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A Comparison of Blood Alcohol Concentrations Estimated
from Drinking Histories of Drivers Charged with
“Over 80” and Their Intoxilyzer® 5000C Results

by

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ARTICLES

A COMPARISON OF BLOOD ALCOHOL CONCENTRATIONS ESTIMATED FROM DRINKING HISTORIES OF DRIVERS CHARGED WITH "OVER 80" AND THEIR INTOXILYZER® 5000C RESULTS

T.L. Martin¹, J.G. Wigmore¹ and K.L. Woodall^{1,2}

ABSTRACT

Two hundred and thirty self-reported drinking scenarios from drinking-drivers charged with an impaired driving offence were examined. Estimated blood alcohol concentrations (eBAC) from drinking scenarios were calculated using standard forensic calculations (i.e. Widmark Formula) and compared to the lowest or first Intoxilyzer® 5000C results. Using a rate of elimination of alcohol from the blood of 10 mg/100 mL/h, eBACs were more than 10 milligrams of alcohol in 100 millilitres of blood (mg/100 mL) lower than the Intoxilyzer® 5000C results in 194 scenarios (84%), within \pm 10 mg/100 mL of the Intoxilyzer® 5000C result in 32 (14%) drinking scenarios and more than 10 mg/100 mL higher than the Intoxilyzer® 5000C result in 4 (2%) drinking scenarios. The number of eBACs more than 10 mg/100mL lower than the Intoxilyzer 5000C increased to 221 (96%) when a rate of elimination of 20 mg/100mL/h was employed. The greatest discrepancy observed was a truncated Intoxilyzer® 5000C result of 300 mg/100 mL and a corresponding eBAC of less than 10 mg/100 mL. Test records for each Intoxilyzer® 5000C test were examined and all instruments were verified as calibrated and in proper working order at the time of testing. It is concluded that the vast majority of drinking scenarios provided by arrested drivers are unreliable when compared to the Intoxilyzer® 5000C.

RÉSUMÉ

Les scénarios de consommation décrits par deux cent trente conducteurs accusés d'avoir conduit avec facultés affaiblies ont été examinés. Les alcoolémies estimées (AlcE) à partir de ces scénarios ont été calculées en utilisant la formule de Widmark et comparées avec la plus basse valeur obtenue à la suite d'une analyse de l'haleine avec l'Intoxilyzer® 5000C. Lorsqu'un taux d'élimination de l'alcool sanguin de 10 mg/100 mL par heure était appliqué, les AlcE ont été inférieures à plus de 10 mg/100 mL des résultats obtenus par l'Intoxilyzer® 5000C dans 194 (84 %) des scénarios, à \pm 10mg/100 mL des résultats obtenus par l'Intoxilyzer® 5000C dans 32 (14 %) des scénarios et supérieures à plus de 10 mg/100 mL des résultats obtenus par l'Intoxilyzer® 5000C dans 4 (2 %) des scénarios. Lorsqu'un taux d'élimination de 20 mg/100 mL à l'heure était appliqué, le nombre des AlcE inférieures à plus de 10 mg/100 mL des résultats obtenus par l'Intoxilyzer® 5000C augmente à 221 (96 %). Le plus grand écart observé consistait en un résultat obtenu avec l'Intoxilyzer® 5000C tronqué à 300 mg/100 mL et une alcoolémie théorique calculée correspondante à

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moins de 10 mg/100 mL. Les fiches de chacun des tests effectués avec l'Intoxilyzer® 5000C ont été examinées et tous les instruments ont été considérés bien calibrés et en bon état de fonctionnement au moment des tests. En conclusion, la vaste majorité des scénarios de consommation décrits par les conducteurs arrêtés sont non fiables lorsque comparés avec les résultats de l'Intoxilyzer® 5000C.

