INFLUENCE OF STUDDED TIRES ON WINTER DRIVING SAFETY IN QUEBEC

Jean Normand, Department of Roads, Quebec

This paper summarizes winter accident data and winter driving conditions in Quebec and investigates the improvement in safety given by the use of studded tires. This investigation was conducted by comparing accident data in Quebec City for both the group using studded tires and the group not using studded tires. The general characteristics of these two groups were investigated by means of a questionnaire. Answers to the questions indicate that, for the purpose of the present study, both groups can be considered as identical. An analysis of the classification of the accidents shows that an improvement of safety related to the use of studded tires, if any, is inferior to the precision of the data. Answers to the questions also indicate that the use of studded tires does not seem to have improved the accident record of persons using studded tires.

•THE USE of studded tires in Quebec started during the winter of 1963-64. Because the publicity emphasized the security aspect, to which the public is very sensitive, studded tires soon became very popular as shown in Figure 1. This publicity has been substantiated since then by technical papers (1, 2, 3) reporting the ability of these tires to reduce braking distances on ice or hard-packed snow. The reduction of the braking distance on ice is approximately 20 percent when two studded tires are used and is approximately 35 percent when four studded tires are used. These figures are often used by marketing agencies and lead the general public to think that these reductions in braking distances are directly related to an increase in safety for the consumers. This obviously implies that the driver who has a car equipped with studded tires drives his car in the same manner as if he did not have any. The objective of this paper, therefore, is to investigate the true safety benefits of studded tires as used in Quebec.

The importance of the problem can be easily appreciated because studies conducted in Europe (4, 5, 6), in the United States (7, 8, 2), and in Canada (9, 10, 11) have indicated very clearly that studded tires do damage the pavements. The apparent scatter of the results is due solely to the number of variables involved in the wearing process of the pavement (10).

GENERAL CONDITIONS IN QUEBEC PROVINCE

All safety analyses are difficult, but, in the present case, an additional problem arises from the fact that winter driving conditions are modified from year to year by improvements of the roads, increased quantities of de-icing chemicals, and use of studded tires. The improvement of roads over the years can be neglected because the data are given as a percentage of the total number of accidents for each year. For the purposes of this study, a year is defined as the period starting on March 1 and ending on February 28. The winter is considered as starting on November 1 and ending on February 28.

Figures 2, 3, 4, and 5 show the variations over the years of the different types of winter accidents expressed as a percentage of the total number of accidents occurring during a year. The figures also show the percentage of yearly traffic occurring during

Sponsored by Task Force on Effect of Studded Tires and presented at the 50th Annual Meeting.

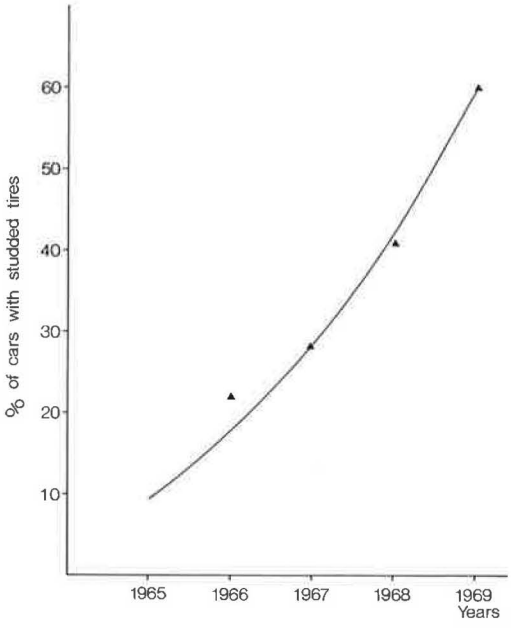

Figure 1. Increase of use of studded tires in metropolitan Quebec.

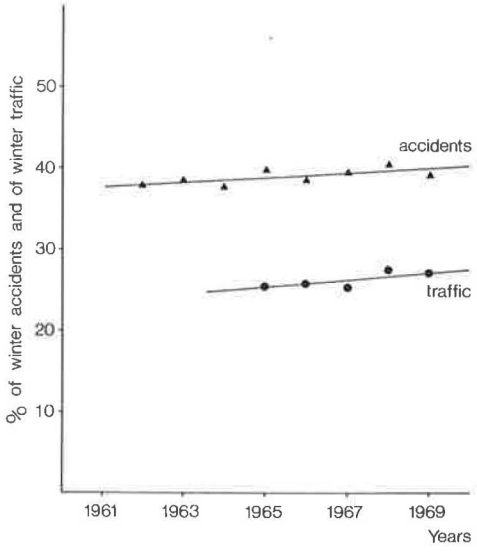

Figure 2. Increase of winter accidents and of winter traffic in Quebec Province.

