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TRAFFIC ACCIDENT RESEARCH UNIT

COMPULSORY WEARING OF SEAT BELTS IN NEW SOUTH WALES, AUSTRALIA

AN EVALUATION OF ITS EFFECT ON VEHICLE OCCUPANT DEATHS IN THE FIRST YEAR

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The Traffic Accident Research Unit was established within the Department of Motor Transport, New South Wales, in May 1969 to provide a scientific approach to the traffic accident problem.

This paper is one of a number which report the results of research work undertaken by the Unit's team of medical, statistical, engineering and other scientists and is published for the information of all those interested in the prevention of traffic accidents and the amelioration of their effects.

D. R. Coleman

Commissioner.

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Introduction

The effect of seat-belt wearing on the chance of death or injury in a road traffic crash is beneficial to an extent which is not shared by any other single measure currently available (Kihlberg and Robinson, 1967; Bohlin, 1967). When the low cost of these simple devices is taken into account, their effect on the reduction of crash losses has been shown to be especially favourable in comparison with other measures and devices which might soon become available ("RECAT" Committee, 1972).

But vehicle occupants are demonstrably resistent to traditional efforts to encourage the wearing of seat belts. Even the most sophisticated communications activity has failed dismally (Robertson et alii, 1972). There is reason, too, to doubt that current attempts in the U.S.A. to remind occupants to fasten seat belts by the use of warning buzzers and lights will be successful for the population as a whole (Robertson and Haddon, 1973), and the success of the planned introduction in that nation of seat belts linked electrically with the vehicles' ignition systems remains to be seen. In any event, measures such as this can apply only to new cars.

In reporting the results of an interview study conducted in Sydney in 1970, Freedman et alii (1971) showed that there was widespread public belief in the safety value of seat belts, even among those who never wore them. They concluded, however: "If seat belts are to continue as occupant restraints, legislation for compulsory usage may be the only way to markedly increase the wearing rate". The question of compulsory wearing of seat belts had, in fact, been argued in Australia for some time before (Henderson, 1970), and favourable results had been reported when the operators of a large fleet of vehicles were compelled to wear belts (Anderson, 1967).

In November, 1970, the Cabinet Standing Committee on Road Safety of the N.S.W. State Government accepted in principle the case for making seat-belt wearing compulsory. The Commissioner for Motor Transport then submitted a detailed proposition in the

form of a Traffic Accident Research Unit report, '"Compulsory Wearing of Seat Belts : a Feasibility Study" (Skinner et alii, 1970), which was published in December and widely circulated.

In December, 1970, as a result of a recommendation by the Victorian Parliamentary Select Committee on Road Safety (Joint Select Committee on Road Safety, 1969), seat-belt wearing became compulsory in that State of Australia. Encouraging results have already been reported (Foldvary and Lane, 1972; Andreassend, 1972).

The wearing of seat belts when fitted to cars became compulsory in New South Wales on October 1, 1971, but the law was not enforced until November 1, 1971. By early 1972, all States in Australia had enacted similar legislation, making this country the first developed nation in the world to take the step. In New Zealand the decision was taken to follow suit as from June, 1972.

In New South Wales, the wearing of seat belts was compelled by a new regulation (Regulation 110F) under the Motor Traffic Act, 1909, in the following terms: "No person shall, while occupying a seat position in a motor car to which a seat belt has been fitted for the seat position, drive or travel, upon a public street, in that motor car unless he is wearing that belt and the belt is properly adjusted and securely fastened." The penalty for an offence under this regulation was set at $20 (Australian). Exemptions were set down for various categories of vehicle use (such as house-to-house delivery work) and vehicle occupant (such as children of under the age of eight years).

Vehicle occupant deaths in the first year of the regulation

The number of occupants of motor vehicles killed in traffic crashes in New South Wales during the year 1972 was 701, as compared to 860 (18.5% more) in 1971. These figures, however, if unsupported by other data, do not indicate that the legislation requiring the wearing of seat belts by occupants was solely responsible. A number of alternative explanations have to be considered.