INTRODUCTION

In Ontario, a common defence raised at trials involving drivers charged with operating or having care or control of a motor vehicle while having a blood alcohol concentration (BAC) exceeding 80 milligrams of alcohol in 100 millilitres of blood (mg/100 mL) is commonly known as the 'Carter Defence'. This defence evolved from a criminal case (*R. v. Carter*, 1985) involving a blood sample with continuity problems. The Ontario Court of Appeal ruled that submission of a drinking scenario in defence of an accused can provide evidence to the contrary and rebuttal of the two-hour presumption if expert opinion concludes that this scenario would result in a BAC of less than 80 mg/100 mL at the time of driving. If the drinking history is believed by the trier of fact, such evidence to the contrary ultimately provides opportunity for dismissal of an over 80 charge (1).

As this decision is now commonly applied to Breathalyzer® 900/900A and Intoxilyzer® 5000C cases, the need for a scientific evaluation of the defence exists. The objective of this study was to evaluate the reliability of self-reported, defence drinking scenarios compared to Intoxilyzer® 5000C results.

METHODS

Self-reported drinking scenarios were retrospectively examined and compared to Intoxilyzer® 5000C results for two hundred and thirty drivers charged with an "over 80" offence in Ontario during a two-year period (2000–2002). The lawyers of the drivers submitted these scenarios in writing. Estimated blood alcohol concentrations (eBAC) were calculated from drinking scenarios provided by the accused. The eBAC was performed using standard Widmark calculations (2–5). Widmark's rho factor employed in these calculations was 0.7 for men and 0.6 for women. These calculations project the BAC from a drinking pattern using the weight and sex of the individual, and a range of rates of elimination of alcohol of between 10 and 20 milligrams of alcohol in 100 millilitres of blood per hour (mg/100 mL/h).

Since the breath test procedure in Ontario comprises duplicate breath tests conducted at least 15 minutes apart, the eBAC was projected to the time when the lowest of the two Intoxilyzer® 5000C tests was performed. In cases where the two, truncated, breath test results were identical, the eBAC was calculated to the time of the first Intoxilyzer® 5000C test. The Intoxilyzer® 5000C (CMI Inc. Owensboro KY, USA) is an approved instrument in Canada. The instrument uses three wavelengths of infrared light to determine the blood alcohol concentration and automatically prints the results of the tests on a record card (6). In the current study, each Intoxilyzer® Test Record was examined to determine the time and result of each breath test and to verify that instrument was functioning properly. The sequence of testing in Ontario consists of an air blank, three internal standards, 10 system checks, a calibration check, another air blank, three internal standards, 10 system checks, the subject test, and a final air blank. In Canada, the Criminal Code and the recommendations of the Alcohol Test Committee (ATC) of the Canadian Society of Forensic

Science, state that two breath tests be conducted a minimum of fifteen minutes apart (7). The sequence is, therefore, repeated. In total, 6 air blanks, 12 internal standard checks, 40 system checks, 2 external alcohol standard tests and 2 subject tests are conducted. Subject test results are truncated as recommended by the ATC and must agree within ± 20 mg/100 mL to be considered acceptable (7).

The external alcohol standard test (calibration check) was conducted using a wet bath simulator (usually a Model 34C, Guth Laboratories Inc. Harrisburg PA, USA) at a temperature of 34 ± 0.2 C. The calibration of the instrument is considered acceptable if the result of the alcohol standard test is within 90 mg/100 mL –110 mg/100 mL for alcohol standard solutions containing 1.21 ± 0.03 mg/mL ethyl alcohol (7).

RESULTS AND DISCUSSION

The majority of the 230 individuals in the current study were male ($n = 197$, 86%); only 33 of the drivers were female (14%). This distribution of male-to-female drivers is consistent with previously published male-to-female ratios in drinking and driving cases (8,9). The type of alcoholic beverage reportedly consumed by our drivers (Table 1) is also consistent with previously published studies (10, 11). The most commonly reported beverage consumed was beer, which was stated to have been ingested by 70% of the male drinking drivers in our study.

