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Face Masks as a Factor in Eventuality of Changes in Driving Safety

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ABSTRACT

During the COVID-19, pandemics or worsening virus situation, taxi and regular-route bus drivers are recommended to work in medical masks. However, the quantitative and qualitative influence of wearing protective face masks on safety of driving vehicles has not been previously studied. Therefore, this became the objective of preliminary studies to determine the specifics of the influence of a face protective mask on the change in psychophysiological qualities of a car driver as a factor in safety eventuality under urban traffic conditions.

The method of an open-ended survey of 108 healthy adult drivers was used to obtain a quantitative subjective assessment of the effect of face masks on changing driving safety conditions and a comfortable emotional state while driving. A qualitative analysis of assessment of the level of psychophysiological qualities of drivers wearing and not wearing a face mask was carried out using Meleti hardware-software complex.

A sharp decrease in neuropsychic functions with a simultaneous increase in quality of thinking and visual analysis of the traffic situation was revealed regarding the drivers wearing a face protective mask compared to those driving without a mask while the level of psychomotor reaction remains unchanged regardless of the gender of the driver.

The subjective assessment of survey participants of the effect of a face mask on professionally important, psychophysiological characteristics of drivers revealed a significant (41,7 %) or insignificant (20,4 %) decrease in reaction, while 38 % of drivers did not notice significant changes in driving because of the effect of the mask.

Based on these results, it is assumed that the face mask may serve as a predictor of a road pre-accident situation.

To assess the effect of the face mask on the driver, a coefficient of eventuality of reducing road safety is proposed. It is recommended to use it as an additional factor in a situational pandemic environment when developing recommendations for the use of face masks for car and bus drivers, and when analysing the causes of road accidents.

Keywords: face protection mask, driver, road safety, psychophysiological qualities, external factors, eventuality coefficient, road traffic accidents.

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INTRODUCTION

Following the outbreak of the SARS-CoV2 pandemic, the use of face masks is widely recommended by international [1], national [2] and local authorities [3]. The purpose of new sanitary and hygienic requirements is to reduce the release of droplets from the respiratory tract of persons with pre-symptomatic and asymptomatic infectious respiratory conditions [1, p. 4].

Depending on the type, masks can either be used to protect healthy people or to prevent further spreading of infection (source control). WHO continues to recommend that anyone with suspected or confirmed COVID-19 who is awaiting laboratory test results wears a medical mask in public (this does not apply to those waiting for a test before travelling). Any type of mask requires proper use, storage, and cleaning or disposal to ensure maximum effectiveness and avoid an increased risk of infection transmission.

The current recommendation to wear a mask when in contact with other people affects millions of civilians, not just medical employees, who must wear masks during all labour hours. So, taxi and regular-route bus drivers are advised to work in medical masks during pandemics and outbreak of viral diseases. However, the quantitative and qualitative influence of protective and medical masks on the safety of driving vehicles has not been previously studied. An example is the case in the United States, where the first serious car accident involving COVID-19 personal protective equipment occurred. « The driver is «believed» to have passed out behind the wheel after wearing an N-95 mask for too long, police said. As a result, vehicle careened, front bumper first, into a wooden pole. The driver suffered non-life-threatening injuries; accident scene investigation did not reveal that the driver was not under the influence of drugs or alcohol» [4, 5]. As it is known, respirators with this protection class filter about 95 % of the air, and they are usually worn only by medical employees who are constantly in contact with infectious patients. According to law enforcement officers, the victim had not taken off the mask for several hours and, most likely passed out behind the wheel due to insufficient oxygen intake.

The data of foreign studies evaluating the effect of physical exercises performed by a person with a face shield on cardiopulmonary load capacity, give unequivocal results regarding the negative impact on such parameters as maximum voluntary ventilation that a person can exhale (MVV) and maximal oxygen consumption (VO_{2max}/kg), affecting breathing and ventilation of air in the lungs. Masks significantly reduce pulmonary parameters at rest and during maximum exercise. In addition, wearing masks was perceived as very uncomfortable and significantly affected subjective breathing resistance with the mask. «Wearing the FFP2/N95 mask resulted in a reduction of VO2max by 13 % and of ventilation by 23 %» [2]. These changes are consistent with increased nasal and breathing resistance (e.g., [3, p. 920]). Studies that have tested the increased obstruction of the upper airways caused by additional resistance in the mouth report a similar effect on the parameter of lung function followed by increased breathing resistance [4, p. 1374]. The decrease in ventilation was the result of a lower respiratory rate with corresponding changes in inspiratory and expiratory times and a decrease in tidal volume. This is consistent with the effects of respiratory protective devices or additional external resistance to breathing [5, p. 279]. In particular, breathing resistance, warmth, oppression and general discomfort when wearing masks are factors that are perceived as subjectively disturbing and are accompanied by increased perception of stress [6, p. 509]. Obviously, masks have a negative effect on the dynamics of perception, especially at the limit of exercise tolerance and indicate the associated discomfort

[1] Mask use in the context of COVID-19: interim guidance, 1 December 2020. The World Health Organization (WHO). [Electronic resource]: https://apps.who.int/iris/handle/10665/337199. Last accessed 29.04.2021.

