Letter to the Editor

Incorrect Overestimates of Blood Alcohol Concentration from Breath Test Results

To the Editor:

In 1982 Dubowski (1) concluded, "[T]he 2100:1 conversion tends to underestimate the actual BAC in about 86% of the population by a mean of about 8%, because the functional alcohol partition ratio between blood and breath in healthy adult males was found to be 2.28×10^3." In other words, from a sample of healthy men known to be "fully postabsorptive," Dubowski concluded 86% of the population would have actual BAC underestimated, even though there is no assurance that people in the general population are "fully postabsorptive" or that the general population consists of healthy males. These conclusions were apparently based on results presented in 1979 (2), funded by the Insurance Institute for Highway Safety. As pointed out earlier (3), 86% underestimates are not only unrepresentative of the general population, they are also not consistent with appropriate areas under a normal error curve. Clarification of Dubowski's conclusions was made in recent testimony given for the New Jersey Supreme Court. From the Findings of Fact,[1] *State v. Downie*, Docket No. A-167, September Term, 1988, written by Hon. P. McGann, Dubowski's testimony is reported as the following:

> Based on all of his studies of some 390 paired results from several hundred subjects, his experience has been that when Breathalyzer readings are converted to blood/alcohol readings using a 2100 to 1 ratio, in 86% of those pairs, the converted BAC will underreport or underestimate the measured venous whole blood BAC, in the post-peak state of healthy adult males. In 2.6 percent of the pairs the supposed BAC and actual BAC turned out to be the same, and in 11.4 percent of the pairs, the supposed BAC was higher than the actual BAC (that is, for those pairs the calculated blood-to-breath ratio for that subject at the time the paired samples were taken was lower than 2100 to 1 and at the critical 0.01% level). Even where the breath analysis converted into assumed BAC overestimates the true BAC (the 11.4%) many of those are harmless. If for example the converted result is 0.109 and the true BAC is 0.100 (a 9% overestimate), when the converted BAC is reported it is truncated and becomes 0.10. Of the 11.4% total overestimation only 2.3% would overestimate at the critical 0.10 level. The others would be lower—where they do not count—or higher, where it would not make any difference, or so close, that with truncation they would be the same.[2]

Dubowski's results for healthy men known to be "fully postabsorptive," published in 1985 (5), yielded a mean, ±SD, CV, and range of 2280, ±241.5, 10.6%, and 1706-3063. From these results, it is possible to make a rough estimate of the percentage of fully postabsorptive healthy men who would have actual venous BAC underestimated or overestimated, either by using his actual data (which do not appear to have been published, indicating that details of this work were never subjected to peer review) or by using normal error analysis. It is incorrect, however, to draw any conclusions about the percentage of harmful overestimates expected in the population based on this sample. This is because the percentage of subjects above or below a BAC of 0.10% at the time of the test is dependent on the value of the subject's BAC at the time of the test, which is dependent on the researcher's choice of alcohol dose and the time at which BAC is measured. If, for example, Dubowski had chosen to dose his subjects so that all BACs were near 0.015% at the time of the test, *no* harmful overestimates would have occurred in that sample. This does not mean that no harmful overestimates would occur in the population.

Clearly, the percentage of harmful overestimates indicated by Dubowski (2.3%) applies only to that particular sample of subjects and cannot be used to estimate the percentage of harmful overestimates in the population. The danger with such an inappropriate projection is the likelihood that a reasonable juror, or judge for that matter,[3] would misinterpret this as meaning breath analysis is 97.7% reliable when used for law enforcement purposes.[4] (The percentage of harmful overestimates in the population will depend on the number of people having a breath test result equal to or greater than the statutory BAC limit, but whose actual BAC is less than the limit. The number of people in this situation can be determined by measuring actual BAC at the time of the

1. Dr. Dubowski is George Lynn Cross Research Professor of Medicine at the University of Oklahoma College of Medicine. From the resume included in the Findings of Fact, his present positions also include State Director of Tests for Alcohol and Drug Influence, State of Oklahoma (since 1970); Criminalist, Oklahoma Department of Public Safety/Oklahoma Highway Patrol; Criminalist, Oklahoma State Bureau of Investigation; and Criminalist, Oklahoma City Police Department.
2. A similar explanation is given in reference (4), in which it is stated, "[I]n 1980, one of the leading contemporary authorities, Dr. Kurt Dubowski, former president of the American Academy of Forensic Sciences, discussed the problem in testimony in a trial in Anchorage, Alaska. In his testimony, Dr. Dubowski stated that in his experiments using instruments relying on the 1:2,100 ratio, in 86% of the cases the instruments yielded results lower than independtly determined blood alcohol concentrations at the same time. In 14% of the cases the underestimate did not occur. Dr. Dubowski has pointed out, however, that it would be fallacious to leap to the conclusion that the use of the ratio leads to an overestimate in 14% of the cases. As he has explained, the 14% figure includes estimates identical to the actual blood-alcohol concentration, harmless overestimates in the third decimal which were eliminated by truncating, and finally a much smaller percentage of true overestimates."
3. Not only did the New Jersey Supreme Court adopt this interpretation in *State v. Downie* 117 N.J. 450, 569 A. 2d. 242 (1990), the majority and dissenting opinions relied strongly on it, stating that the Breathalyzer has "...a maximum overestimation error margin of 2.3%..." and that it "... is highly reliable, underestimating blood-alcohol content in most cases but materially overestimating blood-alcohol content in approximately 2.3% of all subjects tested."
4. It is doubtful if even blood test results are 97.7% reliable, assuming that at best the uncertainty is about ±5% for 95% confidence limits under field conditions.

breath test in an appropriate sample under field conditions. Under these conditions, some subjects will be "fully postabsorptive" and some will not be "fully postabsorptive." The percentage of harmful overestimates depends strongly on the absorption status of the subjects (6), requiring that great care be taken to select a representative sample. Without such results, it is inappropriate to conclude anything that goes beyond the percentage of people having actual BAC underestimated or overestimated.) A statistical approach based on a normal error curve has already been applied to Dubowski's results (6), yielding 77% underestimates and 23% overestimates, rather than 86% underestimates.[5,6] If ±5% uncertainty in actual BAC is considered acceptable agreement between results from breath and blood tests, normal error analysis projects that for healthy men *known* to be "fully postabsorptive," 62% would have actual BAC underestimated, 26% would be acceptably close, and 12% would have actual BAC overestimated (7).

