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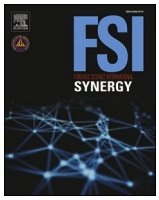

Small samples, big problems—the inability to provide a sample in breath alcohol testing: Case reports

Aaron Olson *

ARO Consulting LLC, PO Box 132, Hugo, MN, 55038, USA

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ABSTRACT

Breath alcohol testing is a cornerstone of impaired driving investigations, yet some individuals are physiologically unable to provide adequate breath samples, leading to charges of refusal despite efforts to comply. This paper presents seven case reports of individuals who failed to meet the minimum volume requirements of the DataMaster DMT breath alcohol analyzer due to factors such as age, gender, respiratory conditions, and smoking history. Despite seemingly genuine attempts to provide valid samples, these individuals were charged with refusing to submit to a chemical test.

The case reports in this paper highlight the vulnerabilities in current testing protocols, including the one-size-fits-all volume requirement, equipment problems, measurement uncertainty, individual anxiety, operator bias, and lack of transparency. Proposed improvements include alternative testing methods (e.g., blood or urine), individualized volume requirements, enhanced operator training, slope-based sampling, changes in equipment design, regular volume calibration, mandatory data collection, and independent scientific review.

1. Introduction

Breath alcohol testing is used by law enforcement to estimate a person's blood alcohol concentration (BAC) in impaired driving investigations. Occasionally, a person submitting to a breath alcohol test fails to meet the minimum volume requirements for an adequate sample.

Individuals who fail to provide an adequate breath alcohol sample are often assumed to be purposefully withholding their breath to evade testing. However, the literature does not support the assumption that all individuals are equally capable of providing valid breath samples [1–19]. Individuals with lung diseases such as asthma, chronic obstructive pulmonary disease (COPD), or who are suffering from a respiratory infection sometimes fail to provide enough breath [20]. Additionally, Ives examined a large spirometry database and found that females, smokers, individuals of short stature, and those over the age of 40 were at an increased risk of not being able to provide a sample into a breath alcohol analyzer [21].

Previous studies have shown that the ability to provide a sample depends on the breath analyzer used, with some devices having a higher success rate than others [5,13,15,18]. Minimum volume requirements vary by device but typically require a minimum volume of 1.1–1.5 L, with some analyzers requiring more breath at higher flow rates [10]. Breath analyzers also have minimum flow rates, a minimum number of seconds required to blow, and a minimum back pressure to overcome.

Previous work has found that forced vital capacity (FVC) is correlated with the ability to provide a sample; however, the relationship is not one-to-one [2–5,8,9,14–16,18,19,21]. For example, Honeybourne tested individuals with lung diseases on the Lion Intoxilyzer 6000, which required 1.2 L of breath, yet 8 out of 9 individuals who failed to provide a sample had an FVC of more than 1.5 L [18].

This paper highlights seven case reports of individuals who failed to provide adequate samples into the DataMaster DMT (Intoximeters, Inc., St. Louis, MO, USA). The individuals appeared to be attempting to provide a valid breath sample but could not give enough breath to complete the test. The individuals in the case reports were charged with refusing to submit to a chemical test. In the United States, those who are charged with refusing a test receive harsher penalties [22]. For example, in Minnesota, those charged with refusing a test are given the same penalties as those over twice the legal limit for alcohol [23].

2. Method

The case reports highlighted below were selected from cases where the author was hired to evaluate the breath alcohol test of an impaired

* PO Box 132, Hugo, MN, 55038, USA
E-mail address: aaron@aaronolson.expert.

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driving investigation. Seven cases were selected from a total of 17 cases where the author served as a consultant in low-volume breath sample cases during 2023 and 2024. The selection criteria to be included in the case reports were as follows:

1. The cases were unique.
2. The subject appeared to make genuine attempts to provide a breath sample.
3. The complete expirogram data and video evidence were available for review.
4. The cases involved the DataMaster DMT breath alcohol analyzer.
5. The subjects were charged with refusing to submit to a chemical test.

