Alcohol in Relation to Traffic Accidents

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FOREWORD

After the repeal of the Eighteenth Amendment and the national prohibition laws, reports from the traffic law enforcement agencies of cities and states began to show a sharp increase in accidents. Further study of the reports showed that, in a great many places, arrests and convictions for drunken driving remained about the same in number as they were before repeal, in none was there a decline, and in some such arrests and convictions jumped startlingly.

Those of us who were working in the safety movement were hoping that something more conclusive in the way of data would turn up, and it was not long before we received a report on the study made in Pennsylvania by Dr. Herman A. Heise.

He had perfected a technic of urinalysis by which the alcohol in a person's system could be accurately measured and had run tests on a number of drivers who had been involved in personal injury accidents. His report seemed to show that no less than 60 per cent of serious accidents involved drinking drivers and that, moreover, it was the *drinking* driver who was causing most of the trouble rather than the driver who was quite drunk.

At a safety congress, however, Dr. Heise said that his estimates should not be taken as conclusive because he had worked with too few subjects.

Then it was that Sidney J. Williams, director of the public safety division of the National Safety Council, suggested to Chief William O. Freeman and to me that the Evanston Police Department could render signal service to the safety movement and to the country by conducting a far more extensive study. The plan was to run a urinalysis on each driver who had been involved in an automobile accident which resulted in the hospitalization of himself or somebody else. Thus we could determine what percentage of drivers so involved had been drinking and we could also determine just how much alcohol had been absorbed by their body fluids and had thus reached their higher nerve centers.

Fortunately Dr. Heise had moved from Pennsylvania to Milwaukee and he agreed to direct the study. The willing cooperation of the St. Francis Hospital and the Evanston Hospital was assured, Miss Ada Belle McCleary, superintendent of the latter institution, serving on the directing committee.

Altogether four organizations cooperated in the study, the Evanston Police Department, the National Safety Council, the Chicago Motor Club and the Evanston Medical Society—in addition to the hospitals and Dr. Heise.

The study was made over a three year period. In 1936 the Northwestern University Traffic Institute was formed. Jointly with the police department, Richard L. Holcomb, who is in charge of research for the Institute, analyzed the records and concluded that, interesting as the results were, they had little practical worth unless it was determined how many drivers in the general population were drinking—and how much.

By this time Dr. R. N. Harger of the Indiana University School of Medicine had perfected his "drunkometer," by which the amount of alcohol in a person's system could be determined by an analysis of breath. Thus a sampling of a large number of drivers was easily practicable and a "control" or "normal" group could be established so that comparisons between the accident group and the normal driving group could be drawn. Holcomb, assisted by Officer Frank Andrews of the Evanston Police Department, then undertook the study which is described herein.

We hope that more research into this knotty problem will be made. Answers to many important questions must still be found and they will be found only by the painstaking methods of science. For example, we do not yet know how individuals vary in their tolerance for alcohol; we know all too little about the effects of differing amounts of alcohol in the blood on the individual's performance as a driver; we know almost nothing about the effect on accidents of the various methods by which the states distribute and dispense beverage alcohol.

I must thank Dr. Heise, who initiated study of this subject and who gave so generously of his time and

energy in this research. I must thank Dr. Harger, who not only lent us equipment but also designed and installed in our trailer-laboratory many of the devices which made large scale sampling possible. I must also express my gratitude to the Medical Specialties Company for the loan of the two Drunkometers used in the study.

The committee which directed the study for the Institute was as follows:

Lieutenant Peter Geischecker, Evanston Police Department, Chairman.

Captain Ray Ashworth, Northwestern University Traffic Institute.

Dr. E. L. Benjamin, Staff, Evanston Hospital.

Mr. Don Berry, Assistant Traffic Engineer, National Safety Council.

Mr. Curtis Billings, Northwestern University Traffic Institute.

Mr. G. W. Dalrymple, Chemist, Evanston Health Department.

William O. Freeman, Chief of Police, Evanston, Illinois.

Dr. R. N. Harger, Indiana University School of Medicine, Indianapolis, Indiana.

Dr. Herman A. Heise, Milwaukee.

Richard L. Holcomb, Northwestern University Traffic Institute.

Miss Ada Belle McCleary, Superintendent, Evanston Hospital.

Dr. C. W. Muehlburger, Toxicologist, Northwestern University Scientific Crime Detection Laboratory.

Mr. Earl J. Reeder, Traffic Engineer, National Safety Council.

Dr. Winston H. Tucker, Commissioner of Health, Evanston, Illinois.

They all have my sincere thanks.

LIEUTENANT F. M. KREML, Director
Northwestern University Traffic
Institute.

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ALCOHOL IN RELATION TO TRAFFIC ACCIDENTS

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There has been much discussion for many years of the effects of alcohol on human beings. A major question now is the effects of alcohol on the automobile driver. All too often discussions involving alcohol have been colored by emotion and have suffered from lack of facts.

Recognizing the importance of drinking to safety, I hope to define objectively and unemotionally the part alcohol plays in the accident problem. Scientific methods have lately been perfected that make such a definition possible. Through their use, it is hoped that a step forward will be taken in the solution of a serious problem.

Alcohol has long been considered an important cause of accidents. Every one will concede that it impairs the judgment and physical abilities. With the coming of the motor car, the importance of alcohol as a causative factor in accidents became increasingly apparent. Driving a motor car calls for quick thinking, rapid and coordinated operation of the controls of the car and accurate judgment. With the increase in speed of motor cars, coupled with increased congestion on highways and streets, the problem of the drinking driver has become increasingly acute.

It is the major purpose of this study to define clearly the place of the drinking driver in the present day accident problem. How much more liable is the drinking driver to be involved in an accident than the sober driver? In what percentage of accidents is alcohol a factor? In other words, an answer is sought to the questions "Are you more liable to be in an accident if

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From the Northwestern University Traffic Safety Institute.

you drive after drinking than if you drive not having had anything to drink? How much more liable are you?"

Most important of all is the aim to show at what concentration alcohol in the human system becomes a factor in accidents. When one encounters a person who has been drinking there is little question in one's mind as to whether or not he is under the influence of alcohol. However, when it is necessary to prove in court that he was under that influence, the problem becomes involved. Police departments have long used simple rule of thumb technics, such as observing the suspect's breath, gait, speech and condition of clothes and putting him through such tests as touching the tip of his nose with his finger, enunciating "methodist episcopal" and writing a few short sentences from dictation to be compared later with his usual writing.

The National Safety Council's Committee on Tests for Intoxication has developed an intoxication report form [1] intended to make the most reliable use of such methods as a means of determining their dependability. This form has refined the technic of determining drunkenness from observation. It attempts to take into account and tries to get proof to rebut all the possible defenses that the person may offer, and it provides for the recording of all subjective evidence as to his condition.