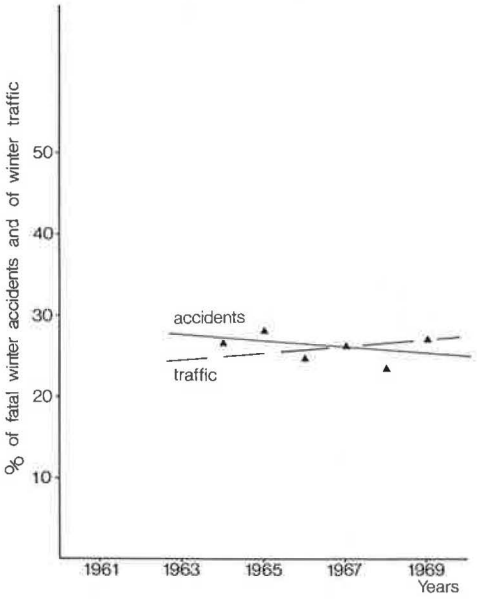

Figure 3. Decrease of fatal winter accidents in Quebec Province.

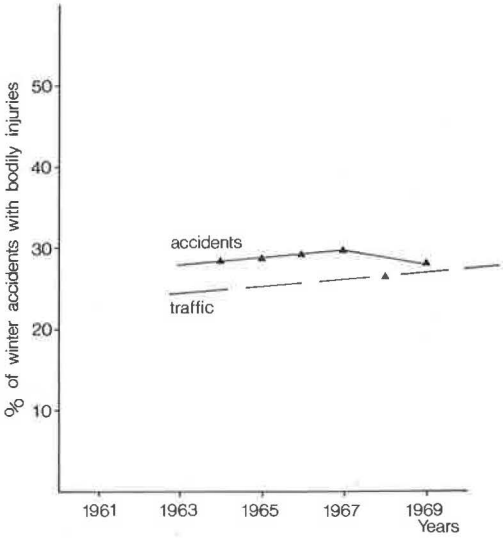

Figure 4. Increase of winter accidents with bodily injuries in Quebec Province.

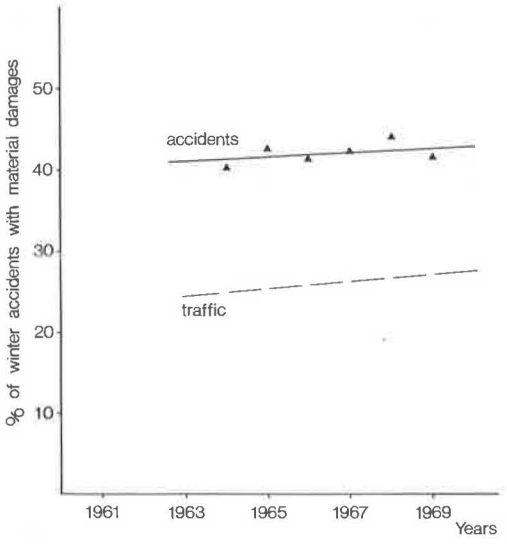

Figure 5. Increase of winter accidents with material damages in Quebec Province.

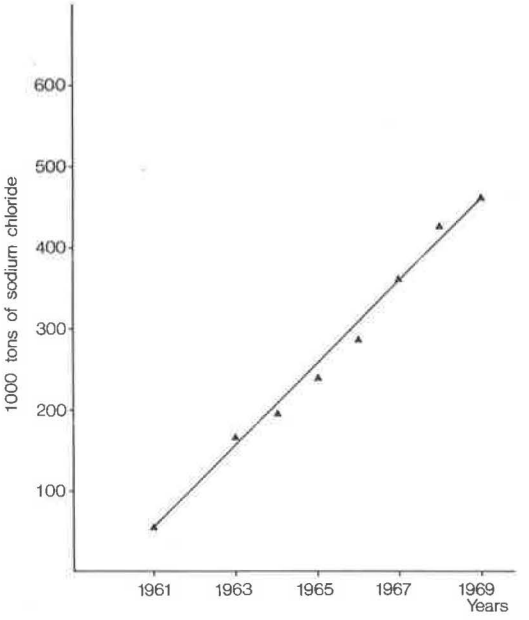

Figure 6. Winter use of sodium chloride in Quebec Province.

the winter. From these figures it can be seen that the annual increase in accidents is inferior to the growth of winter traffic. This is probably due to a general trend to artificial improvements, such as the use of studded tires (Fig. 1), and a wider use of de-icing chemicals (Fig. 6) that tend to eliminate the effects of winter and improve driving conditions. Although the individual effect of both variables is difficult to separate without an independent study, an attempt is made to determine, by analyzing for a period of years, the risk of being involved in an accident in slippery conditions during the winter compared with the risk of being involved in an accident in nonslippery conditions.

These values were based on a determination of the percentage of winter accidents reported as occurring in slippery conditions for 4 years. A pavement was considered to be in slippery condition when the pavement surface was reported as icy or partly to fully snow covered. The basic hypothesis of the investigation is to assume that traffic accidents on a highway network are directly related to the intensity of the traffic.