The eBAC at the time of the first or lowest Intoxilyzer[®] 5000C test ranged from 0 to 355 mg/100 mL (mean = 70 mg/100 mL) using a rate of alcohol elimination of 10 mg/100 mL/h and between 0 and 270 mg/100 mL (mean = 22 mg/100 mL) using a rate of alcohol elimination of 20 mg/100 mL/h. These eBAC were significantly lower than the corresponding Intoxilyzer[®] 5000C results, which ranged from 80 to 310 mg/100 mL ($n = 230$, mean = 127 mg/100 mL, Student t-test, $p < 0.001$).

Using an alcohol elimination rate of 10 mg/100 mL/h, the eBAC was more than 10 mg/100 mL lower than the Intoxilyzer[®] 5000C result in 194 (84%) drinking scenarios and more than 10 mg/100 mL higher than the Intoxilyzer[®] 5000C result in 22 (10%) of the drinking scenarios (Figure 1). In only 14 (6%) of the drinking scenarios was the eBAC within ± 10 mg/100 mL of the Intoxilyzer[®] 5000C result. The difference between the Intoxilyzer[®] 5000C result and the eBAC was calculated for each individual. The mean difference when the 10 mg/100 mL/h rate of elimination was used was 57 mg/100 mL. When an elimination rate of 20 mg/100 mL/h was used to calculate the eBAC, there was an even greater discrepancy between the eBAC and the Intoxilyzer[®] 5000C result (mean = 105 mg/100 mL). The number of eBAC more than 10 mg/100 mL lower than the Intoxilyzer[®] 5000C result increased to 221 (96%) and the number of eBACs in agreement with the Intoxilyzer[®] 5000C result decreased to five (2%) (Figure 2). In four cases (2%) the eBAC was more than 10 mg/100 mL/h higher than the Intoxilyzer[®] 5000C result (Figure 2).

The poor correlation between each eBAC and its corresponding Intoxilyzer[®] 5000C results is illustrated in Figures 3(a) and 3(b). The correlation coefficients (R) for these graphs are 0.25 when a 10 mg/100 mL/h elimination rate is used (Figure 3a) and 0.27 when a 20 mg/100 mL/h elimination rate is used (Figure 3b). Although these values are, in fact, statistically significant ($p < 0.05$), their low value indicates a very poor relationship.

It should be emphasized that no errors in operation were detected on any of the Intoxilyzer[®] 5000C tests records in these cases. The breath test sequence for Ontario was followed properly and all calibration checks were within the acceptable range of 90

TABLE 1

Type of alcoholic beverage reportedly consumed in the 230 drinking scenarios examined. ¹Refers to the reported ingestion of more than one type of alcoholic beverage during the drinking scenario

Type of Beverage	Number of females (%)	Number of males (%)
Beer	11 (33.3)	138 (70.0)
Spirits	5 (15.2)	14 (7.1)
Wine	7 (21.2)	2 (0.1)
Combination ¹	10 (30.3)	43 (21.8)