Ten cases in total were excluded from the case reports. The cases excluded were due to incomplete data (2 cases), ambiguous effort from the subject (5 cases), or similar facts already presented in the other cases (3 cases).

The DataMaster DMT used in the cases presented required a minimum flow rate of 2.87 L/min to begin recording volume and a total volume of 1.5 L. During the test, the subjects had 3 min to provide a sample. The expirogram data for the case reports are available in an online repository [24].

3. Case reports

3.1. Case 1

A 5' 10", 195-pound, 57-year-old caucasian male was administered two evidential breath alcohol tests. He made multiple attempts to provide a valid breath sample, blowing 1.43 L into the analyzer.

During his first test, the mouthpiece came loose from the breath tube and fell on the floor, indicating an improper seal. After several attempts, he told the Officer that he was "old" and that he was "done."

The subject was charged with refusing to submit to a chemical test.

3.2. Case 2

A 5' 5", 132-pound, 64-year-old caucasian female was administered two evidential breath alcohol tests. She made multiple attempts to provide a sample, blowing a maximum volume of 1.31 L on her first test and 1.14 L on her second test, failing to meet the minimum volume.

While the woman was attempting to provide breath samples, she coughed several times and told the Officer that she was getting dizzy. She also told him, "I smoke; I've smoked since third grade." The Officer replied, "You should still be able to do it."

The subject failed to provide an adequate sample and was charged with refusing to submit to a chemical test.

3.3. Case 3

A 5' 1", 110-pound, 78-year-old caucasian female was administered a single evidential breath alcohol test. She made multiple attempts to provide a breath sample but was unable to complete the test. The analyzer recorded her highest volume as 0.70 L.

The Officer conducting the test told the subject, "The more you stop, the longer it's going to take," to which the subject replied, "I'm not stopping dumb***!"

The subject failed to provide an adequate sample and was charged with refusing to submit to a chemical test.

After the test, the subject visited a physician for a pulmonary function test. The test indicated an FVC of 1.6 L.

3.4. Case 4

A 6' 0", 250-pound, 57-year-old caucasian male was administered a single evidential breath test. His medical records showed that he suffered from shortness of breath, asthma, atrial fibrillation, and lung scarring. He attempted to provide a breath sample but could not complete the test. His highest recorded volume was 1.25 L.

After the test, the officer told the subject, "I believe you are trying to manipulate the test." The subject replied, "I tried my best. I have a lot of health issues."

The subject failed to provide an adequate sample and was charged with refusing to submit to a chemical test.

3.5. Case 5

A 5' 5", 122-pound, 47-year-old caucasian female was administered two breath alcohol tests. She made multiple attempts to complete the test, blowing 1.36 L on her first and second tests. During both tests, the mouthpiece fell off of the breath tube, indicating an improper seal.

Despite a real-time graph on the analyzer depicting flow rates above the minimum threshold, the officer administering the test told the subject to try harder and stated that he "could see on the DMT that there was no flow being registered." The subject protested that she was trying, saying, "I have RSV," and "I'm telling you that my lungs hurt. So, can you, maybe, give me a different direction or something?"

Her medical records showed that she had been diagnosed with respiratory syncytial virus (RSV) five days before the test.

She failed to provide an adequate sample and was charged with refusing to submit to a chemical test.

3.6. Case 6

A 5' 9", 155-pound, 56-year-old caucasian male was administered two breath alcohol tests. The subject indicated that he was a smoker. During the tests, the subject was wheezing and coughing, interrupting the continuous flow of breath into the analyzer. He made multiple attempts to provide a valid sample with a maximum breath volume of 1.38 L.

During the test, the Officer administering the test conferred with another officer saying, "It seems like he's farting around a little bit and he's like making a big show of hacking up a lung and keeps talking about how he …. he just can't do it. So I'll try giving him another breathalyzer, but then I might just refuse him."

The subject failed to provide an adequate sample and was charged with refusing to submit to a chemical test.

