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Driving under the influence of alcohol during the COVID-19 pandemic

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A B S T R A C T

Aim: The main objective of this study was to evaluate the effects of the COVID-19 pandemic on the pattern of alcohol use in drivers.
Materials: and methods. At the National Institute of Legal Medicine from Bucharest, we performed a retrospective study on toxicology reports between January 1st 2019 and December 31st, 2020. Breath alcohol concentration (BrAC) was tested using Dräger breathalyzers by police units at the scene, and blood alcohol concentration (BAC) was evaluated using headspace gas chromatography. Most drivers gave two blood samples, separated by a one-hour interval, case in which they could request a retrograde extrapolation of the BAC at the time when they were stopped in traffic.
Results: The distribution of the number of cases depending on the month showed a sharp decline in the first six months of the lockdown, with a slow upward trend afterward. Mean overall values for BrAC were 0.49 +/− 0.40 mg/L, for 1st sample BAC – 1.15 +/− 0.99 g/L and for 2nd sample BAC – 1.29 +/− 0.81 g/L. Mean values obtained for BrAC were 0.48 +/− 0.39 mg/L before the pandemic and 0.52 +/− 0.43 mg/L during the pandemic. The increase was similar in absolute numbers in both male and female drivers (0.03 versus 0.04 mg/L respectively for BrAC and 0.02 g/L for both genders for 1st sample BAC). However, the percentage increase was significantly higher in women. There were 253 cases in which BrAC had values between 0.01 and 0.05, of which 138 occurred before the pandemic and 115 during the pandemic, the increase being highly statistically significant. The percentage of drivers with BAC levels below and above 0.8 g/L (the threshold value for which DUI is a felony in Romania) were similar before and during the pandemic.
Conclusions: During the lockdown, the number of alcohol tests in traffic has decreased significantly. This reduction was not associated with statistically significant changes in BrAC or BAC. We have seen a substantial increase in the number of minimally elevated BrAC and negative BAC cases, changes that could be caused by an increased use of alcohol-based hand sanitizers.

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1. Introduction

The confinement measures following the COVID-19 pandemic since the first half of 2020 have substantially impacted people's travel patterns, lifestyle, and drinking habits. Different studies reported either an increase or a decrease in alcohol use. In France and Belgium, the closure of bars and restaurants during the lockdown was associated with an overall reduction in alcohol consumption, especially among young adults. At the same time, other population groups (such as people aged 35–50 and parents of young children) reported heavier drinking during the lockdown [1]. In Canada, a survey performed by the Canadian Centre of Substance Use and Addiction found that 25% of adults were drinking more alcohol during the pandemic, and more (especially young adults) were using cannabis [2]. Manning et al. identified a significant increase in average drinking days but a decrease in the average number of drinks in problem drinkers during the pandemic compared to before [3]. Alladio et al. found an overall reduction in alcohol consumption during the lockdown and increased consumption in chronic/excessive consumers [4].

The COVID-19 pandemic also significantly increased the use of alcohol-based hand sanitizers (ABHS), leading to potentially unforeseen complications. For example, a study reported by the Texas Poison Control Centers has shown an overall 72.5% increase in reported exposures to ABHS between 2019 and 2020 [5]. In addition, some studies revealed a potential effect of alcohol vapors from hand

sanitizers on the breath alcohol tests [6,7], suggesting they might lead to false positives, at least for 15 min after their use [8]. Almost all alcohol from ABHS is inhaled, the skin absorption being unable to yield positive BAC or BrAC results with clinical significance [9]. Other substances potentially causing false-positive BrAC results in drivers include the use of mouthwash, foods that contain small quantities of alcohol, alcohol-containing nasal sprays etc.

Preliminary studies have shown that the restrictions generated by the COVID-19 pandemic shifted the pattern of BrAC results in drivers. For example, Apodaca et al. showed a significant decrease in the number of driving under the influence (DUI) BrAC tests performed in Los Angeles County in March-April 2020 versus 2019, associated with a substantial reduction in the number of DUI-related traffic accidents [10]. Beccegato et al., on the other side, suggested, using a case-control study, that chronic excessive alcohol and illicit substance abuse were more frequent during the COVID-19 lockdown [11].

