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Breathalyzer® Accuracy in Actual Law Enforcement Practice: A Comparison of Blood- and Breath-Alcohol Results in Wisconsin Drivers

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ABSTRACT: Breathalyzer® and blood-alcohol results from drivers arrested for operating a motor vehicle while intoxicated and for related offenses were compared during a two-year period. Four hundred and four pairs of breath- and blood-alcohol results from specimens collected within 1 h of each other were studied. Blood-alcohol concentrations ranged from zero to 0.421% weight per volume (w/v). Breath-alcohol concentrations ranged from zero to 0.44 g/210 L. The mean Breathalyzer result was 0.16 g/210 L. The mean blood-alcohol result was 0.176% w/v. Compared to the blood-alcohol result, Breathalyzer results were lower by more than 0.01 g/210 L 61% of the time, within 0.01 g/210 L 33% of the time, and higher by more than 0.01 g/210 L 6% of the time.

KEYWORDS: criminalistics, breath-alcohol testing devices, comparative analysis

The Breathalyzer® was introduced by Dr. Robert Borkenstein in 1954 and became the most widely used breath-alcohol[2] testing device in this country. From 1955 until 1984 it was the primary instrument used for determining alcohol intoxication in Wisconsin drivers. The instrument is designed for operation in a nonlaboratory environment by law enforcement personnel. Trained operators follow a protocol that includes observing the subject to ensure that he is free of residual mouth alcohol as well as instructing the subject to provide a steady, prolonged breath exhalation into the instrument.

The enactment of more stringent legislation directed toward operating a motor vehicle while intoxicated (OMVWI) including the specification of 0.10% weight per volume (% w/v) as the concentration at which it is illegal "per se" to drive, has increased the frequency of courtroom challenges to the validity of breath test results. Such challenges are often based on the assertion that the result does not accurately reflect the subject's blood-alcohol concentration. These arguments can appear in several forms: the operator falsified breath results, substances other than alcohol appeared on the subject's breath and increased the reading, the 2100:1 blood- to breath-alcohol ratio employed in the Breathalyzer was not valid for the subject tested, and random error such as radio frequency interference falsely elevated the result.

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[2]The unmodified term "alcohol" in this paper refers to ethanol.

We decided that a systematic examination of paired Breathalyzer and blood alcohol results obtained from actual drivers arrested for OMVWI and related offenses would provide empirical data which would address these concerns. Because Breathalyzers are routinely operated by law enforcement personnel in a nonlaboratory setting, we further decided that such a comparison should reflect these conditions.

Previous studies of Breathalyzer Model 900 and 900A accuracy have been conducted under controlled laboratory conditions on drinking volunteers [*1-6*]. There have been few studies that reflect the use of Breathalyzers in actual law enforcement practice. One study of police officers operating Breathalyzers in a controlled setting has been published [*7*]. There are additional studies where more modern instrumentation was used to analyze breath alcohol in actual drivers [*8-10*].

Wisconsin's Implied Consent Law, which provides either the subject or arresting officer an opportunity to request an additional test (usually blood) after completing the breath test, enabled us to compare Breathalyzer and blood-alcohol results from the same driver. Neither the subjects nor the Breathalyzer operators were aware of the study at the time the tests were conducted.

Method

In 1983 and 1984 we received and analyzed over 500 blood-alcohol specimens on which field administered Breathalyzer test results were reported. Test results from breath and blood samples collected more than 1 h apart were eliminated from this group. The 1-h period was chosen to provide a reasonable number of data pairs for the study, while limiting the variation between the 2 results caused by alcohol absorption and elimination. No attempt was made to adjust individual test results for hypothetical alcohol absorption or elimination occurring in the elapsed time between the sampling of the breath and blood. Additional follow-up information was obtained on 40 data pairs in which the breath result was more than 25% lower than the corresponding blood-alcohol result. In 7 of these pairs, the Breathalyzer operator observed that a poor breath sample had been delivered by the subject. In 2 of the pairs the operator reported that the instrument was not properly operating, as evidenced by a low breath alcohol simulator result. These 9 data pairs were eliminated and the remaining 31 were retained, leaving a total of 404 data pairs meeting our criteria for inclusion in the study.

