Motorist Understanding of Railroad-Highway Grade Crossing Traffic Control Devices and Associated Traffic Laws

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The findings of a survey conducted in Tennessee to evaluate motorist comprehension of railroad grade crossing traffic control devices and associated traffic regulations are documented. The questionnaire survey was administered to 176 drivers and to 35 city police officers. The survey gathered input on driver recognition and understanding of common grade crossing traffic control devices, including signs, pavement markings, flashing light signals, gates, and train whistles, as well as driver perceptions of train capabilities and operating requirements. The survey results reveal that there are deficiencies in driver comprehension of several of the common crossing traffic control devices. Specifically, many drivers are uncertain or are misinformed about the applications of the crossbuck and advance railroad warning signs and about driver responsibilities at passive crossings and crossings with flashing light signals. Many drivers believe that a train operator can and should assume part of the responsibility for crossing safety by slowing or stopping the train. The survey also revealed that most drivers perceive a need to improve crossing safety. They recommend that gates, flashing lights, or both be installed at more crossings, driver education be increased, and more grade separations be constructed. Police officers, although they performed better than the general driving public on the survey, also demonstrated a lack of comprehension of some grade crossing traffic control devices and safety issues.

There are approximately 205,000 public railroad-highway grade crossings in the United States and an additional 150,000 private crossings. These crossings represent a unique and potentially hazardous driving situation, accounting for about 500 fatalities and over 2,500 injuries each year. To help motorists cope with the hazards, a number of traffic control and warning devices (and associated traffic regulations) have evolved and are recommended for use. These devices include the crossbuck sign, advance railroad warning sign, flashing light signals, automatic gates, bells, advance crossing pavement markings, and train horns. A basic presumption about all of these devices is that motorists understand their intended meanings and applications; otherwise, their usefulness as warning and regulatory devices is questionable.

Numerous studies (*1*) have addressed the operational and safety performance of railroad-highway grade crossing devices. Generally, these studies have revealed deficiencies in motorist response to many of the traffic control devices now in use. However, there has been only limited research into motorist understanding and comprehension of these devices. The studies that have been conducted have suggested that there may be serious shortfalls in motorist comprehension of grade crossing devices and associated traffic regulations and that these deficiencies may account for some of the performance problems observed at crossings.

In one study, Sanders et al. (*2*) investigated driver knowledge and attitudes concerning grade crossing traffic control and related drivers' knowledge and attitude to their observed behavior. The study concluded that motorists' ability to make correct decisions at grade crossings is related to their knowledge of and attitudes toward the crossing traffic control. Drivers who were observed performing more safely at crossings had seen and correctly interpreted the traffic control device present.

The Sanders study also found deficiencies in motorist's comprehension of some of the traffic control devices commonly used at crossings. For example, the study found that 15 percent of the drivers in the sample believed that all crossings have active warning devices. More than 40 percent of the drivers believed that the elapsed time between flashing signal activation and train arrival was greater than one minute.

Womack et al. conducted a study in Texas that addressed driver comprehension of the railroad advance warning sign (*3*). The study found that 42 percent of the sampled drivers were unaware that this warning sign was circular, and 60 percent were unaware that it was yellow. More importantly, 64 percent believed that the sign was placed at a crossing rather than in advance of the crossing, and 70 percent said they would not necessarily expect to see a crossbuck sign following the advance sign. In addition, 17 percent said that they would "stop and look for trains" upon seeing a railroad advance warning sign.

All states, including Tennessee, have adopted laws concerning driver duties and actions at grade crossings. Most of these laws have the same or very similar wording as contained in the Uniform Vehicle Code (UVC) (*4*). In adopting the wording of the UVC, states have removed the concept of "stop, look, and listen" applying to all motorists approaching all crossings and have instead outlined, in specific terms, driver's obligations in operating their motor vehicles when certain conditions exist at a crossing.

A driver can proceed through a crossing with activated flashing light signals after stopping, but only when it is safe to do so. However, a person is not permitted to drive any vehicle through, around, or under any crossing gate or barrier while the gate arm is down or being opened or closed.

