How To Cut the Highway Toll in Half in the Next Ten Years

IRWIN D. J. BROSS, Ph.D.

Dr. Bross, chief of the department of statistics, Roswell Park Memorial Institute, Buffalo, N.Y., presents his paper on highway accidents in question and answer form with the express purpose of improving communication with the general reader and of giving a broad picture of the current highway accident situation unobscured by too much detail.

Q. Do you really think that the highway accident toll can be cut in half in the next 10 years?

A. I believe that it is technically feasible to do so. But let me make one point clear—I will be talking about the toll of deaths and serious injuries sustained by the occupants of cars in highway accidents. This toll can be drastically cut even if there is no reduction in the total number of accidents, or even in the total number of injuries. In other words, the highway accidents would still occur, but the occupants would tend to suffer minor or moderate injuries rather than serious or fatal injuries.

Q. What do you mean by technically feasible?

A. Cutting the highway toll in half in 10 years is a realistic target for the large-scale, coordinated scientific attack on the automobile accident problem that I will outline here. The strategy, tactics (techniques), and data for this attack are all developed, tested, and ready to go. The target could be achieved without any remarkable new scientific or technological advances; without revolutionary changes in our cars, highways, or traffic control systems; and without "reforming" the behavior patterns of drivers. In short, I am not serving up a slice of "pie-in-the-sky." At the same time, the scientific program is not a "pianola."

Q. What does that mean?

A. The scientific program won't "play itself"—it will require the wholehearted cooperation of the groups with a big stake in the auto accident problem—the automobile manufacturers, legislators, law enforcement agencies, safety groups, scientists, and, of course, the general public. Getting this cooperation is something more than a technical problem. I think that if the public realized how close we are to a major reduction in the highway toll, the cooperation would be forthcoming. Each year of delay in putting our new knowledge to use costs us thousands of unnecessary deaths and serious injuries on our highways.

Q. Why is this cooperation so essential?

A. The simplest way for me to answer this question is to outline the broad strategy of a scientific attack on the accident problem. There are seven steps in going from the scientific investigation of actual highway accidents to the eventual reduction in the death rates. I will list the steps and then go back to discuss each one:

Step 1. Collect a massive series of detailed, scientific reports on the accident circumstances and resulting injuries of persons involved in highway accidents.

Step 2. Formulate a clear conceptual picture of the chain of events that leads to the trauma in the accidents.

Step 3. Test the theory of step 2 against the facts of step 1. If the theory fails to fit the facts, go back and try again.

Step 4. Once the event-chain is established, consider ways in which the undesirable event-chain can be broken or modified by preventive measures. Estimate the potential savings in lives or reduced degree of injury so as to establish the relative importance of preventive measures.

Step 5. Translate the preventive measures into specific design changes, commonly called "hardware." This step usually entails moving from the field (that is, highway investigations) into the laboratory (the engineering studies). The hardware would be tested in the laboratory under simulated field conditions.

Step 6. Incorporate the specific design changes into the production line—put the hardware on American cars.

Step 7. Evaluate the effectiveness of the design changes. This entails moving out of the laboratory and back into the field. In other words, we must determine how well the hardware works in actual highway accidents. If the hardware doesn't do its job, then it's back to the drawing boards. The acid test is the actual reduction in deaths and serious injuries on the highway.

Q. Is this a new strategy you have presented?

A. Yes and no. In principle this is the same strategic approach which has been so successful in the past in eradicating the infectious diseases or bringing them under control. In other words, these steps can be regarded as an application of the epidemiological approach to the problem of automobile accidents. In practice, this is a new approach. In fact it is only within the last few years that the first step was taken, and only in the past few months that the process has gone all the way through to step 7. But going back to your previous question: Close cooperation between the various groups with an interest in the accident problem is needed in all of the steps and particularly in step 6. Until this step is taken, scientific knowledge cannot actually save lives on the highway.

Q. So it is up to the automobile manufacturers to put the "hardware" on the cars?

A. Not just the manufacturers. They are in a highly competitive situation where minor price or styling changes might make a big difference in sales. Legislation and public support are needed to protect the manufacturer who is willing to give safety priority over styling and sales appeal.

