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ARTICLES

DUPLICATE BREATH ALCOHOL TESTING: SHOULD THE STATUTORY WAIT IN CANADA OF "AT LEAST 15 MINUTES" BETWEEN TESTS BE CHANGED?

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ABSTRACT

A one-year retrospective study was conducted of 2,759 duplicate Intoxilyzer® 5000C test results in the City of Toronto during 1995 with a statutory wait of "at least fifteen minutes" between tests. The time between tests ranged from 19 to 73 minutes (median = 22 minutes). The absolute difference between the first and second breath tests ranged from 0 to 0.042 g/210 L (median 0.007 g/210 L). The distribution of these differences was not normal (KS = 0.1566, skewness = –0.1143). The differences between the truncated first and second tests were not within the recommended 0.02 g/210 L in 7.5% of the paired data. The second test was ≥ 0.01 g/210 L less than the first breath test in 35% of the cases (n=981) but was ≥ 0.01 g/210 L greater than the first breath test in only 7% (n=203) using truncated results. The observed skewness in this distribution is likely due to the elimination of alcohol that occurred during the time between tests. Following the adjustment of the second test to account for the mean pharmacokinetic alcohol elimination rate in drinking drivers, the distribution represented by the difference between the two tests still represented a non-normal distribution (KS = 0.3787) but was less skewed (skewness = –0.0549). The differences between the first and second tests following this pharmacokinetic correction resulted in reduction in the number of tests outside the recommended 0.02 g/210 L difference to 1.6%. It is recommended that the statutory wait of "at least fifteen minutes" in the Criminal Code be changed to a time period of between at least two minutes to five minutes, to reduce the variability between the two test results.

RÉSUMÉ

Une étude rétrospective a été effectuée sur les résultats de 2759 tests d'haleine faits avec l'Intoxilyzer® 5000C dans la ville de Toronto au cours de l'année 1995. Ces tests furent effectués en duplicata en respectant la période d'attente statutaire « d'au moins 15 minutes » entre les tests. La période d'attente entre les tests variait entre 19 et 73 minutes (médiane = 22 minutes). L'écart absolu entre les premiers et seconds tests d'haleine variait entre 0 et 0,042g/210L (médiane = 0,007g/210L). La distribution de ces différences ne correspond pas à une distribution normale (KS = 0,1566, asymétrie = –0,1143). Les écarts entre les résultats tronqués des premiers et seconds tests ne se situaient pas à l'intérieur de la norme de 0,02 g/210L recom-

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mandée dans 7,5% des données appariées. En utilisant des résultats tronqués, dans 35% des cas (n=981) le résultat du second test était inférieur au premier de ≥ 0,01 g/210 L et dans 7% (n=203) le second test était supérieur au premier de ≥ 0,01 g/210 L. L'asymétrie observée dans cette distribution est vraisemblablement due à l'élimination de l'alcool entre les deux tests. Lorsque le second test est corrigé pour tenir compte de cette élimination, la distribution représentée par la différence entre les deux tests demeure toujours asymétrique (KS = 0,3787) mais moins accentuée (asymétrie = –0,0549). Les différences entre les premiers et seconds tests obtenus à la suite de la correction pharmacocinétique ont permis une réduction de 1,6% du nombre de tests à l'extérieur de la norme recommandée de 0,02 g/210L. Il est recommandé que la période statutaire « d'au moins 15 minutes » entre les tests fixée dans le Code criminel soit réduite à 2 ou 5 minutes afin de diminuer la variabilité entre les résultats des deux tests.

INTRODUCTION

Since 1969 the Criminal Code of Canada has required, in part, that two breath alcohol tests be conducted "at least fifteen minutes apart" in order for the crown attorney to have the benefit of a two-hour presumption. With this presumption, a forensic toxicologist is not required at a criminal trial to back-calculate the blood alcohol concentration (BAC) to the time of the incident (1). The Court of Appeal in Ontario has determined that "at least fifteen minutes" means that the police should wait at least 17 minutes in order to take into account differences in timing the first and last minute (2). Other jurisdictions, however allow for a shorter time interval between breath tests. For example, the states of Wisconsin and Washington only require a wait of at least three minutes between tests (3). In Great Britain, the time between two breath tests is also three minutes (4). The National Safety Council Committee on Alcohol and Other Drugs of the United States maintains that at least two separate breath samples should be collected at intervals of not less than two minutes and not more than ten minutes (5).

