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Crash Risk of Alcohol-Impaired Driving:  
The Repeat of the Grand Rapids Study

by

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# THE ROBERT F. BORKENSTEIN COURSE ON ALCOHOL AND HIGHWAY SAFETY

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## CRASH RISK OF ALCOHOL-IMPAIRED DRIVING: THE REPEAT OF THE GRAND RAPIDS STUDY

by

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Princess Diana's Mercedes

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## OVERVIEW:

The GRAND RAPIDS STUDY (“The Role of the Drinking Driver in Traffic Accidents,” conducted by Indiana University Professor Robert F. Borkenstein and colleagues in 1962-63 and published in 1964 (1<sup>st</sup> ed.) and republished in 1974 (2<sup>nd</sup> ed.), was the largest controlled study of alcohol-related automobile collisions when it was conducted. It was sponsored by USPHS, and included 5,895 accident group and 7,590 control group drivers. Its findings correlating relative probability of crash causation in single and multi-car collisions with BACs contributed to alcohol-and-driving policy decisions, countermeasures, and enactment of traffic laws for several decades in North America, Europe, Australia and elsewhere and led, i.a., to the “0.08” alcohol concentration driving threshold. The Grand Rapids Study data were also used to generate a relative risk calculations for crash involvement as a function of the BAC (Allsop, 1966). Conclusions of the Grand Rapids Study included these:

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## OVERVIEW, continued:

- “Blood alcohol concentrations over 0.04% are definitely associated with an increased accident rate.”
- “The probability of accident involvement increases rapidly at BACs over 0.08%, and becomes extremely high at BACs over 0.15%.”
- “High BACs are always associated with bad accident experiences.”

**Source:** R. F. Borkenstein, et al., “The Role of the Drinking Driver in Traffic Accidents,” *Blutalkohol* 11 (Suppl. 1): 1-131 (1974).

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## OVERVIEW, continued:

None of several similar studies conducted since the Grand Rapids Study was a true case-control effort, until the “New Grand Rapids Study,” sponsored by NHTSA, conducted by Richard D. Bloomberg and others June 1997–Sept. 1999 in Long Beach, CA and Sept. 1998–Sept. 1999 in Ft. Lauderdale, FL. This case-control study was published as “CRASH RISK OF ALCOHOL INVOLVED DRIVING: A CASE-CONTROL STUDY – FINAL REPORT” in Sept. 2005 by Dunlap and Associates, Stamford, CT. The 1997-99 CA-FL case-control study substantially confirmed the major findings and conclusions of the 1960s Grand Rapids Study. The Executive Summary includes these statements:

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## OVERVIEW, continued:

- In conclusion, the study results confirm a notable dose-response relationship beginning at 0.04% BAC and increasing exponentially at  $\geq 0.10\%$  BAC.”
- The final adjusted relative (crash) risk function.... illustrates the extraordinary magnitude of the crash risk a higher BACs.”

**SOURCE:** R. D. Bloomberg, et al.: “CRASH RISK OF ALCOHOL INVOLVED DRIVING: A CASE-CONTROL STUDY. FINAL REPORT. September 2005.” Retrieved from [dunlapandassociatesinc.com/crashriskofalcoholinvolvedddriving.pdf](http://dunlapandassociatesinc.com/crashriskofalcoholinvolvedddriving.pdf) on 3/19/2007

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## SCIENTIFIC ASPECTS

***ABSTRACT of Bloomberg, et al.: “CRASH RISK OF ALCOHOL INVOLVED DRIVING: A CASE-CONTROL STUDY. FINAL REPORT. September 2005.”***

“A case-control study was conducted in Long Beach, CA and Fort Lauderdale, FL to examine the relative crash risk associated with drivers’ blood alcohol concentrations (BACs). Data were obtained for drivers involved in 2,871 crashes of all severities. Two control drivers for each crash driver were sampled a week after the crash at the same location, on the same day of the week and at the same time of day. For both groups of drivers, a research team recorded observations, administered a brief questionnaire and obtained breath specimens for BAC measurements.

