Injury Prevention 2000;6:158–161

INJURY CLASSIC

Probability of arrest while driving under the influence of alcohol

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This is the latest paper in a series of Injury Classics. Our goal is to reprint one or two such papers in each issue to introduce newcomers to these old, often quoted, and important contributions. As many are difficult to find, it should help all of us to have a copy at hand. Your suggestions about future articles are welcome. Write to the editor with details of your favourite, most quoted paper.

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Summary
The probability of arrest while driving at a blood alcohol level over 0.10% was 0.0058 (about one in 200).

There is considerable interest in defining the relationship between the probability of being arrested for driving under the influence of intoxicants (DUI) and blood alcohol concentration (BAC)*. Such information, if accurately known, could be put to a variety of uses, including public information, police patrol management information, DUI patrol evaluation, and estimation of the number of drunken drivers on the road.

In surveys associated with the Alcohol Safety Action Projects (ASAP), thousands of persons have been interviewed and asked, among other questions, what they thought their chances were of being stopped by the police after having had too much to drink. The object of such a question is to measure the level of public awareness of enforcement of the DUI laws. Even those who pose the question do not know the answer, however; and such a question has no single answer unless the level of intoxication, or BAC, is specified. There have been no detailed studies to establish such probabilities. Previous estimates suggest that the probability of being arrested while staking a 10 mile trip with a BAC above 0.10% is about 0.0015†.[1] Accurate knowledge of the probabilities of being arrested for DUI is necessary if a public education campaign against drunken driving is to retain the trust and confidence of the public.

This kind of knowledge could also prove to be a valuable police patrol management tool. The officer in charge of DUI patrols would have a standard against which to measure the performance of his unit.

In addition, if the probability of arrest for DUI under specific patrol conditions can be established with confidence, it should be possible—by patrolling a particular area and obtaining traffic count data—to infer the percentage of drivers who will have a given BAC range. Such a means of estimating the number of drunken drivers would be more readily adaptable to communities without ASAPs than a costly voluntary roadside survey.

This report describes a method of determining the probability of being arrested for DUI, and applies it to a driver with a given BAC who comes under the surveillance of a police officer skilled in the detection of drunken drivers. To compute the probability of arrest as a function of BAC, it is necessary to know the unconditional probability of being arrested. A police patrol experiment was designed and conducted which provided the required information. The BAC distribution of the population of drivers who are not arrested was taken from the results of a random survey[2] of volunteer motorists conducted within the patrol area two months before the initiation of the patrol experiment. The BAC distribution of drivers arrested was obtained from police records.

Method
Let $P(B_j)$ be the unconditional probability that a driver has a BAC in range B_j where, for example, B_1 = 0.00%, B_2 = 0.01–0.04%, B_3 = 0.05–0.09%, etc. The conditional probability that a driver, who has not been arrested for DUI, has a BAC in range B_j is $P(B_j|A_0)$. These probabilities obtained by a roadside survey of volunteers, are presented in table 1.

Table 1 Distribution of drivers as a function of BAC between the hours of 2230 and 0130, and the probability of having a particular BAC if arrested for DUI*

BAC (%)	Surveyed drivers $P(B_j\|A_0)$	Arrested drivers $P(B_j\|A_1)$
0	0.68000	0.0001
0.01–0.04	0.20000	0.0007
0.05–0.09	0.06000	0.0200
0.10–0.14	0.04000	0.2610
0.15–0.19	0.01500	0.4250
0.20–0.24	0.00400	0.2130
0.25–0.29	0.00087	0.0620
0.30–0.34	0.00010	0.0160
0.35–0.40	0.00002	0.0020
0.10–0.40	0.06000	0.9790
0.15–0.40	0.02000	0.7180

*Distribution obtained from best fit negative exponential function describing actual data.[2] The data were comprised of 1022 BACs obtained during the late evening and early morning hours, with the findings weighted to correspond to the hours of the police patrol experiment.

*BAC is defined as the percentage of ethyl alcohol by weight in the blood, and is the single best measure of the level of alcohol intoxication.

†The subjects of this report were 836 alcoholics who stated that they had made an average of 120 10 mile trips each per year after drinking, resulting in an average of 0.18 DUI arrests per person. We can also reasonably assume that their BAC after drinking was higher than 0.10%.