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With regard to passive crossings, a driver is required to stop if a train is an immediate hazard or is in hazardous proximity to the crossing. However, if a driver cannot see or hear the train, there is no obligation set forth in the UVC or most state laws for drivers to stop or even slow down. In other words, all motor vehicles are not required to always stop or slow at all railroad-highway grade crossings. In fact, there are no requirements whatsoever to slow a motor vehicle down on an approach to a railroad-highway grade crossing or to take precautions other than those that would be required when traveling through a normal highway intersection.

The training that drivers receive, whether in a high school driver education course or in the state driving training manuals, will normally follow the state's legislative requirements for drivers at crossings. However, some public service programs tend to provide information that is contradictory to the law in the states and that therefore may be contributing to confusion on the part of motorists regarding highway-railroad grade crossings, whether the drivers had formal training or not.

A driver survey similar to a survey conducted by Tidwell and Humphreys (*5*) was conducted in Tennessee. In addition to assessing motorist comprehension of standard and innovative crossing traffic control devices, the survey gathered input on driver awareness of the grade crossing safety problem, the level of driver education relative to crossing traffic control and regulation, and driver suggestions for traffic control improvements.

SURVEY DESCRIPTION

Survey Instrument

Data for the research were gathered by using a questionnaire with 16 multiple-choice and 1 short-answer questions. These questions were designed to evaluate driver knowledge, recognition, and comprehension in the areas of adequacy of instruction and training on grade crossing devices and traffic regulations, two signs commonly used at crossings (the advance railroad crossing sign and crossbuck sign), understanding of and experience with flashing light signal installations, crossing gates, advance railroad crossing pavement markings, understanding of the passive traffic control strategy, train operation and train operator's responsibilities at a crossing, and suggestions on needed remedies or improvements for crossing safety.

Sampling Plan

The survey was conducted in three Tennessee cities: Nashville, Chattanooga, and Knoxville. An effort was made to obtain an unbiased and representative sample of the state's driver population by randomly surveying motorists as they renewed their driver's licenses. Subjects were recruited on a volunteer basis, that is, they were not paid for their services.

The majority of the questionnaires were administered by Tennessee Department of Safety (TDS) personnel to visitors at driver licensing centers in each of the three survey cities. The Department of Safety personnel distributed survey forms to motorists waiting to renew or, in some cases, to obtain their Tennessee driver's licenses. The TDS personnel, who had been trained to administer the survey, instructed the participants on completing the forms and collected completed questionnaires as the motorists departed. All participants were warned not to collaborate in their responses.

The survey was also given to a limited number of staff members at the University of Tennessee in Knoxville. No faculty members were surveyed.

Sample Size and Characteristics

A total of 176 motorists were sampled from the general driver population. This number was dictated by the time and funding constraints of the study; however, this sample size was adequate to accomplish the objectives of the research and assure reliability of the results. Participants were asked to complete a driver information form that gathered data on each individual subject's age, sex, education level, driver license status (i.e., in state, out of state, both, or none), and annual driving mileage.

The sample included drivers from a variety of socioeducational classes and therefore covers the entire driver population range. However, it should be noted that for some unexplained reason, the sample underrepresented older drivers. This fact does not invalidate the survey results, but it should be recognized that the survey may not accurately represent the comprehension level and conceptions of the older driver population.

Data Reduction and Analysis

The questionnaire and driver data were analyzed by using the Statistical Analysis System (SAS) battery of computer programs. As part of the data evaluation, several comparisons and contrasts were made. The validity and significance of these comparisons and contrasts were tested by using appropriate statistical tests, including chi-square tests, tests of proportions, and the Wilcoxon Sign Rank Test.

One question required subjects to give a short answer or narrative response. Subjects' responses to this question were reduced manually. Responses were paraphrased and grouped as appropriate for the sake of clarity and uniformity.

Police Survey

In reducing the survey data, it was noted that the sample by chance included two police officers and that the officers' responses appeared to be very different from the responses as a whole. This finding raised questions about the general comprehension level and conceptions of the law enforcement community concerning grade crossing traffic control and associated traffic regulations and prompted a second, smaller survey of 35 Tennessee police officers. The purpose of this second survey was to evaluate how police officers as a group perceive the intended meaning and application of the various grade crossing traffic control devices and regulations. The survey also permitted a comparison of the comprehension level and conceptions of the law enforcement community versus those of the general driver population.