The committee recognized that this method is subject to a variety of attacks by the defense because many times the condition reported could have been caused by injury or illness.[2] Defense attorneys make the most of this. In many cases they are able to create enough doubt as to the defendant's intoxication to secure an acquittal, especially in a jury trial. It is difficult even for a physician to take the stand and say positively from a subjective examination whether or not a person was under the influence of alcohol. It is still more difficult for the police officer to do so. While systematic, complete recording of physical symptoms of intoxication are of value, more objective tests are obviously

1. National Safety Council, Committee on Tests for Intoxication: Tests for Driver Intoxication, National Safety Council, 20 North Wacker Drive, Chicago, 1937.

2. Gunn, H. M.: A Paper delivered before the prosecutors' section of the Ohio Bar Association, July 1936; available in mimeographed form from the National Safety Council, Committee on Intoxication, Chicago.

necessary in many cases. To encourage the use of more accurate and scientific methods, the form also includes provision for chemical tests of body fluids.

Long before automobile accidents became the serious problem they now are, it was known that a relatively accurate measure of the amount of alcohol in a person's system could be made from the analysis of body fluids, as well as from the analysis of the organs themselves.

Further, an accurate correlation was found between the amounts of alcohol after absorption in the different body fluids and organs. If the amount of alcohol in one part was known, the amount in another could be accurately calculated. For convenience the amounts found in the various other fluids are related to the amount of alcohol in the blood. For example, the alcohol in the blood is 1.2 times that in the brain, 0.9 times that in the spinal fluid, 0.8 times that in the urine and 2,000 times that in the alveolar air.

When the need for such analysis was felt, certain of the body fluid tests were refined and developed. The most practical of the tests determined the alcoholic content of the spinal fluid, blood, urine, breath and saliva. There are serious objections to the first two. The spinal fluid test is dangerous because of the difficulty in drawing out a sample. Also it has the practical difficulty that it requires a physician to take the sample. The blood test has similar disadvantages to a lesser degree. Courts frown on any technic that might endanger the person examined, and there is a possible danger of infection in taking a blood sample.

Extensive developmental work has been done on tests of the urine [3] and breath.[4] They have been refined so that they now are of practical value. The saliva test is of proved accuracy and may come into as general use as the tests of the urine and breath.

Through urinalysis the alcohol in the blood and thus in the brain can readily and with fair accuracy be determined. It is the alcohol in the brain that affects the person, and not the gross amount drunk. Through the use of the test it is possible to tell the extent of intoxication. The Committee on Tests for Intoxication

3. Heise, H. A.: The Specificity of the Test for Alcohol in Body Fluids, Am. J. Clin. Path. **4:** 182 (March) 1934.

4. Harger, R. N.; Lamb, E. B., and Hulpieu, H. R.: A Rapid Chemical Test for Intoxication Employing Breath, J. A. M. A. **110:** 779-785 (March 12) 1938.

of the National Safety Council has determined the percentage of alcohol in the body fluids above which all persons will unquestionably be under its influence. A lower point has been determined that will, when coupled with supplementary evidence, serve as prima facie evidence of intoxication.[5] There are two objections to the use of urinalysis for establishing intoxication. The first is the difficulty of obtaining the specimen; the person to be tested may be either unwilling or unable to cooperate. The second is that it requires the services of a technically trained person, who is not always immediately available. However, specimens may be preserved indefinitely, allowing later checks to be made by the defense as well as the prosecution.

The breath test for alcohol has important points in its favor. In the first place, an immediate result can be obtained. Secondly, the apparatus can be operated by any intelligent person after only a short course of training. Moreover, it is a simple matter to secure a specimen of breath. Both tests are rapidly coming into use by police authorities, and their value is being proved. The saliva test is of too recent development for proper appraisal.[6]

These chemical tests have made possible two attacks on the problem of the drinking driver. The first attack is in court; prosecutions based on the tests have been unusually successful. The second attack is less direct but just as significant; the tests make possible research into the relation of alcohol to accidents. Experimenters are able to find out through their use how much drinking occurs in the accident group of drivers and in the normal driving group; they can find out when this drinking occurs and the age and the sex of the drivers who drink. They can find from these tests just how much more liable a person is to be involved in an accident when he has been drinking than when he has not. Data can be uncovered on the relation between the drinking of drivers and the seriousness of accidents. In other words, by the tests it is possible to isolate an important factor in the accident problem—alcohol. If

5. The point representing "conclusive" evidence of alcohol influence was chosen as 0.15 per cent (1.5 parts per thousand) of alcohol in the blood or its equivalent in other fluids or tissues. The prima facie, or presumptive, value was chosen as 0.10 per cent of alcohol in the blood or its equivalent.

6. Friedmann, T. E., and Klaas, Rosalind: The Determination of Ethyl Alcohol, J. Biol. Chem. **114:** 63 (Aug.) 1936.

this important factor can be set apart, one can then more successfully analyze such other causes as speed, lighting, fatigue, inexperience and poor driving habits. These other causes may be more easily, more thoroughly and more accurately analyzed if the complicating factor of alcohol has been isolated. Thus quantitative chemical tests for alcohol are of unquestionable value in the ultimate solution of the accident problem.

With the research value of these tests in mind, the Evanston Police Department, the Northwestern University Traffic Safety Institute, then known as the Northwestern University Traffic Officers Training School, the Evanston Hospital Association, the St. Francis Hospital, the National Safety Council and the Chicago Motor Club, with Dr. Herman A. Heise as consultant, began on Feb. 1, 1935, a research to determine the amount of drinking involved in accidents which resulted in hospitalization. Urinalyses for alcohol were made for a total of 270 drivers over a period of three years.[3] Rather good cooperation was obtained from the drivers examined. A representative cross section of all drivers involved in injury accidents was thus obtained.

This experiment produced a figure which represented the percentage of drivers involved in serious accidents who had been drinking. It was a first step in the determination of alcohol as a causal factor in accidents. Not until the next step was taken, however, would this figure assume significance. For example, if it was found that 46 per cent of drivers involved in personal injury accidents had been drinking and then it was found that 46 per cent of all drivers had been drinking, the alcohol consumed would seem to have no bearing on accidents. However, if only 12 per cent of all drivers had been drinking and yet 46 per cent of the drivers involved in accidents had been drinking, it would appear that the drinking drivers were suffering more than their share of mishaps, and drinking would seem to be a causal factor in accidents.

Therefore a study was initiated by the Northwestern University Traffic Safety Institute for the purpose of determining the extent of drinking among drivers; of obtaining, in other words, a "normal group." The "drunkometer," recently developed by Dr. R. N. Harger of the Indiana University School of Medicine for use in court, made such a study possible. This device makes a rapid and accurate analysis for alcohol possible.[4] In brief, the test is based on the bleaching of an acid solution of potassium permanganate by the alcohol in the alveolar air, which, of course, is part of the normal breath.