The main aim of this study was to evaluate the effect of the COVID-19 pandemic on the pattern of alcohol use in drivers.

2. Materials and methods

We performed a retrospective study on toxicology reports for drivers brought at the National Institute of Legal Medicine for blood alcohol concentration (BAC) testing after either being involved in road traffic accidents or stopped during police traffic actions between January 1st, 2019, and December 31st, 2020.

Usually, the drivers were previously tested at the scene using a breathalyzer to detect BrAC. According to its manual, the allowed error for a calibrated Romanian Police Drager alcohol test is +/−0.01 mg/dL. However, in rare instances, the subjects refused to be tested in traffic and only agreed to be tested at the National Institute of Legal Medicine for BAC, or they accepted the test in traffic but refused to give samples for BAC. Also, in sporadic cases, the drivers were the ones who requested to be tested for BrAC/BAC.

Briefly, the legal framework for BrAC and BAC testing in Romania is as follows: every driver stopped in traffic by the Police may be requested to give either a BrAC test or a drug test. These tests are mandatory for drivers involved in road traffic accidents with victims. If the BrAC test is above 0 (or even 0 if the driver was involved in a road traffic accident with victims), they are brought to the closest medical unit with an emergency room (including the National Institute of Legal Medicine), where they are examined clinically, and blood sampling is performed for BAC. If the driver has a BrAC value below 0.4 mg/L will be fined and have the license suspended. If the BrAC value is above 0.4 mg/L, a BAC test is mandatory and, if its value is above 0.8 g/L, it will face criminal charges (up to one to five years in prison). Optionally, the driver may give a second blood sample (one hour after the first), allowing to request a retrograde extrapolation to estimate the BAC at the time of the traffic event.

BAC is detected using headspace gas chromatography.

We then separated the cases into two study groups: pre-pandemic and during pandemic groups. We used the following inclusion criteria: (1) drivers for which the Police requested a BAC after traffic events (either police raids or car crashes); (2) the request for the test was received between January 1st 2019 (hour 0.00) to December 31th 2020 (h. 23.59). The threshold date was March 17th 2020, when the Emergency state was declared in Romania due to the COVID-19 pandemic. We only included subjects who had at least either a BrAC or BAC test.

Two observers extracted the data separately and added it in the specially designed Excel 365 Datasheets which included the following sections: age, gender, alcohol values in expired air, blood alcohol values (1st and 2nd sample), retrograde extrapolation calculation value, date and time of stopping in traffic, date and time collecting the first sample.

The final database included for 2019, 3258 samples registered (3048 males and 210 females) at the request of the Police and 18 at the request of individuals. In 2020, 2026 samples were recorded at the request of the Police and four at the request of individuals.

Statistical analysis was performed in IBM SPSS software. We performed descriptive statistics, ANOVA to evaluate the differences between two or more groups and the Pearson Chi^2 test to test associations between qualitative variables.

3. Results

Out of the 5284 drivers included in our analysis, 3258 were tested in 2019 (61.7%) and 2026 in 2020 (38.3%), a 37.6% year-to-year decrease in requests. Four hundred seventy-seven subjects refused the BrAC test but agreed to the BAC, and 17 refused the BAC test but agreed to the BrAC test. Overall, BAC was accepted by 5267 drivers, 3866 drivers gave a second sample, and 843 drivers requested retrograde extrapolation.

By separating the cases using the threshold mentioned above date (March 17th), we found that in 2019 and 2020 before the lockdown, the number of requests was 3749 (71%), with an average of 8.52 cases/day, while in 2020, after declaring the state of emergency that led to various mobility restrictions – the number of requests was 1535 (29%), with an average of 5.29 cases/day. Subjects tested during the pandemic were significantly younger (40.60 +/− 12.99 years) compared to pre-pandemic levels (42 +/− 15 years), ANOVA test yielding an F value of 9.28 (p = 0.002). The number of women tested decreased significantly (79 cases before lockdown, representing 5.1%, versus 247, representing 6.6% of all tested subjects) (Chi^2 test had a value of 3.94, significant at a p = 0.047). By separating the drivers depending on the age group, we found the smallest decrease in the number of tested drivers in the 18–20 years-old age group (Pearson Chi2 = 19.74, p = 0.003). See Table 1.