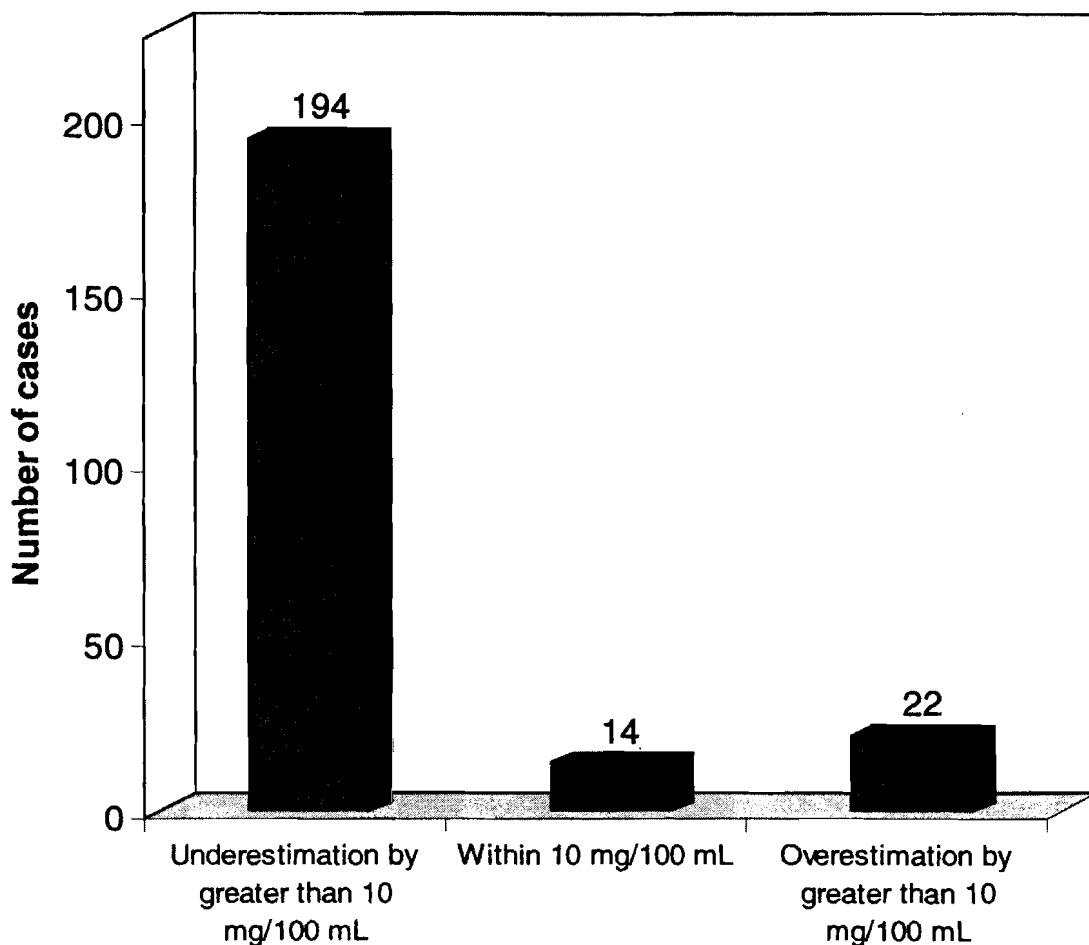


Figure 1. Number of cases in which the eBAC (calculated using a 10 mg/100 mL/h elimination rate) was more than 10 mg/100 mL less than the Intoxilyzer[®] 5000C, within ± 10 mg/100 mL of the Intoxilyzer[®] 5000C result and more than 10 mg/100 mL greater than the Intoxilyzer[®] 5000C result.

mg/100 mL to 110 mg/100 mL. The accuracy of the Intoxilyzer[®] 5000 has been studied extensively in the laboratory and has been found to be a reliable and scientifically valid instrument for determining blood alcohol concentrations (12, 13).

Field studies, evaluating the performance of the Intoxilyzer[®] 5000 when operated by police officers for the purposes of testing actual drinking drivers, have further demon-