This study was conducted to determine the time interval that actually occurs in the field using the results from the City of Toronto, and if this time interval affects the differences between the duplicate breath alcohol results.

MATERIAL AND METHODS

This one-year retrospective study covered the period between January 1st 1995 and December 31st 1995 in the city of Toronto, with the co-operation of the Toronto Police Services. The Intoxilyzer® 5000C (CMI Inc. Owensboro KY, USA) is the sole evidential breath alcohol testing instrument used by the Toronto Police Service and is designated by the Federal Minister of Justice as an approved instrument in Canada. This instrument is computerized and automatic, and uses infrared light to determine a blood alcohol concentration (BAC) from a breath alcohol concentration (BrAC) (6). The instrument records details of the breath alcohol testing sequence, including the BrACs recorded to three digits, and the time of the tests. In order to ensure a minimum time period or wait of at least 17 minutes has elapsed, the Intoxilyzer® 5000Cs used in Toronto have a lockout timer that prevents the qualified breath technician from initiating a second breath test until 17 minutes have elapsed. As several minutes are required for the breath alcohol testing sequence, a second breath alcohol test cannot be conducted for approximately 19 minutes. During the study period, 13 Intoxilyzer® 5000Cs were in use in Toronto and the data stored in these instruments are the basis of this study.

The BrACs are reported in this study as grams of alcohol in 210 litres of breath (g/210L), the units that is widely used in the United States. It is equivalent to the units used

in the *Criminal Code* of milligrams of alcohol in 100 millilitres of blood (mg/100mL) with the appropriate blood to breath alcohol conversions. The BrAC conversion is based on a forensically accepted blood to breath alcohol ratio of 2100 to 1. The Criminal Code and the Alcohol Test Committee (an advisory committee to the Federal Department of Justice) use mg/100mL to define BACs, whether they are obtained from blood or breath samples (7). Only BrACs > 0.020 g/210L were evaluated.

Results were examined for normal distribution using the Kolmogorov-Smirnov (KS) test. Skewness from the normal distribution was reported as required. The Mann-Whitney *U*-test was used for the comparison of the medians of continuous variables. Significance was determined at $P < 0.05$.

RESULTS AND DISCUSSION

The wait or time interval between two Intoxilyzer® 5000C tests conducted on 2,759 arrested drinking drivers in the city of Toronto during 1995 ranged from 19 to 73 minutes (median = 22 minutes). Figure 1 shows the distribution of the time intervals. Some of the long time intervals between the tests were due to the driver changing their minds during the "at least fifteen minutes" wait between the two breath tests and requesting to speak to a lawyer before providing a second breath test.

Figure 2 shows the absolute differences between the two Intoxilyzer® 5000C tests for both the truncated test results and the untruncated test results. Both the Alcohol Test Committee and the US National Safety Council Committee on Alcohol and Other Drugs recommend that breath test results should be truncated or reported to two significant figures (4, 6). After truncation, 206 of the duplicate results (7.5%) were not within the recommended 0.02 g/210L and consequently a third breath test should have been conducted (Figure 2).

Figure 3 shows the signed differences between the first and second Intoxilyzer 5000C tests for both truncated and untruncated results. The medians of these data are significantly different from each other. Both distributions are skewed towards the left or to a lower second Intoxilyzer test result ($KS_{untruncated} = 0.1566$, $skewness_{untruncated} = -0.1143$). Eleven times as many second Intoxilyzer tests were 0.01 g/210 L or more lower than the first test (n=839) compared to 75 second Intoxilyzer tests which were 0.01 g/210 L or more, greater than the first test. Using the truncated data, nearly nine times as many second Intoxilyzer tests were 0.01 g/210L or more, lower than the first test (n=1273) compared to 143 second Intoxilyzer tests which were 0.01 g/210L or more, greater than the first Intoxilyzer tests (Table 1). This type of skewed distribution does not occur in jurisdictions where duplicate breath tests are conducted at a much shorter time interval of three to five minutes. The number of higher and lower second breath tests are more equally distributed around zero (8,9).