The "Horse Shoe Nail" Story

Q. Let's get down to brass tacks. Can you give an actual example of how this strategy was used?

A. I'd be glad to. Let me tell you a story that might be called "The Horse Shoe Nail." For want of a nail a kingdom was lost—for want of a quarter inch of steel, some 15,000 lives have been lost in the past 5 years. The story starts with the first step in the strategy, the development of the factfinding system of the Cornell Automotive Crash Injury Research Program (ACIR). The basic ACIR sample consists of tens of thousands of case histories of occupants in injury-producing rural highway accidents. An occupant comes into the sample if (*a*) the accident occurs in a designated sample unit, (*b*) it is investigated by State troopers, and (*c*) someone in the car is injured. The trooper fills out a detailed report of the accident circumstances, such as the speed, accident configuration, seated position of the occupants, and so on. He also takes photographs of the car. The attending physician fills out a medical report on the nature and degree of the injury. The ACIR staff receives these field reports and processes them. The processing consists of collating the reports on a given person, checking the reports for errors or omissions, analyzing these reports, and putting the information on punchcards.

The ACIR factfinding system has provided information which is adequate, both in quality and quantity, for a genuine scientific study of the accident injury problem. The success of its program is due to the fine cooperation of the law enforcement agencies and medical societies in a dozen different States and also, of course, to the individual doctors, troopers, and others who take part in this program.

Q. Why do you place so much stress on the factfinding system?

A. For one thing, it plays a key role in all subsequent steps; for another, the lack of progress toward a solution of the crash injury problem in the past generation—the failure to make any appreciable dent in the death rates—is due, to a considerable extent, to a lack of cold, hard facts. You cannot base an effective safety program on slogans, scapegoats, and suppositions. In the days of the plagues, it was believed that disease was a punishment for sins and heresy. But exhorting sinners or burning heretics didn't stop the plagues. Nowadays the highway plague is blamed on the sins of the driver. But exhorting people to drive carefully or cracking down on "crazy mixed up kids" hasn't cut down the death rates. We need an approach that starts with solid facts.

Q. But isn't the driver responsible for deaths and injuries?

A. The driver may be responsible for the accident—for setting the stage—but once the accident starts, driver behavior has little influence on the event-chain that leads to the injuries. After the accident starts, psychology leaves off, and physics and biology take over.

Q. You have referred several times to event-chains. Could you give an example?

A. Gladly. First let me set the stage. Let us suppose that we are watching a car that is traveling 50 miles an hour down a ditched, high-crown rural highway. For some reason—an oncoming vehicle, a crate in the road, a misjudgment—the driver veers on to the narrow shoulder and the car starts to roll. Our event-chain starts the instant before the occupant, say the driver, begins to move relative to car structure—say his seat.

Q. Does this type of accident happen very often?

A. Rollover is a common rural highway accident. About one-fifth of the occupants in the ACIR sample are in rollovers. Now, when the car begins to roll, two things happen simultaneously. In a typical event-chain the occupant starts moving toward the door due to the centrifugal forces. At the same time, the frame of the car is deformed or twisted. This deformation of the frame disengages the door lock and the door pops open. Next the driver is thrown through the open door: he is ejected. He then follows a trajectory through the air. Up to this point in the event-chain, it is quite possible that the driver has not sustained any injury.

Q. In other words, the injury will depend on what he hits and how he hits it?

A. Yes. If he lands head first on concrete he is likely to sustain a fatal skull fracture. If he happens to land just right on a patch of grass, he may not be hurt at all. This brings up a useful conceptual device: the probability event-chain. In a given case history, there is a single chain of events, but when we consider a series of individuals we find a branching process. In other words, if we have a set of occupants with the same event-chains up to a given point, we find that beyond this point the chains branch off and lead to different degrees and types of injuries. By means of design changes we may be able to prevent some of the event-chains that terminate in death or serious injuries.

Q. How so?

A. Well, let's go back to the point in the rollover event-chain where the frame twists and the door lock disengages. If the door lock does not disengage, the door stays closed, the occupant stays inside of the car, and we get a very different event-chain. An extra quarter of an inch of steel in a bolt-action door lock would probably hold the door closed. In this way a design change can modify the chain of events in any automobile accident. When we change the event-chain, we also change the injury picture for better or for worse.