From this hypothesis, the percentage of vehicle-miles driven during the winter is the theoretical percentage of winter accidents. Because accidents occuring in nonslippery conditions are not related to the winter accidents when their number is deducted from the total number of expected accidents, the remainder is the theoretical number of winter accidents that would occur if the roads were not slippery when in fact they are slippery. Therefore, this remainder divided by the theoretical number of winter accidents represents the percentage of vehicle-miles driven in slippery conditions during the winter. It represents a winter serviceability index that is related both to the severity of the winter and to the efficiency of winter maintenance. The total number of accidents occurring in slippery conditions divided by the expected number of accidents is an index of the susceptibility to car accidents when the road is slippery. This index may be compared to nonslippery conditions, in which case the index is equal to 1.0 from the hypothesis mentioned previously. This index is given in Eq. 1, and the symbols are shown in Figure 7.

$$I = \frac{MA}{T - M(1 - A)} \qquad (1)$$

where

I = index of susceptibility to accidents in slippery conditions;
T = percentage of annual traffic occurring during the winter, which is also equal to the theoretical expected percentage of winter accidents;
M = percentage of annual accidents occurring during the winter; and
A = percentage of winter accidents occurring in slippery conditions.

Because the variable I is in some ways related to climatic conditions for a given region, observation of I over a longer period of time than that shown in Figure 8 could be more informative.

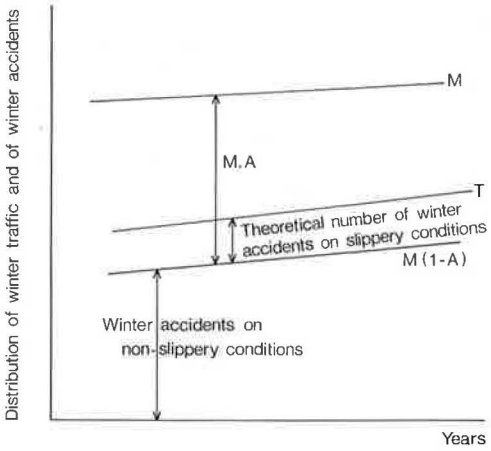

Figure 7. Determination of index of susceptibility to accidents in slippery conditions.

MODEL OF THE STUDY

Because an analysis of these statistics could not give a specific answer to the problem, a special investigation was carried out in Quebec City to determine the safety benefits of studded tires. The investigation consisted primarily of classifying all traffic accidents that occurred in Quebec City according to road conditions and to possession of studded tires. Assuming that both groups are identical, the distribution of accidents can be predicted when the size of both groups is known. By comparing the predictions with the observations, the advantages of studded tires can be determined.

VERIFICATION OF ASSUMPTIONS

The hypothesis of identical groups was checked by means of a questionnaire that contained the following questions: Do you own a car? Since when? Do you use your car during the winter? Does your car have studded tires? How many? Why did you buy studded tires: improved braking, improved traction, greater speed, improved security, other? Why did you not buy studded tires: too expensive, no need, inefficient, never thought of it, other? What is the average annual mileage of your car? How many miles are driven yearly within Quebec City? As a driver have you ever been involved in a car accident (damages greater than $100)? How many times in the last 10 years? As a driver have you ever been involved in a minor car accident (damages less than $100)? How many times in the last 10 years? When did you have your last and penultimate accidents? When did you have your last and penultimate minor accidents? Do you use your safety belt? To which age group do you belong: 17 to 25, 25 to 35, 35 to 45, 45 to 55, 55 and over?

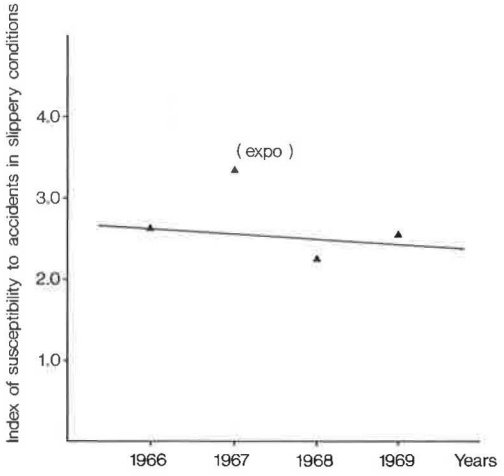

Figure 8. Annual variation of index of susceptibility to accidents in slippery conditions in Quebec Province.

The questionnaire was mailed to 786 persons chosen at random in metropolitan

Quebec. A letter enclosed with the questionnaire explained that answers would be obtained by a personal telephone call.