The first question is whether the number of motor vehicle occupants[1] killed in 1972 reflects a significant deviation from previously well-established trends. A fluctuation in the number of occupant deaths from year to year is perfectly usual. Therefore, a regression line representing occupant deaths against time was derived from the data shown in Table 1 for the years 1961 to 1971 (Figure 1). The straight line which was so derived and fitted to these data does not provide an impeccable fit, but is probably the only justifiable model[2]. The line provides a prediction that the number of motor-vehicle occupant deaths in 1972 could have been expected to be 939, with a 95% confidence interval of plus or minus 143, that is, between 796 and 1082.

This means that the observed number of vehicle occupant deaths in the first full year of the regulation in N.S.W., at 701, was some 25% below the number which might have been

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1. "Occupants" in the context of this paper means the occupants of all motor vehicles, whether in heavy trucks or passenger cars, and whether seat belts were available or not.
2. In order to test the assumption, implicit in the use of the regression analysis, that year-by-year deviations are normally and independently distributed, the value of the Durbin-Watson d-statistic was calculated and found to be 1.83, that is, not significant. This means that there is no suggestion of the presence of a serial correlation in the error terms of the regression, and the calculation thus provides no evidence to contradict the above assumption.

predicted from the previous trend over a 10-year period, and was from 12% to 35% below figures representing, at the 95% confidence level, extremes of fluctuation from year to year. For all earlier years examined, the observed number of occupant deaths would lie within these confidence limits.

An alternative approach to the same data is to examine the specific proposition that 1972 occupant deaths were significantly lower than predicted by previous trends. A "one-tailed" test shows that the null hypothesis (that 1972 fatalities did follow the existing trend) can be rejected at the 5% level of significance if 1972 fatalities numbered fewer than 766. Since the observed figure, 701, lies well below this value, we can in fact reject the null hypothesis in favour of the alternate and conclude that the observed reduction is statistically significant.

The influence of associated variables

Before drawing any conclusions about this observed deviation from an existing trend, it is desirable to examine trends in other variables. The yearly number of motor-vehicle occupant deaths, as a population statistic, is associated numerically with various other population statistics: total population, total number of holders of motor-vehicle driving licences, annual registrations of new motor vehicles, and the total number of vehicle registrations on record, for example. For at least some of the variables, it is reasonable to assume that this association has some meaning underlying the observed numerical correlation. Population growth, for instance, with varying time lags, affects the number of drivers on the roads, as does the number of people licensed to drive. The annual number of new motor-vehicle registrations under prosperous economic circumstances reflects increased car-buying activity and consequent mobility.

One of the most desirable but currently unattainable indicators of a population's exposure to risk on the roads is the number of miles driven each year by each person. In New South Wales, isolated estimates of mileages, based on surveys, appear from time to time, but most regular estimates are based on figures derived from the consumption of vehicle fuel. Therefore, the annual consumption of motor spirit in N.S.W. has been included here as the most consistent estimator of the overall degree of motor vehicle usage over the 10-year period, despite its many limitations as such.

Figures for all the above statistics are shown in Table 1, and the associated trends are depicted in Figure 2.

All these variables appear to increase in an approximately linear relationship to time, and are under the influence of various known and unknown factors. For instance, the number of driving licences on issue must be dependent not only on the size of the population but also on other factors such as social custom, and the joint effect of these factors appears to be approximately linear.

Casual observation of these data indicates that none of the trends for possibly associated variables underwent any significant change in 1972, in contrast to the trend for vehicle occupant deaths. Nevertheless, more detailed examination is justified. The linear "time" effect was extracted from all the data in order to remove from each variable the effect of any other associated variable which also has a linear relation to time. To do this, regression lines (linear on time) were fitted to all six variables, "estimates" for the years 1961 to 1971 were derived, and the differences between the derived and observed figures calculated. These "residual" figures are shown in Table 2, together with calculations of the correlations of the residual figures for occupant deaths with those for the associated variables.

The highest degree of correlation with residual figures for occupant deaths is seen in figures for new-vehicle registrations. However, linear regression of the former variable on the latter gives a result which is not statistically significant, indicating that, for the years 1961-1971, the numerical relationship between occupant deaths and the other associated variables can be expressed satisfactorily in terms of their linear dependence on time. There is therefore no advantage to be gained from, say, multiple regression analysis of occupant deaths on any combination of the other five chosen variables for 1961-1971 in order to "predict" a figure for 1972 to be compared with the observed figure of 701. For statistical purposes, the simple linear regression is adequate, and it can be fairly concluded that motor-vehicle occupant deaths dropped in 1972 but the other population statistics did not.