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## SCIENTIFIC ASPECTS, continued

### ***ABSTRACT of Bloomberg, et al. continued***

Of the 14,985 sampled drivers who were potentially available for testing, 91.7% of crash drivers and 97.9% of control drivers provided breath specimens. When drivers who fled the crash scene are included in the number of potentially available drivers, the percentage that provided a breath specimen reduced to 81.3%. Relative risk models were generated with logistic regression techniques with and without covariates such as driver age, gender, marital status and ethnicity.



# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## SCIENTIFIC ASPECTS, continued

### ***ABSTRACT of Bloomberg, et al., continued***

The models without adjustment for the covariates show elevated relative risk beginning at 0.05–0.06% BACs with an accelerating increase in risk at BACs greater than 0.10%. With adjustment for covariates and bias due to missing data (non-tested hit-and-run drivers, refusals, and incomplete responses), risk was elevated at a slightly lower BAC and the risk curve was steep. Statistically significant risk occurred at 0.04% BAC and small, non-significant elevations occurred at BACs closer to zero. Relative risk models were also produced for age groups and alcohol consumption levels.”

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## SCIENTIFIC ASPECTS, continued

*Bloomberg, et al. Long Beach/  
Ft. Lauderdale Study (2005)*

**SOURCE:** R. D. Bloomberg, et al.: "CRASH RISK OF ALCOHOL-IMPAIRED DRIVING: A CASE-CONTROL STUDY. FINAL REPORT. September 2005."

