Intoxication Is Not Always Visible: An Unrecognized Prevention Challenge

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T HE USE OF alcohol or other drugs (AOD) to alter consciousness and produce intoxication is not new. Alcohol, for example, is the most widely used and abused drug on earth and has been consumed for its intoxicating effects for thousands of years. One consequence of AOD intoxication is impaired driving. One of the challenges facing prevention specialists is that many factors contribute to intoxication as well as to whether a person is "visibly intoxicated." "Visible intoxication" (meaning a series of perceptible acts and behaviors consistent with gross impairment) is, in some cases, different from "obvious intoxication," a term used in some state statutes (and some older studies to mean visibly intoxicated), that relates to a combination of all the factors used to determine whether a person is or is likely to be alcohol impaired. "Intoxication" is not always visible even to trained observers.

The goals of this review are (i) to educate prevention specialists about the state of knowledge in determining intoxication, (ii) to provide an authoritative treatise on the subject of visible intoxication, and (iii) to address the medicolegal consequences of such intoxication—primarily the prevention of impaired driving.

Historically, most of the direct consequences of intoxication have been limited to individual drinkers who, if they lived long enough, would eventually incur significant medical consequences (Brick, 2008). However, the introduction of motor vehicles and the eventual proliferation of mechanized transportation dramatically changed society. No longer were the effects of alcohol overuse limited to the drinker, but now others (passengers, occupants of other vehicles, and pedestrians) were included as well. Today about 14,000 alcohol-related fatal crashes occur per year (Yi et al., 2006). The actual number of crashes directly due to intoxication is probably lower

as most recent epidemiological studies of this type include drivers with blood alcohol concentrations (BACs) of more than zero, and statistical methods, such as intupation, assume intoxication based on driver and crash profiles. But even when objective blood alcohol evidence is missing (US Department of Transportation/National Highway Traffic Safety Administration, 2002), drunken driving is a major health hazard.

Diverse approaches have been applied to prevent drunken driving (Hingson et al., 1996a,b, 1999; Holder et al., 2000; NIAAA, 2000) but only three approaches specifically relate to identifying signs of alcohol intoxication: DWI laws, dramshop/related host liability, and Alcohol Beverage Control Board laws. A review of differences between DWI-related issues and visible intoxication (the focus of dram shop laws) is important to the general public's awareness and understanding of this problem, and the reduction of motor vehicle and other injuries due to intoxication. In this article, we review the development, scientific foundation, implications, and interrelationships among these approaches.

ALCOHOL AND THE LAW: THE RELATIONSHIP AMONG BAC, BEHAVIOR, AND LIABILITY

Early Definitions of Intoxication

By the beginning of the twentieth century, a combination of scientific research and societal changes was leading to the awareness of public health issues caused by intoxicated motor vehicle operators. Although systematic epidemiological research on what became "drunken driving" was sparse, the relationships among drinking alcohol, intoxication, and motor vehicle crashes were apparently sufficiently robust to attract public attention. This eventually led to legislation to reduce drunken driving. In an attempt to clarify "drunken driving" and its reliance on gross signs of intoxication, legislation later included the terms "under the influence of alcohol" and "alcohol-impaired" (Voas and Lacey, 1990).

Pioneering work in Sweden by Widmark, 1932 (translated in 1981) and in the United States by Heise and Halporn (1932) and Heise (1934) led to protocols for use in evaluating suspected drunk drivers. Until then, such evaluations (usually

performed by clinicians or police) were neither systematic nor objective. A diagnosis of drunken driving, often introduced by expert testimony, usually included highly exaggerated behaviors such as staggering gait and incoherent speech. These early studies gave us improved methods to quantify alcohol in blood (Jones, 2000). Such work led to a general understanding that the signs of alcohol intoxication were proportional to the concentration of alcohol, and these adversely affected safe motor vehicle operation. The work of Heise and other luminaries of the time contributed substantially to a body of evidence on drunken driving that helped expand the newly formed interests of the National Safety Council Committee on Tests for intoxication. As motorized transportation increased, so did awareness of the public safety issues related to driving, so that by 1939 the first legislation defining intoxicated driving based on BAC was passed in Indiana. The original statute was three tiered: a BAC of less than 50 mg/dl was considered presumptive evidence of no intoxication; a BAC between 50 and 150 mg/dl was considered to be supportive evidence of intoxicated driving; and a BAC of 150 mg/dl or more was considered to be "prima facie" (evident without proof, obvious) evidence of guilt (Borkenstein, 1984). In the context of the early Uniform Vehicle Code, driving while intoxicated has been defined as "operating a motor vehicle with signs of intoxication by alcohol (or other drugs) manifested by gross behavior and, frequently, by chemical testing for alcohol…" (Keller et al., 1982, p. 106). This definition is set at an alcohol concentration at which there is no doubt of obvious intoxication (Heise, 1956), namely, 150 mg/dl.

Today, the term intoxication is strongly associated with impaired driving laws and the now well-known relationship between intoxication and accidental injury. However, early prevention specialists did not have the benefit of decades of epidemiological data, driving-simulator, divided attention, and other laboratory test data to define intoxication. Intoxication was based on BACs at which impairment was so obvious that driving was deemed unsafe. Harger and Halpieu (1956) noted that in prior research on the relationship between BACs and behavior, "…*the definition of intoxication was practically synonymous with drunk*" (p. 170), wherein common and easily recognized signs of intoxication were present. Heise (1934) had earlier noted that a BAC of 150 mg/dl was considered prima facie evidence of intoxication, meaning that there is sufficient evidence from the BAC alone to raise a presumption of fact or to establish the fact that a person was too intoxicated to drive. Prima facie evidence shifts the burden of proof to the defense counsel to rebut the charge.

Later Definitions of Intoxication

What eventually followed was the development of state alcohol control codes that, in consultation with lawmakers and the American Medical Association (AMA), led to the approval of the Model Uniform Vehicle Code. This legislation extended the previous regulations that drivers with a BAC of 150 mg/dl were grossly intoxicated and should be presumed to be too intoxicated for the purposes of driving (Langenbucher and Nathan, 1983). Over the ensuing decades, research on alcohol-related roadway crashes highlighted the effects of alcohol at BACs below 150 mg/dl. In other words, data were evolving that showed impairment of driving at BACs below which drivers presented as gross, easily recognizable signs of intoxication (Harger and Halpieu, 1956). Early researchers recognized that impaired driving occurred at lower BACs; however, in order to get legislation passed they were apparently willing to begin with a legal definition of intoxication that was so high, and by which most persons would be obviously drunk that would be acceptable to most skeptics (Borkenstein, 1984). By 1960, the data on drunken driving crashes were so compelling that the AMA recommended that a BAC of 100 mg/dl be accepted as prima facie evidence of intoxication. The recommendation made note that with regard to driving, some individuals are under the influence at BACs of 50-100 mg/dl. This was the first shift from commonly and easily recognized signs of gross intoxication that were believed to reflect impairment in the ability to drive. Langenbucher and Nathan (1983) pointed out that "This standard was subsequently adopted by most states as the statutory equivalent of the subjective terms of intoxicated, visibly intoxicated, and obviously intoxicated" (p. 1071), although they did not provide a reference to any such statute. They also noted the vagueness of state alcohol and vehicle codes which led legislators to objectively define "intoxicated" and "visibly intoxicated" without much distinction. In other words, older terms used to describe drunken driving (e.g., gross intoxication and easily recognized signs of intoxication) were still used even though new DWI laws defined intoxication on the basis of a chemical test.

Recent Definitions of Intoxication

During the first half of the twentieth century, most but not all states defined, for the purposes of motor vehicle operation, a BAC of 100 mg/dl to be evidence of impairment, i.e., too intoxicated to drive safely. At the time, such legislation was consistent with data from the National Highway Transportation Safety Administration (NHTSA). In the late 1970s, NHTSA reported that about 35% of the nearly 14,000 motor vehicle fatalities involved at least 1 driver or nonoccupant (e.g., a pedestrian) who was intoxicated at a BAC of 100 mg/dl or more (US Department of Transportation/National Highway Traffic Safety Administration, 1994). By 1985, the time the next update was completed, it appeared that about 50% of drivers in fatal crashes had a BAC of at least 100 mg/dl. In 2004, the people who died in alcohol-related traffic crashes constituted about 40% of the fatal number of traffic fatalities (Yi et al., 2006). However, unlike the earlier epidemiological studies, more recent studies included drivers with any measurable BAC above zero. In some cases, these drivers would not be considered "drunk" or impaired. Moreover, NHTSA frequently uses a statistical method of intupation in which it is assumed that a fatally

injured driver was intoxicated based upon driver profile (age, gender) and the nature of the crash, even when no BAC data are available (US Department of Transportation/National Highway Traffic Safety Administration, 2002). Although this and similar frequently cited statistics probably overestimate the number of fatalities caused by alcohol intoxication, there is little doubt that alcohol intoxication is a significant factor in fatal crashes.

As would be predicted from a drug with well-known dose-dependent effects, analyses of relative risk have revealed that crash risk increases as driver BAC increases. Of public safety importance is the finding that the relative probability of a fatal crash increases slightly at BACs above about 50 mg/dl and greatly as the driver's BAC approaches 80 mg/dl.

Relative risk research is very important in studying fatal crash probabilities. Epidemiological studies attempt to isolate factors that are the most significant in causing accidents. The 2 primary approaches to this are the "case–control" method in which the incidence of alcohol in crashes is compared with the incidence of alcohol in drivers on the same road, location, and time but who are not involved in motor vehicle crashes. The second method, "induced exposure," contrasts intoxicated drivers deemed responsible for accidents with the incidence of intoxicated drivers who were not responsible for the crash but were innocent victims. The latter method would appear to be a more accurate method for determining risk but is more complicated because it is not always easy to determine which driver caused the crash. Moreover, there may be a potential for bias for determining fault if one driver is intoxicated and the other is sober. This bias is minimized if data are limited to single vehicle crashes.

Relative risk studies have demonstrated that the relationship between BAC and crash risk is much stronger for drivers in single vehicle crashes (Perrine et al., 1989; Zador, 1991). Logistic regression analyses using a range of covariates including age and BAC and gender to estimate relative risk have also been employed (Peck et al., 2008; Zador et al., 2000b).