A total of 358 questionnaires were subjected to analysis after elimination of questionnaires for those persons who were not reached by telephone, those who did not own a car, those who did not use a car during the winter, those who refused to answer (6 people), and those who gave incomplete replies. Two groups were then made up of 218 car owners who had cars equipped with studded tires and 140 whose cars did not have studded tires. The questionnaire was designed to determine whether, during the time the interviewed person owned a car, his accident record was different according to whether his car was or was not equipped with studded tires. If a difference had been noted, it would have been attributed to the driver's attitude, because the questions concerning the driver's accident records applied to his entire driving life (which was an average of 13 years and, therefore, accorded little influence to the use of studded tires, because the existence of such tires was limited to recent years). The questionnaire was designed to determine whether the recent accident record of each group showed any improvement over the lifetime accident records of each group. The answers to the questions are given in Table 1. Group A is the group of 218 people owning cars equipped with studded tires, whereas group B is the group of 140 people owning cars not equipped with studded tires.

These results indicate that the experience of both groups is similar (Table 1, item 1). The exposure in Quebec City is identical although the yearly mileage of group B is lower because of the presence of a larger group driving less than 5,000 miles per year. The standard deviation of items 5, 6, and 7 should not be given too much emphasis, because the deviation may be influenced by the presence of two or three reckless drivers in group B. These drivers may also affect the average values to a certain degree.

Assuming that the individuals of both groups are not biased and give equally true answers, it can be concluded from these answers (Table 1, items 1, 2, 3, and 4) that both groups are identical as far as experience, age, and miles driven are concerned. It may also be noticed that the drivers of group A have a better driving record than those of group B (Table 1, items 9 and 12). This record may be ascribed to the fact that they use studded tires or to the fact that they are more safety conscious and for this reason buy safety devices. The last hypothesis is probably more reasonable, because most of them have had cars fitted with studded tires for only a very few years, and the improvement of their accident records (Table 1, items 15, 16, and 17) during the years is inferior to

TABLE 1

RESULTS OF QUESTIONNAIRE SURVEY

Item	Group A[a]		Group B[b]	
	$\bar{x}$	α	$\bar{x}$	α
1. Driver's experience, years	13.39	9.23	13.44	11.43
2. Driver's age	41.5		41.9	
3. Average yearly mileage	13,206	8,570	11,475	6,585
4. Average yearly mileage in city of Quebec	4,920	3,545	4,824	4,027
5. Percentage of mileage in city of Quebec	42.8	26.7	44.0	26.4
6. Number of major accidents per year	0.10	0.16	0.12	0.28
7. Number of minor accidents per year	0.08	0.15	0.09	0.19
8. Total number of accidents per year	0.19	0.24	0.22	0.40
9. Average mileage without major accident	66,633	77,020	61,898	65,637
10. Average mileage without minor accident	76,273	86,400	65,270	70,526
11. Average mileage without any accident	46,097	60,867	49,492	61,990
12. Mileage since last major accident	67,092	76,823	64,698	63,033
13. Mileage since last minor accident	77,604	85,829	68,427	69,723
14. Mileage since any accident	46,772	60,705	51,122	61,466
15. Recent improvement in driving without major accident, (item 12 - item 9)/item 9, percent	0.69		4.52	
16. Recent improvement in driving without minor accident, (item 13 - item 10)/item 10, percent	1.75		4.83	
17. Recent improvement in driving without any type of accident, (item 14 - item 11)/item 11, percent	1.46		3.30	

[a]Cars equipped with studded tires. [b]Cars not equipped with studded tires.

TABLE 2

TWO-CAR ACCIDENT CLASSIFICATION

Date (1969-70)	Two Vehicles With Studded Tires		Two Vehicles Without Studded Tires		One Vehicle With and One Vehicle Without Studded Tires	
	Slippery	Nonslippery	Slippery	Nonslippery	Slippery	Nonslippery
Nov. 16 to Nov. 29	16	34	19	77	17	42
Nov. 30 to Dec. 13	17	60	20	67	19	63
Dec. 14 to Dec. 27	38	55	42	55	30	45
Dec. 28 to Jan. 10	56	49	79	39	50	30
Jan. 11 to Jan. 24	53	85	52	82	60	92
Jan. 25 to Feb. 7	60	39	38	32	52	31
Feb. 8 to Feb. 21	59	31	39	34	40	35
Feb. 22 to March 7	21	26	21	26	17	16
	320	379	310	412	285	354

those of group B. These values were computed by comparing the mileage since the most recent accident with the average mileage without accident during the driver's last 10 years of experience.

The validity of the answers given to the questionnaire was checked in two ways. The first way was to determine the number of miles a driver could expect to drive without an accident in Quebec in 1969. This figure was estimated at 68,000 miles based on the provincial vehicle-miles and the provincial annual number of accidents. This figure is in accordance with the findings of item 11 (Table 1), which excludes commercial drivers, and also with the fact that Quebec City has the highest of the provincial insurance premiums. The second verification on the validity of the answers was made by a second questionnaire. The results will be described later.