Q. Then the question is: Will the occupant be better off inside than outside of the car?

A. Yes, and if we define "better off" a bit more precisely we can now proceed to formulate a scientific hypothesis (step 2) and test it (step 3). For example, if by "better off" we mean a lower risk of death, our hypothesis might be: The risk of death is higher for an ejectee than for a nonejectee in a rollover accident. When we compare the observed risk of death for ejectee and nonejectee in the ACIR data, we find that for occupants ejected through doors in a rollover accident the risk of death is 0.141, or about 1 chance in 10. For nonejectee occupants the risk of death is 0.008, or about 1 chance in 100. The ejectees have roughly 17 times as large a chance of sustaining a fatal injury! Of course, we have only considered deaths and not the full injury scale.

Q. What happens if the full injury scale is considered?

A. One way to deal with the full scale is to use a technique called ridit analysis and to frame the hypothesis in a somewhat different form. Here we would want to estimate the chance that an ejectee will sustain a higher degree of injury than a nonejectee in corresponding accident circumstances, in this case rollover accidents. From the ACIR data we would estimate that the chances are about three to one that the ejectee will sustain a higher degree of injury. Either way it is plain that odds are heavily against the ejectee.

Q. Did you have a special reason for using rollover accidents as an example?

A. Yes, I did. In rollovers, a single factor, ejection, dominates the picture and this simplifies matters. At the same time, rollover accidents are the heart of the ejection problem; about half of the fatally injured ejectees in the ACIR sample were in rollover accidents.

Q. But what about other types of accidents? Might we not want the doors to come open in these accidents?

A. We can proceed for other accident configurations along the same lines as for rollover. The results for death rates and ridit analysis are given in table 1. You will note that the odds are consistently against the ejectee. However, the advantage enjoyed by the nonejectee tends to be less than the advantage in rollover accidents. Also, in some accident configurations, such as head-on collisions, ejection plays a minor role.

Q. Isn't it possible that the seeming advantage of nonejectees merely reflects the fact that ejection tends to occur at higher speeds—where the risks are higher anyway?

A. Table 2 shows what happens when the data are tabulated by the applicable impact speed. You will note that within each of the four speed categories, the odds are against the ejectee. In the same table, you can also see the results of a tabulation by seated position of the occupants.

Q. What would happen if you were to consider all three factors—configuration, speed, and seated position—at the same time instead of one at a time as in your tables?

A. This leads to 4×5×9=180 different accident circumstances and in this fine cross tabulation we often are left with relatively few cases in a given cross category. Subject to

Table 1. Risks of ejected and nonejected occupants in nine accident configurations

Accident configuration	Deaths only			Full injury scale (ridits)	
	Estimated risk of death		Relative risk of ejectees	Estimated probability that ejectee is worse off	Approximate odds that ejectee is worse off
	Ejectees	Nonejectees			
Nonrollover: 2 cars					
I. Head-on collision	0.333	0.107	(1)	0.745	(1)
II. Broadside (impact on passenger compartment)	.086	.033	3	.726	2:1
III. Overtake: trailing car	.000	.010	(1)	.697	(1)
IV. Overtake: leading car	.039	.002	20	.652	2:1
V. All others (fender-fender, etc.)	.120	.020	6	.699	2:1
Nonrollover: 1 car					
VI. Collision with immovable object	.100	.037	3	.642	2:1
VII. Collision with movable or partly movable object	.076	.008	9	.708	2:1
Rollover					
VIII. Principal	.141	.008	17	.759	3:1
IX. Secondary (with impact)	.106	.022	5	.666	2:1

[1] Less than 10 ejectees (too few for reliable estimates).

Table 2. Risks of ejected and nonejected occupants at four applicable impact speeds and in five seated positions

Impact speed of car and seated position of occupants	Deaths only			Full injury scale (ridits)	
	Estimated risk of death		Relative risk of ejectees	Estimated probability that ejectee is worse off	Approximate odds that ejectee is worse off
	Ejectees	Nonejectees			
Applicable impact speed (m.p.h.)					
0–19	0.018	0.004	5	0 708	2:1
20–39	.035	.007	5	.678	2:1
40–59	.099	.026	4	.673	2:1
60+	.211	.096	2	.669	2:1
Seated position					
Driver alone	.156	.043	4	.631	2:1
Driver with passenger	.113	.019	6	.747	3:1
Center front	.061	.014	4	.643	2:1
Right front	.110	.032	3	.662	2:1
Rear	.113	.010	11	.740	3:1

this qualification, I can say that we did not find a significant advantage to the ejectee in any of the 180 circumstances.