Although all earlier studies demonstrated that the risk for a fatal crash increased exponentially, more recent studies estimate the risk to be greater than previously believed (Peck et al., 2008). When age, gender, and BAC are considered together, the stepwise logistic regression coefficients of relative risk for younger drivers (16- to 20-year-old males) being involved in a fatal crash at a BAC of 80 mg/dl is about 34 times greater than controls. By comparison, a 40-year-old male at the same BAC has a relative risk 9 times that of controls (Zador et al., 2000a).

Based on several decades of research and utilizing the most current drunken driving data, prevention efforts gained further traction by 1994, when states were encouraged to lower to 80 mg/dl the BAC that defines driving while intoxicated (Model Driving While Under the Influence of Alcohol and Other Drugs Act, 1993). Strongly supporting this new lower BAC were the AMA and Mothers Against Drunk Driving (MADD).

Now, all states have revised their impaired driving laws to follow federal recommendations to define a BAC of 80 mg/dl as a violation of the motor vehicle code. Interstate commercial operators have an even lower definition of intoxicated driving (40 mg/dl), and persons under the age of 21 typically fall under a "zero tolerance" statute in which intoxicated driving for an underage drinker is defined as a BAC of 10 or 20 mg/dl, depending upon the state. These prevention efforts coupled with increased public awareness about drinking and driving may explain the gradual decline in fatal car crashes involving intoxicated drivers (Centers for Disease Control, 2001; Dee, 2001; Hingson et al., 1996a,b, 2000; Perrine, 1988; Shults et al., 2001; Voas et al., 2000).

Prevention Efforts Create a Detection Problem

In the past several decades, research has supported the need for more precise and lower legal definitions of driving while intoxicated, requiring ever-increasingly sophisticated testing to identify such drivers. Harkening back to an older mind-set, when intoxicated driving was synonymous with the common meaning of "being drunk," some drunken driving defenses relied upon the lack of visible signs of impairment, even though the driver had a BAC in excess of the statute definition. Some states have passed legislation establishing case law in preventing such a defense (e.g., *State v. Gheghan*, 1986; 214 New Jersey Super. 383:A-2100-85-4). Moreover, although behavioral signs of intoxication may be important in establishing probable cause in a DWI arrest, states with laws per se do not require any behavioral evidence of intoxication to convict drivers of drunken driving, as long as the driver had a BAC that the legislature has defined as intoxicated driving (e.g., 80 mg/dl). In more recent years, police have used an increasing arsenal of tools to detect and prosecute drunk drivers. Among these are portable breath alcohol tests that can be used at the scene, breath or blood samples collected and analyzed after a suspected drunk driver is apprehended, and Standardized Field Sobriety Tests (SFSTs). An SFST involves a specific battery of 3 tests that are designed to detect impairment in psychomotor and ocular motor control related to low BACs in the 100 mg/dl range (Burns and Moskowitz, 1977; Burns and Anderson, 1995). Without special tests, the identification of alcohol intoxication at BACs producing impaired driving is not a simple matter to determine (Harger and Halpieu, 1956), even for skilled observers such as police (Langenbucher and Nathan, 1983; Brick and Carpenter, 2001; Pagano and Taylor, 1979; Zusman and Huber, 1979; Vingilis et al., 1982). Thus, a significant obstacle to the further prevention of drunken driving exists, if intoxicated drivers are impaired and at an increased risk for fatal crashes but signs are not detectable except through the use of special tests such as those used by police. For example, passengers, friends, social hosts, and others are at a disadvantage in their ability to make informed decisions regarding intoxication and impairment at low BACs, if intoxication is not readily apparent or obvious.

Low Dose Studies on Impaired Driving and Divided Attention Tasks

As research on the effects of alcohol began nearly a century ago, an overwhelming number of studies have shown that alcohol impairs divided attention and other skills related to safe motor vehicle operation. This impairment begins at BACs significantly lower than earlier investigators thought, and impairment is greater in younger drivers than older drivers. One need to only consider the consensus of scientists and physicians 50 years ago (who believed that impaired driving statues that used 150 mg/dl as the criteria for driving while intoxicated were reasonable and fair) to appreciate how beneficial technological and epidemiological research has become to our understanding of driving impairment.

The literature on the effects of low BACs on motor vehicle operation or on divided attention tasks believed to be critical to safe driving is becoming better known (Moskowitz and Fiorentino, 2000; Ogden and Moskowitz, 2004). Briefly, data from numerous studies demonstrate that divided attention deficits occur in the BAC of 20-30 mg/dl (NIAAA, 1990), with a 100% increase in the probability of being involved in an accident at 50 mg/dl (NIAAA 1993; US Department of Transportation/National Highway Traffic Safety Administration, 1988). Twenty years ago, the National Safety Council Committee on Alcohol and Drugs recommended that the presumption that an individual is not impaired when the BAC is below 50 mg/dl be stricken from DWI legislation, as evidence shows that the performance of a substantial number of individuals is impaired at BACs below 50 mg/dl (Voas and Lacey, 1988). More recent studies have concluded that when age and gender are considered in addition to BAC, the relative risk for a fatal single vehicle accident is significantly greater than controls (Zador et al., 2000a) and than previously believed (Table 1). Despite the increased risk for a fatal crash even at very low BACs, 50% of drivers with BACs in excess of 80 mg/dl and almost 90% of drivers with BACs in excess of 50 mg/dl were not detained by police at a drunken driving checkpoint (Wells et al., 1997).

Postintoxication

In the postintoxication phase, when BACs have returned to zero, physical (fatigue, headache, thirst, nausea, and malaise) and psychological (anxiety, depression, irritability, and extreme sensitivity) changes associated with hangover may be present (Badawy, 1986). Postalcohol effects deserve continued exploration, particularly in light of a growing controversy over urine sampling of employees in the United States. Positive drug screens do not equate to impairment, partly because such testing is usually in urine, but even drug-free blood may not be an indication of unimpairment. For example, Yesavage and Lierer (1986) administered enough alcohol to pilots to reach a BAC of about 100 mg/dl. Fourteen hours later BACs returned to zero, the pilots were tested in a flight simulator, and they showed impairment in the ability to fly compared with controls.

Table 1. Relative Risk for a Fatal Motor Vehicle Crash: Effect of Age, Gender, and BAC

| BAC (mg/dl) | Relative risk | | | | Biobehavioral categories |
	Age 16-20 years ♀	Age 16-20 years ♂	Age 21-34 years ♀ and ♂	Age 35+ years ♀ and ♂	
20	1.8	2.4	1.8	1.7	Zero tolerance (<21)
30	2.5	3.7	2.4	2.3	
40	3.3	5.8	3.2	3	DWI commercial operators
50	4.5	9	4.3	3.9	Psychophysical impairment (SFSTs)
60	6	14	6	5	
70	8	22	8	7	
80	11	34	10	9	Per se DWI
90	15	53	14	11	
100	20	82	18	15	
110	27	127	24	20	
120	37	196	33	26	
130	49	305	43	33	
140	67	473	58	44	
150	90	735	78	57	Visible intoxication (>50%)
160	122	1,141	104	75	
170	164	1,772	138	99	
180	221	2,752	185	129	
190	299	4,273	247	169	
200	403	6,634	330	221	Severe sensory motor impairment
400					
500					LD: 50 (Est.)

SFST, Standardized Field Sobriety Tests; BAC, blood alcohol concentrations; LD, lethal dose.

Relative risk (RR) for a fatal single car crash derived from stepwise logistic regression coefficients rounded to nearest tenth or whole number. Note that for women aged 16-20 years, a coefficient of 0.03 (range: 0.044-0.014) was used (Zador et al., 2000a,b). Also included are biobehavioral descriptors. RR continues to increase exponentially after 200 mg/dl (not shown). Adapted from Brick, 2008.

Liability Laws

In addition to impaired driving laws, there are 3 laws that relate to the service of alcohol to the obviously or visibly intoxicated person: Alcohol Beverage Control (ABC) laws/codes, dram shop laws, and third-party actions under traditional tort reform. State Alcohol Beverage Control (ABC) Board laws (or in some jurisdictions, administrative codes) provide municipalities the authority to regulate the commerce of alcohol. The Twenty-first Amendment of U.S. Constitution gave each state the right to determine whether to allow alcoholic beverages and if so, how to regulate them. The ABC (different states have slightly different variations of this name) is responsible for enforcing a wide range of rules and regulations, including determining a licensee's responsibilities towards intoxicated patrons. In New Jersey, for example NJAC 13:2-23.1(b) "…prohibits a licensee from selling, serving, or delivering any alcoholic beverage to a person who is actually or even appears to be drunk or intoxicated. The licensee may not allow such a person to consume any alcoholic beverage on the licensed premises… Such a person should never be served or allowed to continue to drink an alcoholic beverage while in such condition." Under NJSA 9:1:17B-1 it is illegal to purchase or consume alcoholic beverages. ABC violations result in fines or license revocation if an agent or investigator determines a bartender served alcohol to a visibly intoxicated patron. In some states (New Jersey for example), ABC agents do not need to actually see the bartender serve a visibly intoxicated patron, but need only observe a visibly intoxicated patron at a bar or restaurant to issue a citation (*Alcoholic Beverage Control Handbook for Retail Licensees*, 2004),

Another prevention approach is through "dram shop" legislation. Such laws are designed to prevent the service of alcohol to a "visibly intoxicated" person and impose liability on licensed establishments selling alcoholic beverages (dram shops) to anyone who appears intoxicated. Similar legislation also exists for social hosts who serve alcohol in their homes to guests. Under these laws, if a third party is injured as a result of the actions of an intoxicated person, the injured party may recover damages. The medico-legal question in dram shop and social host (see below) liability cases is, "Was someone served while visibly intoxicated?" If the intoxicated person is underage, the issue shifts from visible intoxication to whether or not intoxication was a significant contributing cause of an injurious event.

The issue of visible intoxication is not limited to dram shop cases but is also relevant in cases of comparative negligence. For example, did a passenger knowingly enter a vehicle with an intoxicated driver? Similarly, in criminal negligence cases the question is, "Was an intoxicated person allowed to operate a vehicle?"—such as in a landmark New Jersey case (*State of New Jersey v. Kenneth Powell*, Indictment—01-0400170-I). This case, a driver arrested for drunken driving, was processed at police headquarters, and the driver was picked up by his friend (Powell) who then returned the intoxicated driver to his vehicle. The drunk driver subsequently struck and killed a Navy Ensign on leave. This was the first case of its kind that hinged primarily on whether the arrested driver was visibly intoxicated and obviously too impaired to drive.

