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Blood alcohol concentration, drinking history, and sociodemographic factors predicting alcohol use disorder among "hard core" offenders in Germany

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ABSTRACT: Driving under the influence of alcohol is one of the greatest dangers to the safety of road users not only in Germany, but across the rest of the world. An essential indicator for both punitive and corrective measures as well as for the prediction of recidivism is the blood alcohol concentration (BAC). This paper examines the relationships between BAC of first-time offenders, former drinking history, traffic related alcohol problem (TRAP), and the outcome of a medical-psychological assessment. The concept of TRAP combines syndromes from Alcohol Use Disorders (AUD) and a non-clinical delinquency category (drink and drive issue without AUD). It is in use for diagnostics among "hard core" alcohol-impaired offenders according to a diagnostic model which is applied in Germany and accepted by the legislator. The present study (N = 505) showed that a BAC of 0.11% upwards must be considered as a risk parameter for the identification of drivers with non-normative, and therefore traffic safety impairing drinking patterns. The importance of BAC as a risk indicator for road safety is underlined by significant correlations between BAC with drinking history and TRAP, but its prognostic value is poor, since BAC was unrelated to the outcome of the medical-psychological assessment. It could be demonstrated that TRAP severity increases with higher age, higher BAC, greater number of drinking days, higher occasion-related drinking amounts, and non-social drinking motivation (against stress and tension). Practical consequences are drawn regarding preconditions for re-issuing a driving licence.

KEYWORDS: blood alcohol concentration, impaired driving, fitness to drive, DUI offenders, driver assessment

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1. INTRODUCTION

As well as driving above the speed limit, driving under the influence (DUI) of alcohol is one of the greatest dangers to the safety of road users in many countries and also in Germany. Although the numbers have been declining for years in Germany in 2019 *N*=186 road users were killed, and *N*=4,634 seriously injured as a result from alcohol-related accidents, so that they were hospitalized for at least 24 hours. There were *N*=76,309 new DUI-entries in the central traffic register considered by criminal code[1], and *N*=35,258 were treated by the penalty point system after driving under less severe alcoholisation (Destatis, 2020). These records are still alarming, so future activities on road safety should continue to place emphasis on detecting the risk potential of DUI offenders in a fair, valid, and objective way. The framework for this approach is supported by a large body of research and literature on DUI offender characteristics.

International and German-speaking studies and reviews suggest that DUI offenders impaired by alcohol differ from *normal* drivers in terms of their socio-demographics, higher-order skills (e.g., self-calibration, self-monitoring, control abilities), personality-specific factors, and the particular significance of alcohol for their individual lifestyle. The prevalence is higher for younger male drivers (< 35 years), having a family history of alcohol abuse, committing other law-breaking activities and belonging to a group of heavy drinkers (e.g., Dunaway, Will, Sabo & Bryan, 2011; Shinar, 2017; Beadnell, Crisafulli, Stafford, Rosengren & DiClemente, 2015; Wickens et al., 2018; Bukasa et al., 2008; Posch, 2000; Strohbeck-Kühner, Zanbili, Van der List-Weiß & Mattern, 1999; Bartl, 1995; Kacena, Knessl, Risser & Schützhofer, 2014; Neuwirth, 2001; Kristöfl & Nechtelberger, 2001; Cavaiola, Strohmetz, Wolf & Lavender, 2003; Cavaiola, Strohmetz & Abreo, 2007; Hilger et al., 2012; Peck, Arstein-Kerslake, & Helander, 1994; Wagner, DeVol, Wegner & Rethfeldt, 2017, Rauch et al., 2010; Moser, 1983). Heavy episodic drinking and strongly habitual consumption patterns, along with a high-acceptance level of such a drinking culture within an alcohol friendly society[2], are associated with increased risk of DUI (cf. Shinar, 2017; Dunaway et al., 2011; Glitsch, Bornewasser, Philipp, Dunkel & Lignitz, 2001; Mullen, Ryan, Mathias & Dougherty, 2015). Binge drinking defined by the National Institute of Alcohol Abuse and Alcoholism (NIAAA) as five or more alcoholic drinks within approximately two

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1 An offence from 0.11% BAC upwards without accident involvement is treated as a severe violation according to criminal code in Germany. It is punishable by the revocation of driving license for at least 6 months up to 5 years, and a fine of between one to several months' worth of salary or imprisonment.

2 Disordered drinking cultures without clear boundaries between normal and abnormal alcohol consumption. Here, there is no clear guideline for the individual to deal with alcohol in a sensible and risk-conscious way.

hours for a single occasion among men, or four alcoholic beverages or more among women (NIAAA, 2004) is a key factor for alcohol-related offences (Dunaway et al., 2011; Shinar, 2017). Therefore, drinking patterns and volumes expressed in the amount of alcohol detectable in the blood - the blood alcohol concentration (BAC) - turn out to play an important role for understanding DUI offences. Against this background, this paper explores the relationships between BAC of first-time convicted offenders in Germany, former drinking history, traffic related alcohol problem (TRAP), and the assessment outcome (= the prognosis of the assessor regarding DUI relapse, in short Assessor Prognosis, AP) of a medical-psychological assessment (MPA). TRAP as a core concept describes how severe the drinking disorder was previously to the DUI offence.

2. THEORETICAL FRAME

2.1 Blood alcohol concentration (BAC) as a risk indicator

Blood alcohol concentration (BAC) is a measure of intoxication and impairment, usually expressed in weight units as 1 gram of alcohol per 1000 g of body fluid (e.g., milligrams of alcohol per millilitre of blood, for details see Shinar, 2017 or Cavailola & Wuth, 2002). The ratio between the quantity of alcohol in grams and body fluid is expressed as a percentage or per thousand (=per mill). In Germany, the use of BAC values in per mill (‰) is defined by law, in this article we prefer the description in percent (%).