The distribution of cases depending on the month and weekday are presented in Figs. 1 and 1 Supplementary, respectively. On the monthly graphs, we see a sharp decline in the number of cases in the first six months of the lockdown, with a slow upward trend afterward. The monthly differences were highly statistically significant (Pearson Chi2 = 542.29, p < 0.001). The distribution of the BrAC tests depending on the day of the week failed to show any statistically significant differences between the lockdown and pre-lockdown periods (Pearson Chi2 = 3.9, p = 0.690).

Overall mean values for BrAC were 0.50 +/− 0.40 mg/L. The mean values for the BAC in the first samples were 1.16 +/− 0.99 g/L, while for the BAC in the second samples were 1.29 +/− 0.82 g/L (Table 2).

Mean values obtained using the BrAC (including 0 values) were 0.49 +/− 0.39 mg/L before the pandemic and 0.52 +/− 0.43 mg/L during the pandemic. The increase was statistically significant (ANOVA, F = 8.19, p = 0.004). Depending on the gender, the increase was similar in absolute numbers (0.03 mg/L) but, as the average values were much lower in women compared to men before the pandemic (0.22 +/− 0.34 versus 0.55 +/− 0.39 mg/L), as a percent,

Table 1
Distribution of drivers, depending on the age group (45 drivers did not have a valid I.D. or other means of adequately identifying their age).

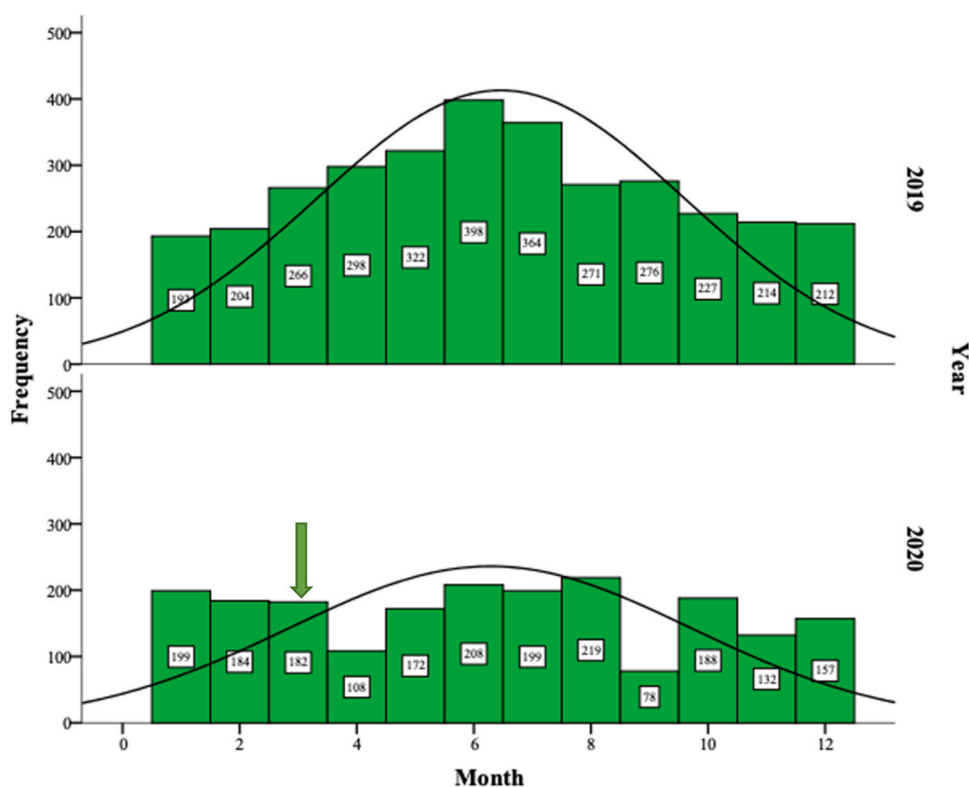|		Pandemic		Total
		No	Yes	
Age Groups	18–20	79 (2.1%)	50 (3.3%)	129 (2.5%)
	21–30	746 (20.1%)	295 (19.2%)	1041 (19.9%)
	31–40	1076 (29.0%)	447 (29.2%)	1523 (29.1%)
	41–50	897 (24.2%)	423 (27.6%)	1320 (25.2%)
	51–60	568 (15.3%)	210 (13.7%)	778 (14.9%)
	61–70	261 (7.0)	81 (5.3%)	342 (6.5%)
	Above 70	81 (2.2%)	25 (1.6%)	106 (2.0%)
Total		3708	1531	5239

