DOI: 10.1590/1413-812320152112.22792015

Car and motorcycle deaths: an evolutionary perspective

Mortes por batida de carro e moto: uma perspectiva evolucionista

André Luís dos Santos Medeiros [1]
Paulo Nadanovsky [1,2]

Abstract *Our aim was to assess differences between men and women in the likelihood of exposure to traffic as drivers of cars and motorcycles, and in the risk of dying from a car or a motorcycle crash, in order to verify the extent to which Darwin's Sexual Selection Theory could have predicted the findings and can help to interpret them. Study population was composed of men and women aged 18 to 60 years residents in the state of Rio de Janeiro between 2004 and 2010, and in the state of Rio Grande do Sul between 2001 and 2010. We built frequency distribution tables and drew bar charts in order to check whether there were differences between the sexes and interactions of sex with age. More men exposed themselves to and died in traffic than women, especially the young. Society should have an especially vigilant attitude towards men on the wheel due to their increased innate tendency to exposure to risk. Darwin's sexual selection theory can be an important ally when postulating hypotheses and interpreting epidemiological findings aiming at improving public policies to reduce the excessive number of traffic deaths, especially in societies where machismo is strong or the stimulus to masculinity is exaggerated.*

Key words *Accidents traffic, Motorcycles, Automobiles, Sex, Biological Evolution*

Resumo *Objetivamos averiguar diferenças entre homens e mulheres na exposição ao trânsito como motorista de carro e de moto e no risco de morrer por batida desses veículos, para verificar até que ponto a teoria da seleção sexual de Darwin pode predizer os achados e ajudar a interpretá-los. A população de estudo foi composta por homens e mulheres de 18 a 60 anos residentes no Estado do Rio de Janeiro, entre 2004 e 2010, e no Estado do Rio Grande do Sul, entre 2001 e 2010. Elaboramos tabelas de frequência e gráficos de barras para verificar se havia diferenças entre os sexos e interação de sexo com idade. Homens se expuseram e morreram mais no trânsito do que mulheres, especialmente os jovens. A sociedade deveria ter uma atitude especialmente vigilante com homens ao volante devido à tendência inata deles de maior exposição ao risco. A teoria da seleção sexual de Darwin pode ser uma potente aliada na postulação de hipóteses que busquem aperfeiçoar políticas públicas para reduzir a quantidade exagerada de mortes no trânsito, especialmente em sociedades onde o machismo for forte ou o estímulo à masculinidade exagerado.*

Palavras-chave *Acidentes de trânsito, Motocicletas, Automóveis, Sexo, Evolução biológica*

[1] Instituto de Medicina Social, Universidade do Estado do Rio de Janeiro. R. São Francisco Xavier 524/Pavilhão João Lyra Filho/7º andar/blocos D e E, Maracanã. 20550-013 Rio de Janeiro RJ Brasil. nadanovsky@ims.uerj.br
[2] Escola Nacional de Saúde Pública, Fundação Oswaldo Cruz. Rio de Janeiro RJ Brasil.

Introduction

Everywhere there are more traffic crash deaths among men, especially young, than women[1]. Despite the social, cultural and political explanations presented by gender and masculinities scholars, there is a gap regarding explanations for the origin, i.e. the ultimate cause, of these differences. An attempt to answer this ultimate cause question may point to risk factors, relevant interactions and effective interventions, scarcely or rarely contemplated up to now.

This study, differently from its predecessors[1], starts with a priori postulated hypotheses on how and why should the risk of dying in a traffic crash (TC) vary according to sex and age. The theoretical basis of our hypotheses, and interpretation of findings, is Darwin's Sexual Selection Theory applied to the study of human behavior, specifically, the "Young Male Syndrome", described ahead.

Risk factors (proximate causes)

The risk factors, or more proximate causes, of TC deaths include the amount or duration of trips, the mode of transport, the use of safety devices, the natural resistance of the individual and the possibilities of cure[2,3]. Human factors alone, such as reckless behavior, driver's mistakes and sleep at the wheel, are involved in more than 90% of TCs[4,5]. Drink and driving is one of the main causes of TCs[6-10]. An increase in speed is associated with both the probability of a crash occurring and of it being severe and the reduction of speed limits may reduce the rate of TCs[9-13]. The use of seat belts seems to be the more effective way of reducing fatal and non-fatal lesions[9,14].

Who dies in TCs?

Men, especially the young, are the main victims of TCs' death everywhere. Among the possible causes for this mortality predominance in young men is the reckless behavior in traffic in addition to an increased use of alcohol[1,8-10,15-19]. Another complementary hypothesis is simply that men drive more. However, even after controlling for distances driven, a large sex difference remains, and this difference depends on age[20,21]. In any case, increased exposure is also part of the explanation of why they die more.

So, how to explain this discrepancy? If men in fact take more risks by exposing themselves more to and in traffic, there must be a cause for this default behavior.

Darwin's Sexual Selection Theory

Throughout history, males have been subject to sexual selection through sexual courtship, fights and coercion more than females. This is especially true in mammals, including humans, in whom the demands for pregnancy and lactation reduce the maximum reproduction limit of females[22]. This evolutionary history generated different adaptations in males and females.

Under this perspective, evolutionary psychologists formulated a theory in which men are more prone to dangerous competition and, therefore, risk situations, than women and that this propensity was adaptive as it increased men's fitness (reproductive likelihood)[23].

The Young Male Syndrome

"Women are, therefore, from the point of view of sexual selection, a "resource" for which men compete. This competition not necessarily takes place as a direct fight for women. Men may adopt different strategies in this fight, competing for other resources that may be converted into reproductive opportunities, such as political influence and social status, for these resources are directly attractive for women or because they help pacify (or repel) rival men"[23].

Several lines of evidence support the conclusion that young men constitute a demographic class specialized by sexual selection for maximum competitive efforts and risk acceptance[24,25]. There is morphological and physiological evidence[26]. Young men seem to be psychologically specialized to embracing danger. In several activities, young men seem to be especially motivated by competition and less discouraged by danger than older men and women[27,28].

