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Educational inequalities in traffic deaths during fluctuations of the economy in four Argentinian provinces, 1999–2013

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ABSTRACT

Objectives: The objective of this study is to analyse how educational differentials in traffic mortality changed during economic fluctuations in four Argentinian provinces.

Study design: Retrospective quantitative analysis of secondary data.

Methods: Data on fatalities due to traffic injuries (all traffic injuries, pedestrians/cyclists, motorcyclists, car users and unspecified road users) in four Argentinian provinces between 1999 and 2013 were linked to population data and information on the educational level of the deceased to compute mortality rates by educational level. Negative binomial models were estimated using age, sex, year, province of residence, year of economic expansion or recession and educational level as explanatory variables.

Results: Annual traffic mortality differentials by educational level were lower during the period of economic crisis. An absolute increase in traffic mortality was observed in individuals of low educational level during economic expansions, but here, there were no traffic mortality differences for individuals of medium to high educational level. The educational gap in motorcyclist mortality widened during the period of quick economic expansion between 2005 and 2013.

Conclusions: We found less educational inequality in traffic mortality during an economic crisis in a developing country. However, the educational inequalities for different subtypes of traffic mortality show different patterns of evolution during the cycle of economic expansion and recession. Considering deaths due to traffic injuries, economic growth seems to be riskier for individuals of lower educational level compared with those of medium-high educational level.

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Introduction

The evolution of socio-economic inequalities in mortality during economic fluctuations has been rarely investigated, and the few studies that do exist^{1–7} have yielded inconsistent results. Furthermore, all these studies come from high-income countries, and almost nothing is known about how changes in the economy impact educational inequalities in mortality in low- or middle-income countries.

In high-income countries, traffic mortality has a socio-economic gradient, in that the lower the socio-economic level of the individual, the higher the chances of suffering a traffic injury or being killed.^{8,9} Only a few studies^{10–12} have investigated this relationship for specific types of road users. To our knowledge, there is only one study that analyses the temporal variations of mortality in child occupants of motor vehicles in developing countries.¹³

Deaths due to unintentional injuries and violence are the main cause of potential years of life lost in Latin America.¹⁴ Injuries are the fifth most common cause of death in Argentina, and traffic injuries and suicide together cause most of the deaths due to injury.¹⁵ For these reasons, this study investigates the changes in traffic mortality during macroeconomic fluctuations and how these changes impact educational inequalities in mortality of different road users.

Between 1998 and 2002, Argentina suffered one of the worst recessions registered in recent decades. In the four-year period 1999–2002, Argentina's gross domestic product (GDP) contracted every year, while unemployment rose to reach almost 20% of the economically active population.¹⁶ After this crisis, the country had an annual GDP growth of between 7% and 8% during the period 2003–2007, while the unemployment rate fell to reach 7% in 2013.¹⁷ During the economic recovery, there was a steep increase in sales of automobiles and motorcycles (Fig. 1).^{18–20}

It is to be expected that abrupt macroeconomic changes are associated with changes in the patterns of use of different types of transportation. Studies carried out in European countries found the following: (i) an increase in the use of public transport during periods of increased unemployment;²¹

(ii) a lower decrease in the use of public transport compared with the use of automobiles;²² and (iii) an increase in the use of buses and trains and a decrease in the use of private motorised transport.²³ These studies did not analyse the transportation changes in relation to different socio-economic level. A study conducted in Brisbane, Australia, found that among individuals who were unemployed or of low income level, there was a decrease in travel activity and a greater likelihood of changing modes of transport in favour of public transport during the world financial crisis of 2008.²⁴

Research on these issues has been very rare in developing countries. A study carried out in Chennai, India, found an increase in motorisation with economic growth, which was a result of non-motorised individuals and public transport users acquiring motorcycles and motorcycle users acquiring cars.²⁵ In Argentina, a recent survey showed a decrease in the use of public transport and an increase in active transport (i.e. pedestrians and bicycle users) due to the increase in public transport fares and rising unemployment.²⁶ These variations in travel patterns according to socio-economic level and in response to macroeconomic changes can also be reflected in the mortality inequalities by educational level of different types of road users.