Fig. 1. Distribution of cases depending on the month. Arrow: lockdown occurred.

Table 2
Mean values and standard deviations of alcohol concentrations separated on gender and compared between pandemic/before the pandemic.

		BrAC (mg/L)		BAC 1st sample (g/L)		BAC 2nd sample (g/L)	
		Mean	SD	Mean	SD	Mean	SD
Before lockdown	Women	0.22	0.34	0.51	0.90	1.01	0.98
	Men	0.51	0.39	1.19	0.98	1.32	0.80
	Total	0.49	0.39	1.14	0.99	1.31	0.80
During the lockdown	Women	0.26	0.38	0.53	0.87	0.78	0.86
	Men	0.54	0.43	1.22	0.99	1.27	0.84
	Total	0.52	0.43	1.19	1.00	1.26	0.84
Overall	Women	0.23	0.35	0.51	0.89	0.94	0.95
	Men	0.51	0.40	1.20	0.98	1.31	0.81
	Total	0.50	0.40	1.16	0.99	1.29	0.82

BrAC in women increased significantly compared to men (ANOVA, F = 8.067, p = 0.005).

Overall, 1202 (32%) of all tested drivers had a negative BrAC before the pandemic, and 396 (25.8%) of all tested drivers had a negative BrAC during the pandemic. The decrease in tested drivers with negative BrAC values during the pandemic was statistically significant (Chi^2 = 29.6, p < 0.001).

If we exclude BrAC having a value of 0 (drivers involved in road traffic accidents, for which the testing is mandatory), the average value before the pandemic started increased to 0.65 +/− 0.32 mg/L out of 2547 cases. During the pandemic, the average value increased to 0.64 +/− 0.38 mg/L out of 1139 cases. The difference was not statistically significant (ANOVA, F = 1.26, p = 0.26).

Mean BAC values (including 0 values) obtained from the first sample were 1.14 +/− 0.99 g/L before the pandemic and 1.18 +/− 1.00 g/L during the pandemic. The difference was not statistically significant (ANOVA, F = 1.98, p = 0.16). By removing cases with a BAC value of 0, the average values increased to 1.67 +/− 0.75 g/L before the pandemic (out of 2564 tested cases) and 1.69 +/− 0.75 g/L during the pandemic (out of 1075 tested cases).

Mean BAC values obtained at the second sample were 1.30 +/− 0.81 g/L before the pandemic and 1.25 +/− 0.84 g/L during the pandemic. The difference was not statistically significant (ANOVA, F = 3.26, p = 0.07). By removing cases with a BAC value of 0, the average values increased to 1.49 +/− 0.67 g/L before the pandemic (out of 2338 tested cases) and 1.51 +/− 0.68 g/L during the pandemic (out of 985 tested cases).

Mean estimated BAC values obtained through retrograde extrapolation were 1.88 +/− 0.69 g/L before the pandemic and 1.84 +/− 0.67 g/L during the pandemic. The difference was not statistically significant (ANOVA, F = 0.435, p = 0.51).

There were 533 cases in which BrAC had values between 0.01 and 0.4 (after which the BAC testing is mandatory to check whether BAC is above the threshold value for which driving under the influence is a felony – 0.8 g/L), with 321 cases before the pandemic (9.4%) and 212 cases during the pandemic (15.24%). The increase during the lockdown was statistically significant (Pearson Chi2 = 53.52, p < 0.001).