One of the challenges to prevention specialists is that there are many factors that contribute to alcohol intoxication. These include pharmacological and nonpharmacological tolerance, genetic, pharmacokinetic, and pharmacodynamic differences in sensitivity to alcohol, physiological or complicating medical conditions, cultural norms as to what is considered as acceptable behavior, and psychological factors including expectancy, environment, and some forms of tolerance (Brick, 1990; Lang and Michalec, 1990). Not every person who is intoxicated and drives has an accident and not all intoxicated drivers, for example, have the same relative risk for crashes. Nevertheless, there is overwhelming evidence that drivers and others with BACs below the current legal definition for driving while intoxicated (80 mg/dl) are impaired, are at increased risk for injury, and a hazard either to themselves, others, or both. Decades of education, public service announcements, and related prevention efforts have focused on increasing public awareness of the hazards of drinking and driving but have done little to educate the public about identifying intoxicated persons.

The BAC at which most persons appear to be visibly intoxicated is less well publicized and in the case of dram shop laws, not well defined. For example, in defining visible intoxication, the New Jersey statute states, "visibly intoxicated means a state of intoxication accompanied by a perceptible act or series of actions which present clear signs of intoxication" (NJSA 2A:15-5-5). In most states the standard is "intoxicated" or "visibly intoxicated" or "obviously intoxicated" (National Alcoholic Beverage Control Association, Inc, 1984). The distinction between visibly intoxicated and obviously intoxicated is not always clear. One distinction is that "visibly intoxicated" persons display observable signs of impairment (e.g., slurred speech, difficulty walking, and decreased inhibitions) whereas a person who is obviously intoxicated may or may not show such signs but because of the amount of alcohol consumed or the BAC, intoxication was or should have been "obvious." For example, in Vermont, New Hampshire, and Rhode Island, it is unlawful to serve an apparently intoxicated person or someone whom it would be reasonable to expect would be under the influence as a result of the amount of alcohol served (Duffy, 2005; US Department of Transportation, National Highway Traffic Safety Administration, 1990). Other states have similar laws (US Department of Transportation, National Highway Traffic Safety Administration, 1990). The interpretation or definition of what constitutes visible intoxication is often left to individual courts and can range from indirect evidence (e.g., number of drinks served or BAC) to direct eyewitness accounts [*Maciszewski v. Flatley*, 705 A.2d 171, 173 (R.I. 1998); *Fandozzi v. Kelly Hotel, Inc.* supra 711 A.2d at 527]. For example, the number of drinks or eyewitness accounts may establish the fact that the server contributed or did not prevent the harm. Some agencies [State of Missouri

Alcohol Responsibility Training, Missouri Department of Transportation's Highway Safety Division, State of Missouri Alcohol Responsibility Training (SMART)] and training programs (Trainer Intervention Procedures—TIPS, Techniques in Alcohol Management—TAM) include rapid or excess drinking as a sign of intoxication, presumably related to decreased inhibitions or impaired judgment. A different standard exists under some social host liability laws. For example in New Jersey and elsewhere, it is unlawful for a host (e.g., a homeowner) to provide alcohol to a person who was "visibly intoxicated" (e.g., NJSA 2:15-5.6). However, in this statute, visible intoxication is in part defined by the BAC. The statute states that when the BAC is less than 100 mg/dl "there shall be an irrebuttable presumption that the person tested was not visibly intoxicated" (NJSA 2A:15-5.6). Thus by current standards of intoxicated driving, lawmakers have concluded that merely being in violation of the impaired driving statute does not mean the driver was visibly intoxicated. The statute also states that at a BAC of at least 100 mg/dl and less than 150 mg/dl, "there shall be a rebuttable presumption that the person tested was not visibly intoxicated in the social host's presence" (NJSA 2A:15-5.6). Such law leads to the logical inference that at BACs above 150 mg/dl, there is a rebuttable presumption of visible intoxication. This is strikingly similar to the early Uniform Vehicle Code. We are unaware of any other state statute of this kind in which the law follows the scientific research.

The concept of visible intoxication is important in the prevention of drunken driving and the enforcement of laws against the serving of alcohol to visibly intoxicated persons also applies to persons who are neither police officers, bartenders nor social hosts. For example, determining if someone is intoxicated is important to a potential passenger in a car operated by someone who has consumed alcohol. The popular phrase is "friends don't let friends drive drunk" but short of abstinence, what can prevention specialists do to assist untrained people to reliably recognize intoxication? Moreover, what signs constitute intoxication, in whom, and at what BACs?

SIGNS AND SYMPTOMS OF INTOXICATION

Definition of Signs and Symptoms

The terms "signs" and "symptoms" are often used together or interchangeably. A sign is any abnormality that is seen during observation or is discoverable on specific examination. In the present context, signs might include observed performance on certain tests, such as a gaze nystagmus test, a memory test, a psychophysical test, or a physiological measure, but may also include visible changes such as slurred speech, decreased inhibitions or grossly impaired cognitive or motor abilities. Technically, a symptom is a subjective indicator that the drinker perceives (e.g., dizziness, nausea) but which may not be visible to others. Sometimes for expediency of language, the distinction between signs and symptoms is lost. For example, slurred speech is described as both a sign and a symptom in some of the studies cited in this review. We will use "signs" in this review for those observed abnormalities associated with alcohol intoxication.

Diagnosis of Intoxication

Clinical diagnoses of intoxication using the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV) involves specific behaviors (American Psychiatric Association, 1994). Some of the signs are detected by casual observation and include 4 criteria: (i) recent ingestion of alcohol; (ii) clinically significant maladaptive behavioral or psychological changes (e.g., inappropriate sexual or aggressive behavior, mood lability, impaired judgment, impaired social or occupational functioning) that developed during or shortly after alcohol ingestion; (iii) one or more of the following signs developing during or shortly after alcohol use: slurred speech, incoordination, unsteady gait, nystagmus, impairment in attention or memory, stupor, or coma; and (iv) not due to a general medical condition or accounted for by a mental disorder. In one known instance, the State Supreme Court of Oregon (*State v. Clark,* 1979) took judicial notice of the following signs or symptoms of alcohol intoxication: odor of alcohol on the breath, flushed appearance, lack of muscular coordination, speech difficulties, disorderly or unusual conduct, mental disturbance, visual disorders, sleepiness, muscular tremors, dizziness, and nausea. Signs and symptoms of intoxication vary due to differences among people but can be reduced to 3 broad categories of behavior: (i) decreased inhibitions (doing or saying things that are inappropriate for the situation); (ii) psychomotor impairment (e.g., slurred speech, slow, clumsy, incoordinated movements, and stumbling); and (iii) cognitive impairment (e.g., difficulty concentrating, remembering, or performing simple math tasks, such as counting change or following directions). Broader, more situation-specific criteria such as the signs of obvious or visible intoxication listed in Table 2 may be more useful to lay persons such as social hosts, prospective passengers, parents, bartenders, etc. The specific signs within each category are derived from various state alcohol prevention publications (State of Missouri Alcohol Responsibility Training, Missouri Department of Transportation's Highway Safety Division, State of Missouri Alcohol Responsibility Training (SMART), 2008; University of Oregon, 2008; Oregon Liquor Control Board), textbook descriptions of intoxication (Brick and Erickson, 1999; Ellenhorn and Barceloux, 1988; Hobbs et al., 1996; Snyder and Andrews, 1996), and the authors' observations and experience observing and testing intoxicated human subjects. There is an overlap between categories, and some behaviors may be present in sober individuals. This list is not inclusive of all behavior.

LITERATURE REVIEW OF EARLY STUDIES OF INTOXICATION

Alcohol is, for the most part, a central nervous system depressant that exhibits dose-dependent behavior. While most

Table 2. Common Categories and Signs of Intoxication

Decreased inhibitions	Psychomotor impairment	Cognitive impairment
1. Doing things that would normally not be done when sober	15. Slurred, mumbled, or incoherent speech	28. Loss of concentration or train of thought
2. Saying things that would normally not be said when sober	16. Slow speech	29. Delayed response to questions
3. Boisterous	17. Swaying while sitting, standing, or walking	30. Illogical comments or answers to questions, nonsequiturs
4. Argumentative	18. Staggering, stumbling, holding onto objects for balance	31. Impaired short- or long-term memory
5. Confrontational	19. Difficulty reaching for and picking up objects (money, food, drinks, etc.)	32. Lighting more than one cigarette at a time
6. Obnoxious	20. Inability to maintain eye contact (lack of focus or wandering gaze)	33. Lighting the wrong end of a cigarette
7. Annoying to others (e.g., strangers)	21. Head on bar or asleep	34. Lighting a cigarette but not smoking it
8. Hanging on to people or otherwise intruding on their personal space	22. Falling off stools, chairs, etc.	35. Excessively quiet, sullen
9. Loud comments about other people in the vicinity	23. Bumping into objects or people while walking	36. Denial of impaired driving ability
10. Animated or exaggerated actions	24. Leaning for support while standing or sitting	37. Consumption of large amounts of alcohol without thinking
11. Rapid drinking	25. Exaggerated hand or arm gestures	38. Trouble counting money or with basic math
12. Acting silly or "cutesy"	26. Spilling food or drinks	39. Difficulty following instructions or directions
13. Complains about the strength of drinks or service	27. Fell down or lost balance	
14. Bravado		

of the effects of alcohol are related to decreased cognitive and psychomotor performance, biphasic effects (i.e., stimulation and depression) have been reported (Pohorecky, 1978). Early studies of the relationship between BAC and behavior often included a thousand or more subjects, a robustness that today is usually limited to epidemiological studies, and rarely involving the analysis of acute intoxication in live subjects. Also, the technology available, 50 or more years ago, to measure alcohol in blood and experimental designs that included subjects with various degrees of experience with alcohol requires careful examination. For example, early studies typically did not report specific screening criteria for subjects. In some studies subjects were described as alcoholics, nondrinkers or "not at all" drinkers. Chronic alcohol abuse or alcoholism and the very high BACs often reported in these studies suggest that many subjects were exceptionally tolerant to at least some of the effects of alcohol. Similarly, subjects in many of the older large-scale studies were being observed by police or physicians after a motor vehicle accident, arrest for drunken driving, or other potentially biasing circumstances. Nevertheless, the results from these large-scale studies are valuable in answering the question of how signs of visible intoxication occur in relation to BAC and what signs are commonly present with relatively casual observation.