In low- and middle-income countries, a high proportion of traffic deaths corresponds to vulnerable road users (e.g. pedestrians and bicycle and motorcycle riders).²⁷ This suggests that increasing sales of motorcycles may be associated with increasing traffic mortality of individuals of low socio-economic status, because this is the population who most frequently ride motorcycles as their mode of transportation.

This investigation started with two hypotheses. First, individuals of lower educational level have an increased risk of traffic mortality. Second, that educational inequality in traffic mortality varies through economic fluctuations. Our results are consistent with both hypotheses.

Methods

Deaths by age, sex, province of residence and educational level for the period 1999–2013 were obtained from vital

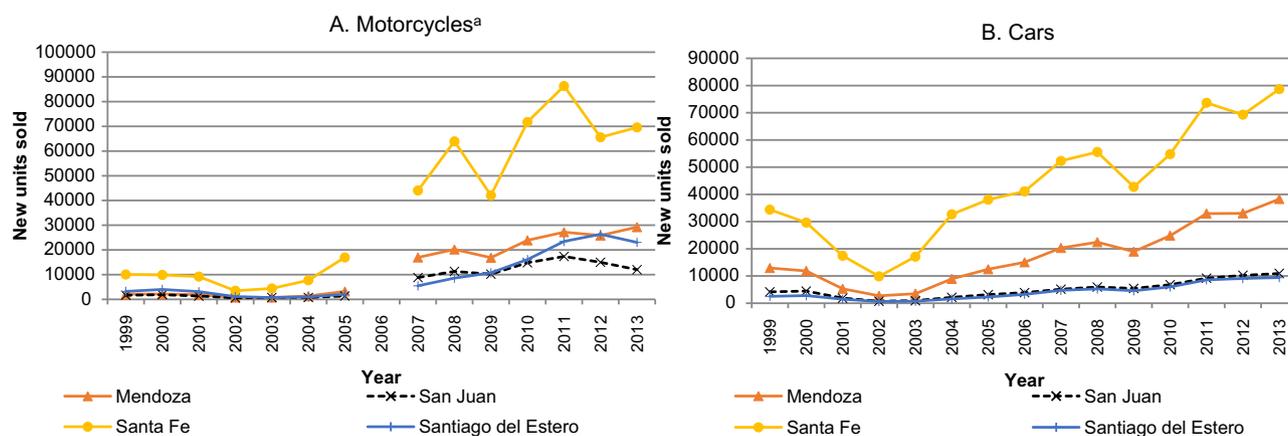


Fig. 1 – Sales of new motorcycles^a and cars in the provinces of Mendoza, San Juan, Santa Fe and Santiago del Estero. ^aNo data were available for 2006.

statistics of the Argentinian Ministry of Health (Directorate of Health Statistics and Information). For the investigation, we included deaths due to traffic injuries according to the following International Statistical Classification of Diseases and Related Health Problems (ICD)-10 codes (the number in square brackets is the 3rd digit of the ICD-10 code): V01-06 [1] and V09 [2 to 3] (pedestrians); V10–V18 [3 to 5, 9] and V19 [4 to 6, 9] (bicycle riders); V20–28 [3 to 5, 9] and V29 [4 to 6, 9] (motorcycles riders); V40–48 [4 to 7, 9] and V49 [4 to 6, 9] (car occupants); V87 [0 to 9] and V89 [2 to 3, 9] (unspecified road users). Because small numbers, the deaths of pedestrians and bicycle riders were analysed together.

Age was included as a categorical variable (25–34, 35–44, 45–54, 55–64 and ≥ 65 years) in the regression models. The educational level was categorised as low for individuals with less than complete secondary school, medium for individuals with complete secondary school and high when education included at least some higher education. Because small numbers, the categories of medium and high educational level were analysed together.

Provinces were selected for investigation if $\geq 80\%$ of the annual average data on traffic mortalities contained information on educational level of the deceased, during the period 1999–2013. Four provinces, Mendoza, San Juan, Santa Fe and Santiago del Estero, met this criterion. Additional information on the distribution of deaths without educational level data by province, year, sex, age groups and type of death can be found in [Table S1](#) (see online supplementary material). Population by age, sex and educational level was estimated for each year between 1999 and 2013 by a linear projection using census data from 2001 and 2010.²⁸ With a total population of 6.5 million, corresponding to 16% of the population of Argentina (2010 population census), Mendoza, San Juan, Santa Fe and Santiago del Estero produced 13% of the Argentinian GDP in 2005.