3.7. Case 7

A 5' 8", 120-pound, 29-year-old asian female was administered two breath alcohol tests. She made multiple attempts to provide a valid breath, with her best efforts being 1.30 L on the first test and 1.37 L on the second.

During the test, the subject asked the officer, "Did it work?" The Officer replied, "No, you're not blowing at all," while a real-time graph showed a valid flow rate. After the second test was finished, the officer told the subject that he would be charging her for refusing to submit to a chemical test. The subject protested, saying, "Are you kidding? I was blowing in it." and "That's not fair, I tried to do it."

The subject failed to provide an adequate sample and was charged with refusing to submit to a chemical test.

4. Discussion

The above case reports demonstrate the difficulties faced by individuals with respiratory issues and vulnerable populations (those over the age of 40, women, smokers, and those of short stature) when attempting to provide breath samples for alcohol testing [21].

Table 1 summarizes the gender, race/ethnicity, age, height, maximum volume achieved, percentage of required volume, predicted FVC [25], and any known respiratory issues of the subjects.

Table 1
Gender, race/ethnicity, height, age, maximum volume achieved, percentage of required volume, predicted FVC, and known respiratory issues of the case subjects.

Case	Gender	Race/ ethnicity	Height	Age	Maximum Volume Achieved (L)	Percent of Required Volume Achieved	Predicted FVC (L)	Respiratory Issue
1	Male	Caucasian	5′ 10″	57	1.43	95 %	4.8	Unknown
2	Female	Caucasian	5′ 5″	64	1.31	87 %	3.8	Smoker
3	Female	Caucasian	5′ 1″	78	0.70	47 %	2.7	Unknown
4	Male	Caucasian	6′ 0″	57	1.25	83 %	5.2	Asthma, lung scarring
5	Female	Caucasian	5′ 5″	47	1.36	91 %	4.3	Respiratory syncytial virus
6	Male	Caucasian	5′ 9″	56	1.38	92 %	4.7	Smoker
7	Female	Asian	5′ 8″	29	1.37	91 %	4.3	Unknown

The mean volume achieved in the above cases was 1.25 L (range, 0.70–1.38 L), with the mean percentage of required volume being 84 % (range, 47–95 %). The predicted FVC would seem to indicate that all subjects should have been able to meet the minimum volume requirements of the DataMaster DMT of 1.5 L. However, as previous investigators have found, there is not a one-to-one correlation between FVC and the ability to provide a valid sample into a breath alcohol analyzer [2–5,8,9,14–16,18,19].

The one-size-fits-all approach to breath sampling fails to account for individuals' diverse physiological limitations. Charging these individuals with "refusal to submit to a chemical test" may be unfair and inaccurate, as it implies a deliberate refusal rather than a physical inability.

4.1. Uncertainty of volume measurements

Cases 1, 5, 6, and 7 raise a unique challenge related to the breath alcohol analyzer's ability to measure volume accurately. In those cases, the subjects provided enough breath volume to come within the tolerance limits of the analyzer's ability to measure volume. During annual calibration, the analyzer was tested against a 3 L reference syringe. The analyzer was required to measure within ±0.15 L of the reference value. Given that the subject volume came within ±0.15 L of the minimum requirement of 1.5 L, it is possible that the individuals provided the minimum volume, but due to measurement limitations, the breath was not accepted.

The ability of a breath alcohol analyzer to measure volume should be checked at the minimum threshold rather than an arbitrary volume, such as 3 L. Furthermore, some jurisdictions do not regularly check the breath analyzer's ability to measure volume or verify the manufacturer's minimum flow rate or volume requirements. For example, in the state of Minnesota in 2019, defense counsel discovered that the manufacturer of the DataMaster DMT had misrepresented the minimum flow rate requirement [26]. Additionally, Morris and Taylor found that as the flow rate increased, the minimum volume requirement also increased [10].