Accident Classification and Studded Tire Ownership

To achieve the objective of classifying accidents according to whether did vehicles or did not have studded tires, the Police and Traffic Department of the city of Quebec provided the needed data. All data of the accidents occurring in the city from November 16, 1969, until March 7, 1970, were classified according to road conditions and to the presence or absence of studded tires on vehicles involved in accidents. All accidents involving a bus or a truck were omitted, and incomplete reports were rejected. A total of 2,060 accidents of varying severity involving two cars in each case were classified. There were 46 percent of these accidents that occurred in slippery conditions.

The distribution of accidents is given in Table 2. While these data were collected, various ways of measuring the relative importance of each group were devised. The first method of measure was from the questionnaire, the second was from a sampling of cars parked in streets in the middle of November, and the third was from a sampling of 2,000 cars in movement in all areas of the city, with the importance of the sampling being related to the number of accidents in the different areas and streets of the city. The results of these classifications are given in Table 3.

TABLE 3

CLASSIFICATION OF ACCIDENTS ACCORDING TO TIRES ON VEHICLES

Source	Group A (percent)	Group B (percent)
Questionnaire survey	60.9	39.1
November survey	49.8	50.2
February survey	56.4	43.6
Day	54.7	45.3
Peak hours	58.8	41.2

It was noted in the February 1970 survey that 14.3 percent of those who owned cars equipped with studded tires had them on all four wheels. This represents 8.0 percent of the car traffic in Quebec City. The difference obtained between the November 1969 and the February 1970 surveys is attributed to the fact that in November 17 percent of the vehicles still had summer tires. The percentage of the February survey is used in this study because it takes into account the exposure that is a function of the mileage and of the possession.

Analysis of Accident Data

This classification of car accidents can be interpreted in several ways. The first method is to determine the number of single cars in each group that was involved in accidents during the winter and to compare the distribution with the results of the February survey (Table 4).

TABLE 4

DISTRIBUTION OF ACCIDENTS

Accident	Group A (percent)	Group B (percent)
In slippery conditions during winter	49.9	50.1
In nonslippery conditions during winter	47.6	52.4
During February survey	56.4	43.6

From these results one can note that the drivers of group B are more prone to accidents. This only confirms the results of the questionnaire (Table 1, items 8 and 11). It is however surprising to note that, in slippery conditions, the drivers of group A using a "safety device" are then more prone to accidents than in nonslippery conditions, in which studded tires are not useful and may even be a disadvantage (3).

A second method of interpreting the classification is to compare the percentage of accidents for each group according to road conditions and to compare these values with the expectancy of accidents based on the exposure of both groups. The results (Table 5) indicate that both groups had a higher rate of accidents than expected within their own group and a lower rate of accidents than expected between groups. This, in itself, is a strong indication of a bias in the data, because the advantage of one group over the other should be indicated in two categories. Because group A should be showing a better performance, it is somewhat surprising to note that the general performance of the group is not so good when the roads are reported as slippery, the condition in which studded tires should work the best.

Notwithstanding the bias, a close examination was made of 199 accidents out of 285 occurring in slippery conditions in which one car was equipped with studded tires and another was without. Out of these 199 cases, at least one car skidded in 99 cases or 48.7 percent of the time. In the other cases, the fact that the pavement was reported as slippery had no direct effect on the cause or the severity of the accident because no skid occurred. In all cases where skidding occurred, the accident was classified according to the responsibility and to the type of tires. The responsibility was determined from the driver's testimony, and only 6 cases were classified as unknown. Data are given in Table 6. The first observation is that the skidding vehicle is more likely to be responsible for the accident, which is an indication of overconfident driving in slippery conditions. A second observation is that both vehicles with studded tires and vehicles without studded tires are equally involved in skidding accidents with responsibility. An analysis of accidents where the skidding vehicle is not responsible for the accident is impossible to make because of the limited number of cases.

From this last analysis, studded tires do not seem to provide any advantage in safety even without correcting for accident susceptibility of the drivers of vehicles without studded tires as determined from the questionnaire (Table 1, items 8 and 11).

Analysis of Bias and Control Questionnaire

It had been assumed previously that both groups answered the questionnaire with equal honesty. Also pointed out was the possible bias introduced in the accident classi-

TABLE 5

OBSERVED AND THEORETICAL DISTRIBUTIONS OF TWO-CAR ACCIDENTS

Distribution	Two Vehicles With Studded Tires		Two Vehicles Without Studded Tires		One Vehicle With and One Vehicle Without Studded Tires	
	Slippery	Nonslippery	Slippery	Nonslippery	Slippery	Nonslippery
Observed	35.0	33.1	33.9	36.0	31.1	30.9
Theoretical	31.8	31.8	19.0	19.0	49.2	49.2

fication. In order to check these two points, a questionnaire was mailed on March 10, 1970, to 124 car owners living in metropolitan Quebec who were involved as drivers in at least one car accident during the third week of February 1970. Following the same procedure adopted for the main questionnaire, answers were obtained by telephone interviews. There were 46 persons in group A and 45 in group B who were interviewed, and there were 3 in each group who refused to answer.