The police survey was conducted in Knoxville, and the survey sample was composed entirely of Knoxville City police officers. The same questionnaire and driver information forms were used for the police survey. The police subjects were predominantly males between the ages of 25 and 44 with some

college education. In addition, because of their occupation, the police officers all held Tennessee driver's licenses and were high-mileage drivers.

SURVEY RESULTS

Instruction and Training

In the survey, drivers were asked where they had received instructions or training, if any, on crossing safety. As presented in Table 1, 72.3 percent of the survey participants said that they received instructions on crossing safety from a driver handbook, presumably the *Tennessee Driver's Handbook* in most cases. This large percentage is not surprising because the *Tennessee Driver's Handbook* in fact presents one page of general information and instructions on crossing traffic control devices and traffic regulations.

TABLE 1 SOURCES OF INSTRUCTION AND TRAINING ON CROSSING SAFETY

Source	Percent of Drivers[a] (N = 166)
Driver handbook	72.3
Driver education course	34.8
TV, radio, or newspaper safety campaign	12.7
None (no prior instruction)	11.4

[a]The percentages do not sum to 100 percent because individual drivers could list several sources of instruction or training.

Only about one-third of the survey participants (34.8 percent) said that they received instructions, training, or both on crossing safety during a driver education course. This relatively low percentage suggests that many current courses are not devoting enough attention to crossing safety or that many licensed drivers simply have not had a formal driver education course. This finding is consistent with the fact that the young drivers (18 and below) performed poorly on most of the comprehension questions on the survey in comparison to older, more experienced drivers. The implication is that young drivers are not getting the training on crossing safety that they need and that knowledge on crossing safety is gained through experience that comes after drivers are licensed.

Table 1 also shows that 12.7 percent of the survey participants recalled receiving information on crossing safety through media safety campaigns, for example, Operation Lifesaver. The percentage is both encouraging and discouraging. On the positive side, crossing safety campaigns do appear to be reaching some motorists. However, the relatively low percentage of survey responses suggests a need to expand or improve these campaigns.

It is also significant to note that 11.4 percent of the drivers in the survey (19 of 166 drivers) could not recall ever receiving any instructions or training on crossing safety. This number, combined with the relatively poor showing of driver education courses and safety campaigns, indicates a general deficiency in crossing safety instruction and training for the driving public.

Grade Crossing Signing

The survey evaluated motorists' comprehension of two signs commonly used at or near grade crossings: the railroad crossing (crossbuck) sign and the railroad advance warning sign (*6*). With respect to the crossbuck sign, 76.3 percent of the survey participants correctly identified this sign as the one placed at the crossing. However, 19.0 percent of the drivers incorrectly identified the railroad advance warning sign as the one placed at a crossing. The implication is that some motorists do not associate the crossbuck sign with the actual point of hazard. Also, there is some confusion on the part of motorists between the crossbuck and advance railroad warning signs as to their meaning.

For the railroad advance warning sign, the survey addressed two questions: (a) do drivers recognize this sign as an advance crossing warning sign? and (b) what do drivers believe the sign means? Table 2 summarizes the drivers' responses to the first question on sign recognition. From Table 2, 63.6 percent of the survey participants (110 of 173 drivers) identified the railroad advance warning sign as the one placed before a crossing to give advance warning of the crossing location. This percentage is relatively low and may suggest that many drivers are not as familiar with the advanced warning sign and its application as they should be.

A significant precentage of drivers (16.6 percent) incorrectly identified a diamond shape sign with the message "RAILROAD CROSSING" as the appropriate advance warning sign for a crossing. This choice, although incorrect, is consistent with other types of warning signs and therefore its selection is not surprising. What is surprising is that 13.3 percent of the survey participants incorrectly identified the crossbuck sign as the sign that is used several hundred feet in advance of a crossing. This result again suggests that some drivers do not understand the full intent of the crossbuck sign and that there is motorist confusion between the crossbuck and railroad advance warning signs.