4.2. Instrument errors

In Minnesota in 2011, defense counsel discovered that the Intoxilyzer 5000EN (CMI, Inc., Owensboro, KY, USA) had a programming error, which caused samples that met the minimum volume of 1.1 L to be rejected [27]. The Minnesota Bureau of Criminal Apprehension, responsible for maintaining the instrument, had received a software patch to fix the problem in 2007 but failed to install it. This situation highlights the need to hire high-quality personnel and have an independent third-party software review [28,29].

Breath alcohol analyzers have a series of tubes and valves that direct airflow into the sample chamber. The valves have distinct positions that allow reference gas from a cylinder to flow into the chamber when appropriate. Occasionally, one of the valves on the DataMaster DMT gets stuck in a position that does not allow the subject to blow into the sample chamber [30]. If the valve sticks intermittently, the operator will have no way of knowing that this has occurred. In cases where this is suspected to have happened, it is essential to review the video and data collected by the instrument and listen carefully to the subject's personal experience.

4.3. Mouthpiece errors

In case reports 1 and 5, the mouthpiece fell off during sample delivery. Due to manufacturing errors, some mouthpieces do not fit snugly onto the breath tube. If the mouthpiece does not attach properly to the instrument, it can leak breath, causing the subject to fail to meet the minimum sample volume.

Additionally, in 2023, the Alaska State Crime Detection Laboratory (ASCDL) distributed a memo to defense agencies alerting them of a manufacturing defect in the mouthpieces used on their breath alcohol analyzer [31]. The memo stated that some of the mouthpieces had a "… plastic blockage, resulting in a subject not being able to provide a successful breath."

4.4. Back pressure

Another consideration for low-volume samples is the amount of pressure required to overcome before the analyzer begins recording a minimum volume. As discussed in case report 6, overcoming this pressure sometimes causes the subject to produce a rapid dry cough [2]. In 1975, Dubowski mentioned this problem and called for a radical redesign of the mouthpiece to allow more air to flow into the analyzer [32]. He noted that mouthpieces used for common pulmonary testing have large bores, allowing unrestricted flow, while those designed for breath alcohol testing have small bores, restricting flow.

4.5. Operator bias

Forensic toxicological analysis and interpretation are not immune to bias [33–35]. The officer administering the breath alcohol test is usually the officer who arrested the subject. Officers typically only have 2–40 hours of breath alcohol-related training [36,37]. This situation can introduce an element of confirmation bias, as the officer may want to confirm that there was a good reason for the arrest [38,39]. Charging the subject with refusing to submit to a chemical test provides a way to support their arrest.

Breath alcohol training programs should train breath test operators to provide a blood or urine sample in cases where the ability to provide a sample is questioned. It may also be helpful to remove the arresting officer from the testing process and have specialized technicians trained to conduct breath alcohol tests. At a minimum, breath test operators should receive specialized training in dealing with individuals who may not be able to provide a sample and in learning how to mitigate bias.

4.6. Anxiety

The breath alcohol test requires the subject to perform a single exhalation breathing maneuver. Learning the maneuver takes practice. For many, this is a new and unusual task that, when coupled with the

anxiety caused by being arrested [40,41], can reduce respiratory function, exacerbate respiratory muscle tension, and increase respiratory symptoms [42–44].

4.7. Breath test operator training

There is considerable guidance for respiratory therapists on coaching patients to optimize their performance on pulmonary tests [45]. Coaching efforts include verbal encouragement, demonstrations, vocal feedback on performance, observing nonverbal cues, and graphically displaying the patient's efforts.

Officers should be trained to demonstrate the proper single exhalation maneuver and spot individuals with reduced lung capacity. Given the adversarial relationship between the arresting officer and the subject, it may be optimal to outsource this process to a neutral third-party technician trained in breath alcohol testing.

4.8. Minimum volume requirements

Evidential breath alcohol analyzers such as the DataMaster DMT, Intoxilyzer 9000, and the Alcotest 9510 require a minimum of 1.1–1.5 L of breath for an acceptable test. The requirements vary depending on the software tailored to the jurisdiction. In addition, instruments have different levels of back pressure that must be overcome before an analyzer will accept a sample. More research is needed regarding the back pressure for each instrument.

