

## IMPACT OF LEGISLATION REQUIRING MOPED AND MOTORBIKE RIDERS TO WEAR HELMETS

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### ABSTRACT

*In 1992, a package of measures was adopted by the city of Barcelona to obligate riders of motorcycles with a power capacity inferior to 125 cc to use helmets, until then only compulsory for larger motorcycles. Interrupted time series analyses with the use of a control group is used to investigate the effect of these measures on the number of serious injuries and number of deaths. The results indicate a significant decrease in the number of serious cases in the treated group—smaller motorcycles and mopeds—a decrease which does not occur in the control group—larger motorcycles. The impact of the adopted measures is abrupt and permanent but the change in riders helmet wearing habits has not been influenced so much by the media campaign as by the coming into force of the legislation with the potential application of sanctions.*

### INTRODUCTION

In the last 15 years, there has been an important increase in the number of vehicles in Spain. Directly associated with this increase is a significant growth in the number of deaths and injuries from accidents until 1989, the year in which the aggregate number of victims from accidents began to decrease (Institut Català de Seguretat Viària, 1992; Del Campo, 1995). Spain has taken a number of actions to curtail the rising rate of traffic injuries and deaths experienced during the 1980s. Traffic accidents were given greater consideration in the agendas of Spanish government institutions and new legislation was approved as part of an evolutionary development that follows the model of neighboring countries (Ross, McCleary & Epperlein, 1981–1982).

One of the major changes in legislation took place in 1992 with the extension of the legal obligation to wear a helmet in urban areas to all riders of mopeds or motorcycles (until then only in effect for riders of larger motorcycles). The reform of the legislation was accompanied by a media campaign advertising the intensification of

surveillance, the imposition of monetary sanctions and the immobilization of vehicles. Thus, creating a *system of deterrence*, as it is generally known in the literature on traffic safety (Ross, 1982).

The purpose of this paper is to evaluate the effects of the deterrence-based reforms on the use of helmets by motorcycle and moped riders. Briefly, the model of deterrence is based on the assumption that the threat and certainty of a punishment for a prescribed behaviour will induce the desired behaviour. In the safety literature, a number of evaluations have demonstrated the short-term effects of changes in the system of penalties. However, the analysis of long-term effects has not provided evidence on subsequent changes of attitude and behaviour with a few exceptions (Campbell & Ross, 1970; Hilton, 1984). Thus, we were interested in examining whether there was a difference in the effects in the short and in the long-term, and whether the greater amount of publicity following the changes in the legislation justify those differences as suggested by Ross (1982) and West, Hepworth, McCall & Reich (1989).

A quasi-experimental design with non-equivalent

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control groups (Cook & Campbell, 1979) is applied to evaluate both short- and long-term effects of the actions taken in the city of Barcelona to increase the use of helmets among riders of mopeds and small motorcycles. The study examines the impact of the reform in both serious and minor accidents using a control group of riders of larger motorcycles for whom the law had not changed but who were presumably subject to the same external (weather, traffic...) conditions in the city of Barcelona.

### ORIGINS OF THE HELMET LAW

No one would dispute the fact that traffic accidents constitute one of the most serious concerns in our society. The dimension of this problem is well known to the majority of citizens who agree with the need to limit the consequences of traffic accidents. If we look at the data for Spain in the last decade, the increase in the number of injuries and deaths has not been uniform. One of the groups which experienced a higher relative growth in the number of victims was the group of riders and passengers of two-wheel vehicles. Technical innovations introduced by the motorcycle industry as well as the construction of new road infrastructures has fostered the use of motorcycles as a mean of transportation, increasing the number of miles ridden and therefore, the risk of accident.

In 1991, the year before the new legislation came into force, there was a total of 6797 deaths in traffic accidents in Spain. 17% (1173) corresponded to two-wheel vehicles: 706 to motorcycles and 467 to mopeds. For motorcycles and mopeds, the number of deaths on inter-urban roads (806) was higher than the number of deaths on urban roads (367). However, the total number of accidents was higher on urban roads, but due to the slower traffic speeds, the injuries tend to be less serious.<sup>1</sup>

Barcelona, the city where the present investigation was conducted, has a population of 1,643,542 city residents not including the metropolitan area. It is a highly motorized city. The favourable weather conditions combined with the difficulties in parking and congested traffic, make the use of two-wheel vehicles an efficient means of transportation. Barcelona has around 200,000 two-wheeled vehicles, a quarter of which are mopeds. In 1991, there was a total of 8090 victims from accidents (22 per day) including 43 cases of death.

In 1990 and in 1991 publicity campaigns were carried out to promote the use of helmets by riders of two-wheeled vehicles. At the time, helmets were only obligatory in urban areas for motorcycles and mopeds with a cylinder capacity equal or superior to 125 cc. Riders of

motorcycles of less than 125 cc and mopeds had a greater flexibility since the law only required them to use a helmet outside urban areas.