Meta-analyses have shown that cognitive functions and visual capacity decline with increasing BAC level, impairment already starts at 0.01% (e.g., Reimann, van der Meer & Schubert, 2016; Moskowitz & Fiorentino, 2000 or Schnabel, 2011) with reliably measurable effects from a BAC of 0.02% and substantial curvilinear increases with BACs beyond 0.08%. Importantly, at a BAC of 0.03%, several cognitive processes, e.g., divided attention, response time, perception, action monitoring, executive function and risk-taking have all been shown to be adversely affected (450 studies, e.g., Moskowitz & Robinson, 1988; Moskowitz & Fiorentino, 2000 or Schubert & Stewin, 2009). The vehicle accident risk increases exponentially from a BAC of 0.05% (cf. e.g., Krüger, 1995; Borkenstein, Crowther, Shumate, Ziel & Zylman, 1974; Blomberg, Peck, Moskowitz, Burns & Fiorentino, 2005; Reimann et al., 2016; Krüger & Vollrath, 2004) including accident risk ratios of about 10 at a BAC of 0.11%, and of about 40 at a BAC of 0.16% upwards, compared to sober drivers (Krüger & Vollrath, 2004).

BAC may also serve as a risk indicator in terms of re-offending, but findings are mixed and ambiguous. Some studies found a positive relationship between BAC and re-offending rates (e.g., Portman et al., 2010), others did not (e.g., Schützenhöfer & Krainz, 1999) or demonstrated a negative relationship (Hubicka, Laurell & Bergman, 2008). DeVol, Schreiber, and Perlich (2016) calculated the recurrence frequency from numerous studies and found that the relapse frequency is at 8 – 40% in cases of a BAC below 0.1% and between 24 – 44% at a BAC of between 0.10% and 0.159% and at higher BAC values it still increases. Repeated DUI offenders, even with low BAC levels, (e.g., between 0.05% and 0.08%) share similar abnormal drinking patterns compared to those offenders caught with a BAC of more than 0.08% (Wickens et al., 2018).

The negative effects of alcohol on road safety were used to assign legal penalties, driver improvement programs (for overview see Shinar, 2017; Beadnell et al., 2015; Bartl & Willmes-Lenz, 2002; Bartl et al., 2002) or medical and/or psychological examinations (DGVP & DGVM, 2013; Brenner-Hartmann, Wagner, Mußhoff, Hoffmann-Born, Löhr-Schwab & Seidl, 2014; Cavaiola & Wuth, 2002; see also Groeger's concept of "examination of competence and fitness", Groeger, 2011).

2.2 Medical-psychological assessment: Structure and Procedure

Research indicates that DUI offenders often have clinical issues with alcohol use or are consuming too much alcohol on certain occasions. This may result in them jeopardising compliance with safety regulations, particularly with regard to riskier driving, suggesting that DUI offenders need to change their long-term drinking behaviour according to the requirements from the common safety regulations among all 27 member states of the European Union (European Commission, -EC-, 2018). For the purpose of solving this road safety gap, EC is demanding in driving licensing affairs after an alcohol-related issue that any European driver must be able to refrain from drinking and driving. In cases of a dependency, a proven period of abstinence and subject to authorised medical opinion and regular medical check-ups are demanded before driving licences may be issued or renewed. Those minimum standards of physical and mental fitness to drive are defined in Annex III No. 14 of the European Directive on driving licenses (EU Directive 2006/126/EC and Amendments 2009/113/EC, 2014/85/EU, 2016/1106).

Since the EU specifies the basic conditions of regulations, the transition into national legislation is the responsibility of each member state. The implementation of EU Directive in Germany is carried out through Driving Licence Ordinance, Annex 4a, No. 1f, demanding that a driving licence may only be renewed if the person concerned demonstrates conditions that make another DUI (=relapse) unlikely. In the case of dependency, an alcohol cessation therapy as well as a proven year of abstinence after treatment is required, in other cases the termination of the alcohol abuse through a consolidated change in drinking behaviour (Driving Licence Ordinance, Annex 4, No. 8). From a BAC value of 0.16% upwards, every DUI offender in Germany is obliged to pass a medical-psychological assessment (MPA) to check and confirm his fitness to drive, while MPA is required between 0.11% and 0.159% BAC only in exceptional cases.

MPA is including two complementary objectives as displayed in the model of figure 1 (simplified description of the diagnostic process according to Brenner-Hartmann et al., 2014): Firstly, diagnosis of the severity of alcohol problems (Y-axis of figure 1) and secondly, checking the person's changes that have occurred since the DUI offence (X-axis of figure 1), whereby this information flows into the expert's estimation of re-offending risk. All information volunteered by the client are to be checked for biassing influences, such as social desirability tendencies, contradictions to the scientific knowledge or the situation outlined in the case file [(Z-dimension in figure 1, in the following text summarized as SD (=social desirability)]. If the assessors are convinced of having realistic, useful, and interpretable diagnostic data, they will be able to evaluate the client's case according to appraisal guidelines and the relevant assessment criteria, including rational decision-making methods, which as well facilitate and standardize the interpretation of findings (Gräcmann & Albrecht, 2019; DGVP & DGVM, 2013)[3] .

From the beginning of the assessment process to the final written report, a psychological assessor cooperates with his medical teammate, a physician, by combining medical findings (e.g., physical examination, laboratory parameters from blood, urine or hair testings, treatment documents) with results from a clinical and traffic psychological interview. This interview covers issues dealing with the client's past and present drinking behaviour, his self-reflection upon DUI

3 Both expert systems include the following clinical literature: German version of ICD = International Statistical Classification of Diseases and Related Health Problems (Dilling, Mombour & Schmidt, 2011); German version of DSM = Diagnostic and Statistical Manual of Mental Disorders (Sass, 2003).

episodes, motivation for changes, self-criticism and attitudes regarding alcohol impaired driving, and strategies to avoid future DUI incidents. All these operationalizations through the interview follow requirements from German legislation (DGVP & DGVM, 2013; Brenner-Hartmann et al., 2014).