Studies by Widmark

E. M. Widmark, a pioneer in alcohol research, was one of the first scientists to systematically examine the relationship between BAC and symptoms (signs) of intoxication. He developed a list of "factors" to enable physicians who were typically called upon by police to diagnose suspected intoxicated drivers. Excluding behaviors that would only be detected with the use of a test (e.g., Romberg balance), Widmark noted that picking up small objects, speech, general appearance, condition of clothing, and mental powers were common and obvious (visible) signs that could be used to determine intoxication. In a study of 1,942 subjects, Widmark (1932) found that 30% of those examined were "influenced" by alcohol when their BAC was 81-100 mg/dl, 40% were "influenced" by alcohol when their BACs were between 101 and 120 mg/dl as determined by the presence of various "factors." Most, but not all, of the observed signs were of the nature that they could be detected without specialized tests and were within the behavioral repertoire likely to be recognized by persons who had or took the opportunity to make such observations. Widmark noted that as BACs increased, so did the percentage of subjects who appeared "influenced by alcohol." It was not until BACs exceeded about 150 mg/dl that the percentage of subjects who appeared intoxicated significantly exceeded chance (i.e., more than 50%). Thus, Widmark found that about 68% of subjects were diagnosed as "influenced by alcohol" when BACs were 141-160 mg/dl (average of 150 mg/dl), and with the 160-180 mg/dl (average 170 mg/dl) BACs, about 79% of the subjects were diagnosed as influenced by alcohol. These percentages must be examined in the context in which they were made. For example, 5 of the 7 factors (odor of alcohol on breath, speech, uncertainty picking up objects, swaying while turning while walking, and uncertainty while walking forward) can be observed by casual

Table 3. Relationship Between Blood Alcohol Concentration (BAC) and Certain Behaviors (From Widmark, 1981)

Sign or symptom present	10-60 mg/dl	61-80 mg/dl	81-100 mg/dl	101-120 mg/dl	121-140 mg/dl	141-160 mg/dl (%)	161-180 mg/dl (%)	181-200 mg/dl	201-220 mg/dl	221-240 mg/dl	241-260 mg/dl
Diagnosis of "influenced"	0	0	30	40	46	68	79	88	93	96	97
Alcohol odor on the breath	0	33	63	81	78	82	84	91	92	93	92
Speech stammering	0	0	0	9	14	30	25	35	48	50	57
Uncertainty picking up small objects	0	0	0	21	33	40	42	45	59	69	50
Swaying while turning when walking	0	0	31	30	24	51	56	62	79	73	77
Movement directly forward uncertain	0	0	6	6	4	15	25	29	36	33	36
Swaying in Romberg's test	0	17	47	50	52	60	67	71	82	83	82
Finger to Finger	0	0	18	15	27	42	32	52	58	68	57

observation, but two of Widmark's factors included tests that required some specialized administration. Also, signs of intoxication do not occur as singular events in most drinkers, meaning that as BACs increased it is likely that both the number and severity of signs also increased. The results of Widmark's classic study are presented in Table 3.

From these data, Widmark found that with the exception of the odor of alcohol on the breath, and swaying during a balance (Romberg) test, no signs of intoxication were observed in any subjects when the BAC was below about 80 mg/dl. Also, reliable signs of visible intoxication do not occur until BACs are much higher. For example, at BACs in the 121-140 mg/dl range, fewer than half were identified as intoxicated, but at 141-160 mg/dl about 68% were identified as intoxicated, using multiple criteria. One would expect that less than 68% of the subjects were identified as intoxicated at BACs closer to 141 mg/dl and more than 68% were identified as intoxicated at BACs closer to 160 mg/dl. Signs such as stammering speech, uncertainty picking up objects, swaying while turning when walking, and uncertain forward movement were present in 30, 40, 51, and 15%, respectively, in subjects with BACs of 141-160 mg/dl. As it is statistically impossible that subjects presented only a single symptom (e.g., stammering speech) but none of the other 3 signs, it is more likely that two or more of these signs were observed in 45-91% of the subjects observed. Thus, for all practical purposes, Widmark's finding was that at BACs of about 150 mg/dl or more, the majority of subjects were diagnosed as "influenced" by alcohol.

Studies by Jetter

Jetter (1938a) examined 1,000 subjects who were patients pre-admitted to hospital with a diagnosis of "alcoholism" and described elsewhere as "chronic alcoholics." He reported the percentages of these patients who appeared visibly intoxicated. He specifically avoided "more delicate tests of incoordination, such as finger-to-nose test, or walk a straight line…because such tests are…of too sensitive a nature" (p. 484). To the contrary, a positive diagnosis of intoxication was made "only upon gross physical departure from normal" (p. 484). Jetter's "clinical criteria essential for the diagnosis of clinical intoxication" required that the subject have a gait

abnormality or be unable to walk. Specifically, if gross swaying, reeling, or staggering were not present, the test was considered negative and an overall diagnosis of intoxication could not be made. By this operational definition, subjects who were diagnosed as intoxicated presented gait abnormalities. Of the subjects in this study, there were only 4 instances where gait abnormality was observed without a diagnosis of gross intoxication.

In addition to the mandatory requirement of gait abnormality, Jetter required that 2 of 4 other signs had to be present to diagnose gross intoxication: speech abnormality, flushed face, dilated pupils, or alcoholic odor on breath. For a diagnosis of speech abnormality, the subject was asked simple questions such as name, where he lived, etc. Only if definite slurred or incoherent speech was present could a diagnosis of intoxication be made. Therefore, the clinical signs of intoxication were those that were visible and that could be easily observed by casual observation. However, flushed face and the odor of alcohol on the breath are more related to the recent ingestion of alcohol than to impairment, per se. Jetter's results revealed that 47% of all subjects in the 150-mg/dl group had trouble walking or standing, and had at least one other criterion (abnormal speech, dilated pupils, flushed face, and odor of an alcoholic beverage). As the effects of alcohol are dose-dependent, one can expect greatest sensitivity to impairment at the highest BACs within and between ranges, and vise versa. In other words, at 125 mg/dl, the likelihood of visible intoxication in alcoholics was proportionally less than 47%, and at 175 mg/dl proportionally higher. At BACs in the 200 mg/dl (175-225 mg/dl) range, the percentage of subjects who appeared grossly intoxicated jumped to about 84%; at BAC >250 mg/dl, 90%; and by 400 mg/dl, 100% of the subjects appeared grossly intoxicated. These data showed that at BACs less than about 125 mg/dl, the overwhelming majority of alcoholics did not appear grossly intoxicated. It is not until BACs exceed about 150-175 mg/dl that most (more than half) of the subjects appear visibly intoxicated, presenting readily observable signs such as abnormal gait (i.e., gross swaying, reeling, or staggering) and at least two of the following signs: slurred speech, dilated pupils, flushed face, or the odor of an alcoholic beverage on the breath. These results are summarized in Table 4.

Table 4. Number and Percentage Occurrence of Acute Clinical Intoxication in Alcoholics at Average Blood Alcohol Concentrations (BACs) (Adapted From Jetter, 1938a)

BAC group	50 mg/dl	100 mg/dl	150 mg/dl	200 mg/dl	250 mg/dl	300 mg/dl	350 mg/dl	400 mg/dl	450 mg/dl	500 mg/dl	Total
BAC range (mg/dl)	5-75	75-125	125-175	175-225	225-275	275-325	325-375	375-425	425-475	500	–
Number Ss	38	87	132	330	176	141	74	15	5	2	1,000
Number intoxicated Ss	4	16	61	276	158	133	71	14	5	2	740
Percentage of Ss diagnosed as intoxicated	10.5	18.4	47	83.6	90	95.1	96	93.3	100	100	75.0

Ss = subjects.

In a subsequent study, Jetter (1938b) applied the same criteria for a diagnosis of intoxication (impaired gait and at least 2 of the 4 other signs described above) to a different population of drinkers: nonalcoholics. The subjects in this study were described as "occasional drinkers" or "nondrinkers." Aside from acute tolerance, which develops during a single episode in some drinkers, occasional drinkers or nondrinkers would have no residual tolerance to the effects of alcohol. As expected, acute signs of intoxication occurred at lower BACs than in the alcoholics mentioned above. Although there were fewer subjects in Jetter's second study, it is valuable because today, ethical and federal guidelines for the protection of human subjects would preclude the administration of such large doses of alcohol to relatively naïve or nondrinkers (Lawson et al., 1980). These results are summarized in Table 5, where more subjects in the 100, 150, and 200 mg/dl groups were rated as intoxicated in comparison to alcoholics, especially at the lower alcohol concentrations.

The results of Jetter's studies clearly demonstrate a tolerance to the effects of alcohol with regard to signs of visible intoxication, and the difficulty in identifying intoxicated persons except at high BACs. Jetter is one of a small number of investigators who examined the effects of acute intoxication in subjects with varying degrees of drinking experience, later followed by Goldberg (1943), one of the first researchers to systematically examine the effect of tolerance to alcohol on psychophysical tasks.

Jetter's research demonstrates that experience with alcohol affects signs of visible intoxication. Among occasional or nondrinkers (who would presumably have little or no tolerance to alcohol), about 50% showed signs of visible intoxication when BACs averaged 100 mg/dl (75-125 mg/dl range). A significant portion (57%) of nontolerant drinkers showed visible intoxication when BACs averaged 150 mg/dl (125-175 mg/dl) and all (100%) were visibly intoxicated when BACs averaged 200 mg/dl (175-225 mg/dl). Among alcoholics (who presumably had more tolerance to alcohol), signs of visible intoxication were present 47% of the time when BACs averaged 150 mg/dl (125-175 mg/dl) and 84% of the time when BACs averaged 200 mg/dl.