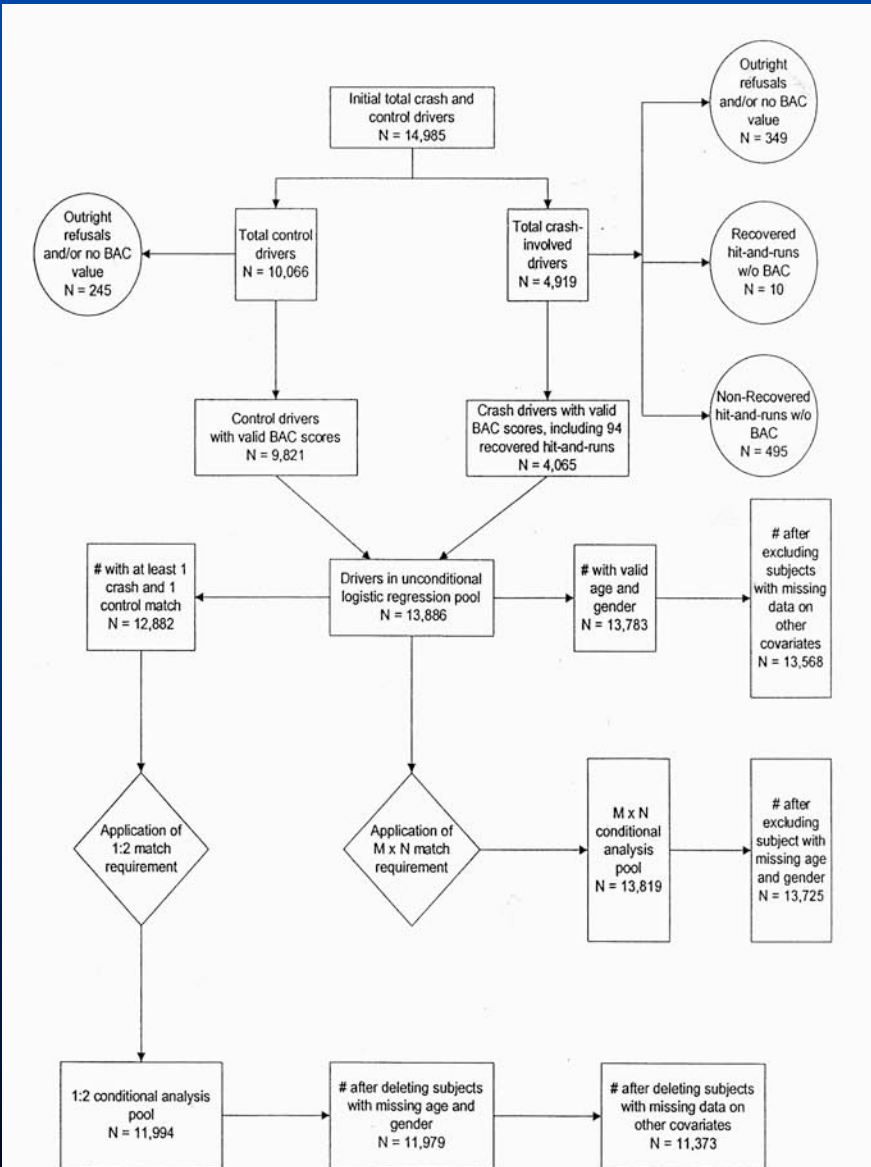


Figure 1. Flow of sample sizes of crash and control drivers resulting from missing data and logistic regression model requirements

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## SCIENTIFIC ASPECTS, continued

### Relative Auto Crash Risk Estimates for 2005 Bloomberg, et al. and 1974 Borkenstein, et al. Studies

**SOURCE:** R. D. Bloomberg, et al.: "CRASH RISK OF ALCOHOL-IMPAIRED DRIVING: A CASE-CONTROL STUDY. FINAL REPORT. September 2005."

Table 1: Relative Risk Models And Comparison with Grand Rapids Results

BAC Level	No Covariates	Non-Reactive Demographic Covariates	Final Adjusted Estimate	Grand Rapids*
.00	1.00	1.00	1.00	1.00
.01	.91	.94	1.03	.92
.02	.87	.92	1.03	.96
.03	.87	.94	1.06	.80
.04	.92	1.00	1.18	1.08
.05	1.00	1.10	1.38	1.21
.06	1.13	1.25	1.63	1.41
.07	1.32	1.46	2.09	1.52
.08	1.57	1.74	2.69	1.88
.09	1.92	2.12	3.54	1.95
.10	2.37	2.62	4.79	
.11	2.98	3.28	6.41	5.93
.12	3.77	4.14	8.90	
.13	4.78	5.23	12.60	4.94
.14	6.05	6.60	16.36	
.15	7.61	8.31	22.10	10.44
.16	9.48	10.35	29.48	
.17	11.64	12.74	39.05	
.18	14.00	15.43	50.99	
.19	16.45	18.31	65.32	
.20	18.78	21.20	81.79	
.21	20.74	23.85	99.78	
.22	22.07	25.99	117.72	
.23	22.51	27.30	134.26	
.24	21.92	27.55	146.90	
.25+	20.29	26.60	153.68	21.38

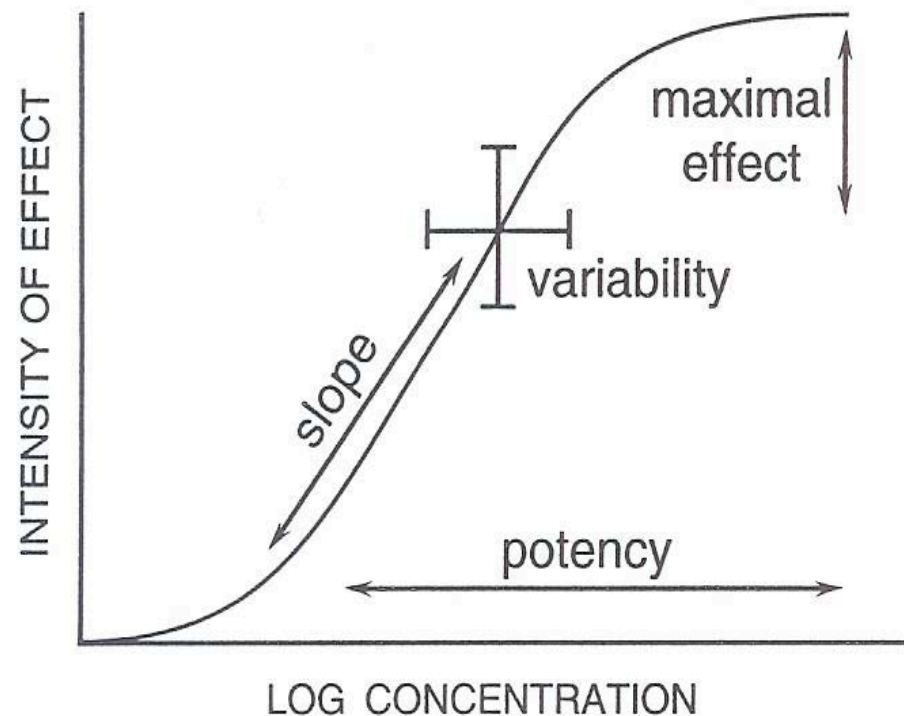
\*From reporting of Grand Rapids Study data in Table 25 (a) of Allsop (1966).