In the period 1999–2013, sales of new motorcycles ([Fig. 1](#), panel A) and cars ([Fig. 1](#), panel B) in the four provinces followed the condition of the economy. Motorcycle sales decreased in the years of economic crisis around the turn of the century and then significantly increased until 2008 (no data available for 2006) and subsequently oscillated. Steep declines in sales of both motorcycles and cars during the crisis of 1999–2002 and the recession of 2008–2009 are observed in the provinces of Santa Fe and Mendoza, where previous sales of motor vehicles had been much higher.

To test the relation between educational level and mortality caused by traffic-related injuries, we used negative binomial regression models. In the right-hand side of the regression equations, we used sex, age, educational level, province of residence and year as explanatory variables. Although Poisson models could be appropriate for this kind of analysis, these were not used because of overdispersion in the data.²⁹

For each cause of death, a second model was calculated, including an interaction between year and educational level, to estimate the differential evolution of mortality rates by educational level. To test the robustness of the results to the completeness of data, all models were recalculated excluding those years in which missing data on educational level were over 20% of the total of cases of each cause of death (see [Table S2](#) in the online supplementary material).

We calculated mortality ratios to compare the mortality rates of populations of low educational level with populations of medium-high educational level. The temporal variation of mortality rates and mortality ratios by cause and educational level was estimated as marginal predicted rates obtained from negative binomial models that included all the explanatory variables and a term for the interaction between year and educational level.

Finally, a dichotomous variable indicating whether the year is one of economic expansion (annual positive change in GDP) or recession (null or negative change) was incorporated into a third regression model. Similar to the second model, an interaction term was included between this variable and the educational level to compare mortality rates and mortality ratios by cause and educational level between years of economic expansion and recession. During the period 1999–2013, the years of economic recession were 1999–2002 and 2009; all the other years experienced economic expansion.¹⁷ Owing to the presence of collinearity, the year variable was excluded from this model. Data were analysed using Stata version 13.1 (StataCorp, College Station, TX).

Results

We analysed a total of 9335 deaths due to transportation injury; of which, 2660 correspond to car occupants, 1480 to motorcyclists, 2050 to pedestrians or cyclists, 2642 to unspecified road users and 503 to other means of transportation (mainly van, truck and bus occupants). Additional information on the distribution of deaths by province of residence, year, educational level, sex, age groups and type of death is shown in [Table S3](#) (online supplementary material). Deaths from all types of traffic mortality steadily increased until 2006, oscillating without a clear trend during the following years. Motorcyclist fatalities ([Table 1](#), column B) had a steep increase between 2010 and 2013. However, fatalities of pedestrians and cyclists had a peak in 2001 during the economic crisis ([Table 1](#), column A). Traffic fatalities were observed mostly among men and individuals of lower educational level. Deaths due to traffic injuries had an age distribution in a 'U' shape, with rates at ages 25–34 years higher than rates in the mid-age population, and these lower than rates at ages ≥ 65 years. For car occupants, motorcyclists and unspecified road users, most deaths (29.7%, 44.5% and 27.9%, respectively) were registered in the young population (25–34 years), whereas most pedestrian and cyclist deaths were in the elderly population aged ≥ 65 years (38.3%).

For all investigated causes, we found higher mortality rates in populations of low educational level compared with populations of medium or high educational level ([Table 2](#)). The highest mortality ratio was found in pedestrians and cyclists, who had a mortality 3.7 times higher in populations of low educational level ([Table 2](#)).

The trends of mortality due to traffic injuries reveal a growing gap in the populations of different educational level. Thus, in 1999, the difference in mortality between the two groups was not statistically significant ([Fig. 2](#), panel A; note how the bars for 95% confidence intervals [CIs] overlap), but then these differences became significant and increasingly

Table 1 – Adjusted annual traffic mortality rates for different road users in four Argentinian provinces (Mendoza, San Juan, Santa Fe and Santiago del Estero) in 1999–2013.