In addition to the recognition issue, the survey evaluated drivers' understanding of the intended (specific) meaning of the railroad advance warning sign. As presented in Table 3, only 8.8 percent of the subjects (15 of 171 drivers) gave the correct response, that is, there is a crossing ahead. Most survey participants (82.5 percent) said the sign meant to slow down to 20 mph because a crossing was ahead. This response is incorrect and undesirable from the standpoint of safety and roadway capacity. That is, if some motorists slow down to 20 mph at an unoccupied passive crossing on a high-speed roadway while others do not, the potential for rear-end accidents is high and traffic flow is interrupted.

Table 3 also shows that 3.5 percent of the subjects (six drivers) believed that the railroad advance warning sign indicates that there are signals ahead at the crossing, and 3.5 percent believed that the sign meant that a stop was required. Both of these are incorrect and totally undesirable with regard to crossing safety.

Passive Crossings

Survey participants were asked what they should do when approaching a crossing that does not have flashing light signals.

TABLE 2 RESPONSES TO THE SURVEY QUESTION "WHICH OF THE FOLLOWING IS USUALLY LOCATED SEVERAL HUNDRED FEET IN ADVANCE OF A RAILROAD CROSSING?"

Responses	Percentage of Subjects N = 173
	0.6
	16.6
	13.3
	63.6[a]
None of them	1.7
Don't know	4.0

[a]Correct response

TABLE 3 RESPONSES TO THE SURVEY QUESTION "WHAT DOES THIS SIGN [RAILROAD ADVANCE WARNING SIGN] MEAN?"

Responses	Percent of Subjects (N = 171)
Slow down to 20 mph due to crossing ahead	82.5
There is a crossing ahead	8.8[a]
There are signals ahead at the crossing	3.5
You will have to stop at the crossing	3.5
Don't know	1.7
Total	100.0

[a]Most correct response.

As presented in Table 4, only 24.3 percent of the subjects (36 of 148 drivers) gave the correct response, i.e., be ready to stop if you see or hear a train. Most subjects (69.6 percent) said that at passive crossings, one should stop, look, and listen for a train. These motorists perhaps were remembering the old grade crossing safety slogan, which did instruct motorists to stop at crossings. However, state traffic laws (*4*) do not require motorists to stop or slow down at a passive crossing unless a train is in hazardous proximity to the crossing, and few motorists do in fact stop at unoccupied passive crossings. Thus the incorrect responses indicate that many drivers are uncertain or misinformed about their responsibilities and required actions at passive crossings. If so, there is a need for better driver training and education.

TABLE 4 RESPONSES TO THE SURVEY QUESTION "WHAT SHOULD YOU DO WHEN APPROACHING A CROSSING THAT DOES NOT HAVE A RAILROAD SIGNAL?"

Responses	Percent of Subjects (N = 148)
Not applicable, because all crossings have railroads signals	6.1
Be ready to stop if you see or hear a train	24.3[a]
Speed up and cross the tracks quickly to avoid an accident	–
Stop, look, and listen at the crossing for a train	69.6
Don't know	–
Total	100.0

[a]Most correct response.

Also, 6.1 percent of the subjects (nine drivers) said that the question was not applicable because all crossings had flashing lights (Table 4). This response suggests that those motorists are completely naive to the passive traffic control strategy, that their traffic control expectancies at crossings are incorrect, or both. In any case, crossing safety would be jeopardized.

Flashing Light Signals

State laws (*4*) require motorists to stop at crossings with flashing light signals when the signals are activated; however, after stopping, motorists may proceed across the tracks if a train is not at the crossing or so near as to create a hazard. As part of the survey, motorist comprehension of flashing light signals at crossings was evaluated. Specifically, survey participants were asked what they should do upon seeing a railroad signal flashing.

As may be seen Table 5, 22.5 percent of the subjects (39 of 173 drivers) said that they should stop and then may proceed over the tracks if a train is not near. Most drivers (74.0 percent) said that they should stop and wait until the flashing lights go off before crossing the tracks. These two response groups together account for 96.5 percent of the drivers, and this high percentage indicates that most drivers understand they must stop in response to flashing light signals. However, most drivers are confused about their responsibilities and required actions after they stop.

The survey results indicate that at least some drivers believe that they must remain stopped at a crossing even when a train is near, whereas other drivers believe they should cross the tracks.