Driving and risky driving may not increase male fitness in the modern environment, but the psychological predispositions that lead modern men to drive more and drive riskily may have been adaptive for our ancestors. For example, overtaking by a man may trigger a risky driving reaction in modern young men and teenagers, who might feel humiliated in this situation. Male teenage drivers were less likely to wear seatbelt, more likely to drink and drive and to be involved in TC, when carrying passengers[29]. On the other hand, middle-aged men, when carrying passengers, especially a woman, were less likely to be involved in a fatal crash – either because in these circumstances they spontaneously drove more carefully in order to protect their women or be-

cause the women insisted that they drove more carefully[29].

To show off skills in the form of keen agility and reflexes while speeding may be an "honest" form of advertising value as a sexual partner to the opposite sex and as an able competitor to other men[30]. To exhibit a lack of fear of driving fast, to drive drunk or speaking on the phone could also be ways of advertising prowess even when handicapped[30].

Women revealed themselves to be more risk averse than men in several activities, including crime, gambling, sexual behavior and drugs and alcohol consumption[31].

Hypotheses and their rationale

If men are more competitive and, consequently, more prone to exhibit risky behavior than women, it is expected that they will expose themselves more to traffic as drivers and die more from TC, as these events are related to behaviors such as speeding, drinking and driving, not wearing a seatbelt, exhibitionism, and disrespecting traffic laws. Even when these reckless driving behaviors are not directly exhibited, as is the case for example with many professional drivers and motorcyclists, if driving everyday for long hours is a way of earning an income, more men than women will feel the pressure to earn resources at any price, including risking themselves in traffic for long hours. The individuals who drive a car or a motorcycle are taking risks, provoked either by themselves or by other drivers. If that is a price to pay for some comfort or convenience, it is expected no difference between men and women. However, if in addition to comfort and convenience driving a car or a motorcycle is a way of showing off personal skills, bravery or of earning resources such as an income, in a competition for sexual partners, more men than women will hold licenses to drive cars and especially motorcycles. Additionally, more male drivers will die from a TC, car or motorcycle, than female drivers.

If the main reason why a man competes and, consequently, risks himself, is to obtain sexual access to women (even if unconsciously), the psychological pressure to take risks should lessen, when he already has a woman and a child. There is a higher proportion of married men with children among older men so younger men should take more risks than the older. The younger are trying to obtain resources that older men already have and want to protect; to protect resources already obtained, it is better not to take many risks. Therefore, the difference between the sexes in the exposure to traffic (proportions that hold a license) especially as motorcyclists, and in TC death should be higher among the younger than the older.

Our aim was to assess differences between men and women in the likelihood of exposure to traffic as drivers of cars and motorcycles, and in the risk of dying from a car or a motorcycle crash, in order to verify the extent to which Darwin's Sexual Selection Theory could have predicted the findings and can help to interpret them.

Methods

Design, settings and population

We carried out an ecological study with annual sectional secondary data that included men and women aged 18 to 60 years, residents in the states of Rio de Janeiro, between 2004 and 2010, and Rio Grande do Sul, between 2001 and 2010.

Data

We collated data for car and motorcycle crash deaths, available at Mortality Information System (*SIM)*, from the *DATASUS* website (www.datasus.gov.br) in January 2012. We compiled the number of inhabitants in each state from the Brazilian Institute of Geography and Statistics (*IBGE*), available at this same website. Anyone visiting the *DATASUS* website can directly access the same data used for our study. The exact link to these data is: http://www2.datasus.gov.br/DATASUS/index.php?area=0205. We asked representatives from the 27 Traffic Departments (*DETRANS)* in Brazil (26 states in Brazil and its capital, Brasília), by e-mail and telephone, about the number of licensed car and motorcycle drivers, by age and sex. Only Rio de Janeiro (RJ) and Rio Grande do Sul (RS) provided these data by sex and age; they provided these data in electronic format, the spreadsheet *Excel*. We did not seek ethical approval because our research relied exclusively on publicly available information legally accessible to the public and appropriately protected by law through the data guardians, i.e., *DATASUS* and on secondary use of anonymous information provided by the *DETRANS* of Rio de Janeiro and of Rio Grande do Sul. These data are not individually identifiable and data linkage does not generate identifiable information. We received the data from *DETRANS* already in an

anonymous format; their representatives provided the data without any participant´s names or any other form of identification. These representatives from the *DETRANS* were civil servants who provided the data officially, and made sure that they were allowed to provide such data institutionally. The information collected from the *DETRANS´* representatives was not publicly available at the time of collection; all of this information is available in the tables of the present article.

Variables

The four outcome variables were:

- Death in a car crash. Driver or other occupant (International Classification of Disease - *ICD10*, V40 – V49);
- Death in a motorbike crash. Driver or other occupant (*ICD 10*, V20 – V29);
- License to drive only cars (*DETRAN*, category B);
- License to drive only bikes or bikes and other vehicles (*DETRAN*, categories A, AB, AC, AD and AE).

The two exposure variables were:

- Sex (men and women);
- Age group (18 to 30 and 31 to 60 years).

Data analysis

The data analyses rationale was to verify the association between sex and the outcomes considering a possible interaction with age. We elaborated frequency tables and bar charts.

We calculated the proportions of the licensed populations to drive car and motorcycle placing on the numerator the number of licensed drivers in the respective categories (*DETRAN* categories A and B) in RJ and RS, separated by sex and age group, between 2004 and 2010 in RJ and 2001 and 2010 in RS. We placed at the denominator the number of inhabitants in the same classes of sex and age in the referred states then multiplied this ratio by 100 to obtain the number of licensed drivers per 100 inhabitants.

The death to inhabitant ratio in car and motorbike crashes were calculated placing at the numerator the number of car deaths (*ICD 10*, V40 – V49) and of motorcycle deaths (*ICD 10*, V20 – V29), respectively, in RJ and RS, categorized by sex and age group, between 2004 and 2010 in RJ, and 2001 and 2010 in RS. We placed at the denominator the number of inhabitants in the same classes of sex and age in the referred states then multiplied this ratio by 100.000 to obtain the number of deaths per 100.000 inhabitants.