Year	Adjusted death rates per 100,000 population ^a (95% CI)				
	A Pedestrians, bicycle riders	B Motorcycles riders	C Car occupants	D Unspecified road users	E All traffic injuries
1999	3.6 (2.7, 4.5)	1.0 (0.6, 1.4)	5.6 (4.5, 6.6)	5.0 (4.2, 5.9)	16.5 (14.7, 18.4)
2000	3.4 (2.6, 4.2)	1.5 (1.0, 2.0)	4.5 (3.6, 5.4)	4.3 (3.5, 5.0)	14.7 (13.0, 16.4)
2001	6.9 (5.6, 8.2)	2.4 (1.8, 3.1)	5.8 (4.8, 6.9)	3.6 (2.9, 4.3)	19.4 (17.4, 21.4)
2002	4.8 (3.9, 5.8)	2.3 (1.7, 2.9)	4.7 (3.9, 5.6)	3.2 (2.6, 3.9)	15.7 (14.0, 17.4)
2003	5.0 (4.0, 6.0)	2.7 (2.0, 3.4)	5.5 (4.6, 6.4)	4.5 (3.7, 5.2)	18.7 (16.8, 20.6)
2004	5.4 (4.4, 6.4)	2.1 (1.5, 2.6)	4.8 (3.9, 5.7)	4.0 (3.3, 4.7)	17.1 (15.3, 18.8)
2005	4.7 (3.8, 5.7)	2.1 (1.5, 2.7)	5.3 (4.4, 6.2)	3.6 (2.9, 4.3)	16.8 (15.0, 18.5)
2006	6.1 (5.0, 7.2)	3.1 (2.3, 3.8)	5.0 (4.1, 5.9)	5.2 (4.4, 6.1)	21.0 (19.0, 23.0)
2007	4.8 (3.8, 5.7)	3.3 (2.6, 4.1)	5.4 (4.5, 6.3)	4.3 (3.6, 5.1)	19.4 (17.5, 21.3)
2008	4.5 (3.6, 5.4)	3.8 (2.9, 4.6)	5.3 (4.5, 6.1)	5.2 (4.4, 6.0)	21.1 (19.1, 23.1)
2009	3.8 (3.0, 4.6)	3.4 (2.6, 4.1)	4.7 (3.9, 5.4)	5.2 (4.4, 5.9)	18.3 (16.6, 20.1)
2010	3.3 (2.5, 4.0)	3.1 (2.4, 3.8)	5.6 (4.7, 6.4)	6.1 (5.3, 7.0)	20.5 (18.6, 22.4)
2011	3.3 (2.6, 4.0)	4.2 (3.3, 5.0)	5.8 (4.9, 6.7)	4.9 (4.1, 5.6)	19.8 (18.0, 21.7)
2012	2.7 (2.1, 3.4)	5.9 (4.8, 7.0)	6.1 (5.2, 7.0)	4.0 (3.3, 4.7)	20.2 (18.3, 22.0)
2013	4.2 (3.3, 5.0)	6.0 (4.9, 7.1)	5.8 (5.0, 6.7)	2.9 (2.3, 3.4)	19.8 (18.0, 21.6)

CI, confidence interval.