Requiring a minimum volume means that some individuals will not be able to meet it. Instead, analyzers could be programmed to automatically capture a sample after the breath alcohol slope achieves a pseudo-plateau and begins to level out. However, more work is needed to standardize volume requirements, back pressure, and flow rates across various devices [46].

4.9. The need for openness and transparency in breath alcohol testing

Openness and transparency are fundamental to scientific inquiry and promoting justice [47]. A review of the scientific literature related to the inability to provide a breath sample comes from Australia, the UK, and Canada. It is not surprising that none of the literature arises from the USA, given that all of the major breath alcohol manufacturers refuse to sell their devices to scientists independent of law enforcement. Manufacturers of breath alcohol analyzers should rethink their policies in light of ISO 17025 impartiality requirements [48].

In addition to the limited access to breath alcohol analyzers by independent scientists, many analyzers do not save the digital expirogram data, which includes flow rate, breath alcohol concentration, and time spent blowing. Indeed, some breath alcohol programs have specifically requested that this data not be collected or stored on the instrument.

The expirogram data is essential to the analysis and interpretation of the breath sample. It includes data related to the quantity, concentration, and quality of the sample, as well as the total volume and time spent blowing [49]. As shown in the case reports above, this additional data may provide exculpatory evidence when a subject is charged with the refusal to submit to a test. Modern breath alcohol analyzers are capable of producing and retaining such data. This data should be stored in a central repository and available for online retrieval [29].

Manufacturers should also allow their source code to be audited by independent investigators to ensure that proper calculations related to flow rate and volume are taking place [50,51].

5. Conclusion

A conviction of refusing to submit to a breath alcohol test can result in severe penalties that negatively impact a person's life. These include restrictions on travel, employment opportunities, the ability to obtain life insurance, and child custody determinations. Individuals making genuine attempts to comply with testing should not face punitive measures designed for those deliberately evading the test.

Equipment malfunctions, measurement uncertainty, restrictive design features, anxiety/stress, operator bias, and inadequate training further exacerbate these issues, undermining the fairness and reliability of the testing process.

The following improvements to the current situation should be considered:

1. Slope-based sampling or individualized volume requirements based on age, height, sex, smoking history, and other physiological variables.
2. Enhanced operator training with a focus on recognizing physiological limitations and mitigating cognitive bias.
3. Require breath alcohol technicians (not the arresting officer) to conduct breath alcohol tests to mitigate the adversarial nature of the test.
4. Modify instruments to allow for large bore mouthpieces and tubing with less restrictive airflow and lower back pressure.
5. Alternative testing options (blood or urine) should be used when breath sample collection is problematic.
6. Regular calibration of volume measurement across the full operational range.
7. Greater transparency through mandatory data collection, storage, and data availability.
8. Independent scientific review of the breath alcohol analyzer's functioning and source code by researchers outside of law enforcement.

The current approach to breath alcohol testing fails to accommodate individual respiratory differences. The above improvements will ensure that the testing process is more fair for vulnerable individuals with reduced respiratory function.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this manuscript, the author used Claude (Anthropic), Grok (xAI), and Gemini (Google) to assist with language refinement, readability, and grammatical improvements. These tools were used to improve the clarity of the writing, identify redundancies, suggest more concise wording, and check for grammatical errors. All content was carefully reviewed, edited, and verified for accuracy by the author, who takes full responsibility for the final content. No analysis, interpretation of results, or scientific conclusions were generated by AI tools.

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Declaration of competing interest

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References

[1] S.J. Quantrill, Failure to provide evidential breath specimens in females, J. Forensic Leg. Med. 82 (2021) 102210, https://doi.org/10.1016/j.jflm.2021.102210.

[2] L.M. Seccombe, P.G. Rogers, L. Buddle, B. Karet, G. Cossa, M.J. Peters, E.M. Veitch, The impact of severe lung disease on evidential breath analysis collection, Sci. Justice 56 (2016) 256–259, https://doi.org/10.1016/j.scijus.2016.04.004.