TABLE 1

Motor-vehicle occupant deaths in N.S.W., 1961-1972,
and associated population variables for the same period.

Year	Population of N.S.W. (June 30)	Total vehicles	Registrations of new vehicles (year ending June 30)	Driving licences on issue	Consumption of motor spirit (gallons x 1,000)	Vehicle occupant deaths
1961	3,917,013	1,024,519	124,179	1,305,910	441,540	524
1962	3,985,000	1,073,634	120,182	1,371,675	465,732	504
1963	4,047,700	1,112,868	144,001	1,414,071	498,861	544
1964	4,105,200	1,177,629	160,140	1,497,288	540,775	610
1965	4,172,400	1,257,815	172,632	1,571,701	581,900	784
1966	4,233,800	1,330,840	158,371	1,627,597	605,625	749
1967	4,292,900	1,401,674	162,226	1,717,161	634,588	706
1968	4,354,600	1,472,316	183,862	1,776,159	668,508	813
1969	4,434,100	1,562,270	190,209	1,841,580	712,117	794
1970	4,513,000	1,669,778	209,320	1,966,152	764,229	881
1971	4,589,556	1,767,009	211,429	2,059,617	801,064	860
1972	4,663,000	1,875,540	209,472	2,110,312	857,387	701

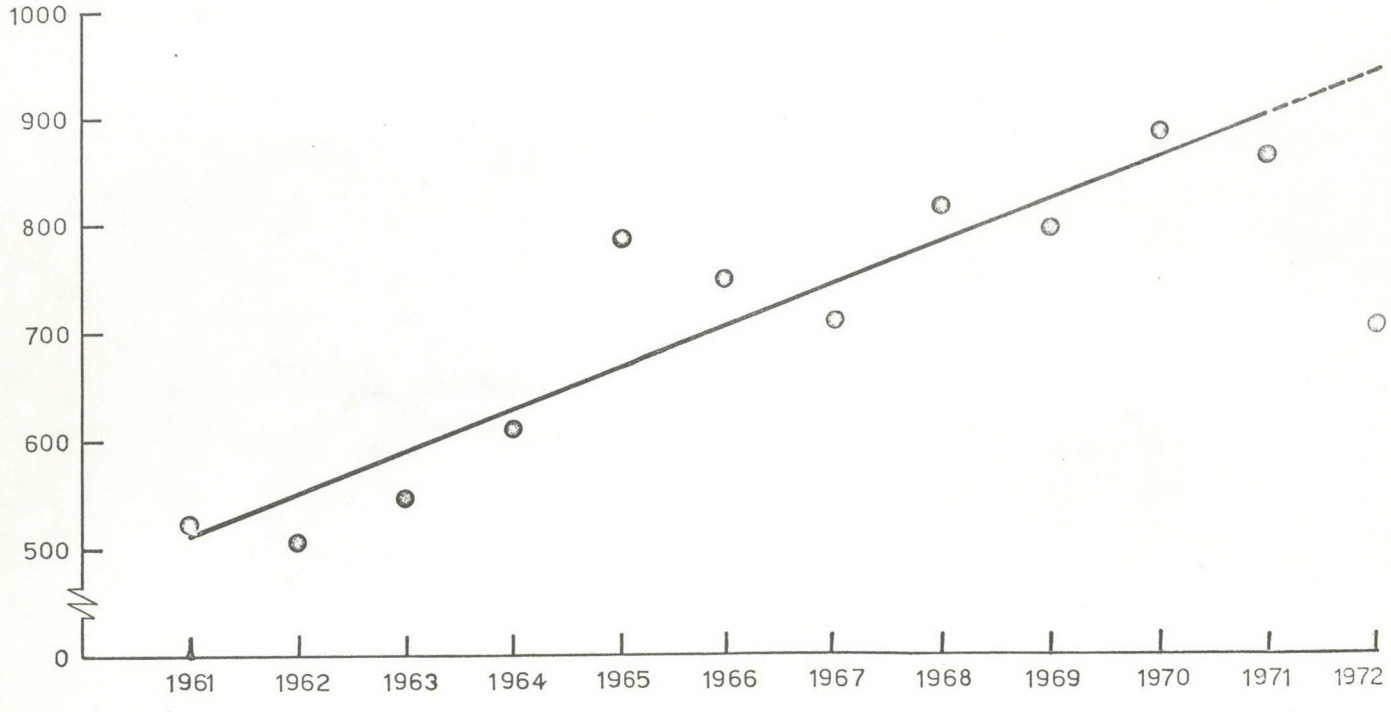

Figure 1: Motor-vehicle occupant deaths, New South Wales, 1961 - 1972, with regression line fitted to data for 1961 - 1971.
Regression equation : $Y = 473.6 + 38.8(X-1960)$.