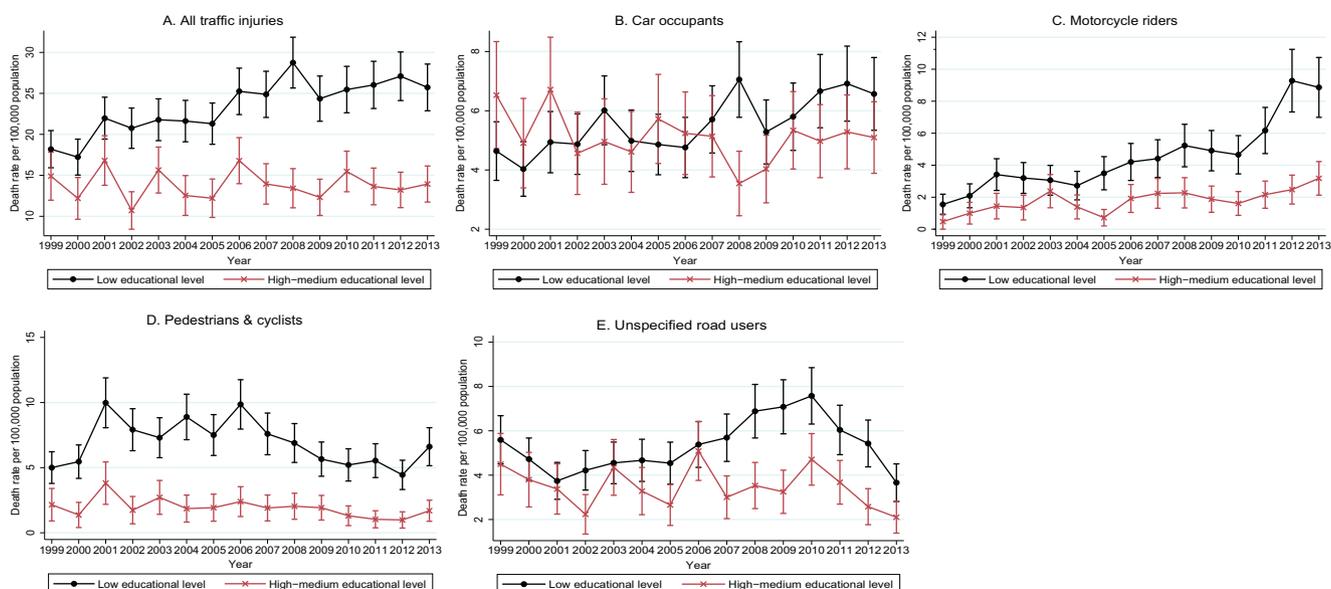
^a Mortality rate after adjusting for sex, age, educational level and province.**Table 2 – Mortality ratios (95% confidence intervals, CIs) for the low educational level population (using medium-high educational level population as the standard) in four Argentinian provinces (Mendoza, San Juan, Santa Fe and Santiago del Estero) in 1999–2013.**

Cause of death	Mortality ratio ^a	95% CI
All traffic injuries	1.7	1.6, 1.8
Car occupants	1.1	1.0, 1.2
Motorcycle riders	2.6	2.2, 2.9
Pedestrians & cyclists	3.7	3.2, 4.3
Unspecified road users	1.5	1.4, 1.7

^a Controlling by sex, age, province and year of death.

large. For mortality of car occupants, differences according to educational level were statistically significant only in 2008 (Fig. 2, panel B). For mortality of motorcyclists, differences in mortality rates by educational level were the smallest in 2003; then they became larger, particularly after 2008 (Fig. 2, panel C). Conversely, mortality rates for pedestrians and cyclists generally showed greater differences by educational level during the period 2001–2007 (Fig. 2, panel D). Considering mortality of unclassified road users, significant differences in mortality by educational level are observed every year since 2007 (Fig. 2, panel E).

Mortality ratios (using the population of medium-high educational level as standard) show significant differences

**Fig. 2 – Annual deaths per 100,000 population due to traffic injuries by educational level in four Argentinian provinces. Vertical bars are 95% confidence intervals.**