[3] A. Stephens, S.D. Franklin, Level of lung function required to use the Camic Datamaster breath alcohol testing device, Sci. Justice 41 (2001) 49–52, https://doi.org/10.1016/S1355-0306(01)71848-5.

[4] J.E. Briggs, H. Patel, K. Butterfield, D. Honeybourne, The effects of chronic obstructive airways disease on the ability to drive and to use a roadside alcolmeter, Respir. Med. 84 (1990) 43–46, https://doi.org/10.1016/s0954-6111(08)80093-5.

[5] A.J. Crockett, D.A. Schembri, D.J. Smith, R. Laslett, J.H. Alpers, Minimum respiratory function for breath alcohol testing in South Australia, J. Forensic Sci. Soc. 32 (1992) 349–356, https://doi.org/10.1016/s0015-7368(92)73091-6.

[6] P.J. Gomm, C.G. Broster, N.M. Johnson, K. Hammond, Study into the ability of healthy people of small stature to satisfy the sampling requirements of breath alcohol testing instruments, Med. Sci. Law 33 (1993) 311–314, https://doi.org/10.1177/002580249303300408.

[7] S. Dowling, D. Reynolds, A. O'Reilly, G. Nolan, C. Gallagher, D. Cusack, A clinical investigation into the ability of subjects with a lung disease to provide breath specimens using the Dräger 6510, J. Forensic Leg. Med. 72 (2020) 101962, https://doi.org/10.1016/j.jflm.2020.101962.

[8] S. Dowling, D. Reynolds, A. O'Reilly, G. Nolan, A. Kranidi, C.G. Gallagher, D. Cusack, A clinical investigation into the ability of subjects with lung disease to provide breath specimens using the EvidenzerIRL evidential breath analyser in alcohol intoxicant driving in criminal justice evidence, J. Forensic Leg. Med. 80 (2021) 102175, https://doi.org/10.1016/j.jflm.2021.102175.

[9] P.J. Gomm, M.D. Osselton, C.G. Broster, N.M. Johnson, K. Upton, Study into the ability of patients with impaired lung function to use breath alcohol testing devices, Med. Sci. Law 31 (1991) 221–225, https://doi.org/10.1177/002580249103100305.

[10] M.J. Morris, A.G. Taylor, Failure to provide a sample for breath alcohol analysis, Lancet 1 (1987) 37, https://doi.org/10.1016/s0140-6736(87)90719-7.

[11] P.G.W. Cobb, M.D.G. Dabbs, Report on the Performance of the Lion Intoximeter 3000 and the Camic Breath Analyser Evidential Breath Alcohol Measuring Instruments during the Period 16 April 1984 to 15 October 1984, Her Majesty's Stationery Office, 1985.

[12] M.J. Morris, Alcohol breath testing in patients with respiratory disease, Thorax 45 (1990) 717–721, https://doi.org/10.1136/thx.45.10.717.

[13] M.S. Odell, C.F. McDonald, J. Farrar, J.S. Natsis, J.J. Pretto, Breath testing in patients with respiratory disability, J. Clin. Forensic Med. 5 (1998) 45–48, https://doi.org/10.1016/S1353-1131(98)90009-8.

[14] D. Honeybourne, A.J. Moore, K. Butterfield, L. Azzan, A study to investigate the ability of subjects with chronic lung diseases to activate the roadside Lion Alcolmeter SL-400, Med. Sci. Law 39 (1999) 337–341, https://doi.org/10.1177/002580249903900411.

[15] A.J. Crockett, M. Rozee, R. Laslett, J.H. Alpers, Minimum lung function for breath alcohol testing using the Lion Alcolmeter SD-400, Sci. Justice 39 (1999) 173–177, https://doi.org/10.1016/S1355-0306(99)72043-5.