The apparatus was set up in a trailer, thus allowing it to be readily moved from location to location throughout the area which approximated the area in which the accidents of the first part of the study occurred. The apparatus, specially built by Dr. Harger, allowed a rapid analysis of the breath samples. Tests of the breath of a total of 1,750 subjects were made in the course of a week. Testing was continuous from midnight Friday,

TABLE 1.—*Hours of Testing*

	Sat.	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.
12- 2 a. m.	X	X	X	..	X	..	X
2- 4	X	X	X	..	X	..	X
4- 6	X	X	X	..	X	..	X
6- 8	X	X	..	X	..	X	..
8-10	X	X	..	X	..	X	..
10-12	X	X	..	X	..	X	..
12- 2 p. m.	X	X	..	X	..	X	..
2- 4	X	X	..	X	..	X	..
4- 6	X	X	..	X	..	X	..
6- 8	X	X	X	..	X	..	X
8-10	X	X	X	..	X	..	X
10-12	X	X	X	..	X	..	X

April 22, to 6 a. m. Monday, April 25. Samples were taken from 6 p. m. to midnight Monday, from 6 a. m. to 6 p. m. Tuesday, from midnight Tuesday to 6 a. m. Wednesday, from 6 p. m. to midnight Wednesday, from 6 a. m. to 6 p. m. Thursday, from midnight Thursday to 6 a. m. Friday and from 6 p. m. Friday to 2 a. m. Saturday, April 30 (table 1). This gave a complete sampling over the period of heaviest drinking, the week-end, and alternate daylight and darkness sampling during the week. Over the week-end three crews, each consisting of four testers, a supervisor and a uniformed police officer, worked on nine hour shifts. These crews were composed of Northwestern University students and police officers (Kemper fellowship students enrolled in the course in traffic police training.)

As about 25 per cent of the accidents in the previous study had occurred in territory where liquor was freely sold and 75 per cent of them had occurred in Evanston

or adjoining suburbs, where liquor is not sold, four of the eight locations chosen were in areas in which it was assumed that drinking drivers would be prevalent. The other four locations were in areas in which it was assumed that drinking drivers would not be very prevalent. The first four locations were on highways passing through Evanston for only a short portion of their length or on streets running into immediately adjoining territory where there were large numbers of taverns. The other four locations, where it was assumed that alcohol would be less prevalent, were well within the interior of Evanston. Actually no difference between the locations was found. This would indicate that because of the ease of movement in motor traffic, at least in limited areas, alcohol is evenly distributed, with little reference to its points of easiest accessibility.

The uniformed police officer stopped all cars in a purely chance order determined by the rate at which the experimenters doing the analyses could work. There was no discrimination as to type or price range of automobile. As soon as the police officer had stopped the car, he immediately retired from the picture so that there would be no hesitancy on the part of the subject through fear of prosecution. No attempt was made to explain the nature of the test to the drivers unless they showed active, intelligent interest in the test and testing procedure. Newspaper publicity was avoided.

Because some difficulty was anticipated in gaining the cooperation of the drivers approached, a technic was very carefully worked out to obtain the samples of breath. After the uniformed officer stopped the car, a tester approached the driver and after a short, set, introductory speech, asked six preliminary questions, such as "Are you bothered by headlight glare?" for the purpose of gaining his cooperation and to allow him to get over the strangeness of the situation. The driver was then presented with the specially constructed wide-mouthed white balloon (the large wooden mouthpiece facilitated inflation) enclosed in a cellophane envelop, so that there would be no possible objection on the grounds of sanitation. The assistants who approached the driver were dressed in physicians' white smocks for the dual purpose of making a favorable impression on the driver and of making themselves readily visible to other traffic, more especially during the night.

Cooperation was readily gained from the drivers with the exception of twenty-four, who refused to be tested.

As soon as the sample of breath was obtained the experimenter wrote the subject's age and sex and the location and time of the test on a tag, which he then attached to the neck of the balloon. The balloon was taken to the trailer laboratory, where one of the testers immediately made a qualitative test on about 1,000 cc. of the breath to determine whether or not alcohol was present. In the event that alcohol was present a quantitative analysis was made on a standard "drunkometer." Breath volume was taken in conjunction with the regular carbon dioxide absorption tube. These tubes were weighed daily at the chemistry laboratory of Northwestern University by graduate students. All the weights were taken on the same balance.

TABLE 2.—*Percentage of Drivers in Normal Population by Blood Alcohol Content*

Blood Alcohol (Parts per 1,000)	Percentage of Total Drivers in Each Group	Percentage of Total Drivers at Each Point or Above (Cumulative)
1.5 and above	0.42	0.42
1.4	0.28	0.70
1.3	0.14	0.84
1.2	0.21	1.05
1.1	0.31	1.36
1.0	0.55	1.91
0.9	0.58	2.49
0.8	1.08	3.57
0.7	0.97	4.54
0.6	0.90	5.44
0.5	0.89	6.32
0.4	1.44	7.75
0.3 or less	4.33	12.09
No alcohol	87.93	87.93

These tests resulted in the establishment of a control group giving an accurate picture of the amount of drinking among drivers in the general population. Analyses were made on the basis of time of day, day of week, sex, age and amount of alcohol present.

THE OCCURRENCE OF DRINKING

The sample of the general population tested showed that about 12 per cent of all the drivers on the road had been drinking and that about 2 per cent of the drivers on the road had been drinking so much that their blood contained 1 part of alcohol to 1,000 parts

of blood (or 0.1 per cent), or enough to impair their driving ability. About one driver in every 250 had been drinking to such an extent that his blood contained 1.5 parts of alcohol to 1,000 parts of blood (or 0.15 per cent), enough to place him unquestionably under the influence of alcohol. Table 2 shows this in detail.

TABLE 3.—*Percentage of Drivers in Personal Injury Accident Group by Blood Alcohol Content*

Blood Alcohol (Parts per 1,000)	Percentage of Total Drivers in Each Group	Percentage of Total Drivers at Each Point or Above (Cumulative)
1.5 and above	13.81	13.81
1.4	1.49	15.30
1.3	1.49	16.79
1.2	2.98	19.77
1.1	2.24	22.01
1.0	3.36	25.37
0.9	0.75	26.12
0.8	2.24	28.36
0.7	4.10	32.46
0.6	0.37	32.83
0.5	0.37	33.20
0.4	0.75	33.95
0.3 or less	12.68	46.63

TABLE 4.—*Percentage of Drinking Drivers Tested by Two Hour Periods for the Week*

		Sat.	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.
Midnight	12- 2	41.6	75.0	50.0	....	34.5	....	52.4
	2- 4	50.0	65.0	50.0	....	46.7	....	40.0
	4- 6	50.0	71.4	0	....	20.0	....	11.1
	6- 8	11.1	28.6	....	3.4	....	3.0	....
	8-10	8.3	19.2	....	2.7	....	0	....
	10-12	8.9	17.7	....	9.1	....	14.3	....
Noon	12- 2	11.1	8.3	....	3.1	....	11.4	....
	2- 4	15.8	0	....	0	....	6.1	....
	4- 6	5.7	11.4	....	11.4	....	6.1	....
	6- 8	15.2	0	8.8	....	8.5	....	7.4
	8-10	12.9	0	2.7	....	15.2	....	20.5
	10-12	16.9	19.4	17.1	....	17.6	....	17.8

The hospital figures (table 3) show that 47 per cent of the drivers involved in personal injury accidents had been drinking, 25 per cent of the drivers so involved had over 1 part of alcohol to 1,000 parts of blood and 14 per cent had over 1.5 parts of alcohol to 1,000 parts of blood.