TABLE 6

ACCIDENTS OCCURRING ON SLIPPERY CONDITIONS INVOLVING ONE VEHICLE WITH STUDDED TIRES AND ONE VEHICLE WITHOUT STUDDED TIRES

Accidents	Number	Percent
Accidents	199	100
With skidding	97	48.7[a]
Unknown responsibility	6	6.2[b]
Non-skidding vehicle responsible	16	16.5[b]
Skidding vehicle responsible	75	77.3[b]
Studded tire vehicle skids	38	50.6[c]
Unstudded tire vehicle skids	37	49.4[c]

[a]Of total accidents.
[b]Of accidents with skidding.
[c]Of accidents with skidding vehicle responsible.

The first point of interest was to determine whether the driver would admit that he had been recently involved in an accident. There were 26 persons, or 30 percent of each group, who failed to admit that they were recently involved in an accident. Most of them were responsible for the accident (16), or the accident in which they were involved was of minor importance (10). Because only 3 weeks had elapsed between the date of the accident and the date of the interview and because the responsibility for the accident had not yet been determined, it was felt that many drivers would be reluctant to talk about the accident. The credibility of the main questionnaire, therefore, might be expected to be greater. This fact is substantiated, as mentioned previously, by analysis of the average expected mileage without accident, which is close to the provincial average. The main conclusion from this control so far is that both groups are equally willing to admit that they have been involved in an accident.

The control questionnaire was also sent to verify whether the classification of the car noted by the police officer in the accident report form was correct. Having established that both groups answered the question with the same honesty, it is assumed that any difference of classification between the two groups would be due to a bias introduced by the police officer while writing his report.

Item	Group A	Group B
Agreement between driver's declaration and officer's report	31	25
Percentage of agreement	72.1	59.5
Introduced bias, percent	—	20.6

This bias was also noticed by grouping the accident reports and both drivers' declarations of their types of tires. This was possible for 13 accidents involving 26 cars. In 3 accidents, both drivers were in disagreement with the officer's classification. These 6 cars were reported as not being equipped with studded tires. Because numerous additional hypotheses would be required to correct the data, no attempt was made to do so.

In the analysis of accident data, the bias introduced by the police officer was not taken into account. This procedure seems justified because the bias should be least when both cars involved in an accident are classified differently. In view of the fact that the bias is introduced by the police officer, the officer is more likely to be correct when he makes a different classification for both cars. This is substantiated by the fact that only 31 percent of the car accidents were reported in that category, whereas 49 percent of the car accidents were expected to fall into this category.

CONCLUSIONS

The conclusions of this study are based on an analysis of the statistics concerning winter driving in Quebec Province, on the results of a questionnaire sent to the public, and on an analysis of accident data in Quebec City.

1. Because of the multiplicity of the variables and the limited number of statistics, it was impossible to determine from the statistics whether studded tires provided increased safety in driving.
2. It was found from the questionnaire that owners both of cars equipped with studded tires and of cars not equipped with studded tires formed comparable groups as far as accident records and honesty in answering the questionnaire were concerned. It was also found that drivers using studded tires on their cars had shown less improvement over the years in their safety record than the other group.
3. The analysis of accident data shows that there was a bias in the data. Assuming the bias to be independent of road conditions, the use of studded tires did not improve the driving safety of those who used them in slippery conditions. Because of its nature, the bias should be least when the cars involved in an accident belong to different groups. In that particular case, the use of studded tires did not improve the safety driving record of the driver using these tires.

For all these reasons, the general conclusion of the study is that, in the Quebec area, the use of studded tires has not brought about any major improvement in winter accident statistics. In fact, the data taken at face value indicate that no improvement has occurred.

ACKNOWLEDGMENTS

This study was carried out with the cooperation of the Police and Traffic Departments of the Quebec City. The author also wishes to thank B. Deshaye and P. Moran, who reviewed the text, and G. Tessier for his assistance during editing.