TABLE 5 RESPONSES TO THE SURVEY QUESTION "WHAT SHOULD YOU DO WHEN YOU SEE THIS RAILROAD SIGNAL FLASHING?"

Responses	Percent of Subjects (N = 173)
Take any action you think appropriate, because the signal is only advisory	2.3
Stop your vehicle only if you are driving a truck	–
Stop your vehicle and wait until the flashing lights go off, then proceed over the crossing	74.0
Stop your vehicle and proceed over the crossing if a train is not near	22.5[a]
Don't know	1.2
Total	100.0

[a]Most correct response.

TABLE 6 RESPONSES TO THE SURVEY QUESTION "WHAT SHOULD YOU DO WHEN YOU SEE GATES ARE DOWN AT A CROSSING?"

Responses	Percent of Subjects (N = 173)
Stop and remain stopped until the gate arms are raised	94.2[a]
Stop and then proceed around the gates if no train is coming	5.2
Slow down and then proceed around the gates if no train is coming	0.6
Any of the above	–
Don't know	–
Total	100.0

[a]Most correct response.

This may result in safety and operational problems, for example, at crossings where trains frequently stop in advance of the crossing with the signal lights flashing. At these crossings, some motorists believe they must remain stopped since the lights are flashing. Other motorists see no need to remain stopped, and they may make drastic maneuvers to get around stopped vehicles in front of them.

Four drivers (2.3 percent) said that flashing lights were advisory and therefore no stop would be required (Table 5). This response is totally undesirable and indicates a serious comprehension or attitude deficiency on the part of the respondents.

In the survey, drivers were also asked if flashing light signals appear at all crossings. This question was prompted by the research of Sanders et al. (*2*), who found that 15 percent of drivers thought that all crossings had some type of active traffic control. Like the Sanders study, the present survey revealed that some drivers apparently had misconceptions about the use of flashing signals and other active devices. In the present survey, 21.7 percent of the participants (37 of 171 drivers) believed that flashing light signals appear at all crossings, and another 1.2 percent (2 drivers) said they did not know if they did. These numbers are very alarming and suggest that some drivers have false expectancies about crossing traffic control, or they do not fully comprehend the passive traffic control strategy.

The previous research by Sanders et al. (*2*) also prompted an evaluation of drivers' perceptions of the elapsed time between signal activation and train arrival. In the survey, 22.5 percent of the drivers said that the elapsed time was always more than 1 minute. This percentage corresponds closely to the findings of the Sanders study, and it suggests that elapsed times between signal activation and train arrival tend to be very long, at least in the minds of drivers.

Crossing Gates

From Table 6, it can be seen that 94.2 percent of the participants (162 of 172 drivers) said that traffic should stop and remain stopped when the gates are lowered at a crossing. This response is consistent with state traffic laws (*4*), which do require all traffic to stop at a crossing when the gates are down and remain stopped until the gates are raised. The high percentage of "correct" responses indicates that most drivers do in fact understand the legal intent of gate arms.

However, Table 6 also reveals that 5.2 percent of the survey participants (nine drivers) said that traffic should drive around lowered gates if no train is coming, and one driver (0.6 percent) said it is not even necessary to come to a complete stop before going around the gates. It is not known if these drivers were aware of the law or whether they felt the law should be disobeyed under the circumstances. In either case, there apparently is a segment of the driver population that believes that it is all right to violate gate arms, and on the basis of field observations (*7*), these drivers and probably many more "follow-the-leader" drivers do in fact violate lowered gate arms.

Advance Railroad Pavement Markings

Drivers were asked which one of a group of pavement marking patterns was used in advance of some railroad crossings to warn approaching motorists. Over 70 percent of the survey participants (106 of 148 drivers) correctly identified the standard railroad crossing pavement markings (*6*) from the available choices. However, 15 drivers (10.1 percent) said that none of the given patterns were used, and 18 drivers (12.2 percent) answered that they did not know. The remaining 6.0 percent identified an incorrect pattern. These percentages indicate that many drivers are still unfamiliar with the "standard" markings.