The relationship between the proportions of drivers in each blood alcohol group (1.5 parts per thousand, 1.4 parts per thousand and so on) for the general

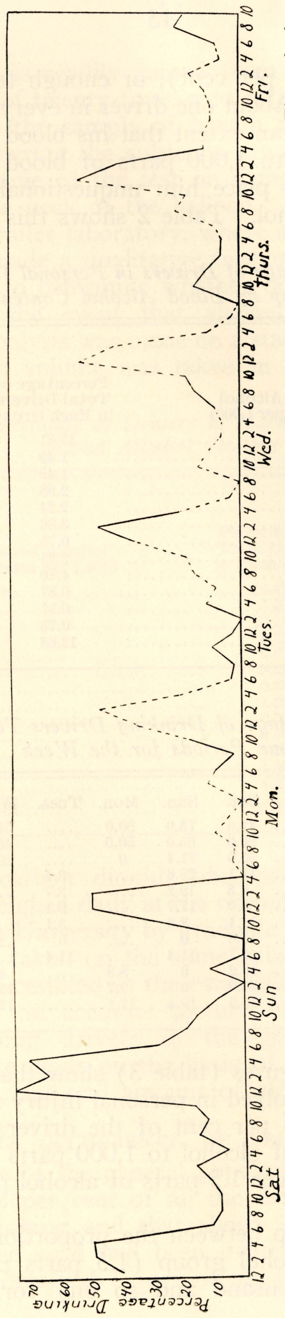

Chart 1.—When drivers drink. Percentage of drivers drinking tested in the control group by two hour periods for the week. The unbroken line indicates the percentage drinking and the broken line the percentage drinking on the following day in hours not tested on the day shown (used to give a continuous curve).

driving population compared with the accident group is the most significant contribution of this research. It will be discussed in detail later.

The percentage of drinking drivers by two hour periods for the entire week is shown in chart 1 and table 4. As testing was not continuous throughout the week but alternated between daylight and dark, the resulting gaps in the chart were filled in by substituting the complementary hours of the following day. While this did not result in as accurate a curve as one drawn from a continuous sampling, it is doubtless sufficiently near the real curve for all practical applications. Conclusions that can be drawn from this curve are obvious. It definitely shows, for example, the preponderance of

Table 5.—*Number of Drinking Drivers by Two Hour Periods of the Day on the Basis of a Total of 100*

Two Hour Period	Number Drinking, Accident Group	Number Drinking, Control Group
12- 2 a. m.	15.5	14.0
2- 4	11.7	5.9
4- 6	7.8	2.4
6- 8	5.8	4.2
8-10	4.9	6.0
10-12	4.9	9.3
12- 2 p. m.	1.9	7.2
2- 4	4.9	6.3
4- 6	4.9	15.7
6- 8	16.5	10.8
8-10	14.6	8.4
10-12	6.8	9.9

drinking over the week-end, a fact of common observation. It should be noted that the peak for Saturday night and Sunday morning goes higher and lasts longer than any other peak. This of course is because Sunday is a holiday.

Because of the relatively few subjects, a similar curve for the personal injury accident group tested is not presented. Fluctuations in the curve would be so great as to render it valueless.

Comparisons have been made, however, on the basis of hour of the day between the personal injury accident group and the general population group. These comparisons were made both by the number of drinking drivers per two hour period and by the percentage of drinking drivers tested during each two hour period. Similar comparisons were made on a day of the week basis.

The hour of the day comparison of the accident group and the general population group on the basis of number of drinking drivers is shown in table 5 and chart 2. That this comparison might be made, the curves were drawn on the basis of 100 as the total number of cases in each group. This method of computation is based on two assumptions: (1) that the sample for the location during the two hour period represents the incidence of alcohol in the city for that period and (2) that the volume of traffic at a base location in the city during the period represents the volume of traffic for the city during the period. The base location, incidentally, has been established for years and is

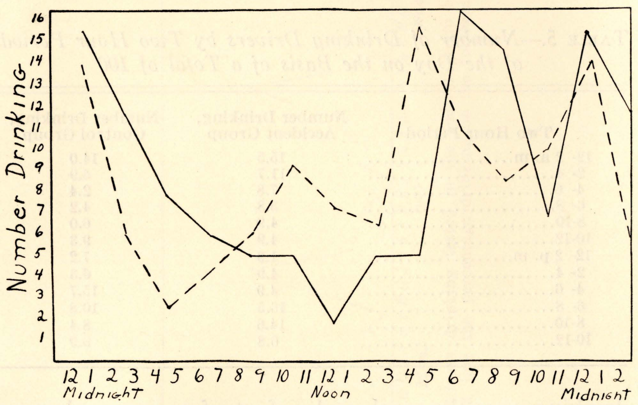

Chart 2.—Number of drinking drivers by hours of the day based on an assumed total of 100. The unbroken line indicates the accident group and the broken line the control group.

constantly used as standard by the city traffic engineer. The volume count at the base location is considered roughly representative of Evanston traffic, so it serves as a constant basis of comparison.

Suppose, as an example, that 10 per cent of the drivers tested between 10 a. m. and 12 noon at a certain location have been drinking and that, according to previously made counts, 1,000 cars pass the base location during the two hour interval. Thus (assumption 1) of the 1,000 drivers, 100 had been drinking. If then, on this basis during the twelve two hour periods of the day, 2,000 drivers passing the base location had been drinking, the 100 drinking from 10 to 12 would represent

5 per cent of the total number drinking in the day. In the case of the accident group no such computation is needed, because the three year experience as taken by the hospitals closely approximates the real distribution. In this case it was necessary only to total the cases and find the percentage that each two hour group was of the total.

The charts showing the number of drinkers in the accident group and the normal group are similar in form. While there are certainly divergences in the curves, they can well be accounted for on the basis of small numbers, as the general form of the curves is

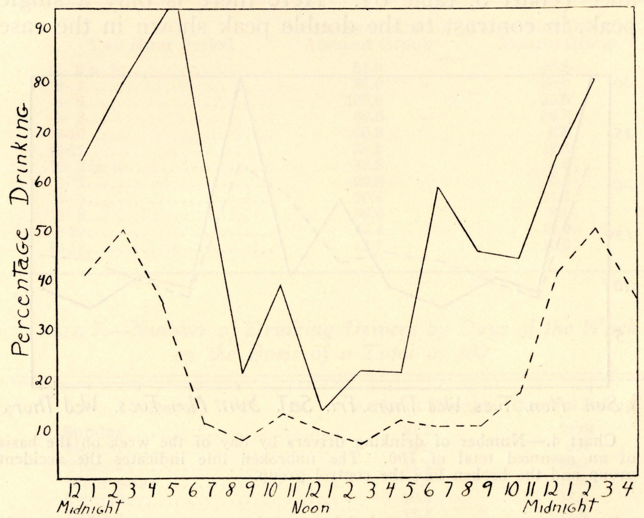

Chart 3.—Percentage of total drivers drinking by two hour periods. The unbroken line indicates the accident group and the broken line the control group.

nearly the same. The similarity is especially noticeable in the case of the two peaks of both curves. The first is at about 6 in the evening and the other at midnight. The lag of the accident curve might well be the result of the difference between the time of accident occurrence and the time the report was made in the hospital, as often the time of occurrence of the accident was not shown on the card and the time the test was made at the hospital was used.