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## SCIENTIFIC ASPECTS, continued

**SOURCE:** Goodman & Gilman's  
THE  
PHARMACOLOGICAL  
BASIS OF  
THERAPEUTICS. 11th  
ed. New York, McGraw-  
Hill Medical Publishing  
Division, 2006, p. 126.

### Schema of a hypothetical plasma drug concentration



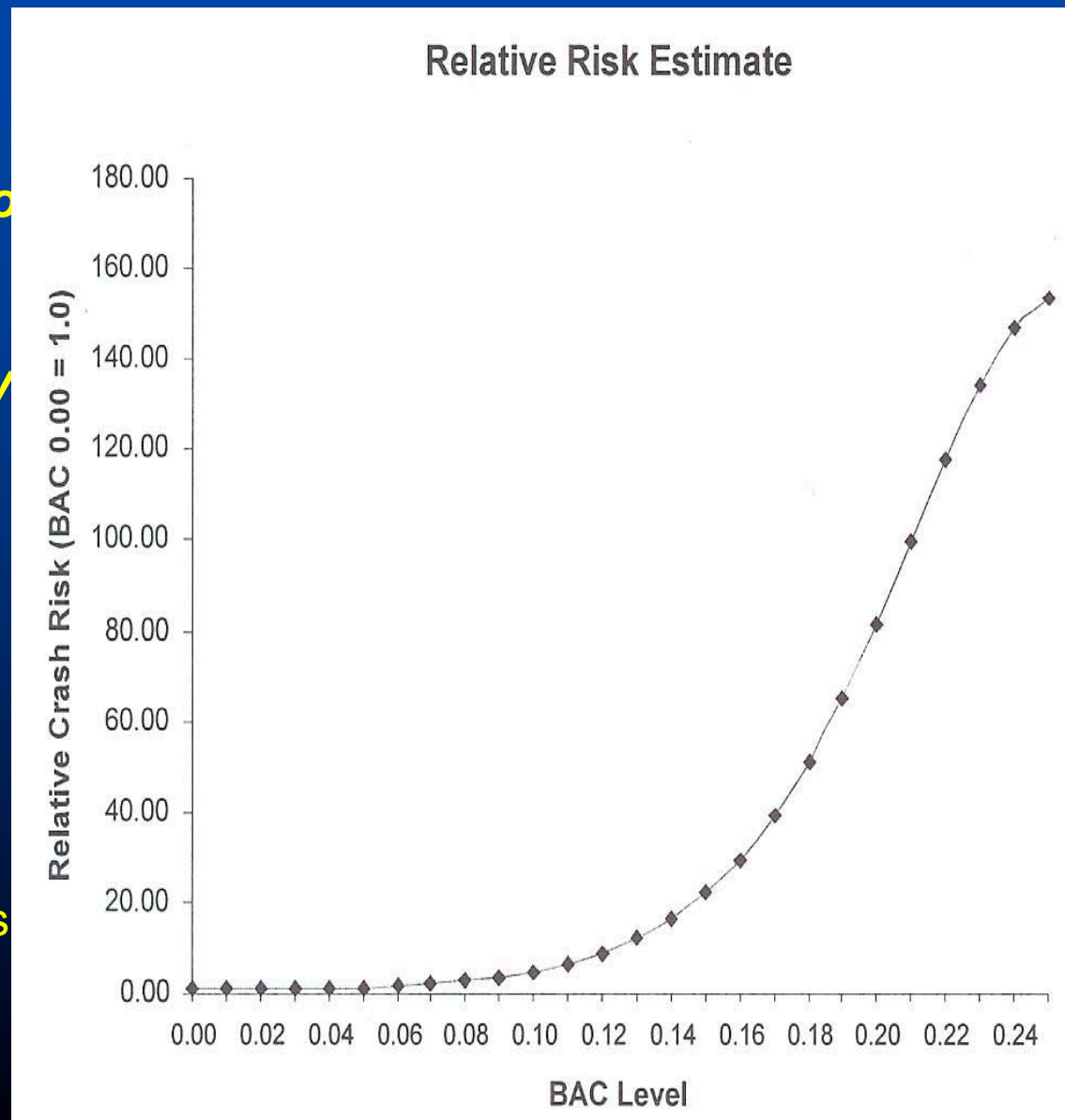
**Figure 5-3.** The log concentration-effect relationship. Representative log concentration-effect curve illustrating its four characterizing variables.