Based on recent studies, alcohol use disorders, including dependency and abuse, were summarized in a one-dimensional diagnosis with varying degrees of alcohol abuse (Hasin et al., 2013), adopted to traffic safety issues and supplemented by a non-clinical category (DGVP & DGVM, 2013), referred to as TRAP (=traffic related alcohol problem). Empirically, there is no qualitative leap from non-dependence to dependence. This is reflected in the DSM-5 in the abandonment of the distinction between abuse and dependence and the conceptualisation of substance use disorders as being located on a continuum including the statement that excessive use can be better explained as "impaired control" than "loss of control" (compare Hasin et al., 2013).

This empirical evidence forms the basis for TRAP as a continuum with a hierarchical structure beginning with the most serious degree of alcohol use disorder (=Alcohol Addiction, main indicators are increasing tolerance – i.e., progressively higher alcohol doses being needed for the same effect -, intense craving, and withdrawal reactions when the alcohol use is stopped) and moving on to less severe maladaptive behavioural patterns, such as Heavy Abuse or Abuse including risky drinking. Main indicators for category Heavy Abuse are increasing alcohol tolerance and substantial impairment of one's ability to control drinking. Abuse with risky drinking consumption patterns is characterized by increasing alcohol tolerance with occasionally binge drinking events and drinking of harmful alcohol doses occasionally with unaffected drinking control in general. From these, we separate a fourth category - called drink and drive issue without syndromes from Alcohol Use Disorders (AUD) - for persons not willing to comply with legal obligations regarding DUI without clinical symptoms. These clients do exclusively exhibit a drink driving problem and are not willing to accept and follow the drinking and driving regulations, e.g., driving with a BAC above .05% or non-sober driving during their probationary period. Among this group of drivers drinking and driving risks were underestimated or the dangers of alcohol for controlling one's own action were misjudged. The affected persons are able to control their behaviour once they have developed realistic risk awareness and a correct insight into the need to adapt their behaviour accordingly while driving.

According to the degree of TRAP different requirements for a positive AP are to be checked as the second part of the assessment (for examples see ellipses in figure 1). This overall result of the assessment represents the medical and psychological expert's opinion about mastering the alcohol problem or not, and the person's ability to separate drinking from driving in the future. Please note, that both assessors (physician and psychologist) jointly decide on TRAP and AP and write this in their final report with a detailed justification. Only these objective findings of the assessors were used in this study for the following statistical analyses.

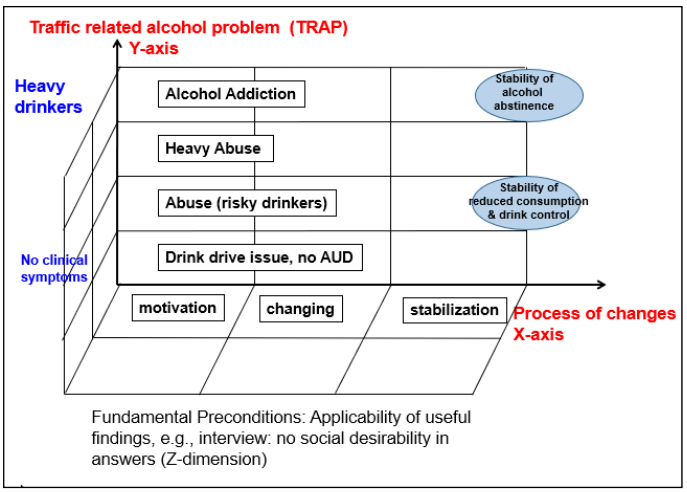

Figure 1: The model of medical-psychological assessment in Germany (after Brenner-Hartmann et al., 2014).

3. METHODS

3.1 Goals

As drunk driving in Germany is a criminal offence starting from 0.11% BAC, this article aims to shed light on hazard potential of BAC scores from this alcohol-impairment on upwards as a kind of "in-depth-investigation".

Therefore, the purpose of this paper is three-fold:

(1) Prevalence of TRAP across the BAC scores was calculated from 0.11% up to 0.21% with 0.16% on average. So, we examine the statistical distribution of alcohol problems with different levels of severity behind DUI-offences.

(2) Analysis of the relationship between drinking history, TRAP and BAC by using different correlational statistical methods. In this second step, we learn whether the alcohol consumption history and the severity of the alcohol problem behind DUI offences are reflected within BAC or not.

(3) Analysis of the relationship between BAC and AP from medical-psychological assessment (MPA) following the termination of the driving licence suspension period. This provides deeper insight into the prognostic value of BAC as a possible predictor for drunk driving in the future.

Based on the previous literature, we expect that a BAC level from 0.11% BAC serves as a predictor for unhealthy alcohol consumption style. However, we expect it to be unrelated to AP, but to show significant associations to TRAP and drinking history.

3.2 Sample

The present study is based on a document analysis of *n*=505 archived examination records including MPA reports, and copies from additional documents, e.g., the court's penalty order or written correspondence from the road administration agencies. This information is used unfiltered in the present study. The offenders' sample had an average age of 40.38 years at the time of the offence (minimum 18 years, maximum 79 years, standard deviation of 14.00 years), most of them were male drivers (82%). The data collection was a retrospective analysis of case files from several driver assessment institutes belonging to the federal states of Berlin, Brandenburg, Bavaria and Baden-Württemberg, in which a MPA arrangement from 0.11% BAC was implemented as exceptions for 3 years (2014-2017) after the permission from several regional higher courts. For this study, solely first-time DUI offenders without any additional offences according to the German penalty point system and with alcoholisation between 0.11% and 0.21% were selected. For all drivers committing a DUI the following applies regarding blood analysis: In Germany, the legally compliant measurement is the value obtained by an authorised physician in the course of an examination and blood sample after the drunk driving incident. Experience shows that there is a time gap between the offence and the time of the blood collection ranging between 50 and 90 minutes (personal communication of this paper's first author with the President of the German Society of Forensic Medicine, Prof. Matthias Graw, on July 20th, 2021). Therefore, much higher BAC values are to be expected at the beginning of the trip, since the biological degradation of alcohol in the liver is minimum 0.01 % per hour while up to 0.025 % may be observed among heavy drinkers (Penning, 2004).