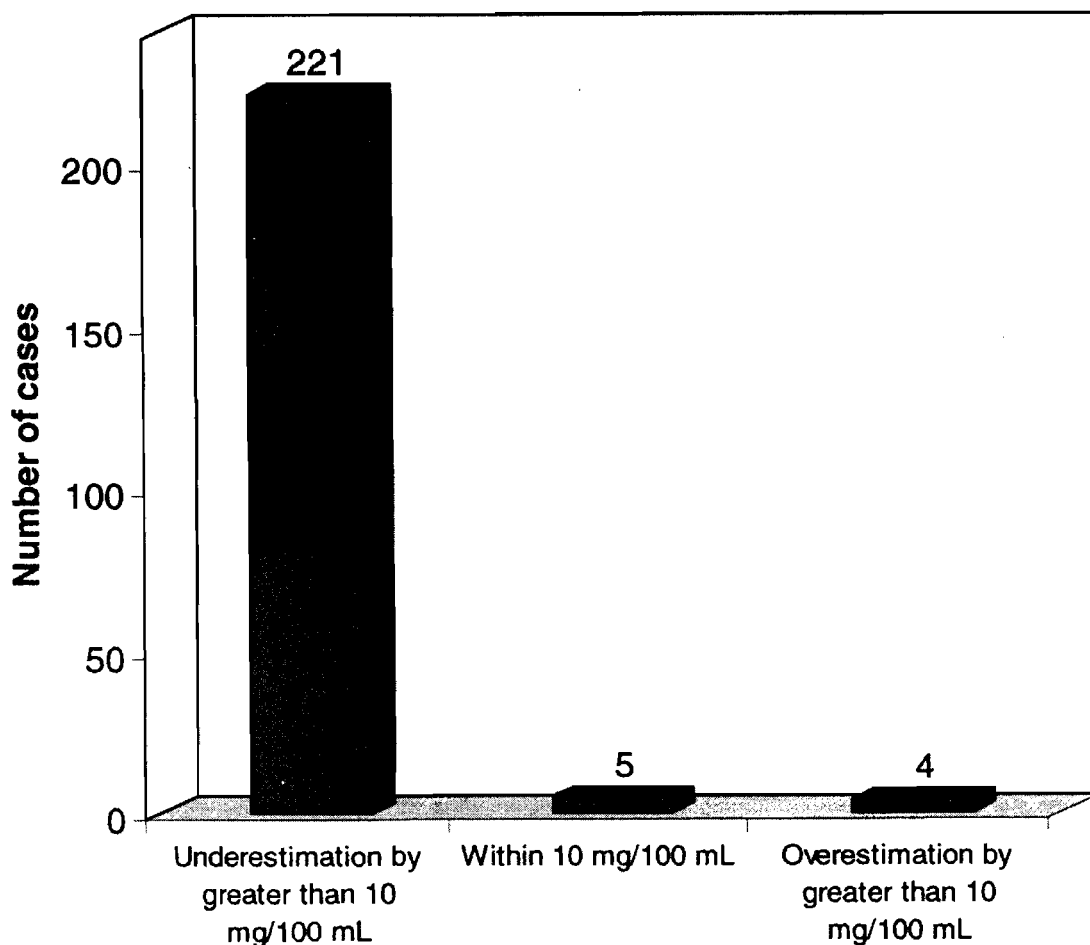


Figure 2. Number of cases in which the eBAC (calculated using a 20 mg/100 mL/h elimination rate) was more than 10 mg/100 mL less than the Intoxilyzer[®] 5000C, within ± 10 mg/100 mL of the Intoxilyzer[®] 5000C result and more than 10 mg/100 mL greater than the Intoxilyzer[®] 5000C result.

strated the reliability of this instrument (14–17). For example, Harding et al. 1990 (14) compared Intoxilyzer[®] 5000 test results with the BAC measured in a blood sample collected within one hour of breath testing for 395 arrested drivers in Wisconsin. It was found that the Intoxilyzer[®] 5000 systematically underestimated BAC by 11.5%, due largely to the fact that the calibration of the instrument is based on a conservative blood/breath alcohol ratio of 2100:1. This underestimation of BAC by the Intoxilyzer[®] 5000 would only cause the underestimation of eBAC in our study to be increased.

The observed discrepancy between eBAC and the Intoxilyzer 5000C results may be due to the different individual elimination rates of alcohol. However numerous studies have shown that the majority of the population eliminate alcohol within the range of 10 to 20 mg/100 mL/h (18,19). In some individuals who consume large quantities of alcohol on a regular basis the elimination rate may be higher than 20 mg/100 mL/h (20, 21). However, if a higher elimination rate were taken into consideration then this would increase the differences between eBAC and the Intoxilyzer[®] 5000C results.