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## SCIENTIFIC ASPECTS, continued

*Final Adjusted Relative Auto  
Crash Risk Estimate as a  
Function of BAC for the  
Bloomberg, et al. 2005 Study*

**SOURCE:** R. P. Compton, et al. "Crash Risk of Alcohol Impaired Driving," Proceedings of ICADTS T-2002, Vol. I, p.43.



# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## SCIENTIFIC ASPECTS, continued

### Discussion of the Bloomberg et al. Long Beach/Ft. Lauderdale Study (2005), included these statements:

- Relative auto crash risks as a function of BAC (capped at 0.12+%) within all groups are remarkably similar, except for a very large increase in risk for drinkers under age 21 at  $\geq 0.12\%$  BAC.
- “The study data provide compelling evidence that alcohol (BAC) is a major factor in traffic crash causation.”
- “Risk of crashes increases at moderate BACs and it increases dramatically at high BACs, findings that are consistent with previous epidemiological and laboratory studies.”

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## SCIENTIFIC ASPECTS, continued

### Discussion of the Bloomberg et al. Long Beach/Ft. Lauderdale Study (2005, included these statements: (continued)

- “The increases in risk at BACs of 0.12% and greater are dramatically higher than those previously reported. Even at a more moderate 0.08% BAC, ... the relative risk is 42% higher than that reported by the Grand Rapids Study.”
- “The present study supports the conclusion that the ‘Grand Rapids Dip’ is largely artifactual.”
- “In the 2005 Study, data  $>0.25\%$  were scarce, and the statistical analyses were capped at BAC = 0.25%.”

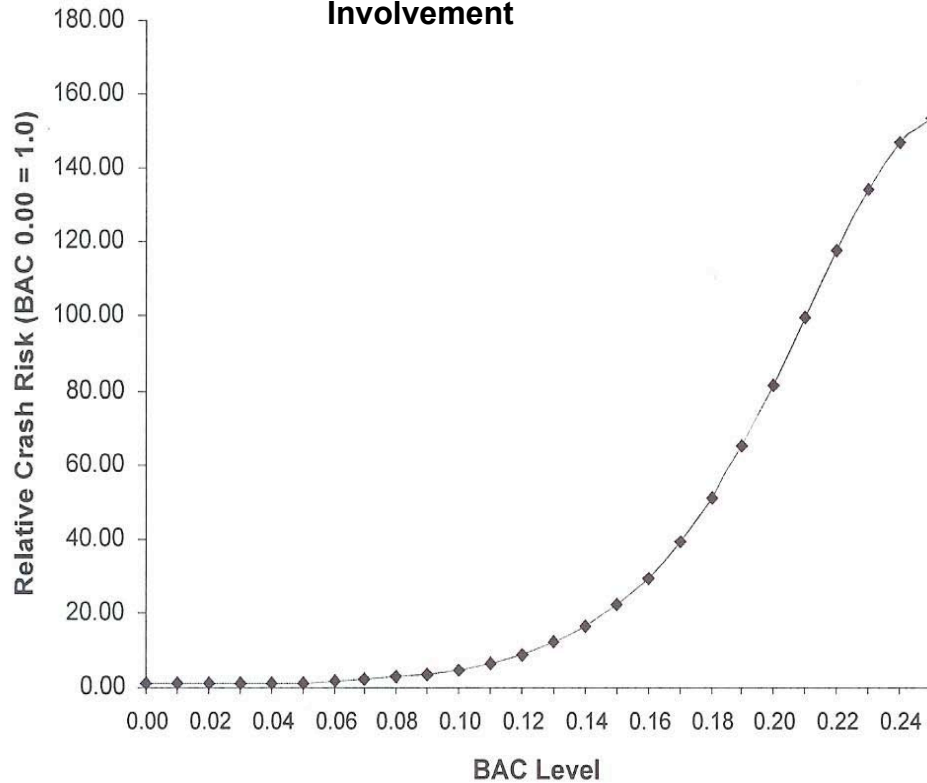
# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## SCIENTIFIC ASPECTS,