As both the curve for the accident group and that for the normal group show a peak at 6 p. m. and at midnight, it can correctly be held that such peaks would exist if the entire population was tested. However, caution must be used in assigning causes to these peaks. Possibly (and this is only conjecture) the 6 p. m. peak is the result of the corresponding traffic peak; that is, a large number of persons on the street would tend to imply a large number of persons drinking. The midnight peak might well be the result of an actual increase in drinking in combination with a still relatively large flow of traffic.

These data when presented on the basis of percentage of persons drinking give a somewhat different appearance (chart 3, table 6). Here there is only a single peak, in contrast to the double peak shown in the case

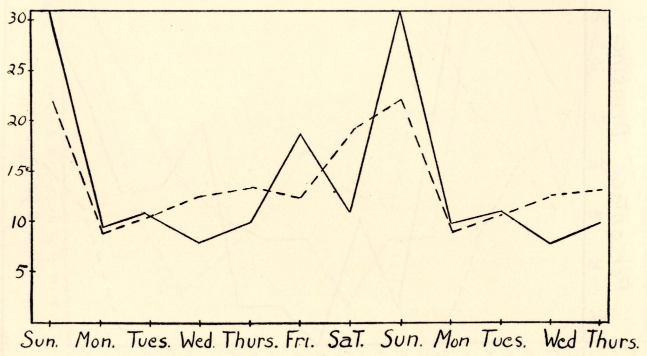

Chart 4.—Number of drinking drivers by day of the week on the basis of an assumed total of 100. The unbroken line indicates the accident group and the broken line the control group.

of the number of drinking drivers. Also the peak occurs much later. The curve for the general population group is quite regular, increasing till early morning, dropping sharply, running on a level from about 6 in the morning till 8 in the evening and then increasing till about 3 a. m. A peak showing 50 per cent of the drivers on the road as having been drinking is then reached. The curve for the percentage of drivers in personal injury accidents is similar though somewhat more irregular. This irregularity can be discounted to a large extent because of the smallness of the sample. A peak is reached in the period from 4 to 6 a. m. of 100 per cent drinking. This, however, is in all probability a result of the smallness of the sample, though

doubtless the true peak would be quite high. A lag is also to be noted that is similar to the lag of the accident group in the charts just discussed, where the number of drinking drivers was presented, and it can probably be accounted for in the same way.

Chart 4 and table 7 present the number of drinking drivers in each group by days of the week. For purposes of comparison, as in the case of the hour of the day presentation, these data were reduced to a per-

Table 6.—*Percentage of Drinking Drivers by Two Hour Periods of the Day*

Two Hour Period	Percentage Drinking, Accident Group	Percentage Drinking, Control Group
12- 2 a. m.	64.0	40.8
2- 4	80.0	50.0
4- 6	100.0	35.0
6- 8	66.6	10.2
8-10	20.8	6.8
10-12	38.5	12.8
12- 2 p. m.	13.3	8.6
2- 4	20.8	6.5
4- 6	20.8	11.7
6- 8	58.6	9.9
8-10	45.4	10.0
10-12	43.7	16.3

Table 7.—*Number of Drinking Drivers by Days of the Week on the Basis of a Total of 100*

Day of Week	Accident Group	Control Group
Sunday	31.2	22.04
Monday	9.6	9.0
Tuesday	11.2	10.8
Wednesday	8.0	12.8
Thursday	10.4	13.5
Friday	18.4	12.6
Saturday	11.2	19.2

centage basis to obtain comparable curves. One point must be noted in the presentation of this curve; because the sample taken (table 1) included alternate periods of daylight and dark on alternate days during the week and if used uncorrected would result in an inaccurate representation, a correction was made. This correction consisted in combining the score for each day with that of the following day in the case of Monday and the previous day and the following day in the case of Tuesday, Wednesday and Thursday. This is better illustrated in table 8.

Again there is a striking similarity between the accident group and the control group. The control group again presents a very regular curve, while the curve for the accident group, because of the small numbers, is somewhat more irregular, although running quite close to that of the control group. The peak for both groups occurs over the week-end, Saturday and Sunday. The peak is actually reached early Sunday morning, as

Table 8.—*Correction for Curve Shown in Chart 7*

Sunday	A complete day, no correction	
Monday (dark)	*Average of Mon. and Tues.* Used for Monday score	*Average of Mon., Tues. and Wed.* Used for Tuesday score
Tuesday (light)	*Average of Tues. and Wed.*	
Wednesday (dark)	*Average of Wed. and Thurs.*	*Average of Tues., Wed. and Thurs.* Used for Wednesday score
Thursday (light)	*Average of Thurs. and Fri.* Used for Friday score	*Average of Wed., Thurs. and Fri.* Used for Thursday score
Friday (dark)		
Saturday	A complete day, no correction	

Table 9.—*Percentage of Drinking Drivers by Days of the Week*

Day of Week	Accident Group	Control Group
Sunday	67.2	21.5
Monday	46.2	10.0
Tuesday	45.1	11.5
Wednesday	31.3	13.4
Thursday	41.9	14.0
Friday	51.1	14.2
Saturday	29.2	18.6

shown in the chart for the week by hours. Thus the largest number of persons drinking is found early Sunday, with the number dropping off sharply and then gradually increasing till the next week-end.

The points discussed in connection with number of persons drinking would apply equally well in a discussion of the percentage of persons drinking (chart 5, table 9). Unlike the peak for hour of the day, the traffic peak for days of the week and the peak for percentage of drinking are the same. The curve for the percentage of drinking drivers in personal injury accidents is irregular in comparison with the curve for the normal group, and the week-end increase is followed by a sharp drop and then a gradual build-up to the week-end. It should be noted that there are over twice as many drinking drivers during the week-ends as on week days.

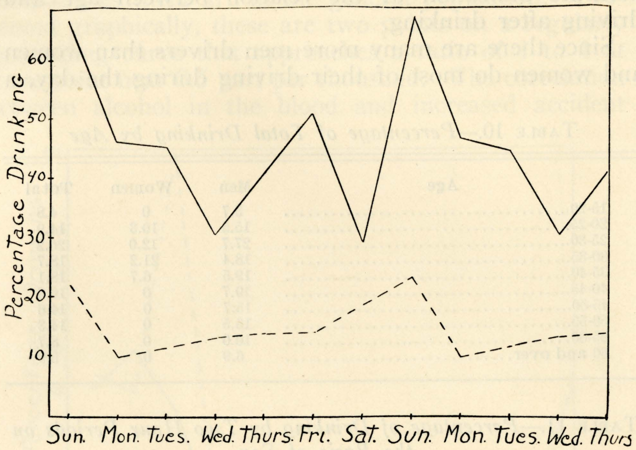

Chart 5.—Percentage of drivers drinking by day of the week. The unbroken line indicates the accident group and the broken line the control group.