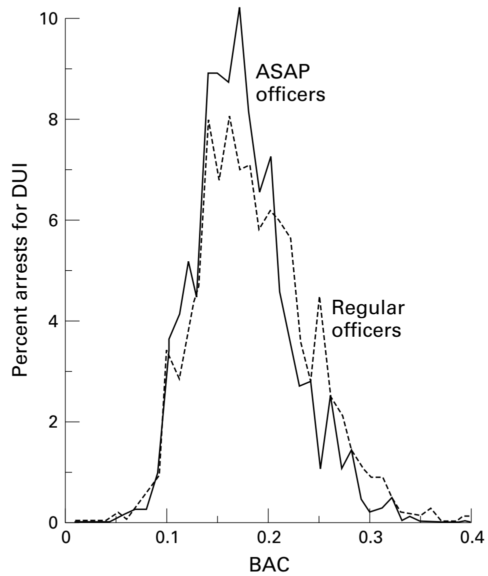

Figure 1 Distribution of BACs of drivers arrested for drunken driving, but not in accidents, by ASAP and regular patrolmen.

The probability that an arrested driver has a BAC in range B_j, $P(B_j|A_1)$ can be obtained with high precision from previous DUI arrest records.

Figure 1 presents the distribution of BACs of drivers arrested for DUI during the 1972 volunteer survey by the same ASAP officers who conducted the patrol experiment described in this paper. Values of $P(B_j|A_1)$ can easily be obtained from these data and are also given in table 1. Also included in fig 1 is the distribution of BACs from arrests by the regular patrol. The similarity between the two distributions suggests that the results presented in this paper need not be restricted to a select group of police officers.

Bayes' theorem allows us to compute the conditional probability $P(A_1|B_j)$ that a driver will be arrested, if it is assumed that he has a BAC in range B_j, from the equation:

$$P(A_1|B_j) = \frac{P(A_1) \cdot P(B_j|A_1)}{P(A_0) \cdot P(B_i|A_0) + P(A_1) \cdot P(B_j|A_1)}$$

where $P(A_1)$ is the unconditional probability of being arrested for DUI if observed by a skilled officer, and $P(A_0) = 1 - P(A_1)$. Although we do not know $P(A_1)$ a priori, we can estimate it in the following manner. From previous performance records of the Kansas City ASAP unit in normal patrol, we know that an officer makes approximately one arrest each five hours of scheduled patrol (this time includes arrest processing, lunch, coffee breaks, and other non-patrol activities). The officers are usually on duty at times and places where the traffic flow is in the range of 100 to 1000 vehicles per hour in two directions. Thus, we can place reasonable estimates on $P(A_1)$, that is, $0.0002 < P(A_1) < 0.002$.

‡A vehicle check involves stopping and questioning a motorist without necessarily charging him with driving under the influence.
**Since these were major streets and in the general vicinity of one of the district stations, other police were in the area on other assignments.

The patrol experiment described in this paper was designed to obtain a more reliable value for $P(A_1)$, using well defined values of traffic volume and a specific set of patrol conditions. With a known value of $P(A_1)$ we shall then be able to compute $P(A_1|B_j)$.

EXPERIMENT

A specified route was patrolled for two hour periods by police officers from the ASAP unit of the Kansas City, Missouri, Police Department. The time and location of each arrest and the BAC of the driver and number of vehicle checks‡ were recorded. Counts of traffic volume were made each night.

Two street segments, approximately parallel, separated by one block at one end and four blocks at the other, were patrolled uniformly. Both streets are major four lane, two way through streets with high traffic volumes. The entire circuit was eight miles. Only drivers who were seen in or entering this area and were subsequently arrested are included in the analysis. The cross streets which connect the two patrol streets were access roads only and not patrolled areas in this experiment.

The patrol effort was supplied by six patrolmen and one sergeant, each of whom spent approximately the same amount of time on patrol. One man patrols were used, and each officer's usual patrol strategy was acceptable. They were all experienced and proficient at patrolling for persons suspected of DUI. Only one of the seven officers was in the patrol area at one time**. A back-up officer normally was in a nearby area, and continued the experimental patrol when the first officer became occupied with an arrest.

The patrol operated for a selected two hour period each night between 2230 and 0130 hours on Tuesdays through Saturdays, as available manpower permitted. The choice of days corresponded to those sampled in the volunteer survey.[2] This time period was chosen because of the uniformly high traffic flow and the relatively high percentage of drunken drivers as previously established by the volunteer survey. The patrol was terminated at 0130 to reduce the influence of bar closing traffic and the appreciable decrease in the volume of non-drinking drivers. The patrol could be interrupted and even terminated in the event of emergency calls or requests for assistance by other officers.

Each night during patrol, two traffic volume counts were made at predesignated (but randomly selected) locations and times. All motor vehicles traveling in both directions were counted for 2 min. If the count was interrupted by police action, the required count was made as soon as time permitted.