Breath Analysis

Breath test results were obtained on Breathalyzer Model 900 and 900A instruments located in law enforcement offices throughout Wisconsin. Wisconsin Breathalyzer operators are trained to follow a 24-step procedure that includes sequential analyses of a room air blank, the subject's breath, and a sample from a breath-alcohol simulator. Results from the room air blank and simulator test must fall within prescribed ranges. The room air analysis must yield a result no greater than 0.01 g of alcohol per 210 L of air or breath (g/210 L) and the simulator test result must be 0.10 $\pm$ 0.01 g/210 L for the subject test to be considered valid. All test results are truncated (not rounded) to 2 decimal places. Breathalyzer operators must hold a current breath testing permit issued by the Wisconsin Department of Transportation. Permits are issued only after the operator has successfully completed a 40-h basic training course in the theory and operation of the Breathalyzer Model 900 and 900A. Recertification is required every 2 years and is contingent upon satisfactory demonstration of continued proficiency.

Blood Analysis

Blood specimen collection kits are assembled and supplied free of charge by our laboratory to law enforcement agencies and hospitals. They consist of two 10-mL Vacutainer® tubes each containing 20.0 mg of potassium oxalate and 25.0 mg of sodium fluoride, a benzalkonium chloride saturated towelette, a Vacutainer holder, a multisample needle, and a Styrofoam mailing container. Also included are labels and tamper-resistant seal strips for the specimen tubes. Blood specimens are collected by medical personnel at hospitals and clinics throughout the state and transported, usually through the U.S. mail, to our laboratory for analysis. Blood samples were analyzed by a modification of Dubowski's direct injection gas chromatographic technique [*11*]. The gas chromatographs are equipped with automatic liquid samplers, glass injection port liners, 4-ft by 1/4-in. (1.2-m by 0.6-cm) glass columns, flame ionization detectors, and recording integrators. The columns are packed with 0.2% Carbowax on Carbopack C (80-100 mesh). The samples are diluted 1:20 with a water solution of 1.2% Triton X-100 containing 0.16% w/v *n*-propanol as an internal standard. Aqueous ethanol standards are analyzed during each run to establish the instrument response to given ethanol concentrations. Overall performance is monitored by daily internal quality assurance and monthly external proficiency testing programs. Chemist-analysts must possess a valid alcohol testing permit issued by the Wisconsin Department of Health and Social Services.

Results and Discussion

The breath alcohol concentrations obtained on the 404 subjects ranged from 0.00 to 0.44 g/210 L, while the blood concentrations ranged from 0.000 to 0.421% w/v. The mean breath-alcohol concentration was 0.16 g/210 L compared to a mean blood concentration of 0.176% w/v. A paired *t* test analysis showed the difference between the means to be significant ($p < 0.001$). Figure 1 shows the distribution of blood-alcohol concentrations included in this study.

Breath and blood results were considered to be in agreement if they differed by 0.01 or less. It was found that 245 (61%) of the Breathalyzer results were lower than the correspond-

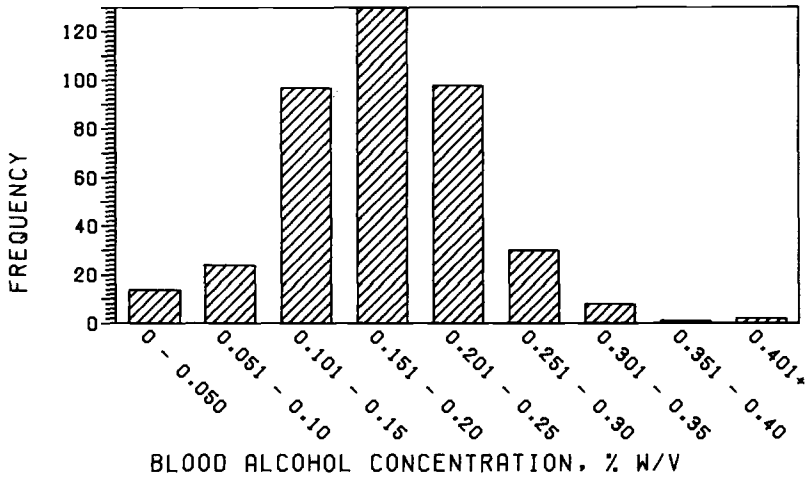

FIG. 1—*Distribution of blood-alcohol results attained by drivers in the study.*

ing blood result, 133 (33%) agreed with the corresponding blood result, and 26 (6%) were higher than the corresponding blood result. Figure 2 shows Breathalyzer results plotted against blood-alcohol results. The line of 1:1 correlation is shown for reference. The data were found to be significantly correlated, with a correlation coefficient of 0.9391. Linear regression analysis of the data yielded the following equation of the line: BrAC= 0.8905 BAC + 0.0008, where BrAC is the breath-alcohol result and BAC the blood-alcohol result.