Q. Would you say, then, that it is always better to stay inside the car?

A. No, there are doubtless some circumstances where it would be better to be ejected. However, these circumstances are quite rare. To sum up, then, we have a massive weight of evidence in favor of keeping the occupant inside of the car. Since most ejection takes place through car doors and since the door lock mechanism determines whether or not the doors stay closed, we are led to specific design change—a better door lock. We are now in step 4 of the scientific process. Let me postpone the last part of step 4—estimation of the lifesaving potential of the door locks—so as to get on with the rest of the process.

Q. But I thought that the new cars were equipped with improved door locks.

A. After the ACIR report on ejection, the automobile manufacturers undertook step 5 of the process. I shall not go into detail on step 5 since this phase is primarily an engineering operation. Suffice it to say that the engineers developed a modified version of the original door lock and that this modification performed well under the simulated accident conditions of the testing labs. Modified door locks have been installed on nearly all American cars manufactured after 1955—thus step 6 was taken. There remained only an on-the-highway evaluation of the modified door locks—step 7.

Q. But you've said that the locks were tested in the laboratory. Why was it necessary to test them on the highway?

A. Quite a few devices and techniques that work nicely in the laboratory fail under actual field conditions. In fact, this is what happened with the modified door locks. They were better than their predecessors, but their performance was disappointing in rollover accidents, which, as we've seen, are the heart of the ejection problem. There was only about a 25 percent improvement in the holding of door locks in rollover accidents.

Q. Why wasn't this weakness discovered in the laboratory tests?

A. I can't give a definite answer on this. However, there are two likely explanations. First, rollover force conditions are not easily simulated in a laboratory. Second, the hardtop styling trend—which came in about the same time as the modified door locks—weakened the top support and hence permitted greater deformation of the frame in a rollover. This tended to cancel out the improvement in the lock. Incidentally, this example points up the need for better cooperation between laboratory and field scientists.

Q. So after going through all seven steps, not much was accomplished after all.

A. Not this time—but I don't think that we have reached the end of this "Horse Shoe Nail" story. After all, if we can package two monkeys to survive a free fall from outer space, we ought to be able to package the occupants of a car to survive the force conditions in a rollover accident. An extra quarter of an inch of steel in a bolt-action door lock could give a happy ending to the story.

Q. Isn't that something of an alibi?

A. I don't think so. I do not deny that the modified door locks failed to hold the doors closed, especially in rollover accidents. However, the lifesaving potential of a positive-acting door lock is still there. We have simply failed to exploit it. But the seven-step process is self-correcting—we may not hit our target on the first shot, but we learn from our mistakes. Next time our aim should be much better.

Lifesaving Potential of Door Locks

Q. You keep talking about the lifesaving potential of door locks, but can you really show that there is such a potential?

A. To make a careful estimate of the potential savings in lives from prevention of ejection requires a fairly extensive statistical analysis such as the one given by Boris Tourin (*1*).

Q. Can you show me how lives could be saved—without going into a lot of confusing statistical technicalities?

A. Well, I can show you—roughly, at least—how a good proportion of the deaths in the ACIR sample of rural injury-producing accidents might have been prevented by a positive door lock. I can do this directly from the raw data given in table 3. To avoid too many numbers, I have consolidated the data into 12 accident circumstances, and table 3 shows the number of fatalities and the number of occupants in each of the circumstances.

Q. What are the circumstances?

A. I have combined the accident configurations into three categories (good, fair, poor) for reasons which will become clear in the course of the discussion. I have considered just two applicable impact speeds (under 60 miles per hour, 60 miles per hour and over). For simplicity, I have given only two ejection categories—not ejected and completely ejected through doors. I have omitted complicated kinds of ejection (partial ejection, ejection not through doors). Hence there are 3×2×2=12 circumstances shown in table 3.

Q. What am I supposed to look for in table 3.

A. Let's start with the cell in the upper left-hand corner, the nonejectees in low-speed accidents in the "good" accident configurations. What do you notice about the risk of death for these occupants?

Q. It's pretty small—less than 1 in 100. What does this mean?

A. To see what this means, take a look at the next cell in the row—the person in low-speed accidents in "good" configurations who were ejected. There are 521 of the ejectees and 42 of them were killed. Now let us suppose that all cars had positive door locks and that these 521 persons would have stayed inside of the car. Under this assumption, these 521 persons would have had the event-chains characteristic of nonejectees instead of the event-chains characteristic of ejected occupants. Now if these people had stayed inside the car, how many of them would have been killed?