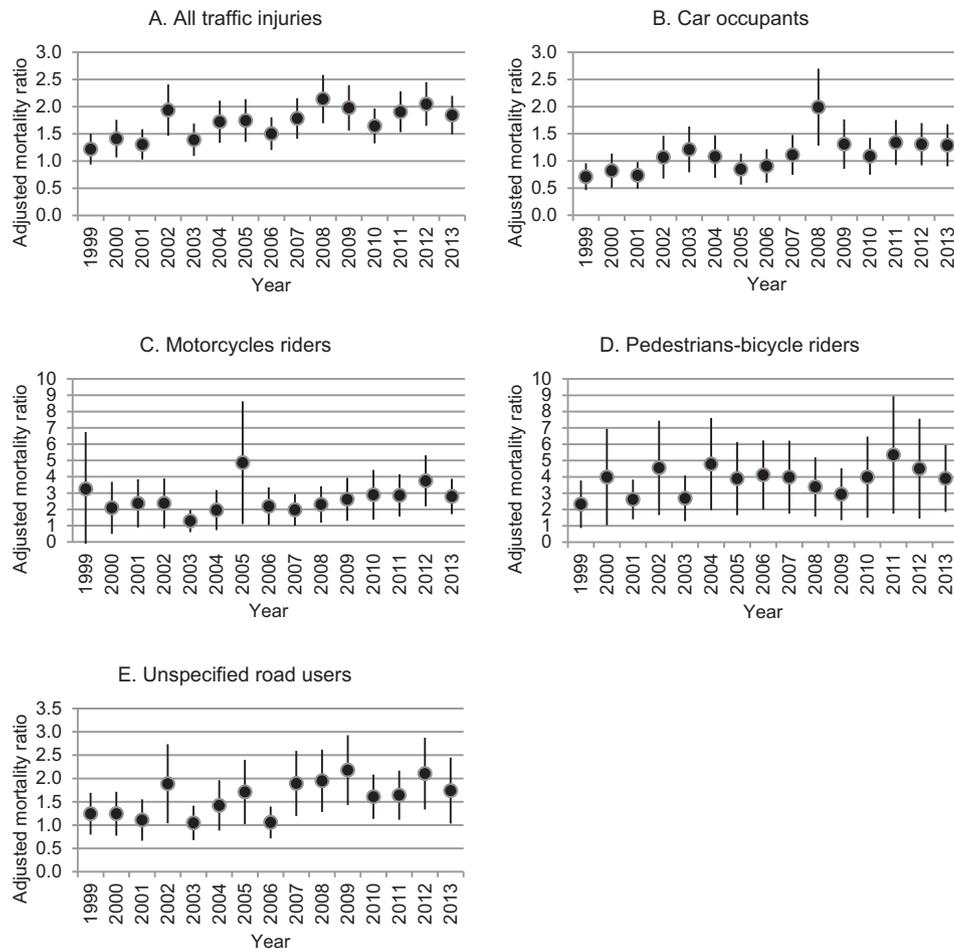


Fig. 3 – Annual mortality ratios, using the population of medium-high educational level as standard. Vertical bars are 95% confidence intervals for the ratio of mortality rates computed with mortality, including all explanatory variables and an interaction between year and educational level.

in mortality (a 95% CI for the relative difference in mortality which excludes 1.0) for all traffic injuries and for deaths of unclassified roads users in almost all years (Fig. 3, panels A and E, respectively). Similarly, the relative inequalities in mortality for pedestrians and cyclists, as measured by mortality ratios, were statistically significant after 2000 (Fig. 3, panel D). For mortality of car occupants, relative inequalities were significant only in 2008 (Fig. 3, panel B). For mortality of motorcyclists, the ratio of mortality rates for different educational levels is significant in 2005 and after 2007 (Fig. 3, Panel C).

Finally, considering the years of economic expansion and recession as a dichotomous variable in the third model, an absolute increase in mortality was observed in individuals of low educational level (20.5 deaths per 100,000 inhabitants [95% CI: 19.3 to 21.7] in years of economic recession; 24.7 [95% CI: 23.8 to 25.7] in years of expansion) and there were no differences in mortality in individuals of medium-high educational level (13.3 deaths per 100,000 inhabitants [95% CI: 12.1 to 14.5] during years of economic recession; 14.1 [95% CI: 13.3 to 14.9] in years of expansion). The same pattern was observed in car occupants (Fig. 4). For motorcycle riders, the absolute difference in traffic mortality was higher in the population of low

educational level compared with the population of medium-high educational level. Pedestrians/cyclists and unspecified road users did not show significant variations in mortality in years of recession compared with years of expansion within each educational level (Fig. 4). Considering mortality ratios, relative inequalities showed no significant changes between years of economic expansion and recession (Fig. 5).

To be sure that our findings were not biased by missing data, we tested the robustness of the results to completeness of educational information. For that purpose, we recomputed the regression models excluding all the years in which the percentage of cases without information on educational level exceeded 20%. The results showed only slight differences with respect to the patterns presented here (see Figs. S1–S5 and Table S4 in the online supplementary material).