We calculated the death to licensed ratio in car and motorcycle crashes placing on the numerator the number of car deaths (*ICD 10*, V40 – V49) and of motorcycle deaths (*ICD 10*, V20 – V29), respectively, in RJ and RS, categorized by sex and age group, between 2004 and 2010 in RJ, and 2001 and 2010 in RS. At the denominator we placed the number of licensed drivers to drive only car (*DETRAN*, category B) and the number of licensed drivers to drive motorcycles (*DETRAN*, categories A, AB, AC, AD and AE), respectively, in the same classes of sex and age in the referred states. We multiplied these ratios by 10.000 to obtain the number of deaths per 10.000 licensed to drive only car, and to drive motorcycle.

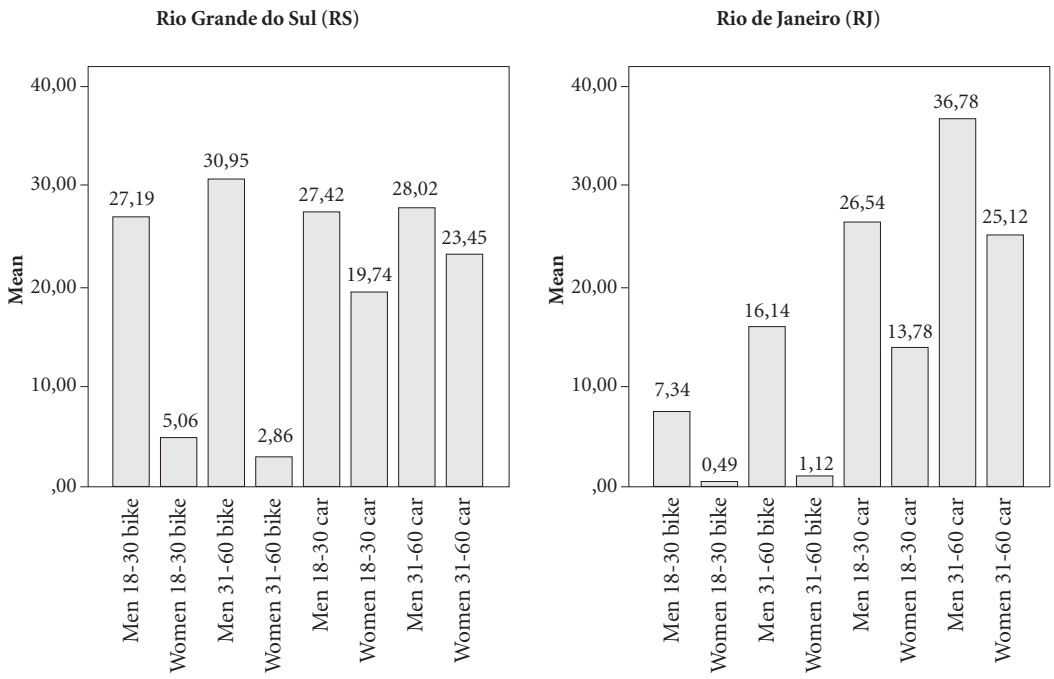
Results

The proportion of individuals licensed to drive a car in the population varied from 36.8% in 31 to 60 year-old men to 13.8% in 18 to 30 year-old women in RJ (annual average in the years analyzed). Regarding motorcycles, these proportions varied from 31% in 31 to 60 year-old men in RS to 0.5% in 18 to 30 year-old women in RJ. The most accentuated differences between the sexes were observed in relation to the proportions licensed to drive motorcycles in RS. The difference between the sexes in relation to license to drive cars was most pronounced in the 18 to 30 age group in RS while in RJ this difference was equivalent in both age groups. The difference between the sexes in relation to license to drive motorcycles was most pronounced in the 31 to 60 year-old age group in RJ while in RS this difference was equivalent in both age groups (Graphic 1, Table 1).

The risk of dying in a car crash in the population varied from 10.3 per 100.000 in 18 to 30 year-old men in RS to 1.6 per 100.000 in 31 to 60 year-old women in RJ (annual average in the years analyzed). In a motorcycle crash, this risk varied from 15.9% in 18 to 30 year-old men in RJ to 0.4% in 31 to 60 year-old women in RS. The difference between the sexes was more pronounced in relation to motorcycle than car deaths. Either regarding car or motorcycle deaths the difference between the sexes was larger in the 18 to 30 year-olds (Graphic 2 and Graphic 3, Table 2).

The risk of dying in a car crash in relation to the number of individuals licensed to drive cars varied from 3.8 per 10.000 in 18 to 30 year-old

Ciência & Saúde Coletiva, 21(12):3691-3702, 2016



Graphic 1. Proportions (%)* of the population licensed to drive motorcycle and car, according to sex and age-group, in the states of Rio Grande do Sul and of Rio de Janeiro.

* Annual averages for the period 2001-2010 in RS and 2004-2010 in RJ, based on Table 1.

men in RS to 0.6 per 10.000 in 31 to 60 year-old women in RJ (annual average in the years analyzed). In a motorcycle crash this risk varied from 38.3 in 18 to 30 year-old women in RJ to 1.3 in 31 to 60 year-old women in RS. In RJ, the risk of dying in a motorcycle crash in relation to the number of individuals of the same sex and ages licensed to drive a motorcycle was higher among women than men in both age groups. The difference between the sexes was more pronounced in relation to motorcycle than car deaths. Either regarding car or motorcycle deaths the difference between the sexes was larger in the 18 to 30 year-olds (Graphic 2 and Graphic 3, Table 2).

Discussion

Driving seems to be a very risky activity in the two Brazilian states analyzed, but it was not uniformly distributed in these populations. Greater proportions of men than women had license to drive cars. In relation to license to drive motorcycles, a riskier activity, the proportions of men were markedly greater. The risk of dying in a car or motorcycle crash in the population followed the same pattern of the proportions licensed to drive; much higher risks among men than among women and more accentuated differences between the sexes in the younger age group, especially in relation to death in a motorcycle. Part of this greater risk of dying in TC among men may be, simply, due to greater exposure to traffic (greater proportions of men licensed to drive). For this reason, we thought useful to verify whether beyond this increased risk due to greater exposure, the risk, considering the level of exposure, that is, in relation to the number licensed to drive, would still be higher among men. Again, we found that the risk of dying in a TC, considering the number licensed to drive, was higher among men. Therefore, the increased risk of death among men was not only a consequence of more men being drivers, but also of men´s behavior while driving. However, there were two exceptions in these ratios: men and women aged

Table 1. Population, number licensed to drive and proportion of the population licensed to drive motorcycle and car, according to sex and age-group, in Rio de Janeiro between 2004 and 2010, and in Rio Grande do Sul between 2001 and 2010.