TABLE 2

Residual figures for population data, representing difference between actual values and values derived from regression analysis.

Year	Population of N.S.W. (June 30)	Total vehicles	Registrations of new vehicles (year ending June 30)	Driving licences on issue	Consumption of motor spirit (gallons x 1,000)	Vehicle occupant deaths
1961	6,222	46,237	1,241	25,653	10,160	11.64
1962	8,271	21,002	-11,560	17,489	-1,461	-47.14
1963	5,033	-14,114	3,455	-14,044	-4,146	-45.92
1964	-3,405	-23,703	10,789	-4,756	1,953	18.70
1965	-2,142	-17,867	14,477	-4,271	7,264	116.52
1966	-6,680	-19,192	-8,588	-22,304	-4,824	42.74
1967	-13,518	-22,708	-13,537	-6,669	-11,674	-39.04
1968	-17,756	-26,416	-706	-21,599	-13,568	29.20
1969	-4,194	-10,812	-3,163	-30,108	-5,773	-28.60
1970	8,769	22,346	7,144	20,536	10,524	19.60
1971	19,387	45,227	449	40,072	11,545	-40.16
Correlation with residuals of occupant deaths	-.281	-.227	.499	-.171	.2104	1.00

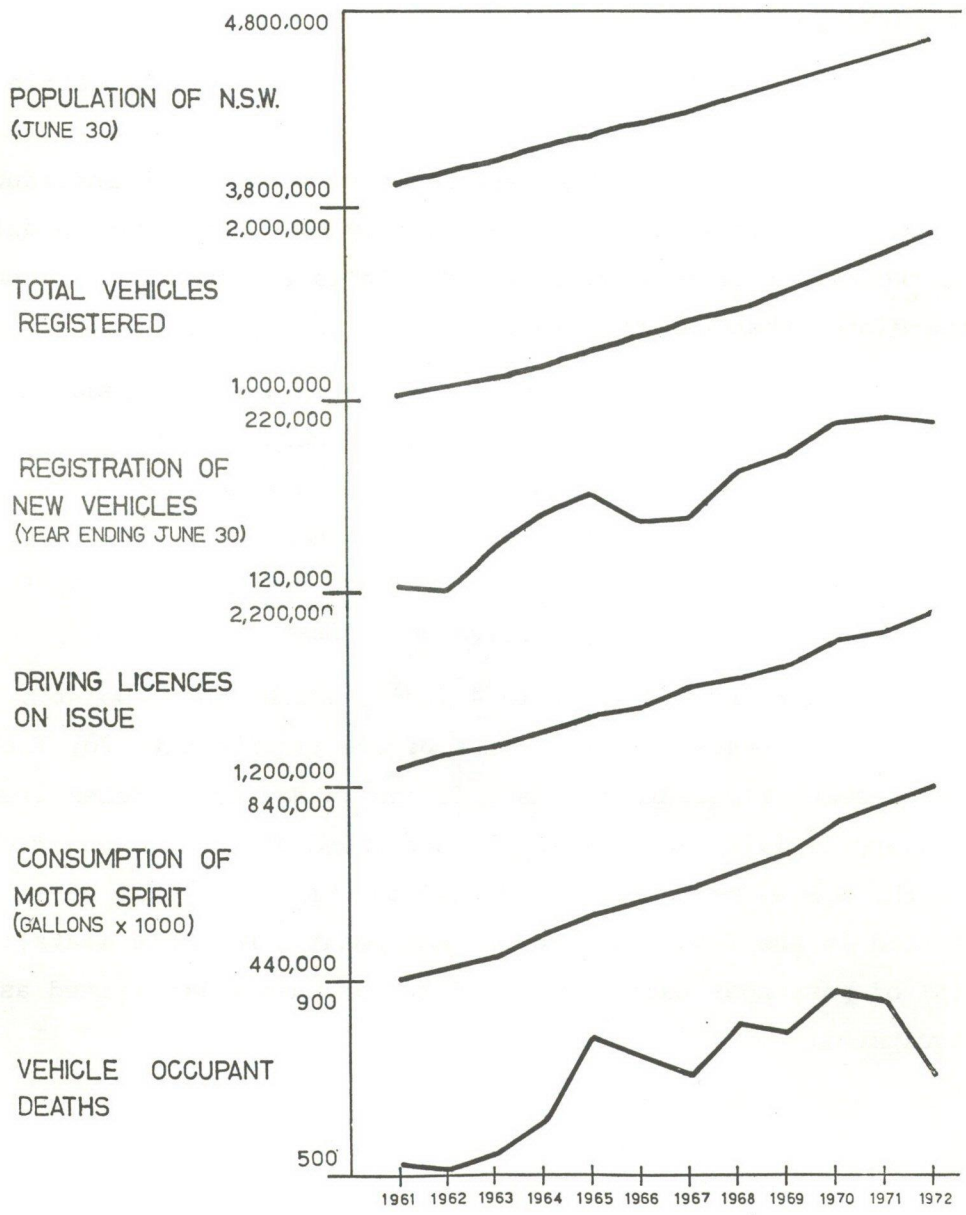

Figure 2: Motor-vehicle occupant deaths, New South Wales, 1961 - 1972, and associated variables.

Discussion

It is almost never possible to evaluate the influence of a given crash loss reduction measure by its effect on the total number of, say, deaths which occur - despite folklore to the contrary - because of the coincident influence of the multitude of associated factors which are also operating in the complex traffic system. The careful use of controlled samples is usually necessary in order to reach scientifically acceptable conclusions as to the success of a given countermeasure. It is especially gratifying, therefore, to be able to demonstrate a large, and statistically significant drop in the annual number of occupants of motor vehicles killed during the year immediately following the introduction of a law making the wearing of seat belts compulsory.

We have not "proved" that the new law was responsible for this drop. However, there was no such drop in a number of associated variables. Further, no other measure was introduced at the end of 1971 which might conceivably have had a marked effect on the number of occupants killed. It is reasonable to assume, therefore, that the relationship was a causal one.