Of special interest are those data pairs where the Breathalyzer result, based on 0.10 per se laws, could have led to a different legal conclusion relative to intoxication than the blood result would have. This occurred in the six cases listed in Table 1 where the Breathalyzer result was below 0.10 g/210 L and the blood alcohol concentration was greater than 0.100% w/v. Table 2 presents the converse situation: the five data pairs in which the Breathalyzer was 0.10 g/210 L or more, and the corresponding blood-alcohol concentration was less than 0.100% w/v. In these instances, representing 1.2% of the subjects tested, only one of the five data pairs has results differing by more than 0.005%. The difference is well within the predicted range of alcohol elimination in the elapsed time (40 min in this case) between breath and blood sampling.

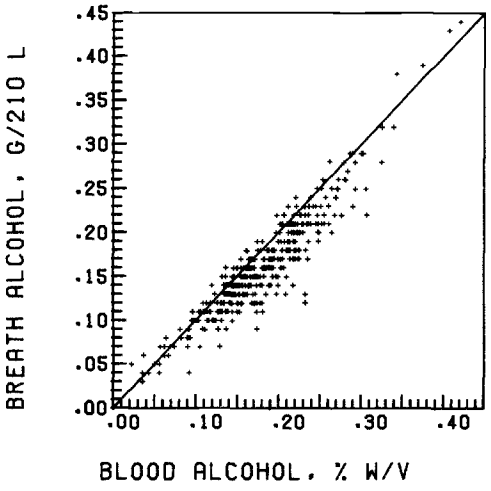

FIG. 2—*Scatter plot of Breathalyzer versus blood-alcohol results. Line of 1:1 correlation is shown for reference.*

TABLE 1—*Instances[a] in which the Breathalyzer result was below 0.10 g/210 L and the corresponding blood-alcohol result was 0.10% w/v or above.*

Breathalyzer, g/210 L	Blood-Alcohol, % w/v
0.07	0.106
0.07	0.129
0.09	0.108
0.09	0.112
0.09	0.127
0.09	0.137

[a]Out of 404 samples in the study.

TABLE 2—*Instances[a] in which the Breathalyzer result was 0.10 g/210 L or above and the corresponding blood-alcohol result was below 0.10% w/v.*

Breathalyzer, g/210 L	Blood-Alcohol, % w/v
0.10	0.095
0.10	0.096
0.10	0.097
0.10	0.099
0.11	0.096

[a]Out of 404 samples in the study.

The systematic underestimation of blood-alcohol concentration by the Breathalyzer found in our study can be attributed to three factors. The first is the calibration of the Breathalyzer using a 2100:1 blood- to breath-alcohol ratio. It is widely recognized that there are a number of physiological factors that can cause variability in this ratio [*12,13*] and that using a blood-to-breath ratio closer to 2300:1 would give a more accurate estimate of blood-alcohol concentrations from breath [*14,15*]. Second, truncation of Breathalyzer results to two decimal places compared to reporting blood results to three decimal places would be expected to contribute slightly to the low bias. Finally, analysis of breath that is not nearly "alveolar" would contribute to a lower reading compared to blood.

Summary and Conclusions

Breathalyzer results obtained in the field were compared to blood-alcohol results on samples obtained within 1 h of each other from Wisconsin drivers arrested for OMVWI offenses. The 404 pairs of results studied were obtained over a 2-year period. It was found that Breathalyzer and blood-alcohol results correlated well and that blood-alcohol concentrations tended to be underestimated by the Breathalyzer. This bias was observed in 61% of the cases in spite of the fact that the Breathalyzer test almost always preceded the blood test and that alcohol elimination would be expected to cause a greater incidence of breath results "overestimating" blood-alcohol concentrations. We found no evidence of operators altering Breathalyzer results, radio frequency interference causing elevated Breathalyzer readings, or volatile substances other than ethanol causing elevated Breathalyzer readings.

In the hands of police officers in a nonlaboratory setting, Breathalyzers can be expected to underestimate blood alcohol concentrations.

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