Year	Men motorcycle Rio de Janeiro						Women motorcycle Rio de Janeiro					
	Population Age-group		Licensed Age-group		Proportion % Age-group		Population Age-group		Licensed Age-group		Proportion % Age-group	
	18-29	30-59	18-30	31-60	18-30	31-60	18-29	30-59	18-30	31-60	18-30	31-60
2004	1551333	2673560	110305	407008	7.11	15.22	1605809	3013469	5882	31439	0.37	1.04
2005	1587930	2735515	109871	408115	6.92	14.92	1643480	3081615	5841	31531	0.36	1.02
2006	1606565	2767061	100522	446002	6.26	16.12	1662671	3116323	5637	33954	0.34	1.09
2007	1568507	2925256	106879	464815	6.81	15.89	1605364	3311509	6526	35654	0.41	1.08
2008	1563093	2980047	116370	487353	7.44	16.35	1596274	3369890	7982	37940	0.50	1.13
2009	1558132	3036901	127426	513652	8.18	16.91	1588017	3431325	10252	41353	0.65	1.21
2010	1560945	3099097	135145	543827	8.66	17.55	1603280	3487173	12703	45182	0.79	1.30

Year	Men motorcycle Rio Grande do Sul						Women motorcycle Rio Grande do Sul					
	Population Age-group		Licensed Age-group		Proportion % Age-group		Population Age-group		Licensed Age-group		Proportion % Age-group	
	18-29	30-59	18-30	31-60	18-30	31-60	18-29	30-59	18-30	31-60	18-30	31-60
2001	1022989	1908220	217530	515585	21.26	27.02	1016076	2015269	18971	39932	1.87	1.98
2002	1033194	1926346	225801	542053	21.85	28.14	1026265	2034536	22418	43163	2.18	2.12
2003	1043867	1945136	239722	569609	22.96	29.28	1036887	2054582	27489	46825	2.65	2.28
2004	1054436	1963903	256184	584041	24.30	29.74	1047512	2074539	34275	50552	3.27	2.44
2005	1078495	2006511	274475	608172	25.45	30.31	1071560	2119832	42425	54869	3.96	2.59
2006	1090781	2028180	293275	633190	26.89	31.22	1083825	2142924	52535	60197	4.85	2.81
2007	1146729	2118289	319752	662110	27.88	31.26	1120978	2240963	64641	66855	5.77	2.98
2008	1121077	2092021	352120	691456	31.41	33.05	1093569	2210067	79195	74884	7.24	3.39
2009	1124165	2119853	374290	721404	33.29	34.03	1094994	2237629	95422	85171	8.71	3.81
2010	1056207	2116746	386877	750392	36.63	35.45	1052768	2247440	106113	95251	10.08	4.24

Year	Men car Rio de Janeiro						Women car Rio de Janeiro					
	Population Age-group		Licensed Age-group		Proportion % Age-group		Population Age-group		Licensed Age-group		Proportion % Age-group	
	18-29	30-59	18-30	31-60	18-30	31-60	18-29	30-59	18-30	31-60	18-30	31-60
2004	1551333	2673560	451924	974910	29.13	36.46	1605809	3013469	231793	754569	14.43	25.04
2005	1587930	2735515	452501	977121	28.50	35.72	1643480	3081615	232343	756242	14.14	24.54
2006	1606565	2767061	420202	1041432	26.16	37.64	1662671	3116323	214195	794047	12.88	25.48
2007	1568507	2925256	411594	1069016	26.24	36.54	1605364	3311509	215333	817032	13.41	24.67
2008	1563093	2980047	404433	1095043	25.87	36.75	1596274	3369890	217907	840895	13.65	24.95
2009	1558132	3036901	398518	1124778	25.58	37.04	1588017	3431325	224476	870143	14.14	25.36
2010	1560945	3099097	379864	1157022	24.34	37.33	1603280	3487173	221419	900502	13.81	25.82

Year	Men car Rio de Janeiro						Women car Rio de Janeiro					
	Population Age-group		Licensed Age-group		Proportion % Age-group		Population Age-group		Licensed Age-group		Proportion % Age-group	
	18-29	30-59	18-30	31-60	18-30	31-60	18-29	30-59	18-30	31-60	18-30	31-60
2001	1022989	1908220	277762	536288	27.15	28.10	1016076	2015269	177145	414885	17.43	20.59
2002	1033194	1926346	293375	545508	28.39	28.32	1026265	2034536	188986	435461	18.41	21.40
2003	1043867	1945136	301117	554690	28.85	28.52	1036887	2054582	198101	455926	19.11	22.19
2004	1054436	1963903	305602	551757	28.98	28.09	1047512	2074539	205839	471464	19.65	22.73
2005	1078495	2006511	305011	560020	28.28	27.91	1071560	2119832	209714	489036	19.57	23.07
2006	1090781	2028180	301043	567248	27.60	27.97	1083825	2142924	212898	506557	19.64	23.64
2007	1146729	2118289	296870	575376	25.89	27.16	1120978	2240963	216242	526062	19.29	23.47
2008	1121077	2092021	293131	582813	26.15	27.86	1093569	2210067	222997	548530	20.39	24.82
2009	1124165	2119853	290963	592541	25.88	27.95	1094994	2237629	234817	577220	21.44	25.80
2010	1056207	2116746	285912	600365	27.07	28.36	1052768	2247440	236673	601681	22.48	26.77

