Dewangan (2009), who state a higher incidents' percentage for the 40-49 years group which was attributed to their physiological conditions.

Related with episodes' location, the highway when incidents were more evidenced was the BR-381 (26.35%), followed by BR-262 (13.51%) and the BR-116 (11.49%) (Figure 4). The Brazilian Federal road BR-381

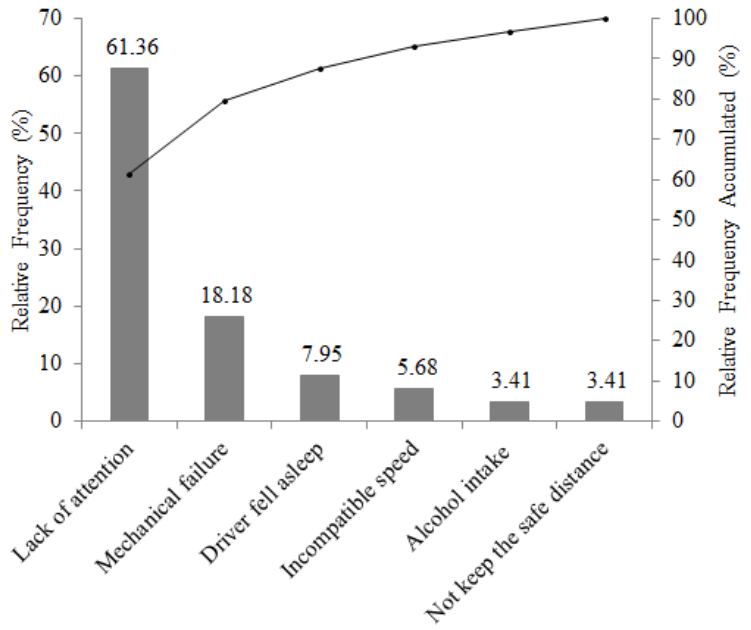

Figure 2. Causes and frequencies of episodes occurred on federal highways in Minas Gerais.

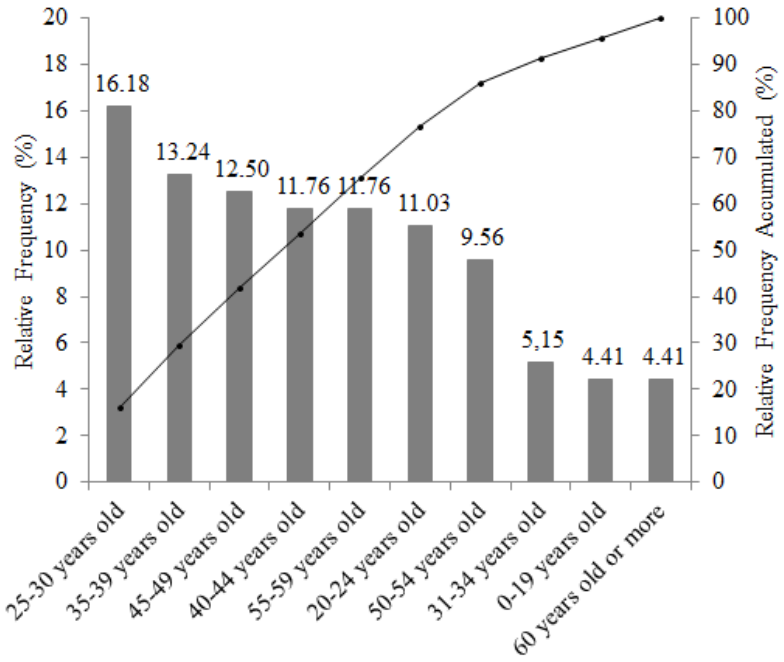

Figure 3. Operators' age groups involved in crash events on federal highways in Minas Gerais.

is the most extensive highway within Minas Gerais State which corroborates to explain the highest amount of occurrences happened in this road.