REFERENCES

1. Whitehurst, E. A., and Easton, E. H. An Evaluation of Studded Tire Performance. Highway Research Record 171, 1967, pp. 14-27.
2. Rosenthal, P., Haselton, F. R., Bird, R. D., and Joseph, P. J. Evaluation of Studded Tires: Performance Data and Pavement Wear Measurement. NCHRP Rept. 61, 1969.
3. Effectiveness of Studded Tires. Canada Safety Council, Ottawa.
4. Wehner, B. Influence of Studded Winter Tires on Pavement Surfaces. Strasse und Autobahn, Vol. 15, No. 7, 1964.
5. Hogbin, L. E. Damage to Roads by Studded Tires. Road Research Laboratory, England, RRL Rept. RL208, 1968.
6. Thurmann-Moe, T. Pavement Wear Caused by Use of Studded Tires and Chains. Norwegian State Road Laboratory, Jan. 1970.
7. White, O. A., and Jenkins, J. C. Test of Steel Studded Snow Tires. Highway Research Record 136, 1966, pp. 31-41.
8. Lee, A., Page, T. A., DeCarrera, R. Effects of Carbide Studded Tires on Roadway Surfaces. Highway Research Record 136, 1966, pp. 59-77.
9. Tessier, G. R., Normand, J. Les pneus à crampons et leurs effets sur une chaussée souple. Canadian Technical Asphalt Assn., 1967.
10. Hode Keyser, J. Effect of Studded Tires on the Durability of Road Surfacing. Highway Research Record 331, 1970, pp. 41-53.
11. Smith, P., and Schonfeld, R. Pavement Wear Due to Studded Tires and the Economic Consequences in Ontario. Highway Research Record 331, 1970, pp. 54-79.

DISCUSSION

R. M. Canner, Jr., Minnesota Department of Highways

I will confine my remarks to a description of the study that is somewhat parallel to Normand's study and that is being conducted by Cornell Aeronautical Laboratory (CAL) for the Minnesota Department of Highways and to a brief summary of tentative findings based on preliminary analyses of the data collected thus far.

In 1969 the Minnesota legislature extended legal use of studded tires for 2 years until May 1, 1971. At the same time it assigned to the Minnesota Commissioner of Highways the task of evaluating "the effects, if any, that discontinuing the use of studded tires will have on highway safety."

Essentially, we were asked to determine whether the use of studded tires had any measurable effect on highway safety and, if so, the degree of benefit or detriment.

Minnesota has nearly 100,000 reported traffic accidents each year. On the average, 22 percent occur on roads classed as snowy and icy. Studies of accident statistics indicate that ratios of the accident rate on snowy and icy roads to the total accident rate are as follows: all accidents, 1.8; fatal, 0.8; personal injury, 1.4; and property damage only, 2.2. One may infer that accidents are more likely to occur on snowy and icy roads but are generally less severe than normal.

Improvements in vehicle performance have been cited as the solution to the problem of how to achieve greater winter highway safety. However, highway safety can benefit from the use of any safety device only if the potential safety improvement is translated ultimately into real reductions in accident severity and occurrence.

Because there was a complete lack of information in 1969 on accident research with regard to studded tires, the department initiated a $70,000 study in December 1969. The Cornell Aeronautical Laboratory was selected to do the study because of its extensive experience in accident data analysis and background of knowledge of studded tires.

The ultimate objective of this study was to determine whether the performance of studded tires do, in fact, provide greater safety on the highways and streets, in mixed traffic, and under all conditions. This was done by comparing studded tires to other tire types in terms of the amount and type of use; the effect on accident precipitation; and the effect on accident characteristics, including damage costs, severity, and injury.

To isolate studded tires from other factors that may influence accidents required the inclusion of a large amount of information in the study, and relationships of many variables were considered in the analysis. There are two principal sources of information: (a) data on the driving population collected through questionnaires sent to randomly selected automobile owners, and (b) data on accident characteristics collected on police accident-report forms used by participating police agencies. Additional information from state accident records was furnished to CAL so that statewide conclusions could be developed.

Questionnaires were sent to a statistically selected random sample of 84,000 of the 1,800,000 Minnesota-registered automobile owners. Specifically, the respondent was asked to describe his vehicle and his driving as experienced the day before filling out the questionnaire. Typical data obtained from the questionnaires included: driver characteristics such as age, sex, driving experience, and attitude toward studded tires; vehicle characteristics such as make, age, power assists, brake type, tire type and wear, and total mileage driven; and road conditions and driving exposure time on the day that was reported. Equal numbers of the questionnaires were mailed twice weekly to sample all days throughout the data-collection period. A cover letter signed by the governor requesting the respondent's cooperation accompanied each questionnaire.

Accident reports, together with a supplementary informational form designed by CAL, were received for each investigated and reported accident from the Minnesota Highway Patrol and 11 municipal police departments. The cities participating were Minneapolis, four suburbs, and five other cities. The Minnesota Highway Patrol furnished statewide coverage of most trunk highway accidents in rural and smaller urban areas. The cities furnished coverage of most accidents on city streets, except Minneapolis where the police normally investigate only those accidents involving injury and fatality.

Typical data obtained from the supplemental police accident forms, in addition to accident data normally reported, included tire type, road conditions, accident severity, officer's opinion of accident cause, driver characteristics, and vehicle characteristics. The use of these data was carefully restricted to research purposes only to protect the rights of all parties involved.

Collection of data for this study was started in February 1970 and continued until May 1, 1970, which was the end of the period of legal use of studded tires. The second data-collection period resumed on October 15, 1970, and continued until January 4, 1971, when it was terminated under the contract agreement.