[16] S. Rathinam, D. Luke, P. Nanjaiah, M.S. Kalkat, R.S. Steyn, Can chest trauma patients provide breath sample with Lion SD-400 Alcometer? Asian Cardiovasc. Thorac. Ann. 17 (2009) 282–284, https://doi.org/10.1177/0218492309104774.

[17] M.B. Prabhu, T.S. Hurst, D.W. Cockcroft, C. Baule, J. Semenoff, Airflow obstruction and roadside breath alcohol testing, Chest 100 (1991) 585–586, https://doi.org/10.1378/chest.100.2.585.

[18] D. Honeybourne, A.J. Moore, A.K. Butterfield, L. Azzan, A study to investigate the ability of subjects with chronic lung diseases to provide evidential breath samples using the Lion Intoxilyzer®6000 UK breath alcohol testing device, Respir. Med. 94 (2000) 684–688, https://doi.org/10.1053/rmed.2000.0797.

[19] T.S. Hurst, Ability of subjects with impaired respiratory function to provide a satisfactory breath sample for the Alcotest® 7410 breath alcohol device, JCSFS (J. Can. Soc. Forensic Sci.) 31 (1998) 269–274, https://doi.org/10.1080/00085030.1998.10757121.

[20] P.M. Williams, D. Honeybourne, D.S. Josty, A. Moore, K. Butterfield, Breath alcohol analysis and the Lion Intoxilyzer® 6000: alcohol plateau monitoring in "normal" subjects, people of large and small stature, and patients with pulmonary disease. 14th International Conference on Alcohol, Drugs and Traffic Safety, International Council on Alcohol, Drugs, and Traffic Safety, 1997.

[21] G. Ives, L. Sbaffi, P.A. Bath, Can all healthy adults use the current evidential breath alcohol analysers? An investigation using a large spirometry database, Med. Leg. J. (2023) 258172231178419, https://doi.org/10.1177/00258172231178419.

[22] R.K. Jones, J.L. Nichols, Breath test refusals and their effect on DWI prosecution, Natl. Highw. Traffic Saf. Administration (2012), https://doi.org/10.21949/1525708.

[23] Sec. 169A.52 MN Statutes n.d. https://www.revisor.mn.gov/statutes/cite/169a.52. (Accessed 17 February 2025).

[24] A. Olson, Refusal case studies expirogram data from the DataMaster DMT. https://doi.org/10.17632/M2JR8JH275.1, 2025.

[25] J.L. Hankinson, J.R. Odencrantz, K.B. Fedan, Spirometric reference values from a sample of the general U.S. population, Am. J. Respir. Crit. Care Med. 159 (1999) 179–187, https://doi.org/10.1164/ajrccm.159.1.9712108.

[26] Intoximeters, Inc, Technical Bulletin-37 DMT Graph Data, 2019.

[27] In Re: Source Code Evidentiary Hearings in Implied Consent Matters, 2011.

[28] R.G. Gullberg, Common legal challenges, responses, and court decisions in forensic breath- and blood-alcohol analysis, in: W.A. Jones, J. Morland, R.H. Liu (Eds.), Alcohol, Drugs, and Impaired Driving: Forensic Science and Law Enforcement Issues, CRC Press, 2020, pp. 203–243.

[29] R.G. Gullberg, Quality assurance in forensic breath-alcohol analysis, in: W. A. Jones, J. Morland, R.H. Liu (Eds.), Alcohol, Drugs, and Impaired Driving: Forensic Science and Law Enforcement Issues, CRC Press, 2020, pp. 245–273.

[30] J. Fusco, Service Memo: 5 Way Valve Update, 2009.

[31] Alaska State Crime Detection Laboratory (ASCDL). Re: Datamaster Ultrap Mouthpieces, 2023.

[32] K.M. Dubowski, Studies in breath-alcohol analysis: biological factors, Z. Rechtsmed. 76 (1975) 93–117.

[33] J. Morgan, Wrongful convictions and claims of false or misleading forensic evidence, J. Forensic Sci. 68 (2023) 908–961, https://doi.org/10.1111/1556-4029.15233.