About to the time period within the day, the time period that has the most occurrences number was 09:00 to 11:59 time period (24.32%), followed by 15:00 to 17:59 (22.30%) and 12:00 to 14:59, respectively (Figure 5).

The number of crashes was the greatest in the 09:00 to

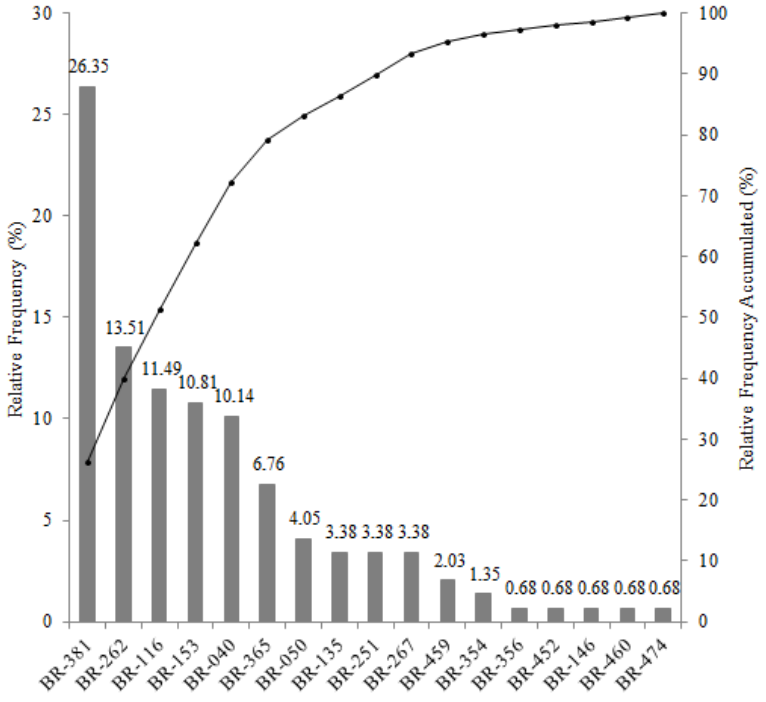

Figure 4. Federal highways in Minas Gerais and their incidents frequency.

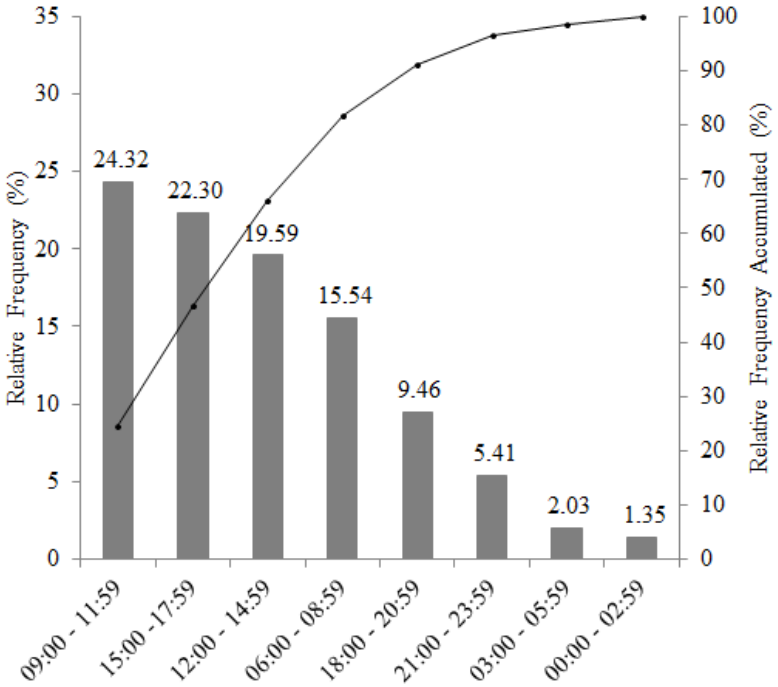

Figure 5. Time of day the cases happened in Brazilian federal highways, Minas Gerais State.