On 1 June 1992, the new Spanish Road Safety Law ("Ley de Seguridad Vial") came into effect and extended the obligation to wear helmets for the users of motorcycles of less than 125 cc at all times. Moped riders (of less than 50 cc) were exempt from the obligation to wear a helmet in towns until 1 September 1992, the date on which the regulations for the development of the law came into effect. From this day onwards, any rider without a helmet could be sanctioned with fines of variable amounts depending on the local laws.

During the first days of September, the City Council of Barcelona announced the decision to immobilize all motorcycles and mopeds whose riders were not using an authorized helmet. The local police offered riders without a helmet the possibility of lending them and accompanied them to their private parking where the motorcycle was immobilized with chains which could only be removed after proving the purchase of a helmet. Otherwise, the police would take the motorcycles directly to the municipal deposit where they could then only be retrieved by showing an authorized helmet, and paying the fine. The administrative procedure adopted to implement the new policy was extensively commented upon by the media. It was severely criticized by one of the opposition leaders who questioned the legal basis of the procedure, thus contributing even more publicity to the campaign.

### REACTIONS TO THE LAW

In order for the new legislation to be effective, it was first necessary to persuade riders and their passengers to use the helmets, something which had traditionally encountered the resistance of a significant number of motorcyclists. In response to the media campaign and insistence of the authorities to use the required helmets, many claimed that the use of a helmet was an infringement on their individual freedom. From this perspective, it was argued that not using a helmet could only harm the person who had decided not to use it and that everyone should be able to do whatever she/he thought best for her/himself. Other arguments were that helmets reduce lateral visibility necessary to circulate among cars in the usually dense city traffic, or simply, that helmets are annoying, especially in the summer.<sup>2</sup>

<sup>2</sup>Other more curious arguments stated that the use of a helmet may produce loss of hair and hearing problems. In the edition of 5 July 1993, *La Vanguardia* informed that the Spanish Motor Vehicle Department would study eventual effects caused on the human ear by the use of the helmet. Such a study was requested by the Catalonia Consumers Association - Mediterranean Food Council (Asociación de Consumidores de Catalunya-Consejo Alimentario del Mediterráneo).

<sup>1</sup>According to the "Boletín Informativo sobre Accidentes, D.G.T. 1991" of the Spanish Motor Vehicle Department.

TABLE 1  
EVOLUTION OF THE USE OF HELMET

Type of Vehicle	March 1992	September 1992
Interurban		
Motorcycles*	81.3%	99.3%
Mopeds	19.6%	93.9%
Urban		
Motorcycles*	50.8%	98.3%
Mopeds	15.2%	95.6%

\*The data of the study does not distinguish between motorcycles with a cylinder capacity superior or inferior to 125 cc. Thus, it is not possible to know the degree of helmet use among riders of larger or smaller motorcycles in urban areas before the reform.

Source: Catalan Institute of Road Safety.

However, the coming into force of the obligation to wear helmets on any kind of motorcycles and the intensive publicity campaign advertising the penalties that would be imposed on infractors did have the immediate effect of dramatically increasing the use of helmets.

According to a study carried out by the Catalan Institute for Road Safety,<sup>3</sup> based on direct observations at 12 points in the region of Catalonia from March to September 1992, the use of helmets for moped riders rose from 15.2 to 95.6% on urban roads, and from 19.6 to 93.9% on inter-urban roads. For larger motorbikes, the use of helmets in September 1992 was very widespread (98.3% urban, 99.3% interurban) and clearly superior to the observed use of helmets in the months before the coming into effect of the new legislation (50.8% urban and 81.3% interurban). The figures are reproduced in Table 1. Obviously there was a very significant change in the behaviour of riders beginning 1 September 1992. It is not that clear that the change was as drastic among the users of smaller motorcycles in the period from June to September. Firstly, because the Department of Transportation had postponed the application of the law to mopeds until the month of September, which delayed the programs of police surveillance and the media campaign until the beginning of that month. Secondly, because the Olympic Games were going to take place in Barcelona that summer and their preparation and development completely absorbed the local police. Immediately after the games, the summer vacations began, leaving the city completely empty that month.

The rigor in the application of the new law by the police in Barcelona was a key factor in the change of

behaviour of many riders. A poll of the Catalan Institute for Road Safety shows that among helmet users in Catalonia in September 1992, 55% were wearing the helmet for personal safety, while 45% were wearing it to avoid the fine. This indicates the apparent success of the system of deterrence. In other words, if the perception of a police threat did not exist, the percentage of helmet wearers would have been lower.