[2] Methodological recommendations for prevention of coronavirus infection (COVID-19). Ministry of Health of the Republic of Belarus, 2020.

[3] Rules of conduct that are binding on citizens and organisations when a high alert or emergency regime is introduced. Decree of the Government of the Russian Federation of April 2, 2020, No. 417.

[4] The driver got into an accident due to a protective mask. [Electronic resource]: https://germania-one.turbopages.org/germania.one/s/voditel-popal-v-dtp-iz-za-zashhitnoj-maski/. [In Russian]. Last accessed 29.04.2021.

[5] Source in English, e.g., Carrega, C. Driver in crash may have passed out from wearing N95 mask too long: Police. ABC news. [Electronic resource]: https://abcnews.go.com/US/driver-crash-passed-wearing-n95-mask-long-police/story?id=70346532. – *Translator's note*.

as the second important cause of the observed deterioration in physical performance [7, p. 950].

The mask wearing in many countries is introduced as partially or completely mandatory measures, depending on the situation [8, p. 152]. And if pedestrians, while observing the social distance, must wear masks in public places and follow the rules for wearing masks [9, p. 1985], then for car drivers, such norms remain controversial. The cases when the driver must wear a mask, and when it is permissible to be without it are not stipulated. Traffic rules do not specifically regulate wearing of medical masks and, therefore, this can be considered as the absence of a ban on wearing them while driving. Therefore, it is relevant to conduct research to determine the causes and consequences of wearing face protection masks as a factor in eventuality of changes in safety of driving and road traffic.

The *objective* of this work is aimed at a randomised study of the effect of a face mask on the change in psychophysiological qualities of a driver as a factor in eventuality of driving safety in urban traffic environment during the COVID-19 pandemic period.

RESEARCH METHODS

The total pooled study sample included 108 healthy participants in a randomised order. In this group, the effects of driving in a protective mask and without it as for men (75 %) and women (25 %) (age 22–48 ± 2,2 years) were quantified. The response to traffic was monitored using a video recorder. After driving with and without a face protection mask (FPM), ten areas of driver comfort/discomfort were assessed using a questionnaire generated in the open web resource Google Forms https://docs.google.com/forms/.

For qualitative assessment of the influence of FPM on the psycho-emotional state of the driver and the degree of its influence on driving safety, about 10 % of drivers were examined using the Meleti hardware and software complex, designed to test, evaluate, and develop the psychophysiological qualities of vehicle drivers. Meleti software issues an automated conclusion without participation of a professional psychologist and allows to assess the level of psychophysiological qualities necessary for safe driving. The respondents were tested twice: with and without a mask. The tests were carried out at the same time of the day, but on different days with an interval of at least 48 hours, to ensure the same experimental environment.

The paper assumes that the type of FPM (medical or tissue) does not affect the passing of the test, because the choice of a mask was offered to the test takers, and the study authors could not control it closely.

Cars and passenger buses were used as vehicles.

All test participants recorded their permission at the end of the survey to use their answers in this research work, since it will not harm the participants and the institutions where they study or work, and all results obtained are confidential and will be presented in general form.

The test takers were not aware of the results of the respective tests to avoid bias in passing the tests. Statistical analysis was performed by an independent investigator who was not involved in the tests.

THE RESULTS OBTAINED

The first part of the research

The first part of the research was dedicated to a statistical analysis of a quantitative subjective assessment by healthy adult drivers of the influence of FPM on changes in safe driving conditions and a comfortable and emotional state while driving. The data obtained in the course of the research obey the law of normal distribution, due to which parametric statistical procedures are applied to them.

The study involved 108 people, most of the subjects (75 %) were males. The age of the respondents is from 18 to 55 years old, and more than half of them are from 20 to 35 years old. Driving experience was from one to 25 years.

The following distribution of respondents per time of driving in FPM was established: 61,1 % of the study participants were driving a car for about 15 minutes, 33,3 % of the subjects drove a car for 30 minutes or more. The rest drove for about 20 minutes.

The respondents' assessment of the influence of FPM on comfort while driving showed that the study participants experienced constant (56,5 %) or noticeable (40,7 %) discomfort when using masks, especially during strenuous driving and at night.

The distribution of respondents per degree of influence of FPM on respiratory function showed that more than half of the study participants (54,6 %) experienced constant difficulty in breathing when using a mask while driving,

another 22,2 % experienced discomfort sometimes, and only slightly less than a quarter (23,1 %) did not experience any inconvenience.