11:59 period. This data may be explained due the fact by this time period Brazilian operators finish the first work shift, usually having his attention decreased which could increase incident risks. Additionally, is important to

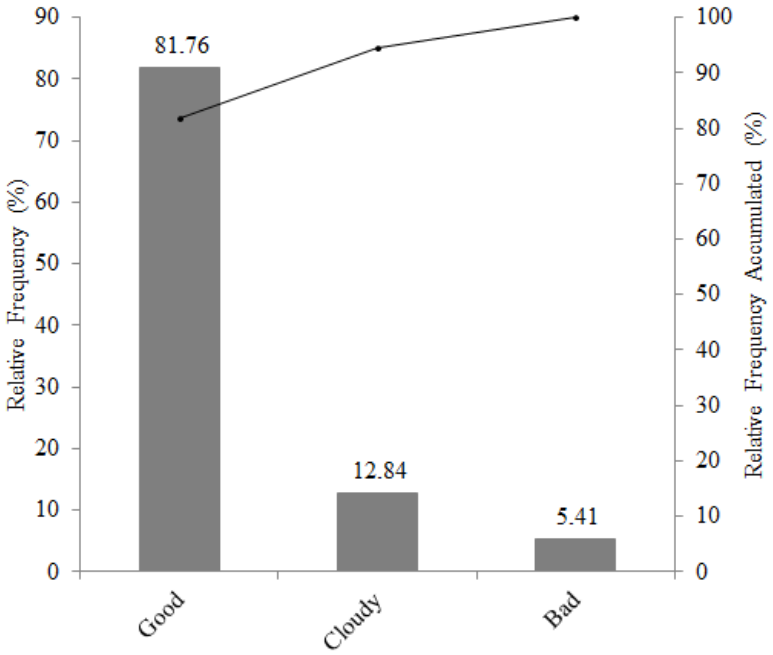

Figure 6. Evaluation of weather conditions on federal highways at the incident time.

highlight the accidents majority happened in daytime period, bearing in mind in Brazil the sun rises at 6a.m and sets at 6 pm, which has not influenced operator's visibility. Macedo (2015) argues that the bulk of incidents' events happen in both the afternoon and the morning, in this sequence, highlighting the crashes that happen when the operators' shift is almost finished, event usually due tiredness.

The weather conditions at the moment the episode happened is illustrated in Figure 5. Is possible to realize the incidents percentage was higher in good climatic conditions (81.76%) which means the operator's visibility had no interference at all (Figure 6).

Considering the events characteristics (70% of the cases happened due lack of attention and 80% happened in good both climatic and luminosity conditions) is possible to argue the incidents were more influenced by operators conditions (physical and psychological conditions) than weather conditions. Therefore, the operator needs to have a special attention in order to reduce the general amount of episodes.

Conclusion

The events' profile indicates collision as the main accident type, lack of attention as the main cause and the time period that has the most occurrences was 09:00 - 11:59 time period. The group aged 25-30 years old was involved in the highest number of episodes, in good climatic conditions and the Brazilian F ederal road BR-381 had the most cases probably due its extension. Operators must have short-time breaks within the tractor operation in order to improve attention. It is not advisable to operate the machinery in roads the tractor speed is not suitable for.

Conflict of Interest

The authors have not declared any conflict of interest.

REFERENCES

Bunn TL, Slavova S, Struttmann TW, Browning SR (2005). Sleepiness/fatigue and distraction/inattention as factors for fatal versus nonfatal commercial motor vehicle driver injuries. Accid. Anal. Prev. 37(5):862-869.

Costello TM, Schulman MD, Mitchell RE (2003). Understanding the public health impacts of farm vehicle public Road crashes in North Carolina. J. Agric. Saf. Health. 9(1):19-32.