## EVALUATION DESIGN

A rigorous evaluation of policies is usually difficult. On the one hand, public intervention tends to be more a result of political pressure than the fruit of a careful and exhaustive analysis of each situation and of the objectives which may be achieved. On the other hand, the problems, not only in measuring but also in identifying the effects, of obtaining valid and reliable data or of applying the most advanced evaluation techniques, tend to have a significant weight at the moment of deciding how to evaluate a policy.

The scientific-rational model of evaluation by objectives makes use of research designs which are based on a relatively simple principle: to be able to evaluate the impact of a policy it is required, first, to identify variables which accurately reflect the results of the policy to be evaluated; and second, to measure the situation before and after the intervention and/or in relation to the situation of control groups which are not affected by this intervention.

In this case, this approach is adequate since the evaluation deals with a well-defined policy, on the basis of an impact model with clear causal relations.<sup>4</sup> More precisely, the question which is analysed here is whether the new legislation which came into effect on 1 June 1992 for the users of motorcycles of less than 125 cc, and on 1 September 1992 for the users of mopeds, is effective in reducing the number of injuries and fatalities in road accidents within that specific target group. Thus, it is considered that this is the objective of the new legislation and that a relatively simple indicator can be used to measure its impact: the number of drivers or passengers who died or were seriously injured.

If the legislation is effective, there should be a significant decrease in the number of deaths or serious injuries among riders, belonging to the group which before the reform was not required to wear a helmet but is required to do so now. However, a change in the trend should not be expected in the data series corresponding to those who were already required to wear helmets before the legislative change: drivers and passengers of motorcycles of a cylinder capacity equal or

<sup>3</sup>“L'ús del casc a Catalunya: Setembre de 1992”, Institut Català de Seguretat Viària.

<sup>4</sup>In an earlier publication, we have analysed the required conditions for the evaluation of results (Ballart, 1992).

superior to 125 cc. More specifically, we would expect that the September intervention would have an effect in the mopeds, while for the smaller motorcycles the effect could happen either in June or in September when the intensification of surveillance and the media campaign took place. We also would expect that neither the June nor the September intervention had an effect on larger motorcycles.

Interrupted time series analysis with non-equivalent control groups (Box & Tiao, 1975; McDowall et al., 1980) is used to evaluate the new policy. The separate analysis of each of the impact indicators for both groups of motorcycles helps to avoid a possible diffusion of the impact of the legislation in the analysis of a single series of data. Such a strategy has previously been used in other studies (Maxfield & Pierce, 1988; Legge, 1990). Maxfield and Pierce, for instance, used it for the evaluation of the impact of the legislation banning the so called "happy hours" (sale of alcoholic drinks at reduced prices) in two states of the U.S. In that case, Maxfield and Pierce assumed that if the prohibition was effective, there should be a reduction in the number of accidents during the days and hours of the week in which the bars had "happy hour," while a reduction in the number of accidents in the other hours and days of the week should not be expected.

The research design eliminates most of the possible threats to internal validity. Certainly, no other factor other than the extension of the obligation to wear a helmet, could explain a significant reduction in the number of drivers or passengers dead or seriously injured in accidents of motorcycles of less than 125 cc after the enforcement of the new law, when such a reduction does not happen (or is much more limited) among the users of larger motorcycles.

## DATA SOURCES

The impact indicators are based on data from the records of the *Guardia Urbana de Barcelona* (local Police), thus limiting the analysis to the area of this city. This is because the records of the Motor Vehicles Department do not register the power of the vehicles, thus, making it impossible to separate the data series for both groups. However, the *Guardia Urbana de Barcelona* records detailed information on all traffic accidents that happen in Barcelona. This information is kept in three data bases, on accidents, vehicles and people. For this research, data on the date of the accidents, the type and power of the vehicles involved, and the medical diagnosis of either drivers or passengers affected by the accidents was used.

Accidents are gathered by weeks, from December 1990 until October 1993. The study considers two interventions and separates three series. The first inter-

vention happens on 1 June 1992, the day the legislation comes in effect for small motorcycles (week 79). The second intervention takes place on 1 September 1992, the day the law becomes obligatory for mopeds (week 93). The pre-intervention series of June and September 1992 have 78 and 92 cases respectively. The first and second series are for mopeds and for small motorcycles—the treated group. The third series is for larger motorcycles—the control group. For each series, we distinguish between two types of accident result: serious cases, corresponding to the dead, and to serious and very serious injury cases; and minor cases, corresponding to those who were diagnosed as having less serious or slight injuries.<sup>5</sup>

To carry out the analysis, two kinds of programs and techniques were used. On the one hand, through the DBASE and SPSS programs, dispersed data was gathered in a single data base to be able to establish conditions and count cases. On the other hand, the ARIMA time series analysis techniques proposed by Box and Jenkins (1976) were applied using the Trends module of SPSS. The ARIMA technique was used to estimate any statistically significant changes in the trend of the time series corresponding to number of victims seriously injured or dead from the treated group. The control group was also examined to verify if comparable statistically significant changes occur.