Every DUI driver was assessed in 2015 but the preparation of these findings for the current study, including coding procedure, was conducted from March to June 2020, since the highest administrative court in Germany declared the procedure of demanding an MPA with BACs from 0.11% to 0.159% to be illegal and prevented this from continuing (Reference code is "BVerwG, Urteil vom 06.04.2017 - 3 C 24.15, including a decision on a second case with reference code 3 C 13.16") triggering further court dispositions on the relevance of BAC scores as risk indicators (the latest court decision was announced on March 17th, 2021; published via press release No. 18/2021 from Bundesverwaltungsgericht, reference code is "BVerwG, Urteil vom 17.03.2021 - 3 C 3.20")[4].

3.3. Variables and data treatment

The variables used in the analysis included *offender variables* (BAC value taken from the court's penalty order; age, gender, alcohol-related accident involvement taken from authorities' documents), *drinking history indicators* [number of drinking days per week (1-7 days), average alcohol intake in grams per drinking day (calculated as an average score across all drinking days or from verbal descriptions of a "typical" amount of alcohol intake), drinking situation, and drinking motives], and *assessor appraisals*. Both *drinking history variables* and *assessor appraisals* (cf. DGVP & DGVM, 2013; Brenner-Hartmann et al., 2014) were taken from the written MPA report, including the client's TRAP diagnosis or alternatively SD assignment without diagnosis. Also, the assessor's prognosis (AP) is taken from MPA report. These expert ratings were treated as rating scales with increasing magnitude at higher values with TRAP categories from 1 (drink and drive issue without AUD) to 4 (Alcohol addiction) and a three-point-scaling for AP: Positive prognosis (1), negative prognosis compensable by a driver improvement course (2), negative prognosis including the expectation of re-offending (3).

From the case files, variable coding was digitized anonymously by five experienced reviewers (all were qualified MPA experts) using a stringent coding key. Interrater reliability of the coding was not calculated, because the coding work did not require any subjective rating or interpretation, but only a transfer of existing original "raw data" records into a data table. Almost all variable values or categories were available from the text of the MPA report. Information on the average quantity of alcohol consumption per drinking day, which had been provided by the assessors in terms of quantity in litres and type of alcoholic beverage, was converted into grams of alcohol according to a standardized calculation procedure (Gilg, 2005; Meyer, Rumpf, Hapke, Dilling & John, 2000). Another facet of the client's drinking history, the drinking situation or "setting", was operationalized as an ordinal 3-point-scale with the categories "social context" (1), "self-related context" (2), and "drinking in dangerous environments" (3), e.g., at the workplace (see also Cooper, 1994; Lindenmeyer, 2005). The drinking motives with expected alcohol effects were also treated as an ordinal rating scale with the categories "positive emotionality" (1), "drinking as a coping strategy" (2) to mitigate negative feelings, and "habitual drinking" (3) (DGVP & DGVM, 2013; Brenner-Hartmann et al., 2014; Cooper, 1994). Both variables have been outlined from lower to higher degrees indicating an increasing importance of alcohol for daily life (Lindenmeyer, 2005) along with the acceptance of accumulating negative consequences. Details about the variables, data level, coding, and examples can be obtained from Table 1.

As a control variable, the client's tendency to answer in a socially desirable way was also measured [SD, recorded dichotomously: SD present (1) vs. SD not present (2); see Spicher & Hänsgen, 2003; DGVP & DGVM, 2013; Brenner-Hartmann et al., 2014; Cavaiola & Wuth, 2002]. The assessment of the SD was carried out by the assessors and documented in the MPA report. A clearly pronounced SD does not allow a diagnostic assessment of TRAP leading to a negative AP (DGVP & DGVM, 2013; Brenner-Hartmann et al., 2014).

Variable name	Data level	Coding (example)
Age	Interval	Numerical years, e.g., 35
Gender	Nominal	0=male, 1=female
Accident involvement	Nominal	0=no, 1=yes
Number of drinking days	Interval	between 1 to 7
Ø g alcohol intake	Interval	137,5 g
Drinking situation	Ordinal	1= social context (socializing and dining, leisure activities, disco, funfair), 2= self-related context (drinking alone, drinking at home, drinking while watching TV) 3= drinking in dangerous environments (at the workplace; during sporting activities like climbing; in context of driving)
Drinking motives	Ordinal	1= positive emotionality (mood enhancement, for joy and happiness, relaxation, reinforcement drinking/being proud), 2= drinking as a coping strategy (e.g., against strain and tension, against negative feelings like sadness, frustration, pain) 3= habitual drinking
Blood alcohol concentration	Interval	in %, e.g., 0.015
AP (Assessor Prognosis)	Ordinal	1= positive prognosis, 2= negative with indication for driver improvement course 3= negative prognosis
Traffic related alcohol problem (TRAP)	Ordinal	1= Drink and drive issue without AUD 2= Abuse (risky drinking) 3= Heavy Abuse 4= Addiction
Social Desirability (SD)	Nominal	0= present 1= not present

Table 1: Variable details and coding

3.4 Statistical analyses

The dataset was analysed using SPSS Statistics software from IBM Corp. (Version 22, 2013), starting with prevalence rates (frequencies in percent) of SD and TRAP across the BACs distribution. Then, a correlation analysis based on Spearman's

4 Core message of this latest court decision is, that a medical-psychological assessment is to be demanded if the person concerned has a blood alcohol concentration (BAC) of less than 0.16% but minimum 0.11% AND despite this alcohol level no alcohol-related impairments were observed or noted. These indications for an above-average alcohol tolerance increase the risk of another drink drive offence (relapse).