Q. When a person is actually thrown out of the car, how can you possibly know what would have happened to him if he had stayed inside?

A. We can't know what would have happened to a particular individual. However, we can make some estimate of what would have happened in the series of 521 occupants. From the upper left-hand cell we can directly estimate the risk of death for occupants who stay inside of the car (0.006). If we suppose this same risk applies to the 521 persons who were hypothetically held inside by a positive door lock, then we can find the "expected" number of deaths in the series by simple multiplication—521×0.006=3.2. In other words, under the above assumptions we would have expected only about 3 deaths in this series of 521 occupants.

Q. But there were really 42 people killed. What does the three "expected" deaths mean?

A. Well, by this line of reasoning, 39 of the 42 deaths could have been prevented by positive door locks. In other words, the great majority of these deaths were unnecessary. Now let's apply the same reasoning to the high-speed accidents in the "good" category. What do you notice in table 3?

Q. The risk of death goes up a bit for nonejectees, but it is still only a little more than 1 in 100. So by your argument most of the 73 deaths in the upper right-hand cell could also have been avoided. That's your point, isn't it?

A. Yes. We would expect only about 5 deaths in the 361 ejectees, and so positive door locks might have saved about 68 lives. Hence in the "good" accident configurations we might have avoided 39+68=107 of the 137 deaths. Of course, the situation is much less favorable in other accident configurations.

Q. What happens in the "fair" configurations?

A. A positive door lock might have saved about 31 of the 137 deaths—roughly one-fifth of the toll, with most of the savings coming from the lower speed ejectees. Hence the positive door lock is just a start—though a good start—toward cutting the death toll in "fair" configurations.

Q. What about the "poor" configurations?

A. You'll notice that ejectees account for only 32 of the 177 fatalities. Moreover, the differential in the risks between ejectee and nonejectee has become smaller, though ejectees still have the higher risks. Thus door locks could be expected to save only about 11 lives in the "poor" configurations. When we total up the savings in lives over all the configurations, it turns out to be about 150, or one-third of the 451 deaths in table 3. However, we couldn't hope to cut the national death rates by this much because no door lock could hold 100 percent of the time, because the door lock would probably be less effective in urban accidents, and for some other reasons. Nevertheless, we would be getting a big saving in lives for a rather small price—an extra quarter of an inch of steel in the door lock. I might note here that a majority of the occupants in table 3 were in cars equipped with the modified door locks.

Other Strings in the Bow

Q. Positive door locks alone couldn't cut the highway toll in half, could they?

A. No, door locks are no panacea. They are just one of a series of design changes that would be needed to do the job. I have emphasized door locks because they provide a clear-cut example of the scientific process.

Q. What other design changes are needed?

A. Quite a list of preventive measures has come out of the ACIR studies and other investigations. I won't have time to go into this list. There are a number of design changes that are effective only in certain specific accident circumstances. There are other design changes that would be important in a wide range of accident situations. The seven-step process would apply to any of these safety features.

Q. What about seat belts?

A. I won't say much about seat belts here because they will be the subject of another ACIR paper. In brief, it is found from Cali-

Table 3. Number of occupants and fatalities in 12 accident circumstances

Accident configuration	Class of occupants	Applicable impact speed				Total
		Under 60 m.p.h.		60 m.p.h. and over		
		Not ejected	Ejected	Not ejected	Ejected	
Good (IV, VII, VIII)	Fatalities	15	42	7	73	137
	All occupants	2, 478	521	497	361	3, 857
Fair (III, V, IX)	Fatalities	52	31	42	12	137
	All occupants	4, 294	319	319	59	4, 991
Poor (I, II, VI)	Fatalities	88	15	57	17	177
	All occupants	2, 975	294	305	63	3, 637
	Total fatalities	155	88	106	102	451
	Total occupants	9, 747	1, 134	1, 121	483	12, 485

fornia data that a seat belt is of value in keeping the occupants inside the car. However, the study failed to demonstrate that the seat belts were of value in preventing contact with an interior structure. Hence the seat belt seems to be a useful interim measure to control ejection, but it has the drawback that its effectiveness depends upon the willingness of the occupants to use the belts. In the California study about two-thirds of the occupants in cars equipped with seat belts were not wearing them at the time of the accidents.