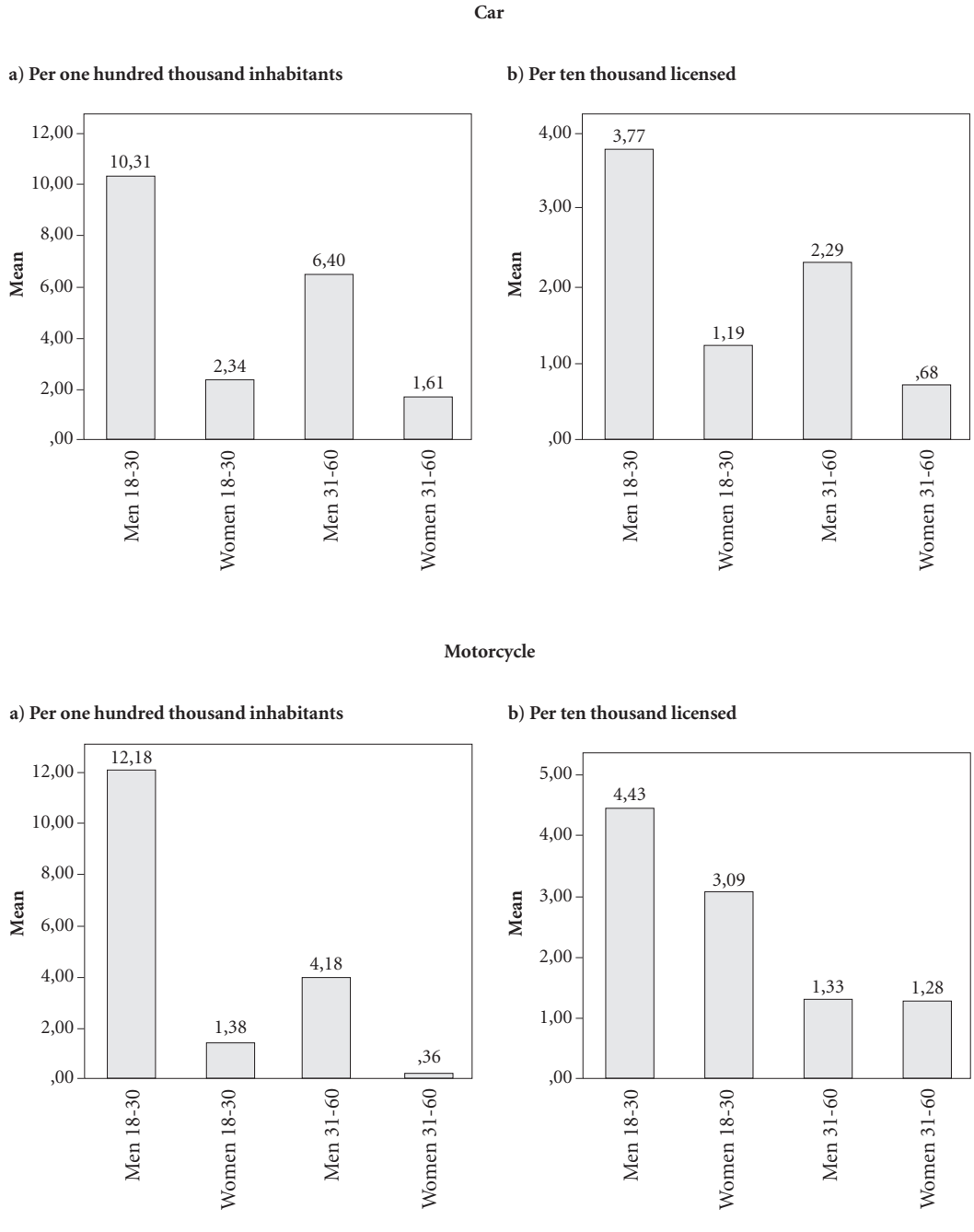
Table 2. Number of deaths and ratios of the number of deaths per ten thousand licensed to drive (a) and per one hundred thousand inhabitants (b) according to type of vehicle, sex and age-group in Rio de Janeiro between 2004 and 2010 and in Rio Grande do Sul between 2001 and 2010.

Year	Men car State of Rio Grande do Sul						Women car State of Rio Grande do Sul					
	Deaths Age-group		Ratios Age-group				Deaths Age-group		Ratios Age-group			
	18-30	31-60	18-30 a	18-30 b	31-60 a	31-60 b	18-30	31-60	18-30 a	18-30 b	31-60 a	31-60 b
2001	82	101	2.95	8.02	1.88	5.29	20	25	1.13	1.97	0.60	1.24
2002	96	113	3.27	9.29	2.07	5.87	30	38	1.59	2.92	0.87	1.87
2003	113	117	3.75	10.83	2.11	6.02	31	36	1.56	2.99	0.79	1.75
2004	110	131	3.60	10.43	2.37	6.67	20	31	0.97	1.91	0.66	1.49
2005	115	128	3.77	10.66	2.29	6.38	22	33	1.05	2.05	0.67	1.56
2006	105	132	3.49	9.63	2.33	6.51	24	25	1.13	2.21	0.49	1.17
2007	112	137	3.77	9.77	2.38	6.47	20	23	0.92	1.78	0.44	1.03
2008	117	127	3.99	10.44	2.18	6.07	29	38	1.30	2.65	0.69	1.72
2009	124	153	4.26	11.03	2.58	7.22	25	37	1.06	2.28	0.64	1.65
2010	137	160	4.79	12.97	2.67	7.56	28	58	1.18	2.66	0.96	2.58

Year	Men motorcycle State of Rio Grande do Sul						Women motorcycle State of Rio Grande do Sul					
	Deaths Age-group		Ratios Age-group				Deaths Age-group		Ratios Age-group			
	18-30	31-60	18-30 a	18-30 b	31-60 a	31-60 b	18-30	31-60	18-30 a	18-30 b	31-60 a	31-60 b
2001	78	36	3.59	7.62	0.70	1.89	5	4	2.64	0.49	1.00	0.20
2002	85	59	3.76	8.23	1.09	3.06	14	7	6.24	1.36	1.62	0.34
2003	104	51	4.34	9.96	0.90	2.62	13	5	4.73	1.25	1.07	0.24
2004	119	97	4.65	11.29	1.66	4.94	11	4	3.21	1.05	0.79	0.19
2005	131	82	4.77	12.15	1.35	4.09	9	7	2.12	0.84	1.28	0.33
2006	140	102	4.77	12.83	1.61	5.03	12	13	2.28	1.11	2.16	0.61
2007	144	99	4.50	12.56	1.50	4.67	13	15	2.01	1.16	2.24	0.67
2008	147	104	4.17	13.11	1.50	4.97	27	2	3.41	2.47	0.27	0.09
2009	185	104	4.94	16.46	1.44	4.91	17	11	1.78	1.55	1.29	0.49
2010	186	120	4.81	17.61	1.60	5.67	26	10	2.45	2.47	1.05	0.44