As Jetter reported his data in ranges of BACs, it appears that among both naive and chronic drinkers, most of the time (more than 50%) at BACs above about 150 mg/dl, it was probable that visible intoxication was present, and the percentage of visibly intoxicated subjects increased dramatically at higher BACs. This conclusion is consistent with that of Heise (1956) who concluded that even in persons with "high tolerance to alcohol" there can be no doubt as to obvious intoxication at BACs above 150 mg/dl. He further noted that practically all people are "drunk" at BACs of about 200 mg/dl. Heise (1956) concludes: "Fifteen hundredths per cent or over is considered prima facie evidence of intoxication," noting that this high level (150 mg/dl) is "…set so high that no injustice will be done even to the most intelligent person who can hide the obvious effects of alcohol temporarily, or the person who has a high tolerance to alcohol" (p. 41). These findings strongly influenced the recommendations of the AMA Committee on Medicolegal Problems who concluded that at 150 mg/dl "every individual with this concentration would have lost to a measurable extent some of that clearness of intellect and control of himself that he would normally possess" (Turner et al., 1958).

Studies by Harger and Halpieu

The results of the studies by Widmark, Jetter, and Heise are consistent with the opinions of other authors of the time. In an exhaustive review of the literature, Harger and Halpieu (1956) noted that in prior research of the relationship between BACs, "…the definition of intoxication was practically synonymous with drunk" (p. 170). The criteria for being "drunk" included signs of intoxication such as weaving gait and other signs of muscular incoordination, slurred speech, and marked loss of self-control. Referring to Widmark and other studies of intoxication, Harger and Halpieu noted that "while some of these authors have used the term 'under the influence' to describe diagnosed intoxication, an examination of the

Table 5. Number and Percentage Occurrence of Acute Clinical Intoxication in Occasional or Nondrinkers at Average Blood Alcohol Concentrations (BACs) (Adapted From Jetter, 1938b)

BAC group	100 mg/dl	150 mg/dl	200 mg/dl	Total
BAC (mg/dl)	75-125	125-175	175-225	–
Number Ss	8	7	5	20
Number intoxicated Ss	4	4	5	18
Percentage of Ss diagnosed as intoxicated	50	57	100	–

Ss = subjects.

criteria for such diagnosis will show that they mean what we popularly call drunk" (p. 170). Harger and Halpieu (1956) (p. 182) also pointed out that the term "under the influence of intoxicating liquor" is widely used and accepted in the courts of many states and "…covers not only all the well-known and easily recognized conditions and degrees of intoxication, but any abnormal mental or physical condition which is the result of indulging in any degree in intoxicating liquors…" (Heise, 1956, p. 39).

The diagnoses of intoxication applied in the studies reviewed by Harger and Halpieu often included a test of some sort. Therefore, some of the data summarized may underestimate the BAC at which "frank intoxication" or unmistakable signs of intoxication occur. Their conclusions with regard to driving are, by today's standards, more a reflection of how people appear physically and not the degree of impairment in the performance of driving related tasks. In a summary of their work, Harger and Halpieu (1956) reached 3 conclusions: (i) very few people are drunk with a BAC below 50 mg/dl; (ii) many people are drunk in the 50-150 mg range; and (iii) the BAC over which practically all people are drunk is around 200 mg/dl (p. 171).

Studies by Pentilla

In one of the largest single studies to date, Pentilla and colleagues (1971) examined nearly 7,000 cases of suspected drunk drivers who were examined by physicians specially trained in forensic alcohol intoxication identification. Although this study did not provide results relating specific BACs to casual behavior, it demonstrates the large number of drinking drivers who developed exceptional tolerance to some of the effects of alcohol. In this study, correlations between BAC (ranging from 0 to 360 mg/dl) and the physician's clinical evaluation ranged from ~0.38-0.67. Statistically, this means that the best physician was successful in identifying alcohol intoxication 44% of the time. As in previous reports (e.g., Jetter, 1938a,b; Widmark, 1932). Pentilla and colleagues (1971) found the highest correlation between BAC and gait, which was accurate about 51% of the time. Using all of the measures of intoxication, which included psychophysical tests, the best physician was successful in identifying intoxicated drivers only 47% of the time. However, the clinical assessment of each case was performed within 2 hours of admission in about 65% of the cases and within 2-5 hours of admission in 12% of the cases. Thus, it is likely that some drivers were tested well into the elimination phase of alcohol intoxication and the results were affected to some degree by acute tolerance. Given the very high BACs in some subjects, some chronic heavy drinkers with exceptional tolerance were probably included in this study. Even so, of the 1,842 subjects with BACs of more than 200 mg/dl, 89% received a score of drunkenness using specific testing criteria. These results are generally consistent with earlier studies demonstrating that by 200 mg/dl intoxication is so high that almost all drinkers are visibly intoxicated.

Studies by Zusman and Huber

As with studies reviewed above, the accuracy of raters improved with higher BACs. Zusman and Huber (1979) used skilled interviewers to identify drunk drivers and found that when BACs were 50-90 mg/dl, even interviewers with special training were only able to correctly identify drinkers 31% of the time. About 70% of drinkers not identified as intoxicated would be intoxicated by law for the purpose of operating a commercial vehicle (40 mg/dl) or other motorized vehicles when the driver is of legal age (80 mg/dl).

Conclusions From the Above Studies

Overall, the results from the above studies lead to 4 conclusions:

1. Among nondrinkers, or drinkers with little or no tolerance, signs of visible intoxication are not reliably observed at BACs that currently define intoxicated driving (80 mg/dl). Visible signs are present in most subjects (i.e., > 50%) at BACs of about 150 mg/dl or higher.
2. Among chronic drinkers or alcoholics with tolerance, at BACs of less than the 150 mg/dl range, most (i.e., > 50%) will not appear visibly intoxicated.
3. At BACs of about 200 mg/dl (175-225 mg/dl), the overwhelming majority (more than 84%) of all drinkers, including chronic alcoholics, will be visibly intoxicated.
4. Visible intoxication is affected by tolerance. Some drinkers have exceptional tolerance (see below) to alcohol that masks visible signs of intoxication, even at BACs that would produce unconsciousness or death in some drinkers.

RECENT STUDIES ON SIGNS OF INTOXICATION

Tolerance

One factor that clearly complicates the identification of alcohol intoxication, particularly in some experienced drinkers, is tolerance. Tolerance is a decrease in the response that occurs as a function of exposure to that drug. This is an important concept in identifying alcohol intoxication. Common misperceptions are: (i) that all alcoholics are tolerant to all the effects of alcohol and (ii) that a diagnosis of tolerance confers immunity from the impairment produced by alcohol intoxication. Tolerance does not develop uniformly across all behaviors or at the same time. Some forms of tolerance develop in social drinkers during a single episode, whereas chronic drinking is often necessary to induce metabolic tolerance, functional (brain) tolerance, or conditioned tolerance (Pohorecky and Brick, 1990). With regard to signs of visible intoxication, the four most relevant forms of tolerance are:

1. *Acute tolerance* develops within a single drinking session and describes a decreased response on the descending limb of the BAC curve than is observed at the same BAC but during the ascending limb of the curve (Beirness and

Vogel-Sprott, 1984; Bennett et al., 1993; Mellanby, 1919). As faster rates of absorption may cause greater intoxication and impairment, differences in intoxication before and after peak concentration may further affect behavior (Conners and Maisto, 1979; Goldberg, 1943);

2. *Functional tolerance* is present when drinkers display few or markedly reduced signs of intoxication even at high BACs (Goldberg, 1943; Lindblad and Olsson, 1976) and may be caused by adaptation to alcohol at the brain cell level (brain tolerance);

3. *Environment-dependent tolerance or Pavlovian tolerance*, in which environmental cues act as conditioned stimuli and affect the response to alcohol (Brick, 1990; Dafters and Anderson, 1982; Mansfield and Cunningham, 1980; McCusker and Brown, 1990);

4. *Metabolic tolerance* associated with specific liver enzymes that are induced as a result of chronic drinking. Enzyme activation increases alcohol degradation and reduces the time during which alcohol is active in the body, thereby reducing the duration of alcohol's intoxicating effects (*liver tolerance*; Brick, 1990; Misra et al., 1971).

Most regular consumers of alcohol have acquired some tolerance to some of the effects of alcohol, so that a tolerant drinker would require more alcohol than a nontolerant drinker in order to obtain the same effect. Tolerance may develop at different rates for different drinkers (Pohorecky et al., 1986; Tabakoff and Kiianmaa, 1982; Vogel-Sprott, 1979) and may be influenced in part by the rate of absorption. Chronic heavy drinkers may become exceptionally tolerant to the intoxicating effects of alcohol (see below). In such drinkers an amount of alcohol that would cause overt intoxication, or even death, in the overwhelming majority of social drinkers, may have little or no such effect. Such drinkers clearly demonstrate exceptional tolerance (see below) to the effects of alcohol so that any standards regarding visible intoxication that might be applied to nondrinkers, social drinkers, or even some alcoholics may not apply to a subset of the chronic drinking population. The size of this subset varies from study to study.

Exceptionally Tolerant Drinkers

Jetter's (1938a) study of alcoholics, discussed above, demonstrated that tolerance could be profound. Three of Jetter's 1,000 subjects were not diagnosed as intoxicated, even though they had BACs in the 350 mg/dl range. Rosen and Lee (1976) compared alcoholics, heavy drinkers, and social drinkers on tasks before and after drinking. Social drinkers showed various signs of gross intoxication (defined as nausea, slurred speech, and poor coordination) at BACs of 100 mg/dl, whereas heavy drinkers and alcoholics showed no such signs. More recent studies have identified numerous individuals capable of drinking to BACs that are often lethal in the overwhelming majority of drinkers. For example, Johnson and colleagues (1982) reported that a patient with a BAC of about 1,200 mg/dl was agitated and "slightly confused." Hammond

and colleagues (1973) reported a woman who was comatose upon arrival at the hospital, but 3 hours later was able to provide a medical history even though her BAC was 520 mg/dl. Similarly, Jones (1999) reported a BAC of 0.545% (545 mg/dl, the highest reported reading in Sweden at the time) in a driver arrested for drunken driving. However, no behavioral signs or symptoms were noted, other than that the subject, a woman, survived.

Lindblad and Olsson (1976) reported that about 8 patients per month (out of 2,500) were admitted to a casualty ward with a BAC of more than 507 mg/dl. They found 14 male (age, 23-63 years) and 2 female (age: 22 and 25 years) patients who were highly intoxicated. Eight of the 16 patients were asleep but could be aroused, answer questions, and sit up in bed and drink fluids. These patients had serum alcohol concentrations of 530 mg/dl, or more. The remaining patients were even less responsive but all survived, even though BACs ranged from 599 to 783 mg/dl. (Note: serum alcohol concentrations are about 10-20% higher than equivalent BACs.)