Taking all of the above points into consideration it is suggested that the discrepancies between the eBAC and the Intoxilyzer[®] 5000C results lie with the self-reported drinking

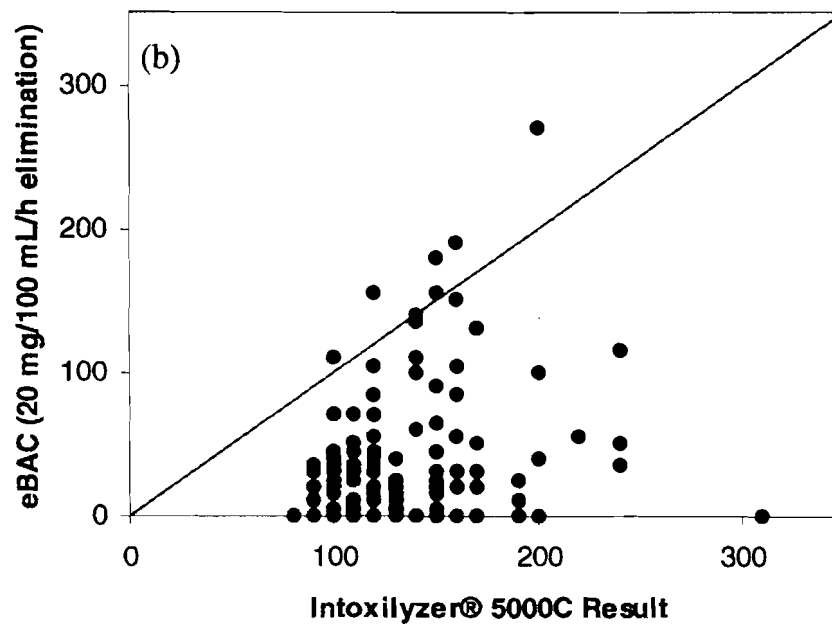
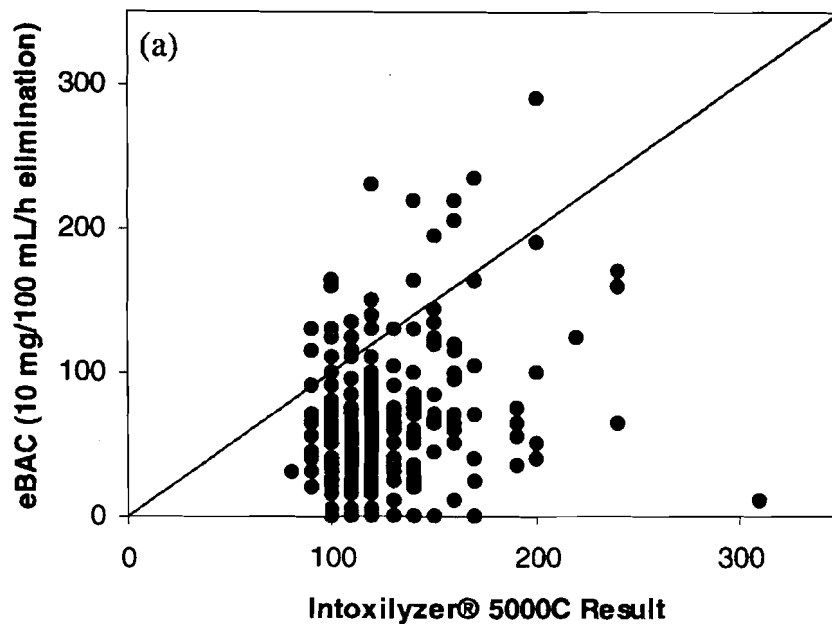