Year	Men car State of Rio de Janeiro						Women car State of Rio de Janeiro					
	Deaths Age-group		Ratios Age-group				Deaths Age-group		Ratios Age-group			
	18-30	31-60	18-30 a	18-30 b	31-60 a	31-60 b	18-30	31-60	18-30 a	18-30 b	31-60 a	31-60 b
2004	141	210	3.12	9.09	2.15	7.85	40	67	1.73	2.49	0.89	2.22
2005	180	223	3.98	11.34	2.28	8.15	41	63	1.76	2.49	0.83	2.04
2006	169	192	4.02	10.52	1.84	6.94	51	48	2.38	3.07	0.60	1.54
2007	148	207	3.60	9.44	1.94	7.08	48	63	2.23	2.99	0.77	1.90
2008	113	172	2.79	7.23	1.57	5.77	34	47	1.56	2.13	0.56	1.39
2009	93	120	2.33	5.97	1.07	3.95	27	43	1.20	1.70	0.49	1.25
2010	97	135	2.55	6.21	1.17	4.36	33	28	1.49	2.06	0.31	0.80

Year	Men motorcycle State of Rio de Janeiro						Women motorcycle State of Rio de Janeiro					
	Deaths Age-group		Ratios Age-group				Deaths Age-group		Ratios Age-group			
	18-30	31-60	18-30 a	18-30 b	31-60 a	31-60 b	18-30	31-60	18-30 a	18-30 b	31-60 a	31-60 b
2004	167	109	15.14	10.76	2.68	4.08	15	6	25.50	0.93	1.91	0.20
2005	209	118	19.02	13.16	2.89	4.31	20	13	34.24	1.22	4.12	0.42
2006	286	140	28.45	17.80	3.14	5.06	32	14	56.77	1.92	4.12	0.45
2007	269	154	25.17	17.15	3.31	5.26	35	21	53.63	2.18	5.89	0.63
2008	306	178	26.30	19.58	3.65	5.97	38	18	47.61	2.38	4.74	0.53
2009	278	171	21.82	17.84	3.33	5.63	21	18	20.48	1.32	4.35	0.52
2010	231	168	17.09	14.80	3.09	5.42	38	21	29.91	2.37	4.65	0.60



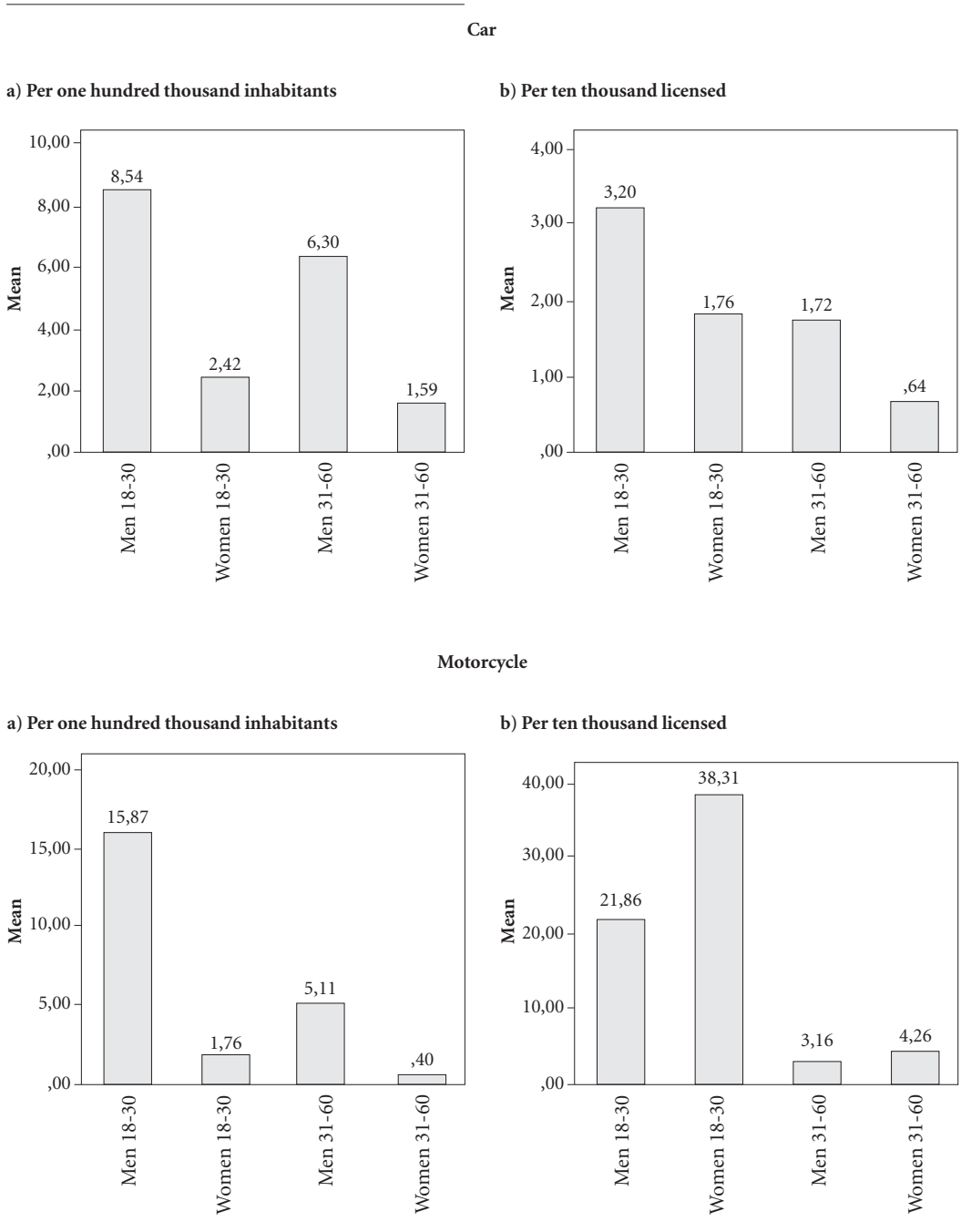
Graphic 2. Ratios* of deaths per one hundred thousand inhabitants (a) and per ten thousand licensed to drive (b) in car and motorcycle crashes in the state of Rio Grande do Sul (RS) according to sex and age-group.