## ANALYSIS AND RESULTS

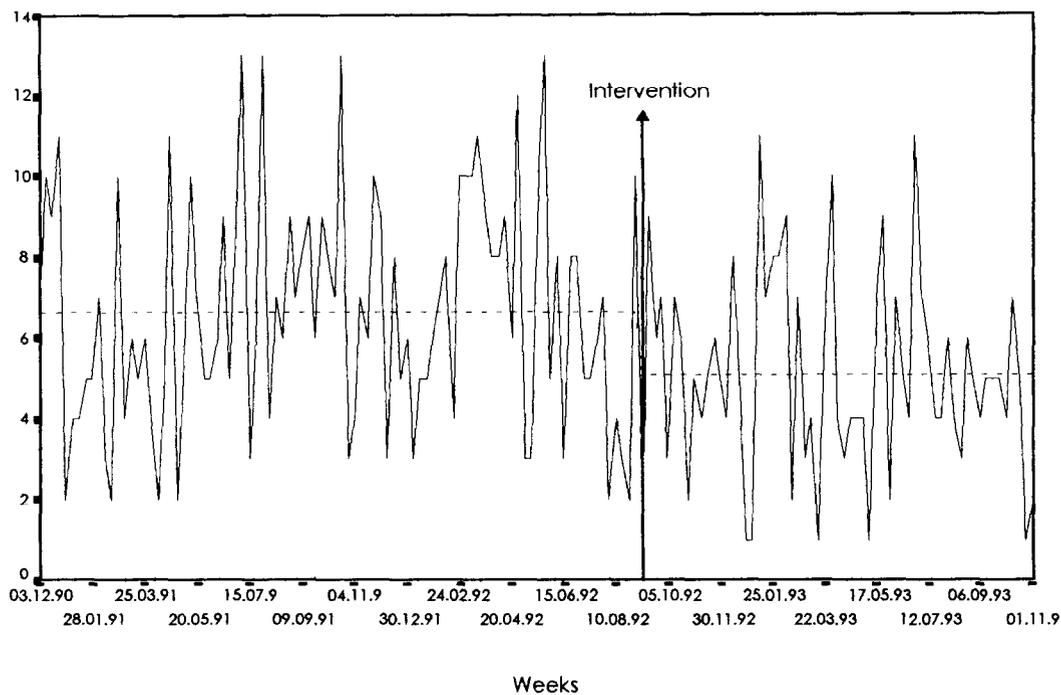
Figures 1–3 are the plot of weekly serious and minor cases for mopeds, small and large motorcycles. The data does not show seasonal fluctuation. However, it is apparent that the average level of accidents tends to decline for mopeds and smaller motorcycles over time. During the weeks after the June and September interventions, there is a substantial drop, but it is difficult to determine from the plot alone whether the drop goes well beyond a long-term decline in average levels for these two series.<sup>6</sup>

Prior to the interrupted time series analysis, a significance test was conducted to determine whether there is indeed any difference in the average number of weekly cases of both types, before and after the enforcement of the new legislation. The results of this test can be seen in Table 2 and already begin to indicate a significant change had taken place. In the series of mopeds and small motorcycles, there was a significant change in the

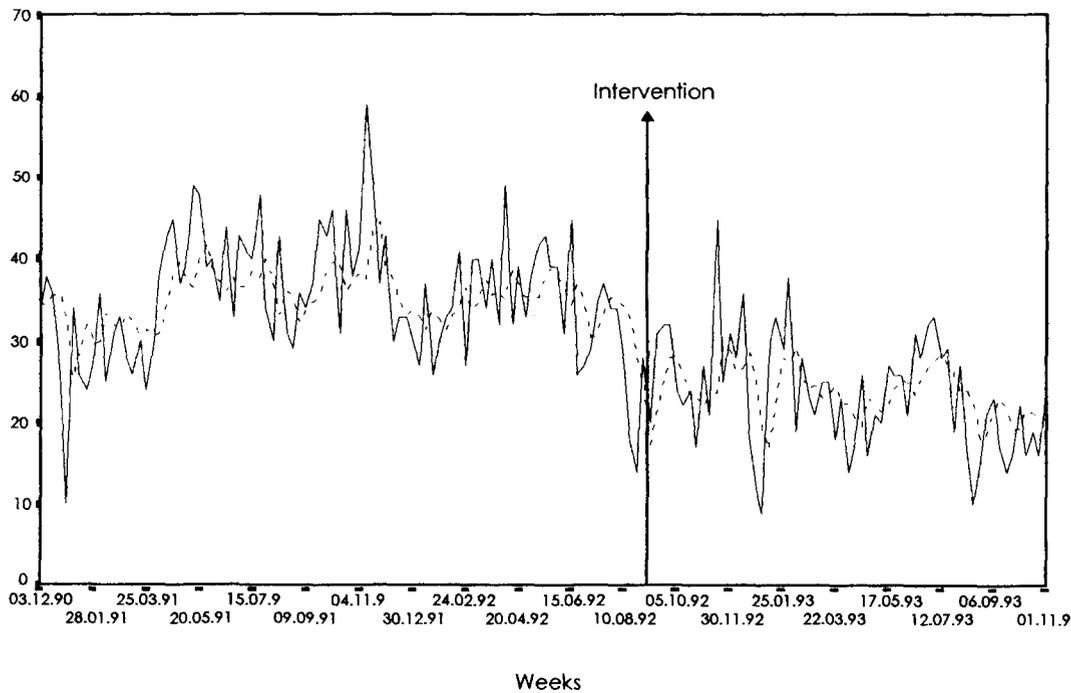
<sup>5</sup>Curiously, the data as to whether victims of accidents were wearing a helmet was discarded since it was found that local police did not record that piece of information in a systematic way during the period under study. The data before December 1990 had to be discarded because of lack of information in a large number of cases.