Any beneficial effect of this legislation in reducing the number of deaths applies only to those occupants of motor vehicles who have seat belts available to them, who wear those belts as a result of the legislation, and who are then involved in a crash which is survived because belts are worn but would not have been otherwise. These points deserve amplification.

Australian Design Rule 4 (under which "three-point", combined lap-and-sash seat belts became requirements for front outer seating positions) was enforced in New South Wales from January 1, 1971. Approximately one-third of the passenger cars on the N.S.W. register in 1972 had on this basis seat belts fitted in the front as original equipment. For rear seats, only 15% of passenger cars registered in 1972 had belts fitted as original equipment.

No accurate figures are available on a State-wide basis as to the number of belts fitted as original equipment before these dates, or for the number of belts fitted voluntarily, but a large number were. Around one million lap-and-sash seat belts are produced for "retrofitment" to older cars each year in Australia, of which about 400,000 would be destined for New South Wales. Assuming that these would normally be sold in pairs, this is equivalent to fitting out the front seats of about 200,000 used cars each year, or 10% of the car population. In the Sydney metropolitan area, 76% of passenger cars and their derivatives (such as panel vans and utility trucks) had seat belts fitted to at least the front outer seating positions in May, 1972, and 16% had belts fitted to all seats. Andreassend (1972) reported very similar figures for the Melbourne (Victoria) metropolitan area. Very few seat belts are fitted to heavy commercial trucks, but the number of occupants killed in these vehicles is a very small proportion - about 4% - of total occupant fatalities (Henderson and Sims, 1970), and no effort was made to extract deaths among truck occupants from the data reported in this paper.