Discussion

To our knowledge, this is the first investigation of differences in mortality by educational level in a developing country during a period of fluctuating macroeconomic conditions (expansion and crisis). It is also the first study to describe

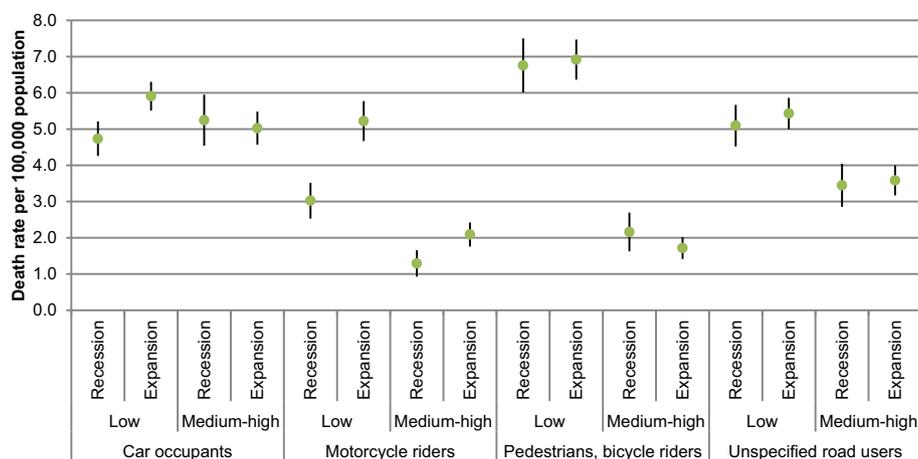


Fig. 4 – Deaths per 100,000 population due to subtypes of traffic injuries, classified by educational level and years of economic expansion and recession in the population of four Argentinian provinces. Vertical bars are 95% confidence intervals.

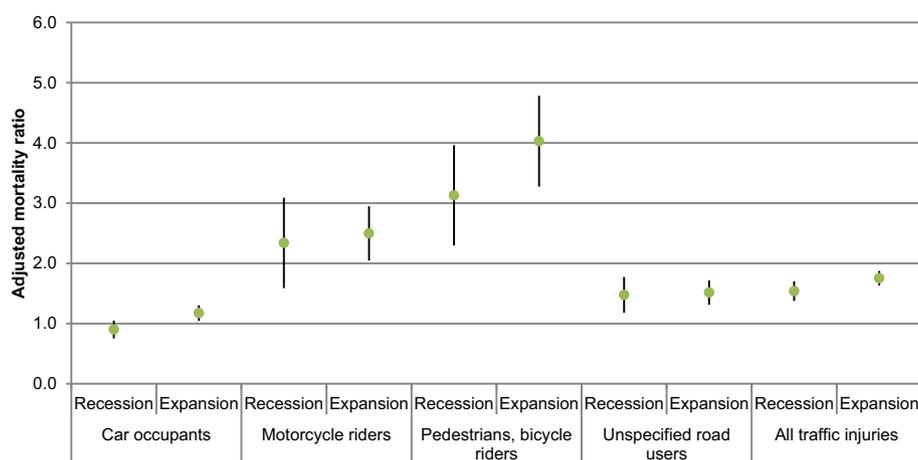


Fig. 5 – Mortality ratios and years of economic expansion and recession, using the population of medium-high educational level as standard. Vertical bars are 95% confidence intervals for the ratio of mortality rates computed with mortality, including all explanatory variables and an interaction between year and educational level.

these differences by analysing rates of mortality due to different kinds of traffic injuries. Controlling for sex, age, province of residence and year of death, traffic fatalities were found to be more frequent in individuals of lower educational level, as expected. However, the changes of educational inequality in mortality differed for the different types of fatalities studied.

As in previous studies,^{3,9} educational inequality in traffic mortality narrowed during the period of economic crisis, both in absolute and relative terms. Similarly, the third regression model showed an increase in mortality in the low educational level population during the years of economic expansion, whereas there were no changes in the mortality of the population of medium or high educational level. During the period of economic crisis for individuals of lower educational level, a reduced exposure to traffic because of unemployment/reduced income and reduction in risky road behaviour because of the decline in alcohol consumption may have contributed to reduce mortality differentials. This is

consistent with an Australian study in which it was found that lower-income households were more likely to reduce the number of trips as a result of the global financial crisis of 2008.²⁴ In addition, both in the province and the Autonomous City of Buenos Aires, the consumption of alcohol among individuals of lower educational level significantly dropped during the economic crisis of 2002.³⁰