* Annual averages for the period 2001-2010, based on Table 2.

31 to 60 in Rio Grande do Sul presented similar risks of dying in a motorcycle crash, and women in Rio de Janeiro, especially the younger, showed a much higher risk of dying in a motorcycle crash than men in the same State.

The first exception was not a surprise, on the contrary, it was in the expected direction and reinforced the thesis that older men are less competitive and ostentatious of their skills than younger men, therefore, present a more prudent

Ciência & Saúde Coletiva, 21(12):3691-3702, 2016



Graphic 3. Ratios* of deaths per one hundred thousand inhabitants (a) and per ten thousand licensed to drive (b) in car and motorcycle crashes in the state of Rio de Janeiro (RJ) according to sex and age-group.

* Annual averages for the period 2004-2010, based on Table 2.

behavior profile, more similar to women. However, the second finding was surprising, apparently refuting the hypothesis that men are more reckless in traffic than women are and, for that, run higher risk of dying.

Therefore, we observed a strong congruency of the findings and the postulated hypothesis; nearly all comparisons suggested that men took more risks than women did, especially the young. However, according to the number licensed to

drive a motorcycle, women died more frequently than men in Rio de Janeiro. How could we explain this unexpected finding that apparently refuted the postulated hypothesis?

One possibility is that the women in Rio de Janeiro died often not as conductors, but as passengers on the motorcycles; as the number of female registered motorcyclists was very small in Rio, every death of a woman as a passenger in a motorcycle would have a strong artifact influence on this death per registered driver ratio. Another possibility is that women motorcyclists in Rio composed a special group, with higher propensity to risk; traffic in Rio was knowingly so deadly for motorcyclists that only a special few would dare to face it driving a motorcycle (the very small proportion of women licensed to drive motorcycles in Rio reinforces this suspicion). A third possibility is that women, in general, appear to have less spatial abilities than men[32], and this skill could be crucial to avoid motorcycle crashes in such difficult driving circumstances as the aggressive traffic in Rio.

One important limitation in our study was that the mortality data did not differentiate conductors from passengers. Therefore, there may be cases in which the conductor was a man, but a woman was a victim as passenger in the car or on the motorcycle and vice-versa. As in the Brazilian culture it is the man who usually drives the vehicle, we presume that it should have been uncommon the situation in which the woman was the driver and the man the victim as a passenger. On the other hand, the inverse should not have been such an uncommon situation; that is, the man driving and the woman being the victim as a passenger. If these assumptions are correct, the deaths of female drivers (based on the number of women licensed to drive) were overestimated in our study.

Another limitation was the small geographical coverage of the data. We tried to obtain data from the 26 States in Brazil and its capital, Brasília, however only Rio de Janeiro and Rio Grande do Sul provided appropriate data. As we did not aim at comparing States or infer about the situation in Brazil as a whole, the analysis, in two States appears to be adequate. Obviously, it is advisable to test this hypothesis in a larger number of populations for it is likely that populations` differences may reveal important interactions.

One advantage of our study was that we obtained information about the number of licensed drivers by age and sex. This made it possible to compare men and women regarding the level of exposure to traffic as drivers and to create an indicator of traffic deaths placing the number of licensed drivers in the denominator.

Implications for public policies

There are important differences related to the risk of dying and killing in traffic, mainly by sex. Therefore, it may be appropriate to treat these groups differently, especially in societies where machismo is strong[23,33]. Preventive strategies to reduce deaths in traffic should contemplate, mainly, universal measures directed towards the whole population[34,35], such as to reduce the level of corruption in traffic[29] and of impunity in general[36-38], but also, measures directed at specific groups, where risk is increased. Some ideas are the following:

- Training, using cognitive-behavioral techniques, to enable men to avoid aggressive and reckless behavior in traffic, derived from situations in which they take as insults to their masculinity and honor or as opportunities for maleness exhibitionism[39]. Obviously, before instituting this kind of training it is necessary to carry out interventional cost-effectiveness studies;

- Monitoring men's traffic history to apply restrictive sanctions to those who have dangerously broken traffic laws, such as speeding, risky overtaking and tailgating;

- Informing men and women about the risk they take exposing themselves in motorcycles in societies where traffic is highly dangerous, as it was the case in Rio de Janeiro in this study.

Obviously, these are exploratory ideas aiming at initiating a debate and not ready to take prescriptions.

Conclusion

Our central argument is that drivers and aspiring drivers of the male sex compose a special group, whom society should treat differently in order to cease traffic deaths from being a routine and become sporadic in Brazil and in other countries with similar or higher traffic death rates. Society should have an especially vigilant attitude towards men on the wheel in these countries.

Darwin's sexual selection theory may be a potent ally in postulating hypotheses and interpreting findings that aim at improving public policies to reduce the excessive number of traffic deaths, especially in countries such as Brazil and others where there is accentuated machismo.

Collaborations

ALS Medeiros and P Nadanovsky contributed equally to all stages of this study and to the elaboration of the paper.