<sup>6</sup>The graphs also show the intervention and the fit values from the ARIMA estimated series.

Serious cases

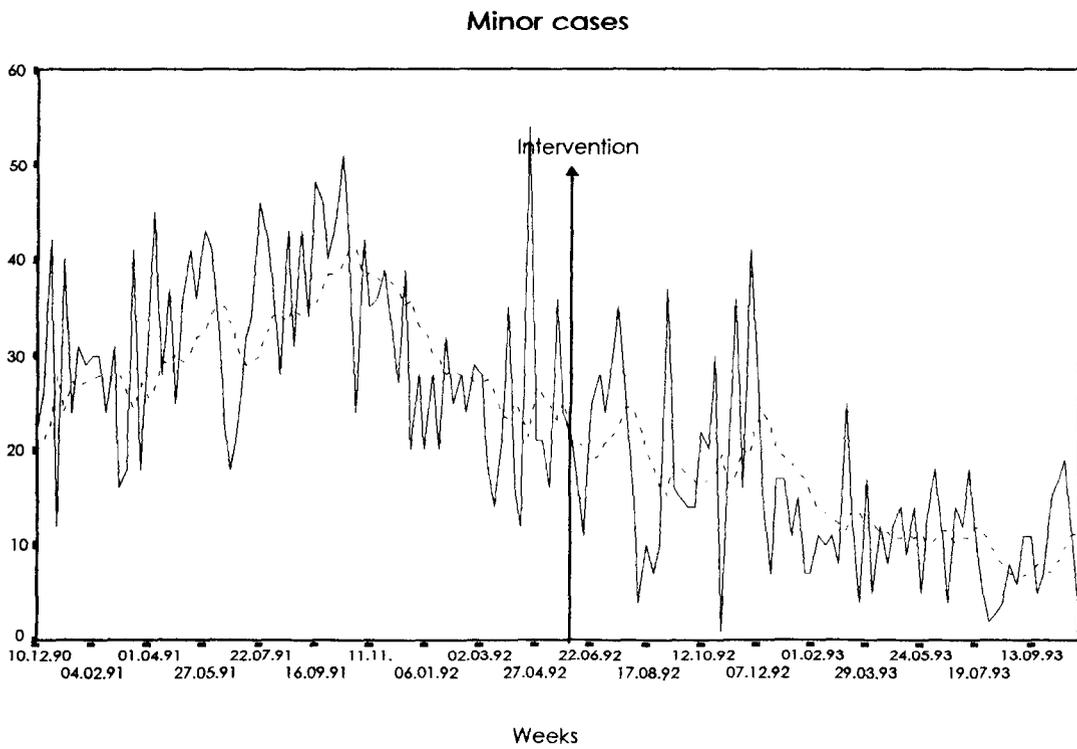
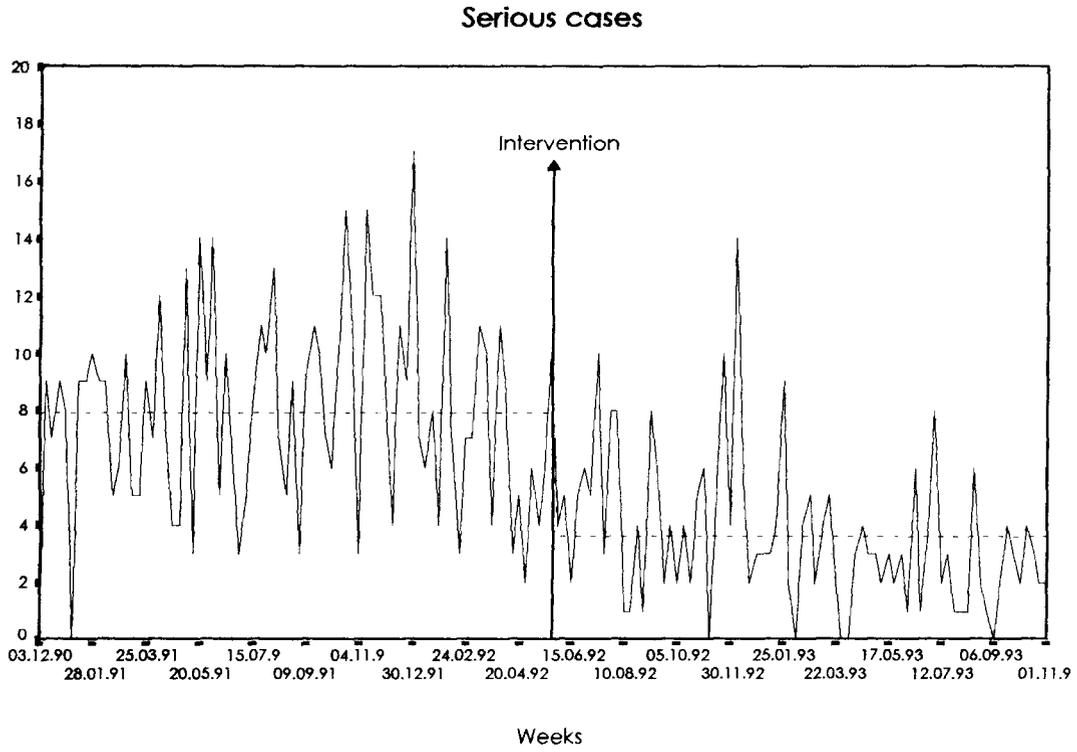