Minion and colleagues (1989) examined 204 emergency room patients with BACs ranging from 400 to 719 mg/dl (mean = 467 mg/dl). At BACs that would probably render most drinkers unconscious, and probably many subjects dead, a staggering 80% of this patient population were conscious enough to be questioned and found to be oriented to person, place, and time. Only 12% were disoriented or unresponsive to noxious stimuli. This study questions the validity of labeling 400-500 mg/dl as the lethal range for all patients because many drinkers are apparently so exceptionally tolerant that they survive significantly higher doses. In some cases, patients in this population were without clinical signs of intoxication. These findings are similar to those of Redmond (1983), who examined subjects who had been arrested for drunken driving or drunk and disorderly behavior and were admitted to detox in a hospital. BACs were measured and observations made regarding consciousness, responding to verbal command, and ability to give an adequate history. Redmond (1983) concluded, "it is apparent that a BAC of 500 mg/dl is not invariably fatal and may exist without serious impairment of conscious level" (p. 89).

Perper and colleagues (1986) found exceptional tolerance in a group of alcoholics who entered a detoxification center with BACs that would produce coma or death in less experienced drinkers. "Clinical experience contradicts the generally accepted dogma that 'regardless of the degree of tolerance, BACs above 400 mg per 100 ml produce stupor and/or coma…'" (p. 213). Remarkably, at BACs of more than 200 mg/dl, about 24% of the sample showed no sign of clinical intoxication, leading Perper and colleagues (1986) to conclude that caution must be exercised in the interpretation of a high BAC as an indicator of incapacitation or as an exclusive cause of death.

The data also point out the importance of understanding the definition of intoxication within any particular study. For example, although the authors note that many of the patients

showed no signs of clinical intoxication, the results also show that speech was impaired in 43% of the alcoholic subjects, gait was impaired in 59% of the subjects, verbal comprehension was impaired in 24% of the subjects, and 50% of the subjects were unable to undress themselves. Even among a population of alcoholics with apparently exceptional tolerance, impairment in speech, gait, fine and gross motor coordination was often seen during casual observation.

The above studies challenge clinical dogma that BACs in the 400-500 mg/dl range would be invariably fatal in all patients. Rather, BACs in this range are lethal for some part of the population (e.g., lethal dose: 50 rather than lethal dose: 100). Although the exact lethal dose of alcohol for a specific population is not known, there are individuals with such exceptional tolerance that they can function to varying degrees with BACs that are sometimes 7 or 8 times the current legal definition for driving while intoxicated in the United States. Such patients are nevertheless impaired with respect to safely operating a motor vehicle.

Observer Reliability Studies

Langenbucher and Nathan (1983) were among the first to observe that following the development of the Model Uniform Vehicle Code, legislators followed the recommendation by the AMA that a BAC of 100 mg/dl be accepted as prima facie evidence of intoxication. The legal standard (100 mg/dl at the time) to define intoxicated driving was subsequently adopted by most states as the statutory equivalent of the subjective terms intoxicated, visibly intoxicated, and obviously intoxicated. In 3 different experiments, these investigators examined the ability of different groups of observers to make accurate judgment calls regarding intoxication in subjects (targets) with different BACs. Observers consisted of social drinkers, bartenders, or police officers.

First Experiment. In the first study observers were 49 social drinkers (age, 18-25 years), half of whom were women and who were mostly moderate drinkers (Oates and McCoy Drinking Inventory scores ranged from 8 to 30 with an average of 18). The male and female target (drinking) subjects (age, 21-29 years) were also diagnosed as moderate social drinkers (Oates and McCoy, 1973). Targets consumed enough alcohol to reach one of 3 BACs: zero (controls), 50 or 100 mg/dl. Each target was rated by 4 groups of observers for a total of 16 group categorical ratings at various BACs. Observers rated each target as sober, moderately intoxicated, or very intoxicated (meaning intoxicated in violation of the impaired driving statute). In the first study, targets were asked to walk into the room, sit down, and answer interview questions designed to elicit a range of verbal behavior. At the end of the interview, the target stood up and walked out. The observers correctly rated intoxication in the target drinkers about 25% of the time. None of the targets with BACs of 100 mg/dl or more were identified as intoxicated by law (100 mg/dl at the time of the study). BAC estimates of most

moderately intoxicated and all four very intoxicated targets were grossly inaccurate. Underestimates of the BAC of both moderately and very intoxicated targets were most frequent. The authors concluded that contrary to some public opinion and 1 court ruling (*NJ Division of Alcohol Beverage Control v. Zane*, 1961), the determination of whether a person is sober or intoxicated is not a matter of common observation, at least not at low BACs.

Second Experiment. In Langenbucher and Nathan's second experiment, the observers rated target subjects as they entered the lounge area of a large hotel complex (off-business hours). Observers were 12 full or part-time bartenders (age, 21-39 years) with 1-15 years of bartending experience. Targets were 2 men (19 and 28 years old) and 2 women (both 24 years old) who were moderate drinkers (Oates scores ranging from 13 to 24), resulting in twelve categorical ratings. In this study, targets were asked to descend a short flight of steps, cross the room, and sit on a barstool. Interviews lasted 2-3 minutes, then the targets walked out of the lounge area. Bartenders correctly rated a target in only one of 4 instances (this target was sober). The second sober target was rated as moderately intoxicated; the third target, who had a BAC of 45 mg/dl, was rated as sober by 8 bartenders. The fourth target (BAC of 110 mg/dl) was rated as moderately intoxicated, as "drunk" by equal numbers of bartenders, and as "sober" by 2 bartenders. All bartenders agreed that they would continue to serve alcohol to the (sober) targets. One bartender said she would refuse service to the third target (BAC = 45 mg/dl) and 9 of the 12 bartenders indicated that they would continue to sell drinks to the most intoxicated target (BAC = 110 mg/dl).

Third Experiment. In the third experiment, the observers were 30 New Jersey law enforcement personnel (police) aged 23-50 years with 1-29 years of full time employment as a police officer with varying experience in DWI arrests. Police were recruited to observe and rate intoxication of target subjects (same subjects as in the previous experiment) in a nighttime simulated roadside arrest (target's vehicle, marked police cruiser, headlights, rotating overhead lights, spotlights, radio transmissions, etc.). Police raters had 3 minutes to test the sobriety of the target in any way they chose. Typically, the police would ask the target to exit the vehicle and perform psychophysical tests, but the target had to return to his/her vehicle at the end of the 3-minute evaluation period. As in the previous experiments, the 2 legally intoxicated and 1 moderately intoxicated target subjects were consistently underestimated with regard to the BAC. This similarity is striking considering that the police had an opportunity to observe the targets perform various sobriety tests. Only 5 police officers were very accurate in their ratings and 4 of those 5 officers were members of a special tactical unit for the apprehension of drunk drivers. The fifth officer was a municipal officer with 50 alcohol related arrests during his 7 years on the force.

Conclusions From the Three Experiments. This series of studies found that overall, social drinkers, bartenders, and most police officers correctly judged the target's level of intoxication only 25% of the time. Raters consistently underestimated BACs and at no time was a legally intoxicated target identified by a significant proportion of the observers. As such, the studies concluded that the then legal definition of intoxication (100 mg/dl) was not an appropriate standard for visible intoxication under dram shop laws.

Other Experiments. Compton (1986) tested the ability of police officers to determine whether subjects had a BAC of 100 mg/dl or more. In this study, police were given different methods to make their determination, including: (i) driving behavior; (ii) driver appearance; (iii) horizontal gaze nystagmus; (iv) divided attention; (v) passive alcohol sensor device; and (vi) stopping distance. Of these, driver observation is the most relevant to the question of visible intoxication, and included characteristics such as the odor of alcoholic beverages, flushed appearance of the face, slurred speech, demeanor, and manual dexterity. Using an experimental DWI checkpoint, police used a "typical procedure" that included only quick observations and a brief conversation before they rated the subject's state of impairment. The information obtained during the brief observation and conversation led police raters to believe that 47% of the subjects were impaired even though they were sober (0 mg/dl BAC). However, at higher BACs (100-150 mg/dl), 87% of the drinking subjects were deemed impaired. Although there was obviously a strong tendency for police to believe that almost half the subjects were driving- impaired when they were not intoxicated, the results also indicate that at higher BACs (nearer to 150 mg/dl) most subjects appeared to be intoxicated when police were able to use screening procedures and make observations of driving. Although law enforcement has many tools available in the apprehension of drunk drivers (compared with bartenders, social hosts, and passengers, etc.), and potentially different motivations, the results of Compton's study are useful for showing that proper screening procedures enhance the accuracy of observing drivers and their level of impairment.

Wells and colleagues (1997) based their study on previous research that concluded it is difficult for police to determine whether drivers are impaired at checkpoints. The survey team conducted interviews or obtained information from police on drivers at 156 sobriety checkpoints. Based on brief screenings, 111 drivers were detained by police because of suspected DWI whereas 182 drivers were not suspected and allowed to pass through the checkpoint. Of the 111 drivers detained for SFSTs, 66 had BACs that exceeded 80 mg/dl (64 of whom were arrested) and 19 had BACs between 50 and 70 mg/dl. The remaining 26 had BACs below 50 mg/dl. The 182 drivers not detained were informed they were selected for a survey that was then conducted by the research team. Of these, 90 surveyed drivers had BACs at or above 80 mg/dl and 92 drivers had BACs between 50 and 79 mg/dl. These impaired drivers were "missed" by police. Wells et al. found that brief contacts with drivers make it difficult to identify drinking drivers and a large percentage of false positives can be noted. Women were missed more often than men (74% vs. 60%) and younger drivers (18-35) were missed more often than older drivers (36 +).