Rho (P) was implemented using bivariate correlation coefficients among main variables. Next, the impact of age, gender, accident involvement, along with drinking history and BAC on TRAP was examined by using binary logistics regression analyses. By comparing different regression models one can observe the additional impact of the predictor BAC beyond age, gender, and accident involvement. The advantage of this approach are comparisons between different regression models, with and without BAC, so that the relative influence of BAC on TRAP can be estimated beyond the person's characteristics (age, gender, accident involvement) as a direct and indirect effect through variance decomposition and methods resembling those of partial correlations.

4. RESULTS

Figure 2 displays both the prevalence rates of SD estimations and different TRAP levels across the BACs distribution. Abscissa shows BACs from 0.11 to 0.21% (note: in figure 2 the categories of BAC are expressed in per mill) and ordinate describes the relative ratio in percent for each of the four categories: SD, Abuse (risky drinkers), Heavy alcohol abuse, Alcohol addiction, while drivers with a drink and drive issue without AUD did not occur. Out of *n*=505 cases a number of *n*=61 (12.1%) cases were evaluated by the assessor to be biased with social desirability tendencies. Interestingly, the prevalence of SD is higher at lower alcohol degrees with peaks of more than 20% between 0.13% and 0.149% BAC. Comparing all groups below and above 0.16% BAC, there is no statistical significance ($\chi^2(1, 505)=2,29$; p=.13).

SD correlates positive with the number of drinking days a week, with the average alcohol intake per drinking occasion, and with drinking motives (compare Table 2, left column). Positive coefficients fell between P=.10 and P= .26 (p <.05 or p <.01). Clients with SD are tending to "sugar-coat" their drinking history by reporting lower number of drinking days, a lower drinking quantity and drinking motives that are presumably more likely to find social acceptance. Consequently, those SD cases can't be used for further analyses. After dropping out subjects with pronounced SD the sample size decreased to *n*=411 up to *n*=444 according to missing data and we observe the following prevalence rates for TRAP categories: Drink and drive issue without AUD 0%, Abuse (risky drinkers, *n*=355; 80%), Heavy Abuse *n*=76 (17.1%) and Alcohol addiction *n*=13 (2.9%).

The next results are presented in two parts. First, the pairwise calculated Spearman's rank correlations (P) between the main variables (SD, TRAP and AP) are reported, followed by a logistic regression analysis regarding the impact of different predictors, especially BAC, on TRAP.

Table 2 shows the bivariate intercorrelations between the socio-demographic variables, accident involvement while committing the DUI offence, drinking history, BAC value and the main variables TRAP and AP as well as SD. After eliminating the cases with SD, BAC is positively correlated with TRAP (P = .24, p <.01), and variables of drinking history also correlate significantly and positively with TRAP (.16 ≤ P ≤ .26, p <.01). The positive direction of the relationships highlight that an increased alcohol problem is accompanied by a higher number of drinking days, higher average alcohol intake per drinking occasion, and the extension of drinking behaviour to non-social contexts along with coping or habitual drinking. A positive correlation between age and TRAP also suggests that older drivers tend to have a more advanced alcohol issue (P = .22, p <.01). The correlations with the AP are mostly not significant or weak, including the relationship between BAC and AP. Therefore, a detailed description of the results is omitted.