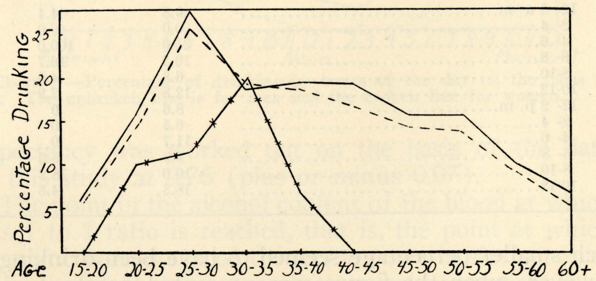

Chart 6.—Percentage of drinking by age. The unbroken line is for men, the line marked with crosses for women and the broken line for all cases.

Unfortunately no data were secured as to the age of the drivers in the personal injury accident group. However, the results of an age tabulation in the control study are of interest (chart 6, table 10). A definite peak showing over 28 per cent of drinking drivers is found at the age level from 25 to 30 and is followed by a gradual decline. The extreme lower and the extreme upper age limits were not determined, but the lower limit was probably about 16 or 17 and several persons in the 70's were tested.

Little comment is needed on the significance of this curve. It follows quite closely the expected. It is an accurate indication of the relation between age and driving after drinking.

Since there are many more men drivers than women and women do most of their driving during the day, a

Table 10.—*Percentage of Total Drinking by Age*

Age	Men	Women	Total
15-20	5.7	0	4.8
20-25	15.5	10.3	14.9
25-30	27.7	12.0	26.2
30-35	18.4	21.2	18.7
35-40	19.5	6.7	18.1
40-45	19.7	0	16.6
45-50	15.7	0	14.6
50-55	15.5	0	14.3
55-60	10.0	0	8.7
60 and over	6.9	0	5.9

Table 11.—*Percentage of Drinking by Two Hour Periods on the Basis of Sex*

Two Hour Periods	Entire Group	Women Only
12- 2 a. m.	40.8	44.4
2- 4	50.0	40.0
4- 6	35.0	100.0
6- 8	10.2	16.7
8-10	6.8	4.0
10-12	12.8	2.9
12- 2 p. m.	8.6	0
2- 4	6.5	0
4- 6	11.7	0
6- 8	9.9	5.3
8-10	10.0	18.2
10-12	16.3	4.3

much smaller percentage seemed to have been drinking. However, when the figures are presented on the basis of percentage drinking by hour of the day (chart 7, table 11) there is little difference between the curve for men and that for women. The peak reached by women at 4 and 5 a. m. is probably spurious and due to the small number of cases, as very few women proportionately were driving at that time. Additional data are needed here to smooth out these curves. No tabulation on the basis of sex was made in the accident group because of the smallness of numbers.

RELATION OF ALCOHOL TO ACCIDENTS

There are thirty-three times as many drivers whose blood contains 1.5 parts per thousand of alcohol in a group of drivers involved in personal injury accidents as in the general driving population. There are ten times as many whose blood contains 1.3 parts per thousand as there are in the general population. Presented graphically, these are two points on a regularly descending curve that approaches a ratio of 1 to 1 at some point near 0.5 part per thousand. The correlation between alcohol in the blood and increased accident

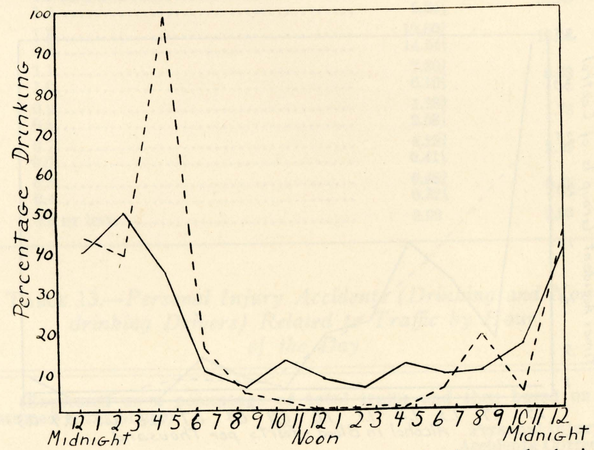

Chart 7.—Percentage of drinking by hours of the day on the basis of sex. The unbroken line is for men and the broken line for women.

expectancy was worked out on the basis of the data of this study at 0.76 (plus or minus 0.07).

The point in the alcohol content of the blood at which this 1 to 1 ratio is reached, that is, the point at which the same percentage of drivers appears in the personal injury accident group as in the general population, is of considerable significance. There has been much discussion of the relation between alcohol in the blood and intoxication, based both on observation and on the use of objective tests, in an attempt to set a point at which the drinking driver should be removed as potentially dangerous. The curve mentioned (chart 8, table 12) goes far toward showing where this point occurs, for, as soon as more drinking drivers appear in the personal injury accident group than in the general population, the ratio goes over 1 to 1. Alcohol can be considered as causing this increase in accidents over the expected. From these data it would appear that this point is about 0.5 to 0.6 part of alcohol to 1,000 parts of blood. Additional cases are needed here to obtain a smoother, more reliable, curve. It is not suggested that a point for the blood alcohol content just over the 1 to 1 ratio be used for other than prima facie evidence of intoxication, but the location of this point should go far toward determining the lower limits of blood alcohol at which persons are considered under the influence of alcohol.

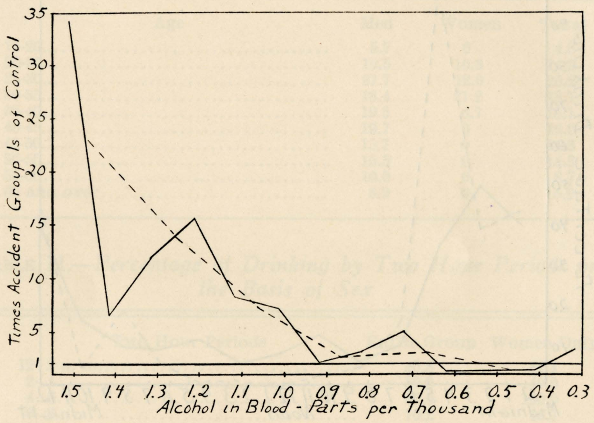

Chart 8.—Number of times drivers in the accident group are of drivers in the control group for each amount of blood alcohol. The broken line shows the curve smoothed.

Thus a concomitant variability is demonstrated. It has been shown further that there are several times as many drinking drivers in accidents as in the general driving population. But does a causal relationship exist? In other words, is this increase in alcohol actually the cause of the increased accidents? Is there possibly a factor or factors causing both the increase in alcoholic content of the blood and the increase in chances of accident? Would there be any basis for advancing some other cause for this relationship?

Among other possible causes, might not a common one be darkness? Could this relationship exist because people normally drink at night, when darkness with its effect on visibility, causes personal injury accidents to

increase? People drink at night because they have free time then; accidents happen at night, when visibility is poor. Then is this relationship between accidents and alcohol just chance? Is darkness really the cause?