For car occupants, we found a higher risk of death in individuals with a lower level of education, but mortality rates did not show significant differences by educational level during most of the analysed period. When comparing years of recession and economic growth in the third model, there was only an increase in traffic mortality in the low education population during years of economic expansion. It is possible that the increase in employment and associated income facilitated the purchase of a car for individuals of lower educational level, thus increasing their exposure and risk of suffering a traffic injury leading to death. In a context of increased motorisation in an Indian city, it was found that

motorcycle users had a high propensity to purchase automobiles.²⁵ This increase in automobile sales could have been differentiated according to socio-economic level in Argentina, with the population of low educational level more likely to buy used cars or cheap new cars. It was common that these vehicles lacked safety requirements (e.g. airbags) during the study period (e.g. in Argentina, the airbag was only mandatory from 2014 for all new four-wheeled vehicles sold), which could significantly increase the risk of death in a traffic collision.³¹

Increasing sales of new motorcycles during the period of economic expansion were probably a key contributor to rising inequality in traffic mortality. In Brazil, where motorcycles have become much more frequent in recent years, motorcyclists mostly belong to poor households and they use the motorcycle for commuting or transportation to school.³² A phenomenon apparently related to the increased number of motorcycles was the crisis of public transport in the Argentinian cities of medium size (approximately 20,000–80,000 inhabitants). The acquisition of motorcycles led to lower use of public transport, which was followed by an increase in the bus ticket price and a further decrease of public transport use.³³ In addition, the increase in sales of motorcycles could occur in a context of differential use of the helmet according to socio-economic level. In Argentina³⁴ and other developing countries, less frequent helmet use has been reported in motorcyclists of lower socio-economic status compared with motorcyclists of a higher socio-economic level.^{35–37}

We found that, in pedestrians/cyclists and motorcycle riders, the evolution of absolute educational inequalities in mortality showed opposite patterns. While the absolute educational difference in pedestrian and cyclist mortality decreased during the expansion, the educational difference in mortality in motorcyclists increased during the same period. A possible explanation for these opposite patterns is a change in the characteristics of traffic during the crisis, so that the volume of traffic significantly declined but the remaining traffic became faster and more dangerous for pedestrians and cyclists who continued using the road for commuting to work or even using the roads and streets to perform various informal economic activities. As employment and purchasing power increased after the crisis of the turn of the century, motorcycle sales rose. Because it is mainly individuals of low socio-economic status who buy and ride these vehicles as their usual mode of transportation, this probably led to a widening educational gap in mortality of motorcyclists (Fig. 2, panel C). On the other hand, with increasing traffic during the economic expansion, the average speed declines and the road may become safer for pedestrians and cyclists (Fig. 2, panel D), who are mostly individuals of low educational level commuting to work rather than individuals of medium or high education using the road for exercising or entertaining.

To summarise, we believe that the different educational inequality patterns of mortality found among road users can be attributed to three major factors: (1) changes in road conditions, with roads less congested but more dangerous in times of economic crisis; (2) the socio-economic differential changes in levels of exposure to traffic, with a reduction of the exposure in low-income groups during times of crisis;²⁴ and (3) changes in modes of transportation associated with economic expansion, when non-motorised users tend to buy

motorcycles and motorcycle users tend to buy cars.²⁵ All this may perhaps be specific for low-income countries as in high-income countries, higher levels of motorisation, better systems of public transportation and the general exclusion of cyclists and pedestrians from highways and most roads may generate quite different patterns.

This study has several limitations. First, the lack of data on exposure of the different road users prevented control by this variable in the regression analyses. Second, underreporting can be an issue for traffic mortality. Third, it is possible that some deaths considered accidental and attributed to traffic injuries were actually suicides. In a study in Finland in the early 1990s, it was estimated that of all traffic deaths, 7% were suicides;³⁸ in Scotland, this proportion was estimated to be 2.8%.³⁹ Therefore, underreporting of this type of suicide and registration of suicides as deaths due to traffic injuries is probably distorting, to some degree, the results of this investigation.

To our knowledge, we have shown for the first time that in a country of medium-level income, educational differences in traffic mortality decreased during an economic crisis. This was the general pattern; however, it was not found for all types of traffic mortality. Further studies on the impact of economic expansions and recessions on traffic mortality are needed to ascertain whether these patterns also appear in other time periods and countries.

Author Statements

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Ethical approval

Ethical approval was not necessary because this research used secondary data.

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Competing interests

Both authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.puhe.2019.06.016>.