The previous volunteer survey[2] included two sites on the streets used in the patrol area, and covered the time period 1700–0300 hours. The results of the survey showed no significant site-to-site variations in the percentage of drunken drivers and very little day-to-day variation. The percentage of drunken drivers was very pronouncedly dependent on time, increasing as it got later. We estimated the BAC distribution of

Table 2 Observed DUI arrests and computed arrest probability

BAC (%)	*Estimated vehicles**	*Observed arrests*	*Computed $P(A_1\|B_j)$*
0	40 000	0	0.000000055
0.01–0.04	11 800	0	0.0000013
0.05–0.09	3 540	0	0.000124
0.10–0.14	2 360	7	0.00244
0.15–0.19	890	6	0.0105
0.20–0.24	240	6	0.0195
0.25–0.29	50	1	0.0258
0.30–0.34	6	0	0.0565
0.35–0.39	1	0	0.029†
⩾0.10	3 547	22‡	0.0058
⩾0.15	1 187	15‡	0.0133

*Distribution estimated from the volunteer survey.[2]
†The seemingly spurious result that the probability of arrest is less at a BAC of over 0.35% than at a BAC of 0.30–0.34% probably arises because the driver who has a BAC over 0.35% will be the driver most likely to be physically unable to undergo a breath test. In the rare cases when a blood test was required, the results were not entered into the Kansas City police computer, from which $P(B_j|A_1)$ was obtained.
‡The two breath test refusals have been included in the >0.15% category.

drivers from the averages obtained on sampling drivers between 2230 and 0130 hours (table 1).

Results

A total of 119 hours were spent on patrol during 66 days between January and May 1973, resulting in 22 DUI arrests and 116 vehicle checks. On the average, there was an arrest for each 5.4 hours of patrol, and a vehicle check each hour. The arrests were fairly well distributed throughout the week, with six on Wednesday, five on Thursday, five on Friday, four on Saturday, and only two on Tuesday.

Fourteen of the 22 arrests occurred on the street with the higher traffic volume (577 *v* 423 vehicles per hour). The average traffic volume was 497 vehicles per hour. The arrests occurred quite uniformly over the patrol time although there was a slight peak at 2300 hours, when patrol time tended to be concentrated.

The average BAC of the 20 drivers who consented to a breath test was 0.171%, in close agreement with the average of 0.173% in the drivers arrested by the same officers on their normal patrols.

Using $P(B_j|A_0)$ and $P(A_1|B_j)$ from table 1, and $P(A_1) = 22/\ 59\ 108 = 0.000374$, we can now compute the probability that a driver with a BAC in range B_j will be arrested for DUI. In table 2, the number of drivers arrested and the corresponding BACs are shown, along with the computed $P(A_1|B_j)$.

The highest observed probability of arrest was about 0.02 (one in 50) at a BAC of 0.20–0.24%. The overall probability of being arrested if drunk (BAC ⩾0.10%) was 0.0058 (one in 200). The probability of being arrested for DUI if a driver "only had one drink, officer" (BAC <0.04%) is about one in 100 000. Since these probabilities are predicated on passing a police officer who is also watching for a drunken driver, the threat of apprehension in general is actually much less.

Not all of the participating officers had equal success in making arrests. In fact, four of the officers in slightly over half of the patrol time made 21 of the 22 arrests (table 3). These differences reflect day-to-day variations, weather conditions, and other chance elements, including personal attitudes toward participating in an "experiment". The sample size is inadequate to judge the relative skill of the officers.

Table 3 Number of arrests, by officer

Officer	*Arrests*	*Patrol time (hour)*	*Arrest per hour*
1	0	10.2	0.00
2	0	28.1	0.00
3	1	20.2	0.05
4	2	6.5	0.31
5	6	12.6	0.48
6	6	24.3	0.25
7	7	17.1	0.41
4–7	21	60.5	0.35

However, even under the "best" conditions, that is, considering only the four officers who made 21 arrests in 60.5 hours, the probability of arrest is only slightly more than double that shown in table 3, and the probability of being arrested for drunken driving (BAC ⩾0.10%) is still only one in 100.

Finally, in addition to the 22 DUI arrests, the officers made 116 vehicle checks for suspected drunken drivers (nearly one per hour). Thus, 19% of the vehicles showing erratic behavior were driven by a drunken driver, whereas we estimate that only 6% of the observed drivers had BACs of 0.10% or over. It can, therefore, be inferred that a drunken driver is about three times as likely to display erratic driving behavior as a sober driver (or, at least, one not subsequently placed under arrest for DUI).