CAL conducted a preliminary analysis of data from the first collection period to get the "feel" of the data. At that point, only simple statistical summaries of information obtained from questionnaires and accident reports were available. These findings, however, were unverified and tentative. Primarily, the findings show relationships between tire type, tire user characteristics, vehicle characteristics, travel exposure, accident characteristics, and accident effects.

The preliminary findings of the first questionnaire survey covering data from February, March, and early April 1970 (50,000 questionnaires) are given in the following:

1. Forty-three percent of the automobiles in the survey used studded tires, 26 percent used standard tires, and 28 percent used snow tires. The percentage of studded tires corresponds quite well with the 40 percent figure determined by the Minnesota Department of Highways field survey.
2. The proportion of automobiles equipped with studded tires decreased from 47 percent in February to 44 percent in March and to 34 percent in early April. The proportion of snow tires also declined in these periods, but at a much slower rate.
3. The proportion of automobiles equipped with studded tires was highest in rural areas, followed by urban areas, and then suburban areas. The differences were small.
4. Use of studded tires varied with vehicle-owner characteristics. In terms of percentage, more females than males owned vehicles equipped with studded tires. Owners over 65 years of age used snow tires more often and studded tires less often. The proportion of studded-tire use tended to increase with annual mileage of the owner.
5. Use of studded tires varied with vehicle characteristics. Proportionately, more sedans and convertibles were equipped with studded tire than were station wagons. Use of studded tires was greater for vehicles equipped with power brakes or power steering. Use of studded tires increased with later model vehicles up to 1969-70 when a decline was noted.
6. Automobiles equipped with studded tires accounted for 47 percent of all driving time in the period studied. Although this percentage was higher for roads completely covered with ice, snow, or slush, such conditions prevailed for only 1 to 8 percent of all driving time in the period studied. Sixty-eight to 87 percent of all driving time in the period studied occurred on roads with little or no road cover.
7. Driving in the northern counties was more likely to occur on roads covered with ice, snow, or slush than was driving in the southern counties.
8. The reported incidence of skidding of any kind ranged between about one-fourth and one-half of the vehicles traveling on other than bare roads. The reported frequency of skidding increased as the degree of road cover increased. Skidding was reported least frequently with studded tires and most frequently with standard-tread tires. In general, the reported skidding experience with snow tires was more similar to that with studded tires than to that with standard tires. The reported nonskidding superiority of studded tires increased as the degree of road cover increased.
9. The majority of respondents expressed the opinion that studded tires allowed one to drive closer to the speed limit on slippery roads. This opinion was held most frequently by owners of studded tires. (This opinion may suggest that the driver who uses studded tires may utilize his traction advantage to drive at higher speeds on slippery surfaces, perhaps diminishing safety benefits.)
10. Only 0.4 percent of the respondents did not drive because of snowy or icy roads.
11. Analysis of 972 unsolicited comments appended to the questionnaires by respondents indicated that 50 percent favored continued use of studded tires, 37 percent favored banning studded tires, and 13 percent expressed no opinion or were undecided. As the questionnaires were returned, the percentage favoring continuation of studded-tire use remained about constant through the period but the percentage for banning increased, indicating increased polarization in attitudes.

The preliminary findings of the first accident report analyses covering data from February, March, and early April 1970 are given in the following:

1. The accident sample studied consisted of 2,756 automobiles in 1,810 accidents with 1,422 injuries of which 57 were fatal injuries.
2. Twenty-five percent of the accidents reported in the study period occurred on roads described as having at least a scattered cover of snow, ice, or frost; 61 percent were on dry roads with little or no cover; and 12 percent were on wet roads. Only 3 percent of the accidents occurred on roads where sand or cinders had been spread.
3. In the sample, for all road-surface conditions, the proportion of vehicles equipped with studded tires and involved in accidents was less than the proportion of travel by vehicles with studded tires. This implies, for the sample only, that the accident rate for automobiles equipped with studded tires is lower than the rate for all automobiles, but this implication is incompatible with the finding that 75 percent of the accidents in the sample occurred on bare roads. It is hoped that the apparent paradox will be resolved by more data and analyses.
4. For each type of tire, there was little difference in the proportion of accidents on roads with at least some scattered snow or ice cover and the proportion of accidents on bare pavements.
5. Vehicles equipped with studded tires showed some performance advantage in reduced involvement in accidents in which slippery roads were reported to be a contributing factor and in reduced incidence of uncontrolled vehicle rotation before the collision impact.
6. Reported impact speeds were sparsely distributed and showed no advantage for any of the tire types in reducing the impact speed of collision.
7. Overall, there was no consistent advantage for any tire type in terms of personal injury and vehicle damage.

CAL has been completing the data coding. Kenneth Perchonok, the project director, has been adjusting the analysis procedure to conform to the specific characteristics of the data as determined from the preliminary results just presented. A final summary report of the findings will have been submitted to the Minnesota legislature before the conclusion of its session in May 1971.