While the percentage of overestimates and underestimates of actual BAC can give some indication of the reliability of breath analysis, the most important piece of information for legal purposes is the amount of error or uncertainty expected in an *individual's* BAC result. In a legal situation, the question is whether or not a particular defendant had a BAC in excess of some limit, not what percentage of people in general have acutal BAC overestimated or underestimated. To express or predict the error or uncertainty expected in such a result, analytical chemists have for many years employed normal error analysis and the details can be found in any undergraduate text on analytical chemistry. There is little dispute that this is the correct approach for determining and predicting the amount of error in concentration measurements. If these standard, accepted methods are applied to BACs determined from breath analysis, a minimum uncertainty of ±15% is predicted for "fully postabsorptive" healthy men (3), using Dubowski's results. If the subject is not fully postabsorptive the uncertainty is greater. For a subject who is absorbing alcohol at the time of the test, the uncertainty is ±53%, based on the capillary blood/breath ratio of 990:1 reported by Jones (8,9). The venous blood/breath ratio would have a lower value, thus requiring even more uncertainty. There is no justification for continuing the current practice of reporting BAC results from breath tests as though they are equivalent to results from blood tests. Standard, accepted methods for determining the amount of uncertainty expected in an individual's BAC result have been available for years; Widmark applied them to his results over 60 years ago (10). It is time for the forensic science community and manufacturers of breath analyzers to adopt these methods in order to properly report the amount of uncertainty expected in individual breath test results.

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References

1. K. Dubowski. Alcohol analysis: clinical laboratory aspects. Part I. *Lab. Management* **20:** 43–54 (1982).
2. K. Dubowski. The blood/breath ratio of ethanol. *Clin. Chem.* **25:** 1144 (1979), [abstract].
3. G. Simpson. Accuracy and precision of breath-alcohol measurements for a random subject in the postabsorptive state. *Clin. Chem.* **33:** 261–68 (1987).
4. P.C. Giannelli and E.J. Imwinkelried. *Scientific Evidence.* Michie Company, Charlottsville, VA, 1986, p. 875.
5. K. Dubowski. Absorption, distribution and elimination of alcohol: highway safety aspects. *J. Stud. Alc.* Suppl. No. 10: 98–108 (1985).
6. G. Simpson. Do breath tests really underestimate blood alcohol concentration? *J. Anal. Toxicol.* **13:** 120–23 (1989).
7. D.M. Lucas. Assessing breath test estimation of blood alcohol concentration [Letter with response by G. Simpson]. *J. Anal. Toxicol.* **13:** 241–44 (1989).
8. A.W. Jones. Variability of the blood:breath ratio in vivo. *J. Stud. Alc.* **39:** 1931–39 (1978).
9. G. Simpson. Accuracy and precision of breath-alcohol measurements for subjects in the absorptive state. *Clin. Chem.* **33:** 753–56 (1987).
10. G. Simpson. Medicolegal alcohol determination: Widmark revisited. *Clin. Chem.* **34:** 888–89 (1988).

5. In the *Downie* decision (see note 3), Hon. J. Garabaldi, writing for the majority stated that "...Dr. Dubowski stated he never testified that .055 should be deducted from each breathalyzer result. Moreover, with respect to the 14% overestimation figure he said that at the time he testified at a trial in Alaska on which the *McGinley* court relied, he did not have the statistical data analysis he now has and that his previous simplified testimony does not fairly and correctly reflect the facts." Based on a normal error curve and Dubowski's data, 77% underestimates and 23% overestimates are projected (6). It is not clear what statistical methods Dubowski might have used to arrive at his results of 86% underestimates, 2.3% exact agreement and 11.7% overestimates, only 2.3% being harmful overestimates. It is particularly unclear which statistical methods permit a conclusion that "...in 2.3% of the cases the breathalyzer states *exactly* the blood alcohol content" (emphasis added).
6. In *Downie*, the Court also misinterpreted testimony about the blood-breath ratio. It was concluded that "calculated blood-breath ratios are worthless for forensic purposes. They are subject to so many variables as to be unuseable except for gross estimates...and only then at a particular moment." At this time, no model is available that permits calculation of blood-breath ratios. They have always been derived from *experimental* measurements of alcohol concentration in blood and air (or breath) under either in vitro or in vivo conditions. Consequently, at least for forensic purposes, there is no such thing as a calculated blood-breath ratio; there are only experimental or empirical blood-breath ratios. The Court confused calculated blood-breath ratios with the calculatd *BACs* produced by the Breathalyzer. Based on the scientific evidence given, a correct conclusion would have been as follows: Because the value of the blood-breath ratio for any given individual is subject to so many variables, a *BAC* calculated from breath alcohol concentration, using an *assumed* value of 2100:1, is unreliable unless it can be proven that the individual was "fully postabsorptive" at the time of the test, in which case the uncertainty in a particular result is at least ±15%. For further examples and discussion of incorrect application of science to the law, see P.J. Neufeld and N. Coleman's "When Science Takes the Witness Stand," *Scientific American* **262(5):** 46–53 (1990).