For duplicate breath alcohol testing with short time intervals there are two main reasons for the differences in the results. One is biological variability, primarily differences in exhalation patterns such as pressure and length of exhalation. Hypo- and hyper-ventilation and breath temperature are also potential factors (10–13). It has been estimated that biological variability accounts for approximately 80 to 90% of the differences in two successive breath alcohol tests (14). Another reason for the differences in two successive breath tests with a short time interval is analytical variability. This has less effect on the differences than biological variability as the analytical variability of the Intoxilyzer® 5000C is low. Under laboratory conditions the coefficient of variation for the Intoxilyzer® 5000C in simulator studies has been found to be 1.6% at a target vapour alcohol concentration of 0.100 g/210L (15).

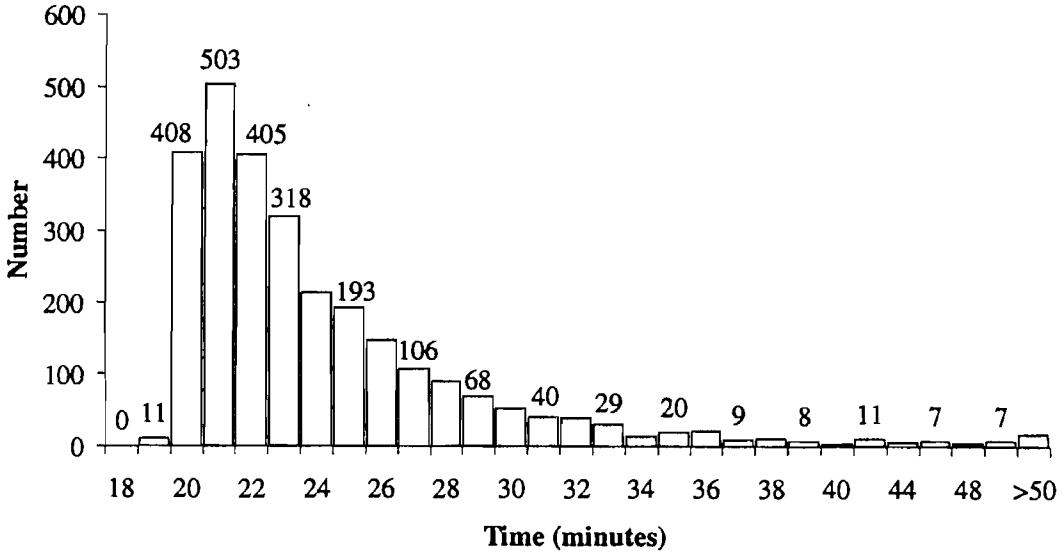

Figure 1. The time interval between the first and second breath tests ranged from 19 to 73 minutes (median = 22 minutes, n = 2759).

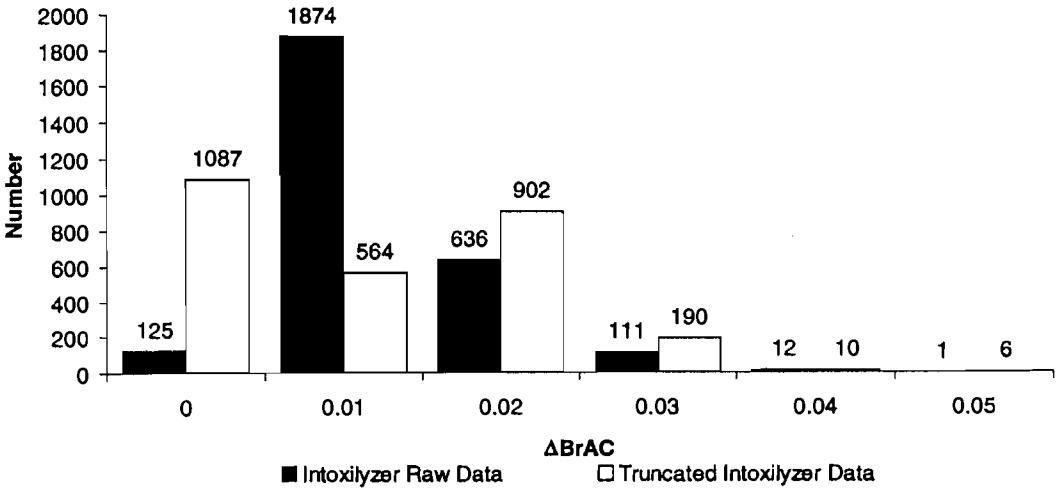

Figure 2. The absolute difference between two Intoxilyzer® 5000C breath tests (g/210L).