Improvements or Remedies

Survey participants were given the opportunity to suggest improvements which they thought would enhance crossing safety. As can be seen from Table 7, 17.6 percent of the participants suggested that gates be installed at more crossings, and 7.4 suggested that flashing lights be installed.

Most of the motorists who suggested one of these improvements said that the improvements should be installed at all crossings. Four percent of the survey participants (seven drivers) suggested more grade separations.

Train Operations

The responsibility for negotiating a crossing safely rests primarily (if not entirely) on the driver; however, there is some question as to how much of this responsibility is recognized

TABLE 7 DRIVER SUGGESTIONS TO IMPROVE CROSSING SAFETY

Suggested Improvements	Number of Subjects	Percent of Total Subjects[a] (N = 176)
Add gates/gates with flashing lights	31	17.6
Add flashing lights	13	7.4
Install grade separations	7	4.0
Reduce roughness of crossing	4	2.3
Reduce gate/signal malfunctions	4	2.3
Improve signs/markings	4	2.3
Reduce train speeds	3	1.7
Install full-width gates	3	1.7
Eliminate crossings	4	1.7
Improve driver education/training	3	1.7
Improve sight distance down track	2	1.1
Install speed bumps	2	1.1
Make crossing bells louder	2	1.1
Require traffic to slow/stop at all crossings	2	1.1

[a]Percentage does not total 100 percent because many subjects did not suggest any improvements, whereas others suggested one or more.

and accepted by drivers. In an attempt to answer this question, the survey explored drivers' perceptions of train capabilities, as well as drivers' perceptions about the duties of the train operator.

Drivers were first asked to compare the stopping distance of a train to that of a large truck. Surprisingly, over 7 percent of the survey participants (12 of 169 drivers) said that a train can stop in the same or less distance than a truck. Another 11.2 percent were uncertain which vehicle could stop quicker, i.e., a train or large truck. Combining these two groups, over 18 percent of the survey sample (31 of 169 motorists) did not know that the stopping distance of a train was much greater than that of a truck or car. This relatively high percentage suggests that some drivers believe that a train could stop or slow down significantly if necessary to avoid a collision.

Participants were also asked what they thought a train operator should do if he or she saw cars crossing the tracks in advance of the train. The responses to this question suggest that some drivers, if not many, fail to recognize and accept total responsibility for their safety at grade crossings. For example, 27.2 percent of the survey participants said that the train operator should slow the train, while 17.7 percent said that the train operator should stop the train. Another 17.7 percent of the drivers said the operator should flash the train's headlight. All of these responses suggest that drivers place some responsibility for crossing safety on the train operator, or at least that they would like to. As further support of this, less than one fourth of the survey participants (21.8 percent) said that there was nothing a train operator could or should do if cars cross in front of the train.

Also in regard to train operations, survey participants were asked when (at which crossings) the train operator sounds the train's whistle. Over three fourths of the drivers (78.2 percent) said that they thought the whistle was sounded in advance of every crossing, 7.5 percent thought it was sounded only for hazardous crossings, and 11.6 percent did not know when it was sounded. The most significant finding is that a large majority of drivers expect a whistle at all crossings, yet research (*1*) has determined that train whistles often cannot be heard inside modern closed motor vehicles. Whether or not motorists also expect to hear the whistle that is sounded is not known.

Driver Variable Effects

As part of the research, the effects of survey location and participant's sex, age, education, license status, and driving experience were evaluated. On the basis of the evaluation, some general trends were identified, while other possible effects were discounted. The statistical reliability of these effects were established or discounted as the case may be by using chi-square tests and tests of proportions.

Survey Location

No significant differences were found in the data from the driver licensing centers in Nashville, Chattanooga, and Knoxville. The data from the university sample, however, differed from the data gathered from the three driver licensing centers. Generally speaking, the university personnel demonstrated a higher comprehension level. The higher correct response ratio is probably due to the generally higher level of education inherent to a college campus.

Sex

No significant differences were found in the responses of male versus female drivers.

Age

Very young drivers (18 years and below) and older drivers (above 54) tended to have more trouble understanding and recognizing traffic control devices. For example, these driver groups performed relatively poorly on the questions that dealt with recognition of the crossbuck and advance railroad warning signs and that asked the meaning of the advance railroad warning sign. The very young drivers also performed poorly on the experience-related questions. Most notably, 62.5 percent (versus 21.6 percent for all drivers) of the drivers 18 years of age and below believed that all crossings had flashing lights.