Teplin and Lutz (1985) developed an Alcohol Symptom Checklist (ASC) that consisted of 28 items obtained from randomly selected emergency room patients. They narrowed the list down to 11 signs, most of which could be easily observed by casual observation. They concluded that the most reliably detected signs of alcohol intoxication included impairment of fine motor control (e.g., fumbling with cigarettes, retrieving ID from a wallet or purse), impaired gross motor control (stumbling, accidentally brushing against objects, difficulty maintaining an upright posture, walking straight or balancing), slurred speech (difficulty enunciating words distinctly), change in speech volume (deviation from normal conversational volume appropriate to the situation), decreased alertness (increased response time to social or other environmental stimuli including conversation), excessive perspiration (not due to temperature or nervousness), slow or shallow respiration, sleepiness, changes in rate of speaking (consistently slow, fast, or alternating), and bloodshot eyes. These investigators found that the presence of three to four of the signs noted above were necessary to make an identification of intoxication, when BACs were greater than 50 mg/dl; however, four to five of the above cited signs were necessary to make an identification when the BACs were greater than 100 mg/dl. Unfortunately, the maximum BACs at which these signs occurred were not reported. The sensitivity of the ASC may also be due to the fact that raters had a significantly long period of time to make observations of the subjects while they were in the hospital. Therefore, these results may not be applicable to the observations within the purview of a bartender, social host, or passenger during a casual conversation. Also, the large number of cues that raters had to choose from may have increased the sensitivity of the instrument as well as the awareness of the raters. Longer periods of observation and a list of cues have potential prevention implications. As in most studies, some inference could have been drawn from raters because the subjects were being treated in a hospital. Nevertheless, the study suggests that those who might need this skill could be trained to identify signs of intoxication.

Maguire (1986) examined roadside survey data from the California Highway Patrol and analyzed it to determine to what extent BACs can be judged by observation. The sample of 934 cases included a 30-second interview by a patrol officer who was charged with determining whether the driver was sober, possibly under the influence, or definitely under the influence (BAC of > 100 mg/dl). The interviewers correctly identified only about 21% of drivers with BACs over 100 mg/dl and failed to identify about 79% who were by law, intoxicated. Unfortunately, BACs above 100 mg/dl were not separated into further groups. McGuire concluded that while sobriety checkpoints are effective in detecting 20% of drunk drivers, applying the same standard to restaurant proprietors

and/or hosts of private parties "seems unfair." Applying these findings to today's legal definition of intoxication (80 mg/dl) would no doubt reveal an even smaller percentage of drivers who were both intoxicated based upon their BAC and identified as intoxicated by casual observation during an interview.

Sullivan and colleagues (1987) attempted to use the ASC developed by Teplin and Lutz, 1985 (described above) to assist in bartenders' identification of intoxication. The eleven symptom checklist included: odor of alcohol on breath detected during face-to-face discussions; impaired fine motor control (digit dexterity); gross motor control such as difficulty walking, sitting, standing, walking a straight line, or performing a finger-nose test; slurred speech; changes in speech volume; decreased alertness; excessive perspiration discernable; slow or shallow respiration; sleepiness or drowsiness out of the ordinary for the time of day; changes in speed of speech; and bloodshot eyes. Sullivan and colleagues found significantly lower ASC scores (i.e., 2.6) than Teplin and Lutz (46) for alcohol concentrations of 100 mg/dl or more. In other words, Sullivan needed fewer signs of intoxication than were reported by Teplin and Lutz for subjects at the same BAC. Compared to other studies, the increased detection sensitivity is probably due to the inclusion of signs such as bloodshot eyes and psychophysical testing, including walking a straight line and finger-to-nose tests.

Carroll and colleagues (1988) examined the ability of mental health therapists with no alcohol experience, and more experienced alcoholism counselors, to recognize intoxication or estimate BACs in community mental health volunteers. Observers viewed videos of an intoxicated drinker engaged in simulated counseling interviews, which included conversations about school, relationships, employment, and opinions about faculty. Observers completed an observation rating form that categorized the target as sober (BACs = 0), moderately intoxicated (50 mg/dl), intoxicated (100 mg/dl), or very intoxicated (150 mg/dl). For the most part, experience working with alcohol-impaired clients did not enhance the counselor's ability to recognize intoxication, compared to mental health therapists. Almost all subjects recognized that the target was at least moderately intoxicated when BACs reached 150 mg/dl, but experience working with alcohol-impaired patients did not improve rater accuracy. In fact, Carrol and colleagues found "the ability of alcohol and mental health counselors to judge intoxication in a clinical interview to be no better than that of the previously investigated social drinkers, bartenders, police officers, and roadside interviewers" employed in other studies (p. 245).

Brick and colleagues (1992) examined the identification of intoxication from a different perspective. Instead of asking raters to make categorical ratings of BACs, these investigators asked raters whether target subjects had been drinking, whether it would be okay to serve them additional drinks, and whether they were okay to drive. Drinking subjects were college-aged men and women (ages 22-35 years), screened to ensure that all subjects were within the normal weight range for their age and height and had no medical or psychological history, including alcoholism that would preclude their participation in the study. Neurological status, blood pressure, respiration, and temperature were all within normal limits. Females were tested to ensure they were not pregnant. All subjects regularly consumed alcohol, could drink 2-3 drinks per hour without illness or discomfort, and had on at least 1 recent occasion consumed enough alcohol to produce a BAC of 150 mg/dl without illness. Based upon the Oates Drinking Inventory and Michigan Alcoholism Screening Test and structured interviews, only moderate drinkers without evidence of prior drinking problems or other risks were accepted into the study. Subjects were dosed to BACs 80-90, 110-130, or 150-160 mg/dl and asked to consume about 3 drinks per hour. Blood alcohol estimates were obtained using a Breathalyzer. Subjects were tested at 2 different BACs so that there were 4 target subjects in each of the 3 BAC ranges and twelve categorical ratings. Testing was performed in an experimental living room set up in a professional television studio. Based on pre-intervention questioning, subjects engaged in a series of recorded 30-60 second social interactions with an interviewer. Sober raters then viewed the video and were asked to determine whether the target subjects: (i) had been drinking? (no implication of intoxication, but only if the subject had been consuming alcohol); (ii) were okay to serve another drink? (if the rater was serving alcohol to the target at a party or as a bartender, would they continue to serve the target); (iii) were okay to drive? (that is, was the target able to safely operate a motor vehicle)? Brick and colleagues found that target subjects with BACs of 150 mg/dl or more were correctly identified as drinking about 53% of the time and the subject with the highest BAC (160 mg/dl) was correctly identified as having been drinking by 88% of the raters. The identification of intoxication was also not reliably obtained until BACs were quite high (150-160 mg/dl). Continued service of alcohol to the targets was considered acceptable by 47% of the raters, and 41% of the raters judged the intoxicated drinkers to be unable to drive. However, the most intoxicated target (160 mg/dl) was deemed not able to drive by 100% of the raters. At the highest BAC, 82% of the raters believed subjects were too intoxicated to drive or were not sure if they could drive safely. Only 18% of the raters thought these subjects were "okay to drive." Although specific signs used to decide who was too intoxicated to drive were not part of the study, the fact that BACs of 150 mg/dl or more were needed before a substantial percentage of raters determined that it was not "okay" to drive is revealing.

The results of this study (Brick et al., 1992) are probably conservative because raters were deprived of one very important cue: the odor of alcohol on the breath. Although this cue is not a sign of impairment, it does convey knowledge that the subject had been drinking. From other studies, the detection of the odor of an alcohol beverage is an important cue in determining intoxication. More than twice as many raters in these studies thought it was not okay to drive, for subjects in the 150-160 mg/dl. If raters had more information (e.g., observed the targets drink alcohol or detected the odor of

alcohol on the breath) the identification of intoxication and driving ability decisions would have been more likely.

In a follow up study, Brick and Carpenter (2001) examined the ability of police to determine intoxication by casual observation. As in an earlier study, raters (primarily police lieutenants, captains, and chiefs) were asked to determine whether a target subject had been drinking, whether or not it was "okay" to serve the target another drink, and whether the target drinkers were "okay" to drive. In this study, a measure of raters' confidence in the accuracy of their decision was also obtained. Brick and Carpenter found that raters were "pretty sure" that targets in the 150-160 mg/dl range had been drinking but not sure whether or not serving another drink or driving a car was okay. When BACs were in the 150-160 mg/dl range, 67% of the police raters did not think it was okay for subjects to drive a car, or were unsure if it was okay for them to drive. At a BAC of 160 mg/dl, 90% of the raters identified drinking and 83% of the raters responded that it was not okay to drive. At lower and intermediate BACs drinking was not readily detected, the service of additional alcohol was considered "okay," and targets were deemed able to drive a car. Again, observers were denied any information to suggest or confirm that the target subjects had been drinking alcohol (e.g., no observed drinking and no odor cues).

Brick and Carpenter (2001) concluded that if two thirds of the raters thought that the targets with BACs of 150-160 mg/dl were too intoxicated to drive or did not know if they were okay to drive, then common sense would indicate that they should not drive and that server intervention was appropriate. One important factor in interpreting these studies is that the drinking targets remained seated for short 30- to 60-second video interviews and the raters were deprived of observations of moving and standing. Therefore, it is reasonable to assume that if raters had more information, such as knowledge that the targets were drinking alcohol, their observations and conclusions regarding the targets' abilities to drive would be more accurate (Table 6).

CONCLUSIONS FROM THE ABOVE STUDIES

Most, if not all, of the studies suggest that BACs that would impair driving and be in violation of the drinking driving statute (80-100 mg/dl, depending on the state and year of the study), do not produce reliable signs of visible intoxication in most subjects (Brick and Carpenter, 2001; Brick et al., 1992; Carroll et al., 1988; Compton, 1986; Harger and Halpieu, 1956; Jetter, 1938a,b; Langenbucher and Nathan,

1983; Maguire, 1986; Pagano and Taylor, 1979; Wells et al., 1997; Widmark, 1932; Zusman and Huber, 1979). Visible intoxication was only reliably detected when BACs were very high, typically above 150 mg/dl (Brick and Carpenter, 2001; Brick et al., 1992; Carroll et al., 1988; Jetter, 1938a,b; Widmark, 1932). At the present time, all states use 80 mg/dl to define intoxicated driving.