Minor cases



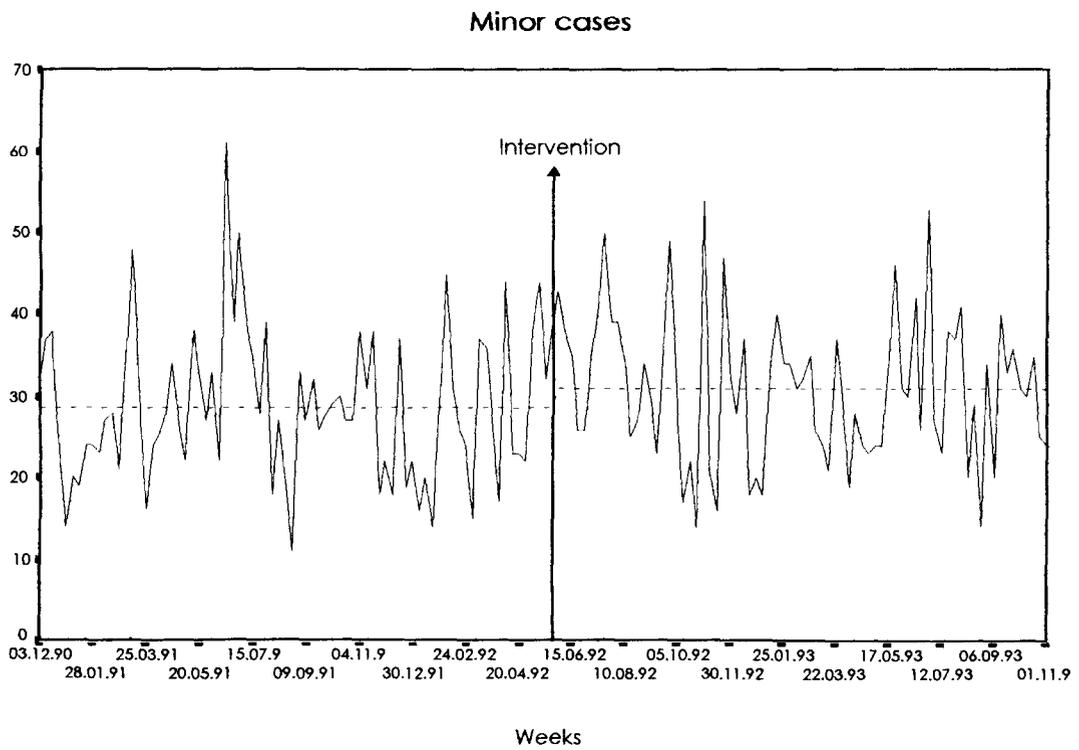
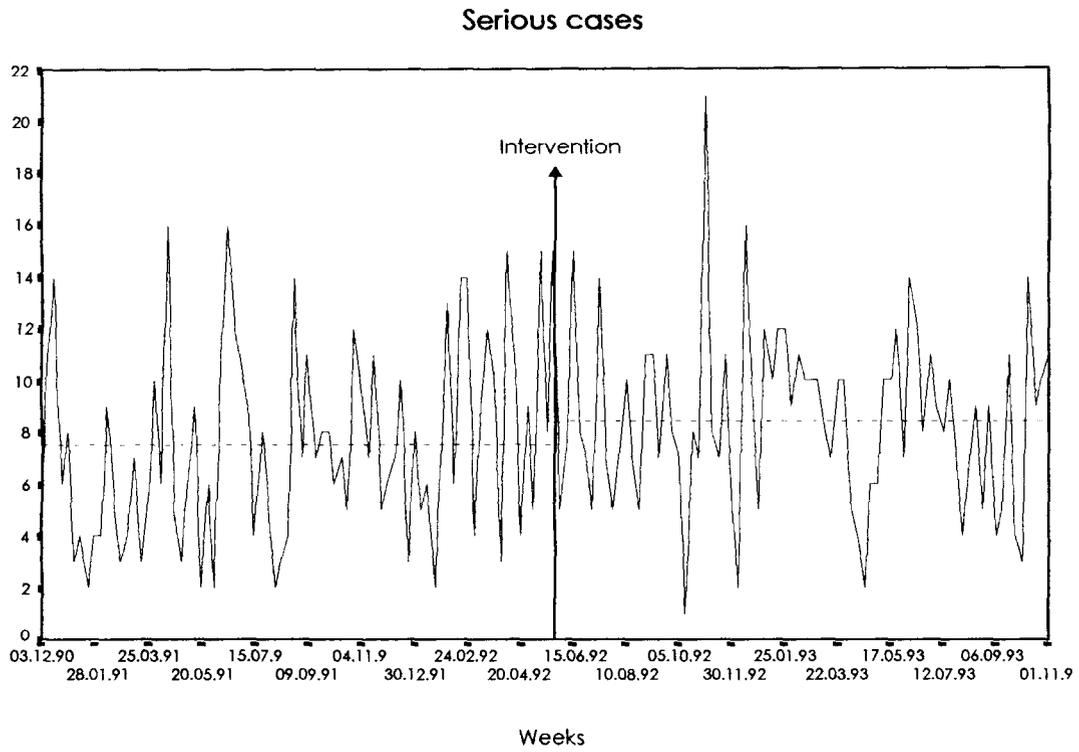
— Serie    - - - - Fit