Q. Can you give some examples of the design modifications that apply to specific accident circumstances?

A. Each accident circumstance has its own particular problems and hence tends to highlight particular components of the car. For instance, in a rollover, it is important to prevent the top structure from caving in during the roll. During the past few years the top supports appear to have been dangerously weakened by the trend to "hardtop" styling. To reverse this trend, safety has to be given priority over style. Another good example of the special problems of an accident configuration occurs when one vehicle rams into the rear of another one—the overtake accident. By Newton's third law, the forces on the two vehicles are equal and opposite. However, it turns out that the risks in the trailing car are considerably higher than those in the leading car.

Q. Why is this?

A. One possible explanation is that the rear impact on the leading car throws the occupants back into their seats. In effect, then, the leading car has the "rearward facing seats" that have been often advocated as a protective measure. A second, and more important, factor emerges when "car-car" accidents are separated from "car-other vehicle" accidents ("other vehicles" are mostly trucks). It would appear that much of the trauma in the trailing cars occurs when they run into heavy, high-bed trucks. This in turn suggests that the rear structure of trucks be redesigned—particularly to prevent a low-hooded car from running under the bed of the truck. Although the injury picture is favorable in the leading car, it could still be improved. Here the indicated design changes would focus on seat backs—particularly for the right front seat occupant. Perhaps these brief remarks will give some idea of how protective measures can be developed for specific accident situations.

Q. What are some of the design changes that are important over a wide range of accident circumstances?

A. One design change is suggested by table 3. You will notice that a substantial proportion of the deaths among nonejectees occur in accidents where the applicable impact speed is 60 m.p.h. or more. Because there is usually some braking action prior to impact, the impact speed tends to be somewhat more than 10 m.p.h. lower than the traveling speed. This means that one of the cars in the high-impact speed accidents was likely to have been traveling at more than 70 m.p.h. However, it is not a difficult technological problem to prevent cars from traveling more than 70 m.p.h.

Q. Hasn't speed restriction often been tried?

A. Past efforts at speed control have emphasized education or law enforcement, but the direct method of control by engineering has been shunned. I would suggest that it be mandatory for all new cars to be equipped with a sealed governor set at 70 m.p.h. To get such hardware on all U.S. cars would require close cooperation between manufacturers, legislators, and law enforcement agencies—and public support—but it isn't an impossible task. A 70 m.p.h. limit would not interfere with the efficiency of the automobile as a means of transportation—only a tiny minority of motorists actually do much sustained driving at speeds in excess of 70 m.p.h. Nor is this any more of an infringement on personal liberty than our present laws against suicide. You can see from table 3 that the lifesaving potential is considerable—especially in the "fair" configurations.

Q. Are there other examples of design changes with a broad scope?

A. Delethalization is another major line of development.

Q. What is delethalization?

A. Broadly speaking, it means getting rid of pointed objects, projections, sharp bends in instrument panels, and other hazards in the car interior. An effective delethalization program requires a careful study of the relationship between specific components—steering wheels, for instance—and specific kinds of injuries—such as chest injuries. Apparently minor matters—such as the number of spokes in the wheel—are likely to be the key to effective delethalization. Each individual modification may seem unimportant, but collectively they can produce a worthwhile reduction in the highway toll.

Q. In all of the examples that you've mentioned, the design changes have been made in the vehicles. Are there other kinds of design changes that are promising?

A. Yes, highway design and traffic control devices also provide promising preventive measures. For example, the "poor" configurations are head-on collisions, broadside accidents (impact on the passenger compartment), and one-car collisions with immovable objects. These configurations are fairly rare on limited-access divided highways of modern design. On the older highways, improved traffic control devices could reduce the frequency of these "poor" configurations. Future research will probably reveal still other ways to influence the event-chains in automobile accidents—but even if we merely exploited our present leads, we could cut the highway toll in half.

Summing Up

Q. What, then, are your overall conclusions about the auto accident problem?

A. To sum up:

There is a practical, scientific approach to the highway accident problem. The strategy, tactics, and basic data for this approach have already been developed and tested.

Scientific investigation of the accident event-chains has suggested a series of preventive measures which have a high potential for the reduction of deaths and serious injuries.

These preventive measures need to be translated into design changes, or "hardware"; the hardware has to be installed on American cars and tested on the road. This is the present bottleneck.