## continued Comparison of Auto Crash Risk Curves

Figure 1

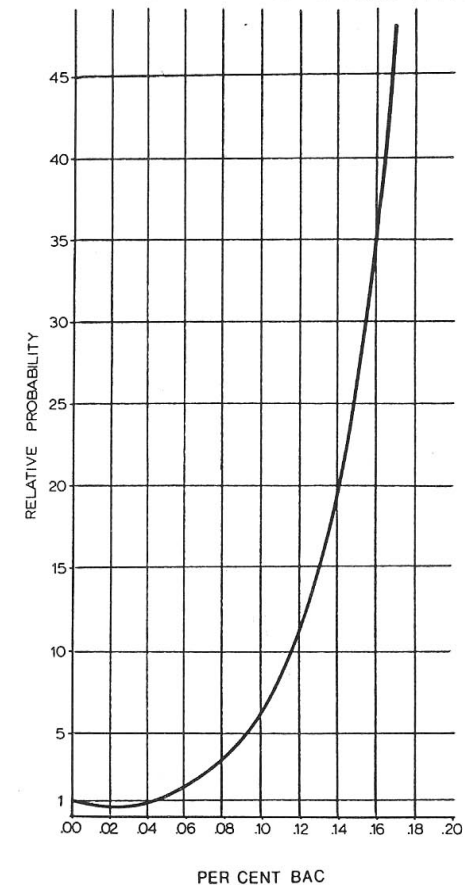
Relative Risk Estimate  
For Auto Crash  
Involvement



R. D. Bloomberg, et al. Study

CHART XV

RELATIVE PROBABILITY OF CAUSING AN ACCIDENT



R. F. Borkenstein, et al. Study



# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## SCIENTIFIC ASPECTS, continued

### Alcohol Concentration Underestimates in the Field Studies

Both the Grand Rapids Study and the Long Beach/Ft. Lauderdale Study utilized *breath-alcohol* measurement results in g/210 L, although reported in both studies as “blood-alcohol concentrations” (BACs). Further, in the Grand Rapids Study, breath-alcohol specimens were collected at study sites in collapsible mylar-polyethylene laminate breath specimen bags and analyzed for alcohol later with Breathalyzers<sup>®</sup>. For sound reasons, no adjustment was made to measured BrAC results for any difference between the measured BrAC and that existing at the time of the studied events (e.g. auto collision, control-case interview, etc.), in either study. Consequently, it can be reasonably assumed that the “blood-alcohol”

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## LEGAL ASPECTS

The epidemiological findings and conclusions of the Bloomberg et al. Long Beach/Ft. Lauderdale case-control study on the auto crash risk of alcohol-impaired driving, reported in 2005, support and confirm the principal findings of the Borkenstein et al. Grand Rapids Study conducted in the 1960s, and thus validate the world-wide public policy, impaired-driving countermeasures, and statute law decisions based on the Grand Rapids Study findings, reported in 1964 and 1974. Thus again validated are 0.04 and 0.08 alcohol concentration limits for drivers, and enhanced-BAC driving offense

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## LEGAL ASPECTS, continued

treatment such as increased penalties at higher BACs. These legislative and public policy responses to alcohol-impaired driving were also based upon and are consistent with the results of many experimental laboratory studies on the mechanisms and magnitude of alcohol-related changes in driver and driving performance. The results of the Long Beach/Ft. Lauderdale Study on the crash risk of alcohol-impaired driving will undoubtedly also be reflected soon in impaired-driving case law, and in enhanced technological countermeasures to prevent or reduce alcohol-impaired motor vehicle driving. Stay Tuned.