Table 12.—*Number of Times Accident Group is of Control for Each Amount of Alcohol*

Blood Alcohol Content	Times (Accident Group Over Control)	Accident Group Is of Control (Smoothed Curve [Average at 2 Parts])
1.5 and above	33.12	21.98
1.4	5.34	
1.3	10.80	13.03
1.2	14.54	
1.1	7.30	6.53
1.0	6.10	
0.9	1.28	1.78
0.8	2.08	
0.7	4.23	2.39
0.6	0.41	
0.5	0.48	0.48
0.4	0.52	
0.3 or less	2.93	2.93

Table 13.—*Personal Injury Accidents (Drinking and Nondrinking Drivers) Related to Traffic by Hour of the Day*

(Expressed as a percentage of total traffic and then based on an assumed total of 100)

Two Hour Periods	Personal Injury Accidents Corrected for Traffic
12- 2 midnight	4.3
2- 4	6.3
4- 6	9.6
6- 8	2.7
8-10	3.7
10-12	3.9
12- 2	4.1
2- 4	2.8
4- 6	3.4
6- 8	3.3
8-10	3.8
10-12	2.1

Table 13 and chart 9 prove that this is not the case. Personal injury accidents when related to the amount of traffic on the road, or exposure, have their peak after midnight. (Divide the traffic count by two hour periods by the personal injury accidents by two hour periods.) If darkness was the cause of this increase, it would be logical to expect the curve to be approximately the same during all hours of darkness. Instead, on the average it is 2.35 times as high in the hours of darkness after midnight as it is in the hours before. Alcohol, it must be remembered, has its peak after midnight, just as do personal injury accidents (table 6 and chart 3).

However, it might be argued that speeds increase. True, but why do they increase? There are two possible major causes. The first is the decrease in congestion and the second the increase in alcohol. Any increase in speed as a result of a decrease in congestion would tend to be offset as a causative factor by the decrease in congestion. While speed doubtless plays an important

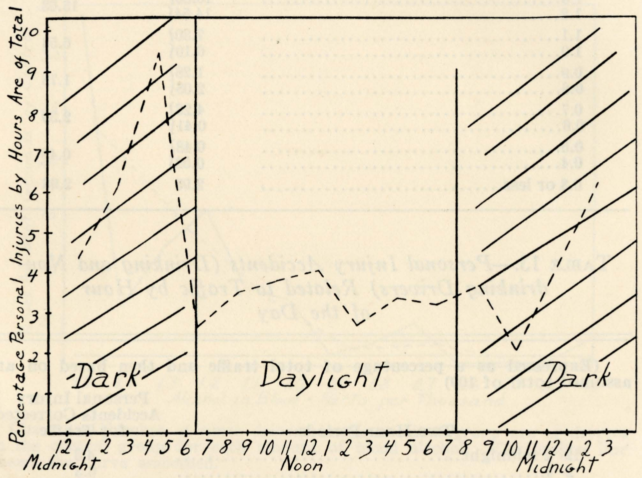

Chart 9.—Personal injury accidents related to traffic, expressed as percentage of total traffic and then based on an assumed total of 100.

part in causing accidents, it might well be treated as a symptom of an underlying cause. Certainly alcohol, with its removal of inhibition, might well be a cause of increased speeds and thus of accidents. It must further be remembered that, unlike decreasing congestion, alcohol offers nothing to compensate for the increase in speeds which it causes. Rather, by increasing reaction time and decreasing perceptual ability [7] it makes the speed still more dangerous.

7. Miles, W. R.: Psychological Effects of Alcohol on Man, in Emerson, Haven: Alcohol: Its Effects on Man, New York, Macmillan Company, 1935, chapter 10.

Fatigue [8] might be a cause of accidents occurring at such times and in such amounts as to displace alcohol as the assumed cause of accidents. Certainly, like drinking, fatigue occurs most commonly at night. Like drinking too it results in diminished ability to drive. However, an examination of the facts will show that it would be impossible for fatigue to account more than superficially for the increase in accidents associated with alcohol.

It is difficult to study the problem of fatigue. No methods that will reliably and validly measure fatigue are available. Actual physical losses in ability are difficult to disassociate from the effects of monotony, as the results of the two factors may be the same. Numerous attempts have been made to measure, subjectively at least, the physical aspects of fatigue, but all too often the results have failed to be conclusive. One measure of fatigue that has found general acceptance is accident records. Long experience in industry has shown that accidents increase in proportion to the time spent at work, with slight decreases as monotony is relieved as the end of the working period approaches. It is probably safe to assume that the curve for automobile accidents caused by fatigue [9] would be similar to that obtained for accidents caused by the driver's falling asleep. Difficulties in assigning causes of accidents may have resulted in some inaccuracies, but the general shape of this curve is reliable. It shows that the largest number of accidents caused by the driver's falling asleep occurs at about 4 o'clock in the morning. Comparison of this curve with the curve showing the number of drinking drivers or that showing the number of personal injury accidents involving alcohol shows little relation. While the fatigue curve has its peak in the early morning hours, the curve for drinking drivers and the curve for accidents have their peaks in the early and late evening hours.

There are several further bits of evidence tending to prove alcohol rather than fatigue the prime causative factor. First, in the area of this experiment fatigue would be at a minimum. The largest part of the area

8. Fatigue for the purpose of this discussion is taken to mean the effects of prolonged activity whether they have only an actual physical basis, such as an actual physical disability, or only a mental basis, such as the effect of monotony, or a combination of these two.

9. Baker, J. S.: Too Long at the Wheel (pamphlet), National Safety Council, 1935.

was unquestionably urban, with a heavy flow of traffic. The average driver would be driving only a comparatively short distance. Because of this fact and the nature of the route, monotony would not be the important factor in causing fatigue that it might be on a highway, where there would be no relief from driving at a relatively constant speed on long stretches of road. Another reason to minimize fatigue is that any data gathered on fatigue as a cause of accidents tend to place it as a causative factor in not more than 2 or at the most 3 per cent of the accidents. The most reliable study so far reported, done in Massachusetts by the Registry of Motor Vehicles and based on actual investigations rather than drivers' reports, shows that 1.98 per cent of the total accidents were caused by sleep or fatigue. Contrast that with this study, which shows that 47 per cent of drivers had been drinking and that 14 per cent had drunk so much that they were unquestionably under the influence of alcohol. Several other points should be noted in passing. For instance, and no experimental evidence exists to back this statement, quite possibly the fatigued driver is more inclined to compensate for his disability than is the drinking driver. Probably the fatigued driver will slow down and in general drive more carefully than the drinking driver. Of prime importance is the ability to recover much more readily from fatigue than from alcohol. Stopping the car, getting out and walking, drinking coffee and other measures will at least temporarily dispel fatigue. This, unfortunately, is not true of alcohol.

With the data at hand it is impossible to make an accurate, complete statement of the relation of fatigue and alcohol as causes of accidents. The previous discussion has of necessity been based more on conjecture than on facts. One point, however, must always be remembered in any discussion of this problem; the effects of fatigue are always heightened by alcohol. Reaction times slowed up by fatigue are even slower when alcohol is present. Vision blurred by need for rest is even more blurred with the addition of alcohol. Fatigue can and does cause a large number of accidents, but all available evidence tends to minimize it as a cause when compared with alcohol.