[34] B. Wandall, S.O. Hansson, C. Rudén, Bias in toxicology, Arch. Toxicol. 81 (2007) 605–617, https://doi.org/10.1007/s00204-007-0194-5.

[35] H.J. Hamnett, I.E. Dror, The effect of contextual information on decision-making in forensic toxicology, Forensic Sci. Int. Synerg. 2 (2020) 339–348, https://doi.org/10.1016/j.fsisyn.2020.06.003.

[36] S. Lefebvre, IACT breath test operator training survey results, International Association for Chem. Test. Newsl. 21 (2010) 5–6.

[37] M. Malhoit, Breath alcohol testing in the 50 states: a state-by-state review of evidential breath alcohol testing associated with impaired driving enforcement, International Association for Chem. Test. Newsl. 35 (2024) 13–21.

[38] I.E. Dror, Cognitive and human factors in expert decision making: six fallacies and the eight sources of bias, Anal. Chem. 92 (2020) 7998–8004, https://doi.org/10.1021/acs.analchem.0c00704.

[39] J. Kukucka, S.M. Kassin, P.A. Zapf, I.E. Dror, Cognitive bias and blindness: a global survey of forensic science examiners, J. Appl. Res. Mem. Cogn. 6 (2017) 452–459, https://doi.org/10.1016/j.jarmac.2017.09.001.

[40] K. Turney, N.F. Sugie, E. Marín, D.E. Kaiser, The waiting game: anticipatory stress and its proliferation during jail incarceration, Criminology 62 (2024) 830–858, https://doi.org/10.1111/1745-9125.12388.

[41] R.I. Simon, The psychological and legal aftermath of false arrest and imprisonment, J. Am. Acad. Psychiatr. Law 21 (1993) 523–528.

[42] T. Ritz, A.E. Meuret, L. Bhaskara, S. Petersen, Respiratory muscle tension as symptom generator in individuals with high anxiety sensitivity, Psychosom. Med. 75 (2013) 187–195, https://doi.org/10.1097/PSY.0b013e31827d1072.

[43] S.M. Witcraft, L.J. Dixon, P. Leukel, A.A. Lee, Anxiety sensitivity and respiratory disease outcomes among individuals with chronic obstructive pulmonary disease, Gen. Hosp. Psychiatry 69 (2021) 1–6, https://doi.org/10.1016/j.genhosppsych.2020.12.004.

[44] M. Leander, E. Lampa, A. Rask-Andersen, K. Franklin, T. Gislason, A. Oudin, C. Svanes, K. Torén, C. Janson, Impact of anxiety and depression on respiratory symptoms, Respir. Med. 108 (2014) 1594–1600, https://doi.org/10.1016/j.rmed.2014.09.007.

[45] H.J. Cheung, L. Cheung, Coaching patients during pulmonary function testing: a practical guide, Can. J. Respir. Ther. 51 (2015) 65–68.

[46] A. Olson, The need for standardization of exhaled volume in breath alcohol testing, DWI J. (2024), https://doi.org/10.61874/dwij/mgqj9294.

[47] M.M. Houck, Open, transparent science helps promote justice, Forensic Sci. Int.: Synergy (2019), https://doi.org/10.1016/j.fsisyn.2018.12.001.

[48] I.E. Dror, M.L. Pierce, ISO standards addressing issues of bias and impartiality in forensic work, J. Forensic Sci. 65 (2020) 800–808, https://doi.org/10.1111/1556-4029.14265.

[49] A. Olson, The limitations of mouth alcohol detection systems in breath alcohol testing: case reports, Forensic Sci. Int. Synerg. 10 (2025), https://doi.org/10.1016/j.fsisyn.2025.100573.

[50] N. Murphy, Give me liberty or give me the source code: challenging a black-box computer algorithm under Daubert, Richmond J. Law Technol. 30 (2024) 348–433.

[51] E.J. Imwinkelried, Computer source code: a source of the growing controversy over the reliability of automated forensic techniques, DePaul Law Rev. 66 (2016).