Education

Drivers with less than a high school education demonstrated a relatively poor comprehension of grade crossing traffic control devices. However, it should be noted that many of the drivers in this low education group were also young, newly licensed drivers. It is believed that the three factors of education, age, and driving experience together affect comprehension.

License Status

No differences were found between Tennessee and out-of-state drivers. Significant differences were again found, however, between newly licensed and experienced drivers, probably due

to the combined effects of age, education level, and driving experience.

Driving Experience

Drivers who drove more than 20,000 miles per year tended to do better in all aspects of the survey. Drivers who drove fewer that 5,000 miles per year tended to do worse than drivers as a whole. It should be noted that most of the very low mileage participants were young, newly licensed drivers, and the combined effects of age, education, and driving experience probably account for their relatively poor performance.

Police Survey

The police officers, as a group, performed generally better on the survey than the general driver sample. That is, the officers in most cases demonstrated a somewhat better understanding and recognition of the traffic control devices and regulations applicable to railroad crossings. The officers' compared performance on the survey is illustrated in Table 8. The table compares the percentages of correct responses on 11 individual survey questions for the two groups, that is, the police officer sample versus the general driver sample. The 11 questions were selected as a basis for comparison because each of the questions had a "more correct response" and they all dealt with driver comprehension of crossing traffic control devices, regulations, or both. The police officers ranked higher than the general driver group on 9 of the 11 discriminating questions (Table 8). If is assumed that each question had an equal weighting on comprehension and if the Wilcoxon Signed Rank Test is used, the overall comprehension difference in the two groups is significant at the 99 percent confidence level. It can also be seen in Table 8 that the responses by the police officers on several of the individual questions were statistically significant on the basis of a one-tailed test of proportions assuming a 95-percent individual confidence interval is assumed.

It is not surprising that the police officers did better than the general public on the survey. First of all, the police officers indicated that they had more training and instruction on crossing safety compared to drivers as a whole. For example, 57.1 percent of the officers said that they had received training or instruction from at least two sources, while only 18.1 percent of the general drivers said that they had received training on crossing safety from multiple sources. It is assumed that the officer's additional training and exposure to traffic laws comes in connection with their general job training. Also, the police officers were predominantly males between the ages of 25 and 44, with some college education and extensive driving experience.

It should be noted that the police officers had a lower percentage of correct responses than the general public on only two questions (Table 8). One question asked what a driver should do upon seeing an activated flashing signal. A disproportionate percentage of the officers (85.7 percent) said that a driver should stop at the crossing and remain stopped until the flashing lights go off. The other question asked what a driver should do at a passive crossing. In response to this question, a very high percentage of the officers (76.5 percent) said that a driver should stop, look, and listen for a train. The officers' responses to both questions are surprising because they are inconsistent with state laws. Apparently the officers answered the questions from a very conservative, safety-conscious viewpoint.

Police Survey Summary

While the police officers responded more accurately in the survey than did the general drivers, the officers' comprehension level was still lower than desirable. As shown in Table 8, no single question was answered correctly by all of the police officers, and in only 6 of the 11 questions did more than 90 percent of the police officers respond correctly. In addition, on three of the questions, fewer than 25 percent of the police officers provided a correct response, and only 14.3 percent responded correctly to one of the questions. These results demonstrate that there is a substantial lack of understanding by the police officers of traffic control devices used at crossings, as well as of regulations regarding those devices.