Another reason for this concomitant variability of personal injury accidents with drinking should be considered. Possibly the person who drinks is the one

who ordinarily drives recklessly and is prone to accidents. Perhaps a certain mental makeup is expressed in drinking and also in proneness to accidents. No positive answer can be given to this question. The possibility is minimized, however, when one considers that the person prone to accidents is even more prone to them after drinking, for alcohol unquestionably increases reaction time and affects vision, ability to coordinate, judgment and the other abilities so necessary in the operation of a motor car. Until experimental evidence is presented to prove otherwise, it seems logical to accept the fact that not speed, not darkness, not inherent proneness to accidents in drivers who

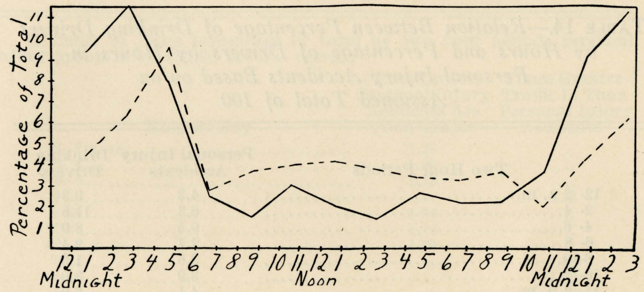

Chart 10.—Relation between the percentage of drinking drivers in the general population by hours and the percentage of drivers in the personal injury accident group by hours, based on an assumed total of 100. The broken line is for the accident group and the unbroken line for drinking drivers (control group).

drink, but rather alcohol, with its demonstrable effects, is the major cause of the high proportion of personal injury accidents in the hours after midnight. The part of these other factors, though, should not be forgotten. Additional work is needed to determine their relation to the accident problem. They unquestionably exist and in themselves do cause accidents. It must be further remembered, however, that alcohol will definitely heighten the effect of any or all of these factors. Thus poor visibility because of darkness is even poorer when the driver has been drinking; increased speeds become more hazardous after alcohol has increased reaction time; drivers prone to accidents become more so after the depressive effects of alcohol release their inhibitions; the effects of fatigue are increased by drinking.

If alcohol is a general, basic, underlying cause of personal injury accidents, two things would be expected:

1. As alcohol varies, personal injury accidents should vary. That is, an increase or decrease in the percentage of drinking drivers should be accompanied by an increase or decrease in the percentage of drivers involved in personal injury accidents.

2. As alcohol varies, personal injury accidents involving alcohol should vary. That is, an increase or decrease in the percentage of drinking drivers should be accompanied by an increase or decrease in the percentage of personal injury accidents in which one or more of the drivers had been drinking.

TABLE 14.—*Relation Between Percentage of Drinking Drivers by Hours and Percentage of Drivers by Hours in Personal Injury Accidents Based on an Assumed Total of 100*

Two Hour Periods	Personal Injury Accidents	Drinking Drivers
12- 2 a. m.	4.3	9.3
2- 4	6.3	11.5
4- 6	9.5	8.0
6- 8	2.7	2.4
8-10	3.6	1.5
10-12	3.9	3.0
12- 2 p m.	4.1	2.0
2- 4	2.7	1.5
4- 6	3.4	2.7
6- 8	3.3	2.3
8-10	3.7	2.3
10-12	2.1	3.7

The first statement is proved by a correlation between the percentage of drinking drivers by two hour periods with the percentage of drivers in personal injury accidents, corrected for traffic, of 0.68 plus or minus 0.08. Chart 10 and table 14 further illustrate this point. In other words, it is demonstrated that there is a rather close correlation between drinking and personal injury accidents.

The second statement is proved by a correlation between the percentage of drinking drivers by two hour periods and the percentage of drinking drivers involved in accidents of 0.73 plus or minus 0.07. It is further borne out by chart 4, which illustrates the close time relation of these two groups.

One more significant fact pointing toward alcohol as a causative factor must be noted. As personal injury

accidents exceed traffic, drinking increases, and as the curve representative of this relationship drops, so does the curve for drinking drivers (table 15). In other words, as personal injury accidents increase over the expected, drinking drivers increase similarly. It seems entirely logical to place the responsibility for this increase in accidents with alcohol. A definite concomitant variability has certainly been demonstrated, and evidence has been given to show that a causal relationship must exist.

Thus it appears that a close causal relationship exists between alcohol and accidents.

TABLE 15.—*Relation of Personal Injury Accidents to Traffic*

(Number of times percentage of total by two hour periods personal injury group is of traffic or vice versa)

Hour of Day	Times Greater Personal Injury Accidents Are Than Traffic	Times Greater Traffic Is Than Personal Injury Accidents
12- 2 a. m.	1.23	....
2- 4	1.86	....
4- 6	2.75	....
6- 8	....	1.32
8-10	1.04	....
10-12	1.14	....
12- 2 p. m.	1.16	....
2- 4	....	1.28
4- 6	....	1.02
6- 8	....	1.06
8-10	1.10	....
10-12	....	1.68

CONCLUSIONS

1. The highest percentage of drinking drivers occurs in the early morning hours and over the week-end.

2. The largest number of drinking drivers occurs in the early evening and over the week-end.

3. The peak age for drinking drivers is from 25 to 30.

4. Women drink and drive as much as men when the number of women driving at various hours of the day is considered.

5. The percentage of drinking drivers in the general population varies as does the percentage of drinking drivers in the personal injury accident group but falls considerably lower at all times.

6. The percentage or number of drivers involved in personal injury accidents varies as does the percentage or number of drinking drivers.

7. As the blood alcohol content increases, the number of drivers appearing in the personal injury accident group increases out of all proportion over that in the general driving population.

8. As alcohol increases, accidents increase and at a rate somewhat proportionate to the increase in alcohol.

9. Equal percentages of drinking drivers are found in the accident group and in the general population group at a point near 0.5 part of alcohol per thousand parts of blood, indicating that alcohol in that amount is not necessarily a significant cause of accidents.

10. It has not yet been objectively and conclusively proved just how important a causative factor alcohol is, and, because of the complexity of the whole accident problem, it may never be proved. The data gathered in this study, however, point in one direction only. They confirm a self-evident fact, that alcohol is a major cause of automobile accidents.

SUMMARY

A study was made of the drinking of drivers involved in personal injury accidents and of the drinking of drivers in the general population. The second study served as a control of the first, allowing conclusions to be drawn as to the part alcohol plays in accidents.

A total of 270 persons were tested in the first study. Drivers involved in personal injury accidents who accompanied the persons injured to a hospital or drivers who themselves were injured were tested by urinalysis for alcohol.

A total of 1,750 persons were tested in the second study. Drivers were chosen at random from an area comparable to that of the first study. A complete testing laboratory, with the Harger "drunkometer," was set up in a trailer, allowing breath tests for alcohol to be made immediately.

Comparisons were drawn between the accident and control groups on the basis of hour of the day, day of the week and blood alcohol content. The control group was presented on the basis of age as related to drinking and sex as related to drinking. The time and the amount of drinking were related to the time and the number of personal injury accidents.

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