Figure 1. Accidents on mopeds.



— Serie    - - - - Fit

Figure 2. Accidents on small motorcycles.



— Serie    - - - - Fit

Figure 3. Accidents on large motorcycles.

TABLE 2  
SIGNIFICANCE TEST: DIFFERENCES IN THE AVERAGE NUMBER OF CASES BEFORE AND AFTER INTERVENTION

	Mopeds		Small Motorcycles		Large Motorcycles	
	Serious	Minor	Serious	Minor	Serious	Minor
Before (01.06.92)	—	—	7.9	30.8	7.5	28.7
After (01.06.92)	—	—	3.6	14.4	8.5	31.0
<i>t</i> -statistic	—	—	8.5**	10.8**	-1.6	-1.6
Before (01.09.92)	6.6	35.2	7.4	29.0	7.6	29.7
After (01.09.92)	5.1	23.6	3.4	13.4	8.6	30.0
<i>t</i> -statistic	3.5**	9.5**	7.9**	10.0**	-1.6	-0.2

\*\*Significant at 0,01 level.

TABLE 3  
ARIMA MODELS

	Mopeds		Small Motorcycles		Large Motorcycles	
	Serious	Minor	Serious	Minor	Serious	Minor
Model (before 01.06.92)	—	—	ARIMA (0,0,0)	ARIMA (0,1,1)	ARIMA (0,0,0)	ARIMA (0,0,0)
$Q_{16}$	—	—	12.9	10.7	10.6	14.5
Model (before 01.09.92)	ARIMA (0,0,0)	ARIMA (2,0,0)	ARIMA (0,1,1)	ARIMA (0,1,1)	ARIMA (0,0,0)	ARIMA (1,0,0)
$Q_{16}$	12.7	9.4	18.4	10.0	15.5	9.0

All  $Q_{16}$  are not significant at 0,01 level.

average number of both serious and minor cases, while there was no significant change in the series of larger motorcycles. In the case of mopeds, the mean difference before and after the September intervention is two serious cases and 12 minor cases. In the case of small motorcycles, it is four serious cases and 16 minor cases.

The first step of the time series analysis used the pre-intervention data (before 1 June and before 1 September 1992) to determine the ARIMA models that best fit each of the series.<sup>7</sup> Results are shown in Table 3.