In duplicate breath samples with a long time interval between tests, such as in Toronto, where the median interval is 22 minutes, another factor affects the differences between the results. This factor is due to the change in blood alcohol concentration by elimination that can occur during that period of time. In drinking drivers, the average rate of elimination has been found to be approximately 0.019 g/210L/h (16–18). In the median time interval between the first and the second Intoxilyzer test, the drinking driver may eliminate approximately 0.007 g/210L. This pharmacokinetic factor is, therefore, even greater than the effect of the analytical variability of the instrument and causes a skew in the distribution of the difference between each Intoxilyzer test that is not observed in jurisdictions in which the time interval between tests is short.

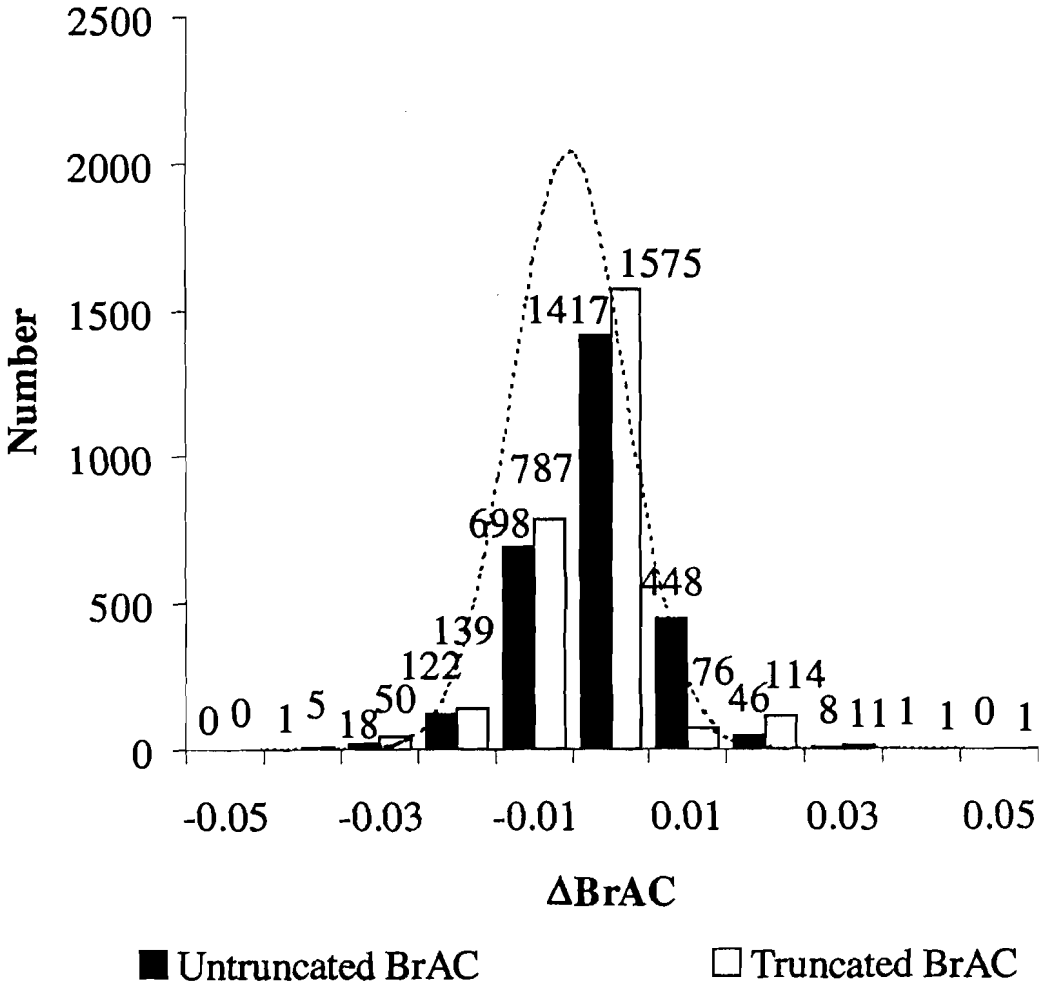

Figure 3. The difference between the first and second test (g/210L). Most second tests were less than the first (median –0.006) (n=2133 untruncated second tests < first test). The dotted line indicates a normal distribution about the median (-0.006) of the untruncated differences.