Not all studies paint such a bleak picture for prevention specialists. Research by McKnight and colleagues (1997) suggests that with the use of "instructional guidance," the identification of alcohol intoxication is possible at lower BACs. (These results are interesting but the criteria for classifying intoxication were described as arbitrary and may be overly sensitive). In this study, McKnight and colleagues asked observers to rate small groups of intoxicated subjects in a social setting. Half of the observers were given instructional guidance on the relationship between signs of impairment and BAC. Drinkers were classified based on the BAC (<40, >40, and >80 mg/dl) and group size (small social group, large social group, and public drinking establishment). BACs ranged from less than 40 mg/dl to 120 mg/dl and there were about 25-35 drinking subjects in each group. Observers were somewhat successful in identifying subjects with BACs over 40 mg/dl as somewhat "impaired" (arbitrarily defined as some loss of ability; not illegal to be served or perform activities that involve potential risk) and less successful in identifying subjects with BACs of more than 80 mg/dl (arbitrarily defined as great loss of ability and risk of injury; illegal to be served alcohol or to perform activities that involve potential risk). About half to two thirds of drinkers with BACs of about 80-120 mg/dl were not identified as intoxicated and there was significant overlap among groups. Guided instruction did increase the accuracy of identifying subjects at the lowest BAC, but not for those over 80 mg/dl.

Odor of Alcoholic Beverages on the Breath

Although pure ethanol is virtually odorless, beverage alcohol once consumed and absorbed into the circulation is detectable by breath alcohol testing and by casual olfactory detection. Most likely what is detected during casual detection is a combination of olfactorants that correlate with the alcohol in blood. The threshold for alcohol detection can be estimated based upon the minimum olfactory threshold for ethanol (alcohol), which is ~84 ppm or 158.27 mg/m^3 (ambient air). This is equivalent to ~158.27 μg/l. Based upon a blood:breath alcohol partition coefficient of ~2448:1, the minimum BAC would be 388,644 μg/l (389 mg/l or ~40 mg/dl). Variations in the partition coefficient would result in a theoretical detection threshold of about 30-50 mg/dl. In practice, the threshold is probably higher. For example, an early study (Widmark, 1932) evaluated the ability of physicians to detect the odor of an alcoholic beverage in subjects who were arrested for allegedly driving while intoxicated. Widmark tested 562 subjects on a variety of tasks, and specifically tested whether raters, in this case 150 trained

Table 6. Perceived Ability of Intoxicated Subjects to Drive—Comparison of Studies

	BAC (mg/dl)	Ability to drive (%)		
		Not okay	Not sure	Okay
Brick et al. (1992)	80-90	25	53	22
	150-160	41	41	18
Brick and Carpenter (2001)	150-160	36	31	33

physicians, could detect the odor of alcoholic beverages. After waiting a sufficient amount of time for residual mouth alcohol to dissipate (about 10-20 minutes), the physicians sampled expired breath of the subjects, and a blood sample was obtained and subsequently analyzed. Of the 562 subjects tested, no one had a detectable odor of alcohol on the breath when the blood alcohol was less than 60 mg/dl. At BACs in the 61-80 mg/dl range, 33% of the subjects had detectable breath alcohol by human smell. At a BAC of about 140 mg/dl, about half the subjects tested had an "alcoholic odor of the breath." More recently, a study by Moskowitz and colleagues (1999) examined the ability of police officers to detect beverage (beer, wine, vodka, and bourbon), also under relatively ideal laboratory conditions. Beverage type had little influence on detection threshold, but bourbon or high BACs resulted in a greater percentage of positive responses. At BACs of less than 80 mg/dl, detection probability was about 60% and above 80 mg/dl, about 80%. From these studies, it can be concluded that there is considerable variability in detection threshold but if a subject has consumed alcohol, after ∼10-20 minutes the detection of the odor of an alcoholic beverage on the breath is probably indicative of a BAC greater than 40 mg/dl and very likely more than 80 mg/dl.

SIGNIFICANCE OF THE AVAILABLE STUDIES

The findings in this review are relevant to a reduction in drunken driving injuries and fatalities and improvement in the application of dram shop or social host liability laws. As with all other dose-dependent drug effects, the BAC is related to a proportional increase in the degree of impairment as well as the percentage of drinkers who are impaired in the performance of complex tasks such as driving an automobile, many of whom appear visibly intoxicated. However, not all intoxication is visible.

In the laboratory and in some drinkers, divided attention failure can be demonstrated at very low BACs, often in the 20-30 mg/dl range. Underage drinkers are at particular risk and sensitive to the effects of very low BACs. In most drinkers, at slightly higher BACs (about 50 mg/dl) there is clear evidence that the relative risk for a fatal crash is significantly elevated, especially in young men (NIAAA, 1990; US Department of Transportation/National Highway Traffic Safety Administration, 1994; Voas and Lacey, 1988; Zador et al., 2000a). At low BACs, behavioral changes such as increased talkativeness, relaxation, and tension reduction are often observed but would not be distinguishable from normal social behavior. At BACs above 80-100 mg/dl there is significant impairment in mental and cognitive ability and subsequent risk for motor vehicle fatalities in virtually all drivers. However, impairment and intoxication at a BAC that constitutes prima facie evidence of drunken driving no longer reliably equates with gross, obvious, or visible intoxication as it once did when motor vehicle laws were first established. To the contrary, available studies suggest that BACs that would impair driving and be in violation of the impaired driving

statute in most states (80-100 mg/dl, depending on the year of the study), do not produce reliable signs of visible intoxication in most subjects (Brick and Carpenter, 2001; Brick et al., 1992; Carroll et al., 1988; Compton, 1986; Harger and Halpieu, 1956; Jetter, 1938a,b; Langenbucher and Nathan, 1983; Maguire, 1986; Pagano and Taylor, 1979; Wells et al., 1997; Widmark, 1932; Zusman and Huber, 1979). Identifying such drinkers before they drive is very difficult, and presents a serious challenge in further reducing impaired driving fatalities. It also highlights the need for more sensitive methods of training to identify intoxication before gross abnormalities appear.

Perhaps most useful in the prevention of drunken driving is the realization that when intoxication is visible, the BAC is almost always well above the current definition for intoxicated driving in the United States. Based upon empirical research, most textbooks, reviews, and other publications during the last 70 years concur that at BACs of about 150 mg/dl, the majority (i.e., more than 50% of drinkers) will present one or more reliable signs of visible intoxication, even among alcoholics. As BACs increase, the probability of detecting intoxication also increases dramatically. Whereas most drinkers are probably visibly intoxicated at a BAC of 150 mg/dl, by 200 mg/dl virtually all drinkers (including alcohol abusers and alcoholics) will appear visibly intoxicated. Yet, there are those rare individuals who by virtue of their exceptional tolerance may not appear visibly intoxicated even at much higher BACs.

Prevention specialists face the often-unrecognized challenge of the need to increase awareness within their profession and the general public about the relationship between alcohol intoxication and behavior. To date, prevention efforts have focused on the harmful consequences of drinking and driving and the message "don't drink and drive." The message that people who drink should not drive is an important one, but as evidenced by a multitude of state and national statistics on drunk-driving arrests, accidents, and fatalities, it is not an effective message. Current strategies in the prevention of drunken driving must include an additional message involving the importance of proper identification of impaired drivers.

Two conclusions having direct implications for prevention specialists are apparent as a result of this review: (i) the lack of visible signs of alcohol intoxication is no guarantee that the drinking driver is not impaired and (ii) if signs of visible intoxication (i.e., trouble walking, speech impairment, impaired cognition or affect, or other signs of intoxication) are present, the person is probably (more likely than not) intoxicated well in excess of the legal definition for driving while intoxicated and is at significantly increased risk for a fatal crash or injury. Better training of alcohol beverage servers and social hosts, and broader public awareness of the relationship between BAC, visible intoxication, obvious intoxication, and risk for a motor vehicle crash should be part of future prevention strategies. Most importantly, drivers who drink but do not show signs of visible intoxication may have BACs that exceed the

current legal definition for intoxicated driving, and may be at high risk for injury to themselves and others. This problem is greatly enhanced in underage drinking drivers, who as a group, are at higher risk for intoxication and fatal accidents than older drinking drivers. Thus, extra vigilance is required of hosts and bar employees whose responsibility it is to prevent drunken driving and its consequences in those they serve. While a portion of the responsibility for reducing drunken driving harm rests with the consumer, alcohol at higher levels clearly reduces inhibitions and impairs judgment so that a responsible drinker can become an irresponsible driver. The consequences of drunken driving are simply too costly for hosts and servers to abrogate their responsibility of overserving entirely to the consumer.

CONCLUSIONS

Based upon a review of relevant studies conducted over the last 7 decades, we conclude that "obvious intoxication" as defined in some courts is not always the same as "visible intoxication." Obvious intoxication may include factors such as the number of drinks served, whereas visible intoxication refers to specific signs. The signs of visible intoxication occur on a continuum, and higher BACs lead to a greater likelihood of seeing the signs and identifying individuals who are alcohol impaired in cases involving the negative consequences of drinking and driving. Training individuals in the identification of signs of intoxication enhances the accuracy of observation and may modify serving practices to limit over-service, particularly if bartenders are supported by management and laws are enforced (NIAAA, 2000). Yet, it is clear that even well-trained individuals (e.g., trained counselors, bartenders, and police officers) often have difficulty discriminating those who are sober from those who should not be driving. However, BACs of 150 mg/dl or more are most related to visible signs of intoxication, even in most highly tolerant individuals. Factors involved with determining visible intoxication include biological differences between individuals (i.e., some people are less sensitive to the effects of alcohol than others), acquired tolerance in experienced drinkers, BAC, and the environment in which the observations are made. Even so, above 150 mg/dl, one or more signs of visible intoxication will probably be present and identifiable by casual observation if persons who care make an effort to find such signs. At BACs of 200 mg/dl or above, almost all individuals, whether experienced or tolerant, will show visible signs of intoxication.

There are some exceptional individuals in whom visible signs of intoxication are not evident even at very high BACs. In such cases, other factors to determine obvious intoxication (e.g., the number of drinks served and drinking history) should be taken into consideration. Drink counting can be a useful prevention approach in many cases. For example, even 1 or 2 drinks in an underage person may increase the relative risk of a fatal crash and is illegal. Even with the uncertainties of whether a person consumed alcohol outside the presence of a bartender, individual differences in anthropometric characteristics and alcohol metabolism, in some tolerant individuals who do not show signs of visible intoxication, drink counting may be one way to limit intoxication. Overall, the following should be included in future prevention efforts aimed at the general public and server training programs: (i) an increased awareness that drinkers who do not appear visibly intoxicated may still be impaired, (ii) the presence of one or more signs of visible intoxication strongly suggests impairment and increased risk for injury, and (iii) if there is uncertainty as to whether someone is intoxicated, it is better to err on the side of caution and follow the maxim: *when in doubt, serve no stout.*

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