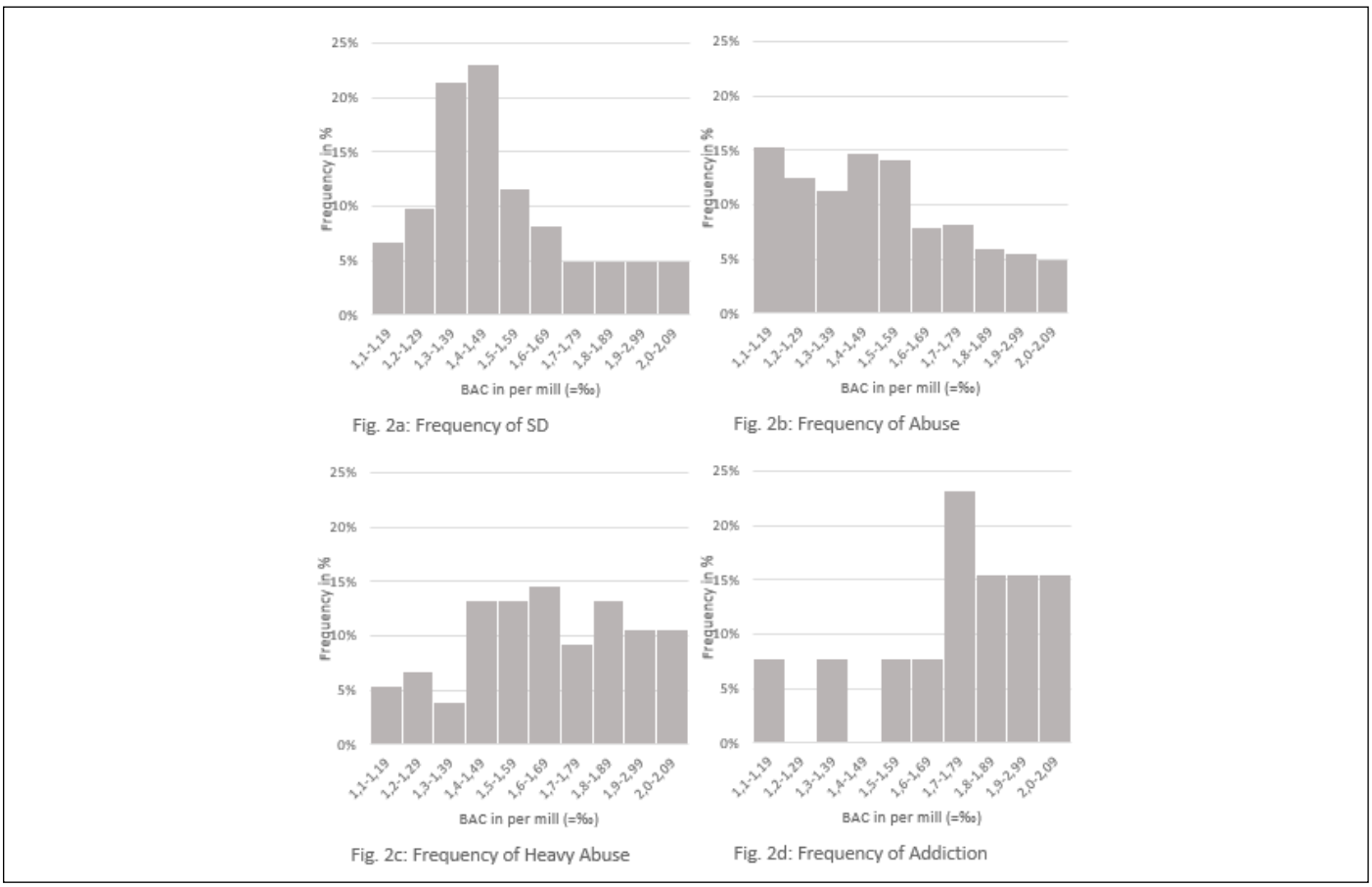

Figure 2: Prevalence rates from Social Desirability (SD) and level of TRAP across blood alcohol concentration (BAC) Categories on abscissa: Numbers in per mill (‰).

For testing effects between BAC, drinking history and TRAP, a comparison between four statistical models was implemented using binary hierarchical logistic regression analyses while TRAP was dichotomized (1=Abuse; 2=Heavy Abuse and Addiction). The independent variables (e.g., age, BAC, drinking situations, drinking motives) are either interval-scaled, nominal with 2 or 3 categories while the latter are coded as dummy variables with the characteristics 0 and 1. With the help of dichotomous dummy variables we can estimate the effect of a certain characteristic of the predictor (variable specification=1) in relation to the reference category (variable specification=0).

The results are displayed in Table 3. Here, the left-hand column lists the predictors followed by parameters of the regression model with respect to changes in the extent of Nagelkerke's R square (R^2), representing a measure of how well the regression model fits the data, with 0 indicating no fit at all and 1 indicating a perfect fit. Nagelkerke's R square can be interpreted analogically to R^2 adjusted in linear regression analysis of explained variance. Third column expresses model fit in %. The next four columns display the predictor's influence on the outcome variable (TRAP) via beta-coefficients and Odds Ratios, including confidence intervals. Table 3 shows the different models from the regression analysis, while Model I considers only age, gender, and accident involvement explaining 10% of the variance in TRAP. When adding variables of drinking history, an additional amount of 14.3 % is covered though these factors with Nagelkerke's R^2=0.25 (Model II). BAC alone is covering exactly 6% for model fit (TRAP) beyond age, gender, and accident involvement (Model III compared to Model I). Best model fit can be observed if all predictors are implemented into the regression equation leading to Nagelkerke's R^2=0.271 (Model IV). Compared to Model II, BAC is improving model fit with 2.5 % as a direct effect while 6% may be attributed to indirect influence via drinking history (as could be shown in comparison between Model II and Model III while 10% of the variance is attributed to age, gender and accident involvement according to Model I).

Variable	SD		TRAP		AP	
	P	N	P	n	P	n
Age	-.071	501	.215**	422	.067	422
Gender	<.001	505	-.084	444	-.084	444
Accident involvement	.052	505	-.041	444	-.105*	444
Number of drinking days	.156**	464	.265**	419	-.036	419
Ø g alcohol (drinking occasion)	.264**	475	.159**	427	-.099*	427
Drinking situation	-.016	478	.207**	430	-.043	430
Drinking motives	.109*	453	.263**	411	.094	411
BAC	.067	505	.240**	444	.022	444

*p<.05, **p<.01; explanations: SD=Social desirability, TRAP=traffic related alcohol problem; AP =assessor prognoses.

Table 2: Intercorrelations between main variables (Spearman's P)

5. DISCUSSION

In summary, the results presented in this paper provide valuable empirical evidence for understanding covariates between offender variables and blood alcohol concentrations. This is important because the BAC serves as an objective risk indicator for the allocation of different measures according to legal regulation and standards. The analyses from this study demonstrated

1. that BACs from 0.11% to .21% occurred only in subjects with an alcohol use disorder (AUD) and therefore an increased alcohol tolerance,
2. that TRAP severity increases with higher age, higher BAC, a greater number of drinking days, higher occasion-related drinking amounts and non-social drinking motivation, and
3. that BAC is unrelated to AP.

This picture of BAC related findings addresses the necessity for an in-depth-reflection on the following pages.

Firstly, BAC from 0.11% upwards indicate dysfunctional drinking patterns that deviate from the normal drinking within society (Wagner et al., 2017; DeVol et al., 2016; Shinar, 2017; Dunaway et al., 2011; Mullen et al., 2015; Wickens et al., 2018), and the association between drinking history and TRAP is confirming clinical research on drinking behaviour (see Dunaway et al., 2011; Mullen et al., 2015; Wickens et al., 2018; DGVP & DGVM, 2013; Müller, 1976). The linchpin of this syndrome complex is an increased alcohol tolerance as a core criterion among all clinical TRAP categories: Addiction, Heavy Abuse, Abuse. All subjects in this study met this criterion and no subject was assigned to the non-clinical category (drink and drive issue without AUD). These findings support the conclusion that DUI offenders between 0.11% and 0.21% represent a risky group consisting of heavy drinkers, according to similar findings from Wagner, Brieler, and Pirke (2020) confirming this ranking of TRAP categories through a different sample of DUI offenders with N=840 subjects.