Also, there were 253 cases in which BrAC had values between 0.01 and 0.05, of which 138 occurred before the pandemic and 115 during the pandemic (Fig. 2). The relative increase in these cases during the pandemic more than doubled, from 3.68% to 7.49%, the increase being highly statistically significant (Pearson Chi^2 = 57.79, p < 0.001). Therefore, most of the relative rise in positive BrAC levels of less than 0.4 during the pandemic was caused by cases with BrAC levels below 0.05 mg/L.

The percentage of drivers with BAC levels below and above 0.8 g/L (the threshold value for which DUI is a felony in Romania) were similar before and during the pandemic (Pearson Chi2 = 1.5, p = 0.470). See Fig. 3.

The mean rate for alcohol metabolization from blood was 0.1840 +/− 0.1266 g/L/h in our study group. Split by gender, the average metabolization rate was 0.1435 +/− 0.1430 in women and for men was 0.1841 +/− 0.1260 g/L/h. The differences were statistically significant (ANOVA, F = 15.080, p < 0.001).
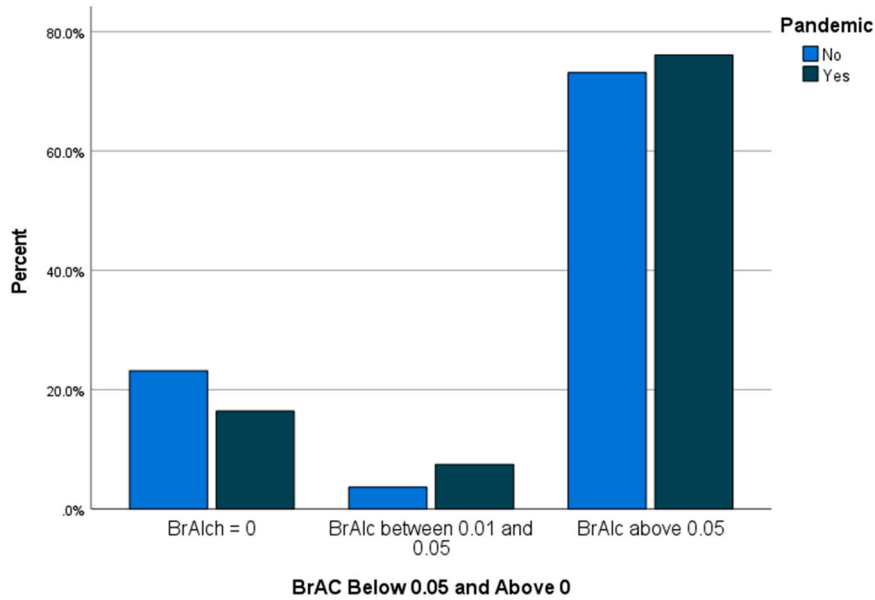
Fig. 2. Breath alcohol concentrations before and during the pandemic.

4. Discussions

To our knowledge, this is the first large-scale study trying to evaluate the actual effects of the COVID-19 lockdown on the pattern of alcohol use in drivers. We compared the BrAC and BAC values before and after the beginning of the lockdown on a representative sample of 5284 drivers that were stopped in traffic and tested for the presence of alcohol in the Bucharest area.

Some preliminary results suggested that the COVID-19 lockdown has changed alcohol use patterns in drivers [11]. Our study has shown that, overall, during the COVID-19 lockdown, the number of traffic tests was much smaller (5.29 v 8.52 cases/day), as found by other studies. For example, Apodaca et al. found a more than 40% decrease in March and April 2020 compared to the same months from 2019 in the number of blood alcohol tests performed in Los Angeles County [10].

Interestingly, BrAC/BAC values were not significantly different before/after the lockdown. The only statistically significant difference was found for the BrAC values, but it was generated by a decrease in the number of drivers having negative BrAC values during the lockdown. Therefore, overall, the percentage of drivers under the influence had similar values before and after the lockdown.

During the lockdown, we saw, while on call, an apparent increase in the number of cases in which the BrAC were minimally elevated (usually below 0.05–0.1), and many drivers having these values denied consuming alcoholic beverages. While taking their personal history before the clinical examination, we often found them to say they have used ABHSs. This was the only potential source of these positive results (if the statements were deemed believable).