Do vehicle occupants now wear belts because of the law? Surveys of seat-belt wearing by passenger-car occupants in Sydney traffic showed that before the legislation the proportion of all front-seat occupants wearing belts was within a range of 10% to 25% (depending on the type of traffic). Similar surveys after the legislation showed that the proportion rose suddenly to a high of 75% among the occupants of cars in commuter traffic, indicating that almost all those front-seat passengers with belts available were wearing them. Again, similar results have been reported for Victoria (Andreassend, 1972), and in neither State have follow-up measurements shown a decline in measured wearing rates. Social pressures now exist in Australia which tend to encourage seat-belt wearing, which is now regarded as perfectly normal behaviour, and not rather "odd" as was predominantly the case before the legislation.

It has not been possible, however, to obtain systematic measurements of the proportion of occupants at relatively high risk of crash involvement who put on and properly adjust their seat belts. Of particular concern are those driving at night and after drinking. Enforcement of this law in the dark is an obvious difficulty; in daylight, on the other hand, police officers can observe whether the sash portion of the belt lies over the shoulder (but not, with any ease, whether the buckle is fastened). Over 14,000 car occupants were charged in New South Wales in 1972 with the offence of not wearing a seat belt, but in the majority of cases this charge was supplementary to others such as exceeding the speed limit or the prescribed level of blood alcohol (personal communication, N.S.W. Police Traffic Branch).

Even when seat belts are fitted and correctly worn there are many crashes which a properly restrained occupant cannot survive because of any one or a combination of the following factors: first, very high deceleration forces above the survivable threshold; second, major structural failure which in turn results in restraint system failure; third, distortion of the passenger compartment which brings the occupant into direct contact with unyielding surface and projections. If continuing inroads are to be made on the number of people killed in cars, then the group of most immediate concern is composed of vehicle occupants who die when wearing seat belts. By virtue of their design and layout, belts provide more protection in frontal and near-frontal impacts than in collisions from the side, and protection of occupants in side impacts thus becomes relatively more important when seat-belt wearing - for the purpose of vehicle and roadside design - can be presumed.

Within the present aesthetic, economic and political constraints of passenger-vehicle and roadside design, it is not likely to be possible to save the lives of all those who crash, even if seat-belt wearing becomes universal. But seat belts do

more than simply save lives; throughout the whole spectrum of crash violence they have a potent effect on lessening the degree of non-fatal injury, an effect which has already been documented by many workers including Bohlin (1967), and which is currently the subject of further study in Australia. Urgent attempts now being made in this country to upgrade the standard of seat-belt installation in new cars should, by improving comfort and convenience, maintain or increase the presently high wearing rate; further, by eliminating the need for individual adjustment, these design advances should prevent those unnecessary injuries which are now occurring as a result of the wearing of belts very loosely.

By the middle of 1973, Australia and New Zealand were still the only two countries in the developed "western" world to have introduced laws to make the wearing of seat belts compulsory. Meanwhile, national and State administrations in the United States, the United Kingdom, Canada and Sweden, to name but four countries, have either shown intense interest in, or voiced overt support for, this measure. Political scientists will no doubt examine one day the mechanics of its introduction in Australia. A powerful and well-informed lobby, supported by many individuals from the medical and engineering professions, was undoubtedly influential. Motorists' organisations actively encouraged the move, which, by the time of its introduction in N.S.W., was also being urged by writers in most newspapers and other public media of communication.

The introduction of a law to make the wearing of seat belts compulsory was undoubtedly a measure restricting the liberty of the individual to choose whether or not to protect himself, but the stand taken by Australian liberals was that this restriction on personal liberty could be justified because its resultant effect was beneficial to society as a whole. A beneficial effect was indeed indicated in 1972, the first full year of the legislation in New South Wales, but vigorous attention must continue to be paid to the details of humane vehicle and environmental design if the full benefits of the measure are to be gained in the future.

Summary

Legislation which now makes the wearing of seat belts compulsory for occupants of motor vehicles for whom belts are available was introduced in New South Wales, Australia, at the end of 1971.

A simple regression model has been used as a predictor for the "expected" number of motor-vehicle occupant deaths in 1972. The actual number of vehicle-occupant deaths that year was 25% below the predicted figure, and this drop is shown to be statistically significant.

There was no accompanying drop in the total population of N.S.W., the number of licensed drivers, the number of vehicles on the register, the annual number of registrations of new vehicles, or the annual consumption of motor spirit. It is probable that the legislation requiring the wearing of seat belts was responsible for the drop in occupant deaths.

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