Drivers with increased alcohol tolerance are less sensitive to alcohol impairment effects and lose their ability for a realistic self-perception (Shinar, 2017). Thus, the driver's ability for a realistic self-assessment of his or her own fitness to drive decreases as well, since strong drinking habits are accompanied by higher tolerance levels (Stephan & Brenner-Hartmann, 2018), also influencing the person's attitude towards alcoholic beverages (Houwer & Bruycker, 2007). This can be explained by three typical components of physiological adaptation: a pharmacokinetic or metabolic component by enzyme induction (1), which contributes to faster alcohol elimination in the liver, a pharmacodynamic component by neuroadaptation (2), which results in weaker feelings of being intoxicated, and an associative or homeostatic component (3) by neutralizing environmental influences leading to desensitisation effects (Julien, 1995; Poulos & Cappel, 1991). This distorted self-perception (see Burger, Brönstrup & Pietrzik, 2004; Kraus, Pabst, Gomes de Matos & Piontek, 2014; Verster & Roth, 2012; Beirness, 1987) along with openness for risks due to the alcohol effect (e.g., Davis, Hendershot, George, Norris & Heiman, 2007; Fromme, Katz & D'Amico, 1997; MacDonald, MacDonald, Zanna & Fong, 2000) are risk accelerators for drink driving in the future.

Secondly, in our study BAC is positively associated with TRAP while a higher BAC may be interpreted as an expression of an impaired control over alcohol intake, which decreases from Abuse to Addiction (DGVP & DGVM, 2013; Brenner-Hartmann et al., 2014). Therefore, BACs from 0.11% upwards can be understood as an indicator of both alcohol tolerance and the increasing of an impaired control. Both "syndromes" of the heavy drinker's group might explain the re-offending rates from increasing BAC levels beyond 0.1% according to meta-analytic findings from DeVol, Schreiber & Perlich (2016). The direct impact from BAC on TRAP is quite small (model fit was improved by 2.5% comparing Model II and Model IV). We also might assume that drinking history is influencing TRAP as well, since 14.3% of total explained variance in TRAP according to Model II can be attributed to factors of drinking history indicators, e.g., number of drinking days per week, average alcohol intake per drinking day,

Predictors	Nagel kerkes R^2	Variance explained	B	Odds Ratio	95% CI for OR	
					lower	upper
Model I						
1st Block						
Age			0.609**	1.839	1.403	2.411
Gender	0.103	10.3%	-0.915*	0.401	0.179	0.896
Accident involvement			-0.001	0,999	0,566	1,762
Model II						
Age			0.518**	1.679	1.220	2.311
Gender			-0.603	0.547	0.228	1.316
Accident involvem.			-0.038	0.963	0.524	1.767
Numb. drink. Days			0.410*	1.507	1.082	2.101
Ø g alcohol intake	0.246	24.6%	0.459**	1.582	1.198	2.091
Drink. situation (1)			0.304	1.355	0.700	2.623
Drink. situation (2)			0.342	1.408	0.457	4.334
Drinking motives (1)			0.872*	2.391	1.049	5.450
Drinking motives (2)			0.874	2.398	0.950	6.049
Model III						
Age			0.583**	1.791	1.356	2.366
Gender	0.163	16.3%	-0.931*	0.394	0.172	0.904
Accident involvement			-0.177	0.838	0.464	1.514
BAC			0.520**	1.683	1.290	2.194
Model IV						
Age			0.506**	1.659	1.201	2.291
Gender			-0.649	0.523	0.212	1.286
Accident involvem.			-0.159	0.853	0.457	1.593
BAC			0.389**	1.476	1.109	1.965
Numb. drinking days	0.271	27.1 %	0.345*	1.412	1.007	1.980
Ø g alcohol intake			0.393**	1.481	1.112	1.971
Drink. situation (1)			0.261	1.298	0.660	2.554
Drink. situation (2)			0.314	1.369	0.437	4.282
Drinking motives (1)			0.840*	2.317	1.010	5.317
Drinking motives (2)			0.936	2.550	0.999	6.512

explanations: *p<.05, **p<.01; N = 366; All metric variables were z-standardized prior to analysis. TRAP: 0=Abuse, 1= Heavy Abuse+Addiction; Gender: 0= male, 1= female; accident involvement: 0=no 1= yes; drinking situation (1) social context vs. self-related context; drinking situation (2): social context vs. dangerous environments; drinking motives (1) positive emotionality vs. coping strategy; drinking motives (2) positive emotionality vs. habitual drinking

Table 3: Multiple logistic regression of TRAP (dependent variable) by predictors of drinking history and BAC

drinking situation, and drinking motives. Together, they explain more than twice as much variance as BAC alone with 6% (according to Model III).

Regarding small effects we have to consider that every BAC score depends on a number of different factors: amount of alcohol drunk, speed of drinking, time period of alcohol intake and rate of alcohol absorption, rate of degradation, time between the last alcohol intake and BAC determination, phase and direction of alcohol flooding at the time of blood sampling (up, peak-level, down, residual alcohol), body weight and gender of the drinker and the reliability of the measurement method (Penning, 2004; Shinar, 2017).