The wholehearted cooperation of groups with a stake in the auto accident problem is needed to break the bottleneck. Vigorous public support of this scientific program could insure the necessary cooperation.

Assuming reasonable cooperation, it would be realistic to set the following target for 1970: A 50 percent reduction in the deaths and serious injuries sustained by occupants of cars in highway accidents.

REFERENCE

(*1*) Tourin, B.: Ejection and automobile fatalities. Pub. Health Rep. 73: 381–391, May 1958.

NOTE: This paper was prepared with the help of Mrs. Barbara McNulty and Mrs. Charlotte Zweifach, who carried out the numerical analyses for this paper, and of the Automotive Crash Injury Research staff, who provided the information in machine runs for this material.

Occupational Health Course for Local Officers

A training course in occupational health for local health officers was held in Jacksonville, Fla., May 5 and 6, 1960. Co-sponsored by the Occupational Health Branch, Public Health Service, and the division of radiological and occupational health, Florida State Board of Health, the course was designed to intensify the awareness, on the part of local health officers, of the significance of occupational health questions and of the ways in which basic health department staffs can contribute to this field of health.

In addition to local health officers, public health nurses and sanitarians were attracted to the course, bringing the total number of participants to 94.

Note on Cigarette Smoking and Lung Cancer

Since the publication of my article, "Tobacco Consumption and Mortality from Cancer and Other Diseases" (*Public Health Reports* 74: 581–593, July 1959), I have received several requests for age-specific mortality rates for lung cancer, particularly among cigarette smokers.

The following table presents age-specific mortality rates computed from the same data as the mortality ratios given in the previous publication. The rates are shown only for ages 55 years and over since the number of deaths for the younger age groups during the period included was not large enough to warrant the computation of age-specific rates.

Among men who were currently smoking cigarettes and who had never used tobacco in any other form, the death rate from lung cancer for each age group consistently increased with an increase in the average daily consumption of cigarettes. The increase in the death rate for heavy smokers—more than a pack a day—relative to that of light smokers—less than one-half pack per day—was highest for the youngest age group, 55–59 years, and decreased with advancing age. The death rate for heavy smokers was 3.9 times that for light smokers at ages 55–59 years; for the age groups 60–64 years and 65 years and over the corresponding ratios were 2.9 and 1.5.

All groups of men currently smoking only cigarettes experienced a definitely greater risk of dying from cancer of the lung than did nonsmokers. The death rate from lung cancer for men who were smoking more than a pack of cigarettes per day was 14 times greater than the rate for nonsmokers at ages 55–59 years, 19 times greater at ages 60–64 years, and 11 times greater at ages 65 years or more.—Harold F. Dorn, *chief, Biometrics Research Branch, National Heart Institute, National Institutes of Health, Public Health Service.*

Number of deaths and death rate per 100,000 per year from lung cancer by age, smoking history, and current amount smoked, U.S. Government life insurance policy holders, July 1954–December 1956 [1]

Smoking history and current amount smoked	Rate per 100,000				Number of deaths		
	55 and over	55–59	60–64	65 and over	55–59	60–64	65 and over
Never smoked [2]	16.6	12.2	14.1	31.6	5	6	6
Cigarettes—total: [3]							
All amounts	158.8	112.9	175.3	261.7	72	94	52
−10 per day	110.9	47.3	100.2	261.1	4	9	11
10–20 per day	137.1	91.2	151.9	230.1	27	41	24
21 or more per day	210.0	159.6	249.2	325.4	41	44	17
Cigarette only: [3]							
All amounts	179.2	134.1	201.1	275.7	55	67	32
−10 per day	104.5	48.2	92.5	242.8	2	4	5
10–20 per day	162.4	115.3	181.2	254.2	22	31	16
21 or more per day	224.9	174.5	269.4	338.0	31	32	11
Cigarette and other: [3]							
All amounts	124.7	74.7	132.9	242.1	17	27	20
−10 per day	116.9	46.4	107.4	278.6	2	5	6
10–20 per day	93.8	47.6	101.2	193.4	5	10	8
21 or more per day	178.6	126.1	207.7	304.6	10	12	6

---

[1] The number of deaths includes all deaths with a diagnosis of lung cancer, whether considered as a primary, contributory, or non-contributory cause of death. [2] Includes occasional smokers of any form of tobacco, past or present. [3] Includes only persons currently smoking cigarettes.