The second BAC was in average higher than the first because many drivers with the BrAC below 0.4 mg/L did not give a second sample, as it would have been meaningless (the second sample is
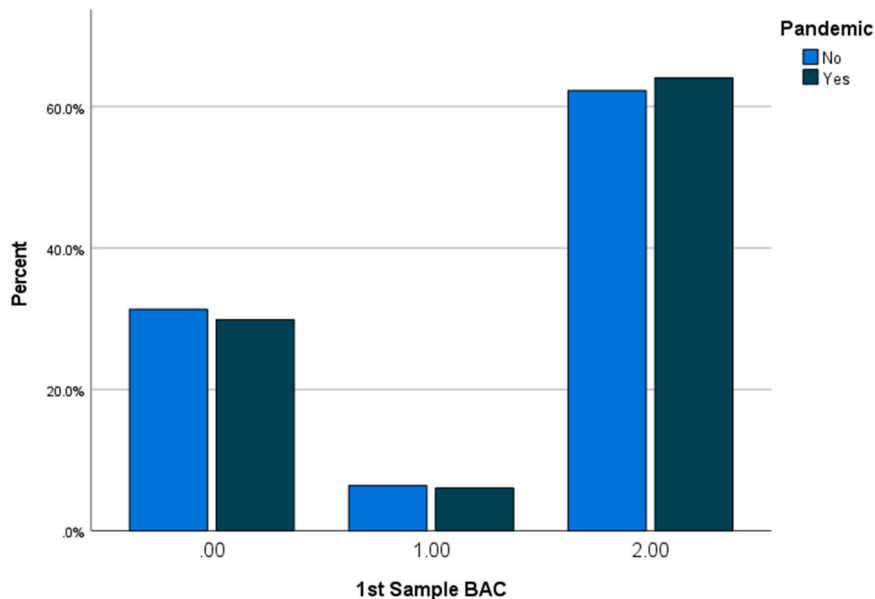

Fig. 3. BAC concentrations before and during the pandemic.

only needed to perform a retrograde extrapolation to estimate if the BAC value was below 0.8 g/L.

BrAC and BAC values can be increased by other means than alcoholic beverages. For example, Modell demonstrated that mouthwash could influence alcohol levels in expired air [12], a result confirmed multiple times afterward [13,14]. Some foods and soft drinks were shown to increase BrAC temporarily. For example, Logan and Distefano found that chewing bread with high alcohol content, such as apple walnut bread, led to values up to 0.027 g/L of pure alcohol in expired air [15]. Lutmer et al. found that more than 40% of subjects drinking energy drinks had positive BrAC tests 1 min after the end of the drinking, with values ranging from 0.006 to 0.015 g/ 210 L [16].