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## THE DUBOWSKI PERSPECTIVE

The 1960s Grand Rapids Study on “The Role of the Drinking Driver in Traffic Accidents” by Robert F. Borkenstein and associates at Indiana University (reported in 1964, 1974) was and remains a watershed for epidemiological research on alcohol-involved motor vehicle crashes. It was a pioneering effort worthy of a Nobel Prize, and its findings and conclusions undergirded alcohol-and-driving policy decisions internationally for several decades, including the 0.08 alcohol concentration threshold. It is of historical interest that a peer-reviewed (Second Edition) report was published in *Blutalkohol* ten years after the study report was submitted to the sponsor, the Division of Accident Prevention, U. S. Public Health Service; and that the organization from which the report emanated – the Indiana University Center for Studies of Law in Action founded by Professor

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## THE DUBOWSKI PERSPECTIVE, continued

Borkenstein – became the 16<sup>th</sup> nongovernmental research organization to be recognized by the International Council on Alcohol, Drugs and Traffic Safety with its highest honor, the Institutional Widmark Award, in August 2007.

Thirty-five years after the pioneering Borkenstein field study was carried out July 1962-June 1963 in Grand Rapids, a similar, slightly larger repeat study on the crash risk of alcohol-involved driving was performed in Long Beach, CA (June 1997-September 1998) and Ft. Lauderdale, FL (September 1998-September 1999) under NHTSA sponsorship, by Richard D. Bloomberg of Dunlap & Associates, and colleagues.

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## THE DUBOWSKI PERSPECTIVE, continued

A “Final Report” of the Bloomberg Study was prepared in September 2005 and posted on the Internet. A peer-reviewed publication does not yet exist.

In general, the 2005 Long Beach/Ft. Lauderdale Study replicates and confirms the principal findings and conclusions of the 1974 Grand Rapids Study report. That is good news, and serves to validate the many world wide governmental and private sector policy decisions, drinking-driving countermeasures, and statutory enactments which were in large measure based upon the Grand Rapids Study. In particular, the exponential – not linear – increase in auto crash risk at higher alcohol concentrations remains striking and demands attention and response. In the thirty+ years between the two reports,

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## THE DUBOWSKI PERSPECTIVE, continued

there have been many changes in automobile and road design, motor vehicle traffic, governmental response to alcohol and drug impaired driving, alcohol consumption, and population changes in both industrialized and developing countries. It seemed possible that those changes had altered the relative risks associated with driving with BACs and BrACs above zero. As well, advances in experimental design of epidemiological studies, data collection, and statistical multi-variate analysis and evaluations have occurred during those decades.

It is thus somewhat surprising that the two major studies yielded quite comparable results, except for the even greater crash risks at higher BrACs which have now been clearly documented. It is also

# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## THE DUBOWSKI PERSPECTIVE, continued

striking, but understandable that the very great increase in crash risk attributable to alcohol-impaired driving (now known to occur even at very low Alcohol Concentrations) largely overrides all other candidate crash risk factors such as driver age, gender differences, etc. The 2005 Study report confirms, and hopefully solves the long-standing mystery of the “Grand Rapids Dip” at BrACs around 0.02-0.04 g/210 L. It has been long suspected of being an artifact in the Grand Rapids Study results attributable to data bias and univariate data analysis, rather than being evidence that small amounts of alcohol in the body decrease the risk of crash causation or involvement. Now we know that such was indeed the case.

Thank you to all parties involved in designing, performing, reporting, and sponsoring this important research!



# CRASH RISK OF ALCOHOL-IMPAIRED DRIVING

## THE DUBOWSKI PERSPECTIVE, continued

With its large data base of (mostly) *breath-alcohol* measurements, the Long Beach/Ft. Lauderdale 2005 Study report will also further strengthen and further confirm the long-established direct relationship between *BrAC* values and driving-impairment and driving crash-risk. The massive *BrAC* data bases for driving impairment and crash risk long ago eclipsed the earlier and much smaller blood-alcohol concentration data base related to these factors, and eliminate any need to refer to *BAC/BrAC* relationships with respect to alcohol and driving impairment.