Thirdly, BAC does not relate to the AP. It seems quite surprising that there is a nearly zero correlation between BAC and estimated risk of recidivism by the assessors; one would expect a low to moderate correlation indicating that offenders with lower BAC scores should more easily achieve a positive prognosis. This is not the case, because the negative experience caused by the drink driving offence and its unpleasant consequences alone do not initiate a stabilized strategy for separating drinking and driving. Maladaptive syndromes develop over a longer time-period and the repeated use of alcohol is leading to habits which can't be terminated easily (Neal, Wood & Quinn, 2006; Ronis, Yates & Kirscht, 1989). Complicating and probably inhibiting factors of an effective change process after the DUI offence are well known from the body of evidence, among them underestimating alcohol-related risks, low compliance to rules in general, traits like sensation seeking, impulsivity, low frustration tolerance, and co-morbidity with mental disorders (cf. Bukasa et al., 2009; Breustedt, 2010; C'de Baca, Miller & Lapham, 2001; Cavaiola & Wuth, 2002; Cavaiola et al., 2007; Christophersen, Beylich, Bjørneboe, Skurtveit & Mørland, 1996; Impinen et al., 2009; Hubicka et al., 2008; Dugosh, Festinger & Marlowe, 2013; Møller, Haustein & Prato, 2015; Jones & Lacey, 2000; Portman et al., 2010; Marowitz, 1998; Peck et al., 1994; Nochajski & Stasiewicz, 2006; Moser, 1983). Drink driving events are transferred to automated action control as a consequence of learning from success (lack of punishment), which is impressively demonstrated by the number of undetected drunk drives in Germany. Haffner (1993) reported that it takes about 300 driving trips under the influence of alcohol to get caught.

Before pointing out the practical consequences of this article, the methodological limitations should be considered. Firstly, despite the exclusion of cases with a predisposition of presenting oneself in a socially desirable way, the remaining cases are not entirely unaffected by dissimulation of their statements according to the pre-contemplative phase of the transtheoretical model by Prochaska and DiClemente (1982, 1986). Also, due to the retrospective data collected in the psychological interview, memory effects of assessed drivers cannot be ruled out (Neisser, 1982). Secondly, the composition of the sample is dependent on the density of police control, the enforcement conditions, the allocation strategy of driving licence authorities and the person concerned, who does not have to face the assessment. Accordingly, selection effects cannot be excluded as there were more cases under 0.16% BAC who were strongly influenced by SD and thus preventing the assessor from the diagnoses of TRAP. Thirdly, it could be argued that the study has quite low statistical effects. This might be due to restricted variance in several variables with lack of heterogeneity, a missing control group, and the "nature" of a non-experimental design. Contrary to this however, mainly conservative methods such as Spearman's rank correlations and binary regression after controlling for SD were used while data sources of different quality were combined. Hence, this study does not suffer from overestimated statistical effects that can be attributed to common method-dependent variance but rather describes the minimum of possible associations between considered variables.

Based on the available knowledge that the range of the 'normal' social drinking is not exceeding a BAC of 0.08% (Müller, 1976; Shinar, 2017; Dunaway et al., 2011), it is not surprising that BAC levels from 0.11% upwards are accompanied by road safety risks. Due to the time lag between starting a DUI ride (= "starting BAC") and being caught by the police, this time gap suggests significantly higher degrees of BAC at the end of drinking or when starting the motor vehicle. Consequently, it can be assumed, that the differences between social drinkers and offenders from 0.11% are very clear leading to the conclusion, that the ongoing procedure of re-issuing a driving licence in Germany without any measures does not seem appropriate according to the severity of their alcohol problem (AUD). Therefore, the treatment of DUI drivers with minimum 0.11 % BAC needs re-thinking of what should be done for enhancing road safety. New ways might have to be explored, picking up the dichotomous categories of alcohol-related offenders in the European Directive on driving licenses (addiction vs. non-addiction regarding different cases of AUD or use of alcohol) starting with the idea of a mandatory counselling promptly after the DUI offence with minimum 0.11 % BAC. This client-centred, face-to-face approach should include a diagnostic assessment of the alcohol problem severity. Simultaneously, the offender should be given recommendations and intervention proposals for restoring his or her fitness to drive. For the second part of the counselling, brief intervention techniques should begin to initiate and shape intentions towards changes in drinking behaviour, so that a willingness to change is elaborated and strengthened at an early stage. In cases of diagnosed alcohol addiction, DUI offenders should enter the addiction health treatment care system, abusers with diagnostic categories Heavy abuse or Abuse should participate at a driver improvement course, and members belonging to the non-clinical category (drink and drive issue without AUD) should receive a training focusing on risk awareness and knowledge about dangers from alcohol combined with learning to separate drinking from driving. For the purpose of stabilizing the changed behaviour and enhancing cognitions for behaviour control, different methods like an in-car breathalyser (i.e., an alcohol interlock) or feedback methods for self-monitoring, and self-reinforcement via computer or by handheld devices with text messages may promote adherence to the developed strategies. Every candidate should be assessed with medical-psychological examination before re-issuing driving licence in order to check individual gains from driver improvement programs or clinical rehabilitation.

What could future research focus on? In a follow-up study, it could be examined whether both groups (0.1 -0.159% vs. 0.16 - 0.21% BAC) are also similar in personality, investigated as self-description with the help of questionnaires, therefore supporting the pattern of a homogeneous risk group that differs from drivers with lower BAC levels (e.g., 0.05 - 0.08%) or as well as from non-offending drivers. The importance of higher-order skills like calibration skills (such as self-evaluation and self-regulation skills, insight in own strong and weak points) or socio-emotional skills (such as showing empathy for other road participants, impulse control, coping with social influences) in safe driving behaviour has been proven in multiple studies.

There is a pressing need for new and more effective strategies regarding "hard-core" DUI offenders with necessary efforts towards checking the entire licensing system for consistency regarding legislation and road safety measures. Here, scientific and empirical wisdom should be taking seriously. A basically perfect system of re-licensing, but one that must be carried by imperfect people, first of all of the vehicle drivers concerned.

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