Once ARIMA models that accurately described the data had been determined, intervention terms were inserted to simulate the effects of interventions in the series of observations. In this case, everything seemed to indicate that if the intervention was effective, the effects would be "abrupt and persistent." Abrupt

because the policy changes radically on two dates, and persistent (thus having long-term effects) since only part of the intervention — the media campaign — is limited in time, while the imposition of monetary sanctions, the immobilization of vehicles and the police pressure is maintained.<sup>8</sup> Thus, the final model can be represented as:

$$Y_t = Nt + \omega It$$

where  $Nt$  is the pre-intervention model,  $It$  represents the intervention and  $\omega$  quantifies impact. The numerical estimates of the parameter values appear in Table 4.

The signs of the  $\omega$  coefficients representing impact of the intervention are for all the series as expected: negative in the case of mopeds and smaller motorcycles —

<sup>7</sup>The ARIMA model identification technique is based on the autocorrelations and partial autocorrelations functions of the series. Models are estimated according to the general criteria of parsimony and statistical adequacy, and for model diagnosis the Box-Ljung Q statistic was used.

<sup>8</sup>Given that in the safety literature, a number of evaluations have demonstrated the short-term effects of changes in the system of penalties but have not usually found evidence of long-term effects, we also tested an abrupt temporary model. However, the parameters for the three categories of motorcycles were not significant in any of the cases.

TABLE 4  
INTERVENTION IMPACT: PARAMETERS OF THE INTERVENTION MODEL

	Mopeds		Small Motorcycles		Large Motorcycles	
	Serious	Minor	Serious	Minor	Serious	Minor
June Intervention						
$\beta_1$	—	—	—	0.8 (18.4**)	—	—
$\omega$	—	—	-4.3 (-8.5**)	-4.1 (-0.8)	0.9 (1.6)	2.3 (1.65)
C	—	—	7.9 (22.2**)	0.1 (-0.7)	7.5 (18.1**)	28.7 (27.5**)
Q16	—	—	10.3	11.9	12.0	9.4
September Intervention						
$\beta_1$	—	—	0.9 (24.2**)	0.8 (16.3**)	—	—
$\phi_1$	—	0.3 (3.8**)	—	—	—	0.2 (2.0*)
$\phi_2$	—	0.2 (2.8**)	—	—	—	—
$\omega$	1.6 (-3.4**)	-10.8 (-4.7**)	0.2 (0.2)	7.4 (1.4)	0.9 (1.6)	0.3 (0.2)
C	6.6 (23.3**)	34.9 (23.6**)	-0.0 (-1.4)	-0.2 (-1.2)	7.6 (19.9**)	29.7 (26.0**)
Q <sub>16</sub>	10.9	16.1	17.9	10.8	11.8	9.4

t-statistics for parameter estimates are in parentheses.

\*Significant at 0,05 level.

\*\*Significant at 0,01 level

All Q<sub>16</sub> are not significant at 0,01 level.

showing therefore a reduction in the number of accident victims — and positive in the case of larger motorcycles. The effect of the September intervention is statistically significant for mopeds for both series of serious and minor cases. There is a decrease of two serious cases and 11 minor cases per week. Concerning smaller motorcycles, the effect on serious cases is very significant in June but not in September, while the effect on minor cases is not significant either in June or in September. There is a decrease of four serious cases after the June intervention in the series of smaller motorcycles. Finally, there are not any significant effects after neither the June nor the September intervention for the series of larger motorcycles. Even though the  $\omega$  coefficients are not significant for any of the four models, their positive sign shows that there has been a slight increase of victims for that group, reinforcing the idea that things happened as expected.

## CONCLUSIONS

The 1992 package of helmet-use measures has been effective in reducing the number of fatalities and serious traffic injuries in Barcelona. These results can be of

interest to those in search of evidence of the utility of helmets for two-wheel vehicle riders. Also, these results are of interest to students of the effectiveness of deterrence systems. Literature has repeatedly shown that the deterrent effects happen only in the short-run and that this might be due to the greater amount of publicity following the changes in the system of penalties. However, the findings of this study indicate a persistent model of impact during the first post-intervention year, that does not seem to be dependent on the media campaign.

The use of an interrupted time series analysis with non-equivalent control groups has been useful to examine the impact of the reform in serious and minor accidents. The impact is significant for the treated group — for mopeds after September 1992 and for smaller motorcycles after June 1992 — and non-significant for the control group — larger motorcycles. On one hand, since the only factor which affected both groups differently was the enforcement of the new obligation to use helmets, it can be stated that it was this factor which caused an average weekly decrease of 6 serious cases and 11 minor cases among users of mopeds and smaller motorcycles in Barcelona during the first year of implementation of the new law.

On the other hand, since the deterrent impact began on the date the new obligation was mandatory, the police threat of a strong sanction seems to have been sufficient to change significantly the behaviour of owners of small motorcycles. However, it did not change the behaviour of moped riders until the date when they could also be sanctioned according to the new law. This result is consistent with the hypothesis of a permanent effect independent of the media campaign, as long as it is perceived that there is police surveillance and capacity to sanction.

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