Discussion

The computed probability of arrest for DUI is as low as it is, partly because we included all vehicles which could have been observed by the officer. We have, therefore, correctly computed the probability which will be perceived by the drinking public. The officer on patrol, however, certainly cannot and does not give each observable vehicle an equal amount of attention.

Consider a common patrol strategy. If the officer cruises at the average traffic velocity for one mile in a cluster of six vehicles, for example, he has an opportunity to observe the behavior of those six vehicles for perhaps 12 intersections over a period of 3–5 min. At the same time, 30 to 50 vehicles will pass by in the opposite direction. He can observe the behavior of any one of these opposing vehicles for only one intersection or 1/10 mile and about 5–10 sec. Thus, the few vehicles traveling in the direction of, and near to, the patrol car have an order of magnitude times the exposure as the many vehicles approaching the patrol car. The two factors (increased exposure for a small portion) combine and would, it seems, raise the probability of arrest for a drunken driver being followed by a highly trained and motivated officer to nearly unity if his BAC is above 0.15%.

We thank Sergeant John Weddle and his unit for their operation in this experiment.

The experimental portion of this study was conducted by members of the Kansas City Alcohol Safety Action Project in conjunction with contract No DOT-HS-077-1-100 with the National Highway Traffic Safety Administration. The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the City of Kansas City or the National Highway Traffic Safety Administration.

1 House WB. *Kansas City Alcohol Safety Action Project, recovering alcoholic survey.* Final report. Kansas City, MO, 1972.
2 Glauz WD, Beitel GA, Sharp MC. *Kansas City Alcohol Safety Action Project—1972 roadside survey.* (Midwest Research Institute Spec Rep No 5, Project No 3560-E.) Kansas City, MO, 1973.

Lucina (*Archives of Disease in Childhood*) writes:
Amputated noses can be reimplanted. "How would a nose come to be amputated?" Lucina asked herself. In the cases of two American children the answer was a dog bite. Neither reimplantation was completely successful and both children needed repeated surgery but the end results were much better then they would have been without any attempt at reimplantation.

* * *

Minerva of the *British Medical Journal* writes:
Between 1989 and 1997, 117 Danes were injured by falling goalposts. Half of them were swinging or doing chin ups on the cross bar at the time, two were sitting on the bar, and a further two were injured trying to crawl up the goal. Padding or securing the goalposts with a counterweight were suggested as means of combatting this. Tighter supervision of teenage boys during soccer practice might also work.

* * *

A 17 month old child fell on to the blunt metal leg of a hi-fi stand impaling himself through the right orbit. On presentation at Middlesborough General Hospital, England, he was conscious but responding to painful stimuli. The stand was removed uneventfully and the child recovered well apart from a mild right hemiparesis which is improving.

* * *

Manchester United football club should consider diverting some funds into injury prevention for British footballers. A study found that injury rates in professional players were 1000 times higher than in comparable risky industrial occupations.

* * *

The incidence of hip fracture in Australia is set to double over the next two decades according to two recent reports. If the predictions are true, every working Australian man and woman will have to contribute $120 a year towards treatment for hip fractures to the year 2051.

* * *

Investigators surveyed over 200 people in Lithuania whose cars had been hit from behind. Half of them had had initial neck pain or headache but all respondents' symptoms resolved within three weeks. After one year this group had no more symptoms that other matched community controls. Few were insured for personal injury.

* * *

Every day 23 000 Americans consult a doctor because of ankle sprains. One survey suggests that nearly three quarters continue to have symptom for months regardless of the type of treatment they receive.

* * *

Over a two year period 50 people were injured by ceiling fans in one town in Queensland, Australia. The message coming out of this study is that children in bunk beds and overhead fans are best kept apart.

* * *

People who vomit after a bang on the head are twice as likely to have a skull fracture than people who don't. A study in the UK found that vomiting was an independent risk factor for skull fracture even when the patients were alert and oriented.

* * *

Evidence is accumulating that activated charcoal is toxic if aspirated into the lungs. This is a common treatment for many forms of poisoning despite lack of evidence that it actually saves lives.

* * *

Accident and emergency doctors in Glasgow have found a new use for metal detectors—finding swallowed foreign bodies in children. They studied 186 children who according to their parents had swallowed something metal and the detectors picked up 183 of the items. Although they can be a cheaper, safer, and less invasive than an *x* ray examination, they can't tell a surgeon the exact position of a foreign body or what shape it is.