Debiasi H, Schloser JF, Wiles, JA (2004). Acidentes de trabalho envolvendo conjuntos tratorizados em propriedades rurais do Rio Grande do Sul, Brasil. Ciênc. Rural 34(3):779-784.

Ericson M (2010). Two-wheel tractors: Road safety issues in Laos and Cambodia. Saf. Sci. 48:537-543. http://dx.doi.org/10.1016 / j.ssci.2010.01.003

Fernandes HC, Furtado Jr MR, Leite DM (2011). Perfil preocupante. Cultivar Máquinas 108:14-17.

Gassend JL, Bakovic M, Mayer D, Strinovic D, Skavic J, Petrovecki V (2009). Tractor driving and alcohol-A highly hazardous combination. Forensic Sci. Int. Supplem. 1(1):76-79.

Gerberich SG, Robertson LS, Gibson RW, Renier CM (1996). An epidemiological study of roadway fatalities related to farm vehicles: United States 1988 to 1993. J. Occup. Env. Med. 38(11):1135-1140.
Gkritza K, Kinzenbaw CR, Hallmark S, Hawkins N (2010). An empirical analysis of farm vehicle crash injury severities on Iowa's public road system. Accid. Anal. Prev.42(4):1392-1397.
Glascock LA, Bean TL, Woo RK, Carpenter TG, Holmes RG (1995). A summary of roadway accidents involving agricultural machinery. J. Agric. Saf. Health 1(2):93-104.
Hines WW, Montgomery DC, Goldsman DM, Borror CM (2006). Probabilidade e estatística na engenharia. Traduzido: Flores V R L F. 4 ed. Rio de Janeiro: LTC. Título Original: Probability and Statistics in Engineering. 588 pp.
Jorgensen K (2008). A systematic use of information from accidents as a basis of prevention activities. Safety Sci. 46:164-175.
Justino NMSR (2009). Sinistralidade rodoviária envolvendo veículos de mercadorias e tractores agrícolas. Dissertação (Mestrado) – Instituto Superior Técnico – Universidade Técnica de Lisboa, Lisboa, Portugal, 102 pp.
Kumar A, Mohan D, Mahajan P (1998). Studies on tractor related injuries in Northern India. Accid. Anal. Prev. 30:53-60.
Kumar GVP, Dewangan KN (2009). Agricultural accidents in north eastern region of India. Safety Sci. 47(2):199-205.
Lehtola CJ, Marley SJ, Melvin SW (1994). A study of five years of tractor-related fatalities in Iowa. Appl. Eng. Agric. 10(5):627-632.
Macedo DXS, Monteiro LA, Santos VC, Albiero D, Chioderoli CA (2015). Caracterização dos acidentes com maquinas agrícolas em rodovias federais no estado do Rio Grande do Sul, Ciênc. Rural. 45(1):43-46.
Minas Gerais (2004). Governo estadual de Minas Gerais. Online: disponível em: http://www.mg.gov.br/governomg/portal/m/governomg/conheca-minas/5662-rodovias/5146/5044
Montgomery DC, Runger GC (2013). Estatística aplicada e probabilidades para engenheiros. Traduzido: Calado V. 5 ed. Rio de Janeiro: LTC. Título Original: Applied statistics and probability for engineers 521 pp.
Peek-asa C, Sprince NL, Whittem PS, Falb SR, Madsen MD, Zwerling C (2007). Characteristics of crashes with farm equipment that increase potential for injury. J. Rural Health 23(4):339-347.
Schlosser JF, Debiasi H, Parcianello G, Rambo L (2002). Caracterização dos acidentes com tratores agrícolas. Ciênc. Rural. 32:977-981.
Welch T (2006). Use caution on Iowa roadways during harvest season, Iowa Department of Transportation, New Release. http://www.iowadot.gov/morgue/news2006/10020601.htm.