Figure 3. Comparison of estimated blood alcohol concentrations (eBAC) with measured blood alcohol concentrations (Intoxilyzer® 5000C results) using rates alcohol elimination rates of (a) 10 mg/100 mL/h and (b) 20 mg/100 mL/h. An $x = y$ correlation line is shown for reference.

scenarios of the arrested drivers. This conclusion is supported by the findings of other researchers who have noted that the amount of alcohol consumed is often underestimated by drinkers in both laboratory situations and bars (22–26). A review of the literature revealed three studies that examined recall of the amount of alcohol consumed among

drinking drivers (27–29). The most recent and relevant study involved 181 patients who were injured in a motor vehicle accident and treated at a hospital, and had blood alcohol concentrations determined (29). Nurses conducted interviews to determine the drinking histories of these patients before their injuries and detailed histories to enable the calculation of eBAC were obtained from 113 patients. A rate of elimination of 17 mg/100mL/h was employed in this study to calculate eBAC rather than 10 and 20 mg/100mL/h. The results are in close agreement with our findings. Sommers et al (29) reported a correlation coefficient of 0.254 and a mean underestimation of 75 mg/100mL. Our correlation coefficients were 0.25 and 0.27 using elimination rates of 10 mg/100mL/h and 20 mg/100mL/h respectively and our mean underestimations of eBAC were 57 mg/100mL and 105 mg/100 mL respectively.

Alcohol has been shown to impair memory (30–32) and/or decrease awareness of the surrounding environment while drinking (33, 34). Both of these effects offer a potential explanation for a lack of accuracy as to the number of drinks consumed in the published literature and in the current study.

Differences between eBAC and the Intoxilyzer® 5000C results could also be explained if the assumption of a BAC of zero mg/100 mL at the commencement of drinking is incorrect. This would result in an elevated BAC at the time of driving even if the amount of alcohol ingested by the drinking driver has been recalled correctly. For example, it would require between 15 and 30 hours for an individual to reach a zero BAC, if the initial BAC was 300 mg/100mL. Therefore a positive BAC would be “carried-over” if the individual commenced drinking again within this period of time. This carry-over effect was observed in a study of automobile alcohol interlock records of 1,878 convicted drinking drivers in Alberta between 1994 and 1999 (35). The most frequent time for interlock “warns” and “fails” was between 7:00 a.m. and 8:00 a.m. on weekdays and between 11:00 a.m. and 12:00 (noon) on weekends, after a night of drinking. The positive results obtained the morning after drinking the previous night were reported to have been “surprising” and even “revelatory” to some of the offenders (35).

The calculations used to project an eBAC are also dependent on the ethyl alcohol content of the beverage consumed. A review of the alcohol content of beverages available for purchase at “The Beer Store” in Ontario indicates that products may contain as much as 10% alcohol by volume (36). This presents a situation whereby an individual may inadvertently consume one or more beverages that do not conform to the typical “standard drink” (e.g a standard size beer would comprise 12 fl. oz., 5% alcohol by volume) over the course of a drinking scenario. In order to accurately predict an eBAC at a given point in time, the forensic toxicologist requires a precise drinking history, to include the type and amount of alcohol consumed, not only on the day in question but for at least the previous 24 hours as well.

CONCLUSIONS

Estimated BACs based on submitted drinking scenarios from drivers charged with an over 80 offence were significantly lower than a measured BAC using an approved breath testing instrument, the Intoxilyzer® 5000C. We suggest that this discrepancy lies not with the Intoxilyzer® 5000C, but is due to an unreliability of self-reported drinking scenarios in these cases. Whether this stems from memory loss, decreased attention, “carry-over” of a pre-existing BAC, misrepresentation or misunderstanding of the amount of alcohol consumed (due to non-standard size drinks being ingested) is unknown. It is also possible that a combination of these factors could result in a significantly underestimated eBAC calcu-

lated from a drinking scenario in a single case.

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