References

1. World Health Organization (WHO). *Global Status Report on Road Safety: supporting a decade of action*. Luxembourg: WHO; 2013.
2. Martin JL, Lafont S, Chiron M, Gadegbeku B, Laumon B. Differences between males and females in traffic accident risk in France. *Rev Epidemiol Sante Publique* 2004; 52(4):357-367.
3. Bouaoun L, Haddak MM, Amoros E. Road crash fatality rates in France: A comparison of road user types, taking account of travel practices. *Accid Anal Prev* 2015; 75:217-225.
4. Evans L. The dominant role of driver behavior in traffic safety. *Am J Public Health* 1996; 86(6):784-786.
5. Petridou E, Moustaki M. Human factors in the causation of road traffic crashes. *Eur J Epidemiol* 2000; 16(9):819-826.
6. Koizumi MS, Leyton V, Carvalho DG, Coelho CA, Mello Jorge MHP, Gianvecchio V, Gawryzewski VP, Godoy CD, Sinagawa DM, Araújo GL, Muñoz DR. Alcoolemia e mortalidade por acidentes de trânsito no Município de São Paulo, 2007/2008. *Revista ABRAMET* 2010; 28(1):25-34.
7. Ramstedt M. Alcohol and fatal accidents in the United States - A time series analysis for 1950-2002. *Accid Anal Prev* 2008; 40(4):1273-1281.
8. World Health Organization (WHO). *World report on road traffic injury prevention*. Geneva: WHO; 2004.
9. World Health Organization (WHO). *Global status report on road safety 2013: supporting a decade of action.* Geneva: WHO; 2013.
10. Saldanha RF, Pechansky F, Benzano D, Barros CASM, Boni RB. Differences between attendance in emergency care of male and female victims of traffic accidents in Porto Alegre, Rio Grande do Sul State, Brazil. *Cien Saude Colet* 2014; 19(9):3925-3929.
11. Aarts L, van Schagen I. Driving speed and the risk of road crashes: A review. *Accid Anal Prev* 2006; 38(2):215-224.
12. Chris G, Rebecca S, Phil E, Judith G, Ben A, Paul W. Effect of 20 mph traffic speed zones on road injuries in London, 1986-2006: controlled interrupted time series analysis. *BMJ* 2009; 339:b4469.
13. World Health Organization (WHO). *Global status report on road safety: time for action*. Geneva: WHO; 2009.
14. Dinh-Zarr TB, Sleet DA, Shults RA, Zaza S, Elder RW, Nichols JL, Thompson RS, Sosin DM. Task Force on Community Preventive Services. Reviews of evidence regarding interventions to increase the use of safety belts. *Am J Prev Med* 2001; 21(Supl. 4):48-65.
15. Andrade SM, Jorge M. Victims' characteristics by road accidents in a city of Southern Brazil. *Rev Saude Publica* 2000; 34(2):149-156.
16. Ho R, Gee RY. Young men driving dangerously: Development of the Motives for Dangerous Driving Scale (MDDS). *Australian Journal of Psychology* 2008; 60(2):91-100.
17. Brasil. Ministério da Saúde (MS). *Mortalidade por acidentes de transporte terrestre no Brasil*. Brasília: MS; 2007.
18. Tavris DR, Kuhn EM, Layde PM. Age and gender patterns in motor vehicle crash injuries: importance of type of crash and occupant role. *Accid Anal Prev* 2001; 33(2):167-172.

19. Vasconcellos E. Urban development and traffic accidents in Brazil. *Accid Anal Prev* 1999; 31(4):319-328.
20. Massie DL, Campbell KL, Williams AF. Traffic accident involvement rates by driver age and gender. *Accid Anal Prev* 1995; 27(1):73-87.
21. Massie DL, Green PE, Campbell KL. Crash involvement rates by driver gender and the role of average annual mileage. *Accid Anal Prev* 1997; 29(5):675-685.
22. Jones D. Evolutionary Psychology. *Annual Review of Anthropology* 1999; 28:553-575.
23. Wilson M, Daly M. Competitiveness, risk-taking, and violence - The young male syndrome. *Ethology and Sociobiology* 1985; 6(1):59-73.
24. Baker Junior MD, Maner JK. Risk-taking as a situationally sensitive male mating strategy. *Evolution and Human Behavior* 2008; 29(6):391-395.
25. Byrnes J, Miller D, Schafer W. Gender Differences in Risk Taking: A Meta-Analysis. *Psychol Bull* 1999; 125(3):367-383.
26. Daly M, Wilson M. Killing the competition. *Human Nature* 1990; 1(1):81-107.
27. Bell NJ, Bell RW. *Adolescent risk taking*. Newbury Park, CA: Sage; 1993.
28. Gove W. *The effect of age and gender on deviant behaviour: A biopsychosocial perspective.* New York: Aldine; 1985.
29. Vanderbilt T. *Traffic: why we drive the way we do (and what it says about us)*. New York: Vintage Books; 2008.
30. Zahavi A. Mate selection – a selection for a handicap. *J Theor Biol* 1975; 53(1):205-214.
31. Harrant V, Vaillant NG. Are women less risk averse than men? The effect of impending death on risk-taking behavior. *Evolution and Human Behavior* 2008; 29(6):396-401.
32. Voyer D, Voyer S, Bryden MP. Magnitude of Sex Differences in Spatial Abilities: A Meta-Analysis and Consideration of Critical Variables. *Psychol Bull* 1995; 117(2):250-270.
33. Daly M, Wilson M. Darwinism and the roots of machismo. *Sci Am* 1999; 10:8-14.
34. Staton C, Vissoci J, Gong E, Toomey N, Wafula R, Abdelgadir J, Zhou Y, Liu C, Pei F, Zick B, Ratliff C, Rotich C, Jadue N, Andrade L, Isenburg M, Hocker M. Road Traffic Injury Prevention Initiatives: A Systematic Review and Metasummary of Effectiveness in Low and Middle Income Countries. *Plos One* 2016; 11:1-15 e0144971.
35. Maffei de Andrade S, Soares DA, Matsuo T, Barrancos Liberatti CL, Hiromi Iwakura ML. Road injury-related mortality in a medium-sized Brazilian city after some preventive interventions. *Traffic Inj Prev* 2008; 9(5):450-455.
36. Castillo-Manzano J, Castro-Nuño M, Fageda X. Are traffic violators criminals? Searching for answers in the experiences of European countries. *Transport Policy* 2015; 38:86-94.
37. Nadanovsky P, Celeste RK, Wilson M, Daly M. Homicide and impunity: an ecological analysis at state level in Brazil. *Rev Saude Publica* 2009; 43(5):733-742.
38. Nadanovsky P, Cunha-Cruz J. The relative contribution of income inequality and imprisonment to the variation in homicide rates among Developed (OECD), South and Central American Countries. *Soc Sci Med* 2009; 69(9):1343-1350.
39. Cohen D, Nisbett RE, Bowdle BF, Schwarz N. Insult, Aggression, and the Southern Culture of Honor: An "Experimental Ethnography". *J Pers Soc Psychol* 1996; 70(5):945-960.

Artigo apresentado em 29/10/2015
Aprovado em 15/04/2016
Versão final apresentada em 17/04/2016