This effect is seen in Figure 4 in which the second Intoxilyzer test has been corrected by adjusting for the time between the tests and using the average rate of elimination of 0.019 g/210L/h (i.e. the pharmacokinetic factor) in drinking drivers. When this correction for the time interval is applied, the distribution becomes significantly less skewed (skewness$_{untruncated}$ = –0.0549). Gullberg observed a similarly skewed distribution (–0.020) in the differences between two tests conducted from three to five minutes apart (9). This reduction in the skewness following pharmacokinetic correction can be illustrated by a reduction in the number of cases where the second test was 0.01 g/210 L or more, lower than the first test (Table 1). The percentages of tests in which the second result was ≥ 0.01g/210 L less than the first were 30% (untruncated) and 46% (truncated). After being corrected for the pharmacokinetic factor, these percentages were reduced to 6.7% and 11%, respectively. After truncation, only 59 (2%) are not within the recommended truncated difference between results of 0.02 g/210L, which is substantially less than the 7.5% found if the pharmacokinetic factor is not considered. Finally, the median difference

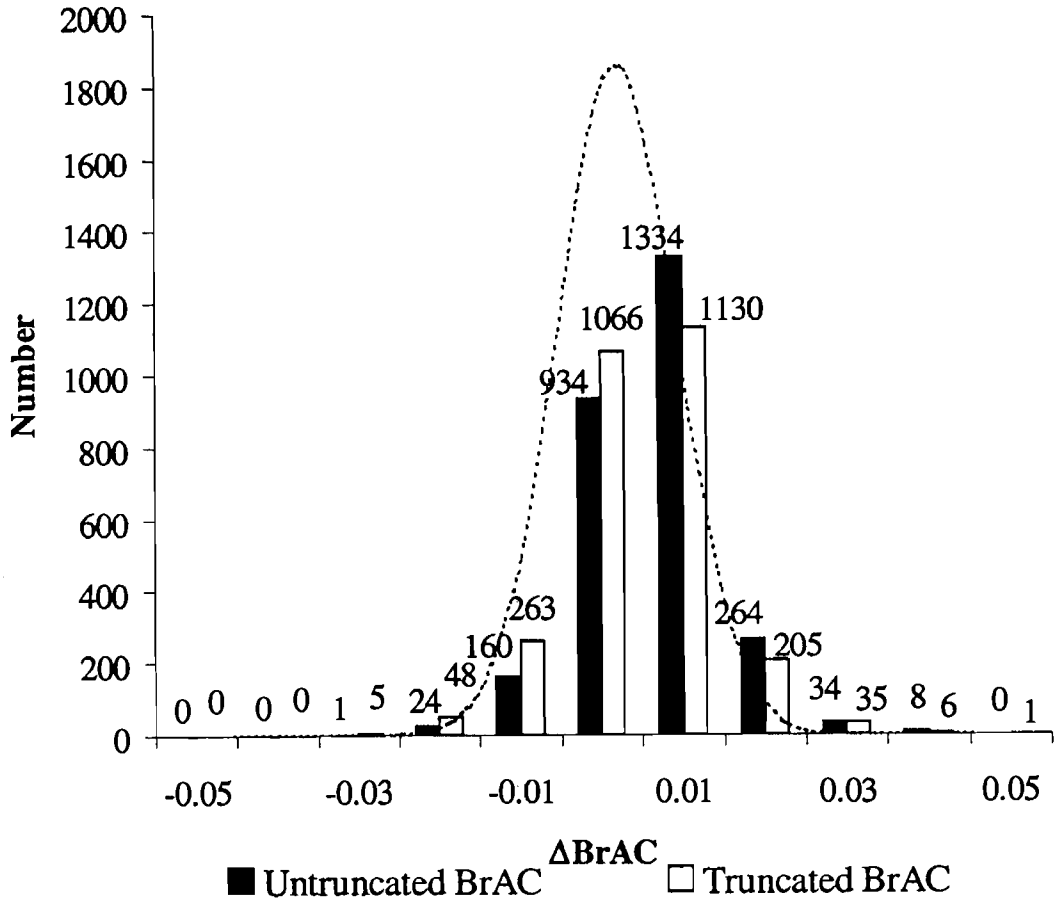

Figure 4. After accounting for elimination during the wait between the two tests using an average elimination rate of 0.019g/210L/hr. The distribution of the differences between tests (g/210L) becomes less skewed. The dotted line indicates a normal distribution about the median (0.002) of the untruncated corrected differences.