TABLE 8 COMPARISON BETWEEN THE POLICE OFFICERS' AND GENERAL DRIVERS' COMPREHENSION LEVELS

Question	Percent of Correct Responses		Differences Significant at 95% Confidence Level[a]
	Police	General Drivers	
Which sign is usually placed at the point where the railroad tracks cross the highway?	94.3	76.3	Yes
Which sign is usually located several hundred feet in advance of a railroad crossing?	71.4	63.6	No
What should you do when you see a railroad signal flashing?	14.3	22.5	No
Does a flashing signal appear at all crossings?	91.2	77.2	Yes
In general, how does the distance needed to stop a train compare with that needed to stop a large truck traveling at the same speed?	91.4	81.7	Yes
What does the Advance Railroad Warning sign mean?	91.4	82.5	Yes
What should you do when the gates are down at a crossing?	97.1	94.2	No
Which standard markings are painted on the pavement in advance of some railroad crossings?	88.2	71.6	Yes
What should you do when approaching a crossing that does not have a railroad signal?	20.6	24.3	No
When does a train operator sound the train's whistle?	94.1	78.2	Yes
What should a train engineer do if he sees cars crossing the tracks in advance of his train?	24.2	21.8	Yes

[a]Based on one-tailed test of proportions.

CONCLUSIONS AND RECOMMENDATIONS

Results from the survey indicate that there are substantial problems with the level of knowledge among drivers about traffic control devices used at crossings, as well as of the regulations that govern those traffic control devices. The percentage of the general drivers who gave correct responses to the questions on the survey was often low. The police officers as a group generally performed better than the general drivers; nevertheless, this group did not achieve the desired results. In certain categories, the percentage of police officers providing correct responses was very low and represented severe lack of knowledge.

Any driver who is confused or has a lack of understanding about how to respond to traffic control devices can cause significant safety problems leading to accidents with personal injuries and fatalities. This problem can be even more pronounced at highway-railroad grade crossings because, in general, the total responsibility for avoiding a collision with a train is placed on the driver of the motor vehicle. Thus if one motor vehicle operator performs unacceptably due to a lack of knowledge, serious consequences can result. Even a small fraction of the driving population performing in an unacceptable manner at crossings can cause the number of accidents occurring at crossings nationwide to increase. The total population does not have to be driving inappropriately.

Operating a motor vehicle inappropriately at a crossing due to a lack of knowledge cannot be construed as willful disregard for safety by a motorist. Often drivers involved in collisions with trains are assumed to have been careless, inattentive, or simply negligent in the operation of their motor vehicles. If this survey represents the general driving population, then one might well argue that at least some of the inappropriate and unsafe operation of motor vehicles at crossings can be due to a lack of understanding or knowledge of how to operate the motor vehicles.

It would be difficult, if not impossible, for all drivers to achieve a complete understanding of traffic control devices used at crossings and the regulations governing these devices. However, there is substantial room for improvement. In some programmatic areas there is a need to address more fully the area of motor vehicle operation at railroad-highway grade crossings. Specifically, increased attention should be given in the following areas:

- State highway and transportation departments should initiate a program with state departments of education to include appropriate training on railroad-highway grade crossings in the high school driver education curriculum. State departments of education normally have a strong influence on the program areas for high school students. State highway and transportation departments should develop a module of training that would be supported by the state departments of education for use in high schools in the driver education programs.
- State highway and transportation departments should work with the state agency responsible for developing driver licensing handbooks to include a sufficient amount of material on railroad-highway grade crossings, traffic control devices for crossings, and regulations pertaining to them. Many state highway and transportation departments already are very involved with developing their states' handbooks; these departments should assess whether the level of coverage of grade crossing issues is adequate.
- State highway and transportation departments should work with the state agency that has responsibility for driver licensing to include items regarding railroad-highway grade crossings on written examinations given to applicants. Although some states are using questions on railroad-highway grade crossings, there is a need for expanded activity in this area.
- Public service activities such as Operation Lifesaver should address more issues involving traffic control devices at crossings as well as the regulations regarding those. These public service announcements should be consistent with state laws governing the operation of a motor vehicle at a crossing.
- Operation Lifesaver and other educational programs should devote more effort to informing and educating the law enforcement community on the meaning and intent of grade crossing traffic laws and traffic control devices. Also, more attention should be given to proper enforcement of traffic laws and regulations at grade crossings, since uniform enforcement will promote driver understanding and obedience.
- Additional survey work should be conducted throughout the United States to determine whether the survey conducted in Tennessee is unique or is perhaps a reasonable representation of the population. If the general population of the United States has the same level of understanding as found in this survey, then there needs to be immediate attention taken to increase the level of knowledge of the driving public of traffic control devices used at crossings and the regulations that govern them.

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