During the COVID-19 pandemic, the use of ABHSs has increased dramatically due to its known germicidal effects [17], which were highly promoted by physicians, state officials, or through official guidelines to minimize the risk of contamination. To be efficient, the user must rub his hands with around 3 mL of ABHS for 30 s. Some manufacturers recommend doing this procedure twice [17,18]. The use of ABHSs generates alcohol exposure for the user in two main ways: through dermal contact, with absorption rates of about 1%, and via inhalation, which leads to rapid absorption in blood via the lungs, and which may cause increased BrAC and BAC [17], as previously shown by different studies. For example, Ali et al. showed that after one pump of ABHS followed by drying, the breathalyzer measurements ranged from 0 to 0.019 g/L; one pump of ABHS without drying led to values between 0.020 and 0.109 g/L, while two pumps without drying increased the range to 0.020–0.166 with a median of .0119 g/L [7]. Brown et al. found that, after intensive ABHSs (30 times/h), BrAC is increased in around one-third of the subjects, with values ranging from 0.001% to 0.0025% at 1–2 min after exposure, and BAC may be increased at 5–7 min after exposure in around 10% of the subjects [19]. Miller et al. found that subjects who applied 5 mL of ABHS 50 times over four hours did not have BACs above 0.005 g/L [20], but they did not present the actual values in the article. Emerson et al. performed a study on ten subjects who used ABHSs in both foam and gel forms, both consisting of 70% ethanol. They showed that BrAC values were similar for both states, with positive BrAC levels of up to 0.15 mg/L immediately after the use. The average value decreased to less than 0.05 after 1 min and less than 0.025 after two minutes [6]. Ahmed-Lecheheb et al. found, on a study performed on 86 healthcare workers from the Nancy University Hospital, which used ABHS containing 70% pure ethanol, a positive breathalyzer test in around one-third of the subjects at 1–2 min after exposure, the mean value being 0.076 mg/L; however, ethanol, acetaldehyde, and acetate were undetectable in blood after a 4-hour shift, and urine tests were negative [21]. On a limited-scale study, Brewer and Streel showed that disulfiram-ethanol reaction might be caused by inhaling alcohol from ABHSs in confined spaces [9]. Strawsine and Lutmer showed that ABHSs could drive increased breath alcohol levels in around 10% of the subjects, causing mouth alcohol effects, and recommended caution in using these products 15 min before testing [8]. As seen from these studies, none tried to replicate the use of ABHS in cars by drivers tested with a breathalyzer. During the COVID-19-related lockdown, many drivers or other occupants' usage of these products increased after entering the vehicle. Due to the confinements of the cabin space, increased alcohol vapors were likely released during abundant use, leading to positive BrAC tests. Our study has shown a significant increase, during the lockdown, in the number of drivers who had minimally elevated BrAC values while being tested in traffic, associated with negative BAC values. Even if the correlation between ABHS and this result is not certain, as it was not evaluated in perfectly controlled conditions, the causation may be readily inferred, as the only significant behavioral difference of the drivers before/during the lockdown that may explain this result was an increased ABHS usage.

This result may have significant practical consequences, especially in countries with a zero-tolerance for driving under the influence, as a measure aimed to minimize infectious risks (the transmission of the SARS-Cov2 virus) is, de facto, generating significant negative legal consequences for drivers, limiting their right to drive. In Romania, such a positive result caused by ABHs is considered driving under the influence due to its zero-tolerance policy and automatically leads to a three-month suspension of the driver's license, which can be theoretically reobtained earlier in these particular cases only after a trial (which often lasts more than three months).

Regarding the average metabolization rates, our findings showed a significant influence of gender on alcohol metabolism, being accelerated in male subjects. This result confirms previous studies, such as those performed by Jones and Andersson [22].

4.1. Limits of the study

Our study was performed mainly on an urban population from a major city; therefore, the results may not be reproducible in other population groups; however, due to the very high number of included subjects and the fact that many tested drivers were in transit, we expect minimal changes for other population groups, at least in Romania, making our results representative at the national level. The correlation between ABHS and minimally elevated BrACs values associated with negative BACs is inferred. However, from our experience, most subjects with minimally elevated BrAC values who denied drinking alcoholic beverages declared, when asked, that they have used ABHSs (either them or other occupants). We even had a few cases where the driver "disinfected" the breathalyzer apparatus with ABHSs before using it, not realizing it had a high alcohol content.

5. Conclusions

The number of drivers tested in traffic for alcohol showed a marked decrease during the lockdown. This decrease was not associated with changes in the BrAC or BAC values. We saw a significant increase in the number of cases with minimally elevated BrACs and negative BACs, possibly caused by increased usage of ABHSs.

CRediT authorship contribution statement

Sorin Hostiuc: Conceptualization, Methodology, Validation, Data Curation, Writing – original draft, Supervision, accepting the final version of the manuscript. **Doina Radu:** Investigation, Formal analysis, Writing – review & editing, accepting the final version of the manuscript. **Lidia Seretean:** Investigation, Formal analysis, Writing – review & editing, accepting the final version of the manuscript. **Cosmin Tirdea:** Formal analysis, Investigation, Data curation, Writing – original draft, accepting the final version of the manuscript. **Răzvan Siminiuc:** Formal analysis, Investigation, Data curation, Writing – review & editing, accepting the final version of the manuscript. **George Cristian Curcă:** Investigation, Data curation, Writing – review & editing, Supervision.

Declaration of interest

The authors declare no conflict of interests.

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None.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.forsciint.2021.111076.

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