between two uncorrected tests was –0.006 g/210 L and when corrected becomes 0.002 g/210 L, a value that is within the analytical variability of the instrument.

The interval of "at least fifteen minutes" has been in the Criminal Code since 1969 and was introduced in part because of initial concerns regarding possible mouth alcohol effects in the field. A fifteen-minute wait between breath tests and good duplication of the two results would ensure that there was no mouth alcohol effect. Since 1969 it has been found that the possibility of the mouth alcohol effect in evidentiary breath alcohol tests conducted at the police station is remote. A study conducted in Wisconsin, in which one breath sample and one blood sample were collected, found no evidence of the mouth alcohol effect at the police station, when the breath test results were compared to each subject's actual blood alcohol concentration (19). Even in the uncontrolled situations in the field in which the suspected drinking drivers were tested on an approved alcohol-screening device, the incidence of mouth alcohol effect was only 0.25% (20). This incidence would be virtually non-existent by the time of the evidentiary test at the police station, as the average time between the approved screening test and the Intoxilyzer® 5000C test was 1.1 hours

TABLE 1

Number of tests in which the difference between the second and first breath result is ≥ 0.01 or ≤ –0.01 g/210 L. Individual breath tests were considered untruncated or truncated and corrected for the pharmacokinetic factor or uncorrected. Values are expressed numerically and as a per cent of the total number of samples (n=2759).

	Uncorrected		Corrected	
	≤ –0.01	≥ 0.01	≤ –0.01	≥ 0.01
Untruncated	839 (30%)	75 (2.7%)	185 (6.7%)	306 (11%)
Truncated	1273 (46%)	143 (5.2%)	316 (11%)	247 (9.0%)

(20). Any potential exogenous mouth alcohol effect would have been dissipated during that time interval in police custody.

The only potential mouth alcohol effect that could occur once the arrested driver is in police custody is from endogenous sources such as blood in the mouth, regurgitation of stomach contents or belching. Recently, it has been shown that blood in the mouth, which could occur from minor cuts or dental work has no significant mouth alcohol effect (21). Alcohol from the stomach from possible hiatus hernias or gastroesophageal reflux disease has been found to cause no significant mouth alcohol effect under practical conditions (22, 23). Belching immediately prior to exhalation into the Intoxilyzer would have no significant effect as any gas from the stomach will be exhaled into and out of the instrument sample chamber and be replaced with the accurate end-expiratory breath sample (23).

A detailed study of the potential for mouth alcohol affecting the results of evidential breath alcohol test results in Great Britain (which has a three minute wait between tests) concluded "In our view the incidence and effects of mouth alcohol on breath testing have been exaggerated. Even if it does occur, its effect is small and short-lived. We do not believe that mouth alcohol results in unjust prosecutions" (24).

Lastly since the mouth alcohol effect is an exponential function, the greatest change in BrAC is within the first several minutes (25, 26). This change would still be detected with a shorter interval between tests. For all of these reasons, the "at least fifteen minutes" wait between tests is no longer warranted to protect against a possible mouth alcohol effect. A shorter time interval between tests would be as effective in ensuring no significant mouth alcohol effect. It would eliminate the pharmacokinetic factor (i.e. a better duplicate breath test agreement) and allow for more rapid and efficient processing of arrested drinking drivers.

CONCLUSIONS

The "at least fifteen minutes" wait between breath tests as specified in the Criminal Code since 1969, is an unnecessary and outdated requirement. A shorter wait of between two to five minutes, as used in other jurisdictions, would be just as effective in preventing the potential biasing effect of mouth alcohol and allow for a better agreement of duplicate breath samples, and a more efficient and rapid processing of arrested drinking drivers.

ACKNOWLEDGEMENTS

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