The study of distribution of cases of allergic reactions to wearing a mask while driving using FPM revealed that 51 % of drivers had various allergic reactions (itching, redness) each time, 16,7 % had such consequences sometimes, and only 32,3 % never had any.

The overwhelming majority of drivers (75,9 %) felt sometimes a desire to take off their masks, and three quarters of drivers felt it all the time.

Also, about 60 % of respondents felt a high degree of fatigue from wearing FPM all the time, 17,6 % – sometimes, and only 23,1 % of respondents did not suffer a negative effect of masks.

At the same time, more than half of the respondents noted a deterioration (38,9 % – significant, and 12,0 % – insignificant) in perception of information from the dashboard of a car when driving wearing a FPM. A narrowing of the viewing angle and some inconvenience in using side mirrors were also noted. This correlates with the results on decrease in accuracy of the use of controls while wearing a mask, since more than half of drivers (53,7 %) noted some inhibition in their control reactions. Similar responses were received to the question about the effect of a face mask on concentration. Thus, for 38 % of drivers, the mask significantly reduced concentration of attention, for 27,8 % the reduction was insignificant, and 34,3 % of respondents did not notice any negative influence of FPM on this characteristic.

The results of studies on subjective assessment of the effect of a protective mask on professionally important, psychophysiological characteristics of drivers revealed the following: about two-thirds of drivers reported a significant (41,7 %) or insignificant (20,4 %) decrease in reaction, while 38 % did not notice significant deviations because of the mask to the response to driving. Since the mask is an additional factor in inattention and physiological fatigue of drivers, this can become one of the causes of a traffic accident.

Thus, it is obvious that in a situation where the risk of infection is minimal, there is no objective need to drive a car in FPM, and a driver without passengers in the car can work without a mask. It is also necessary to clarify that in the summer season, the mask will only complicate breathing and worsen the driver's well-being, and the presence of a mask on the face in summer while wearing sunglasses will lead to fogging when exhaling, which is another negative factor in driving safety.

The second part of the research

The second part of the research was dedicated to a qualitative analysis of assessment of the level of psychophysiological qualities of drivers in FPM and without it using the Meleti hardware-software complex [6] having the necessary certificates of conformity. 11 people, or 10 % of the total number of those tested, passed the testing with Meleti. The testing lasted from 70 to 100 minutes. The personality traits were assessed, such as:

• Psychophysiological traits: parameters of attention (volume, stability, concentration, distribution of attention), parameters of short-term memory, reaction time and accuracy, time perception accuracy, etc.

• Individual traits: risk propensity, aggressiveness, properties of the nervous system and temperament, motivation for safe driving, etc.

As a system for evaluating test results, marks from high to low were taken. Data processing was carried out using statistical analysis tools in MS Excel spreadsheets, the boundary value of each specific coefficient was calculated as the average of the test results from 0,1 to 1.0 (Table 1).

So, the presence of a mask on the driver's face provokes a decrease in the level of professionally important qualities from «high» to «average», the overall assessment of psychophysiological selection from «good» to «satisfactory», a deterioration in the forecast of the success in driver profession from «favourable» to «indefinite». Besides, when wording the final opinion on admissibility of a candidate to work as a driver as «apt», drivers in a mask were assigned to the category of respondents for whom this activity is «not contraindicated» with remark of «conditionally apt».

A parametric model, a radial diagram, which allows to visually evaluate the fields and areas of permissible values was chosen as the main toolkit for identifying the conditionally influencing values of the coefficients on the

[6] Testing of psychophysiological qualities. [Electronic resource]: https://anonmc.ru/deyatelnost/testirovanie/. Last accessed 29.04.2021.

Table 1

The results of assessment of professionally important qualities of the driver in a protection mask and without it (compiled by the authors)

Professionally important qualities of a driver	Indicators			
	with a mask		without a mask	
	rel. units	points	rel. units	points
Concentration and attention	0,14	2	0,45	3
Attention distribution and switching	0,047	2	0,6	3
Short-term memory	0,36	3	0,72	4
Reaction time	0,81	4	0,81	4
Reaction accuracy	0,96	5	0,96	5
Time perception accuracy	0,81	4	0,81	4
Neuropsychic stability	0,047	2	0,6	3
Aggressiveness	0,81	4	0,81	4
Risk propensity	0,96	5	0,96	5
Defence motivation level	0,047	2	0,81	4
Level of motivation to achieve success	0,96	5	0,96	5
Thinking development level	0,96	5	0,81	4
Distance judging	0,96	5	0,96	5
Volume and stability of attention	0,85	5	0,36	3
Speed of formation of psychomotor skills	0,81	4	0,72	4
Total	9,531	3	11,34	4

general psychophysiological state of the driver in FPM.

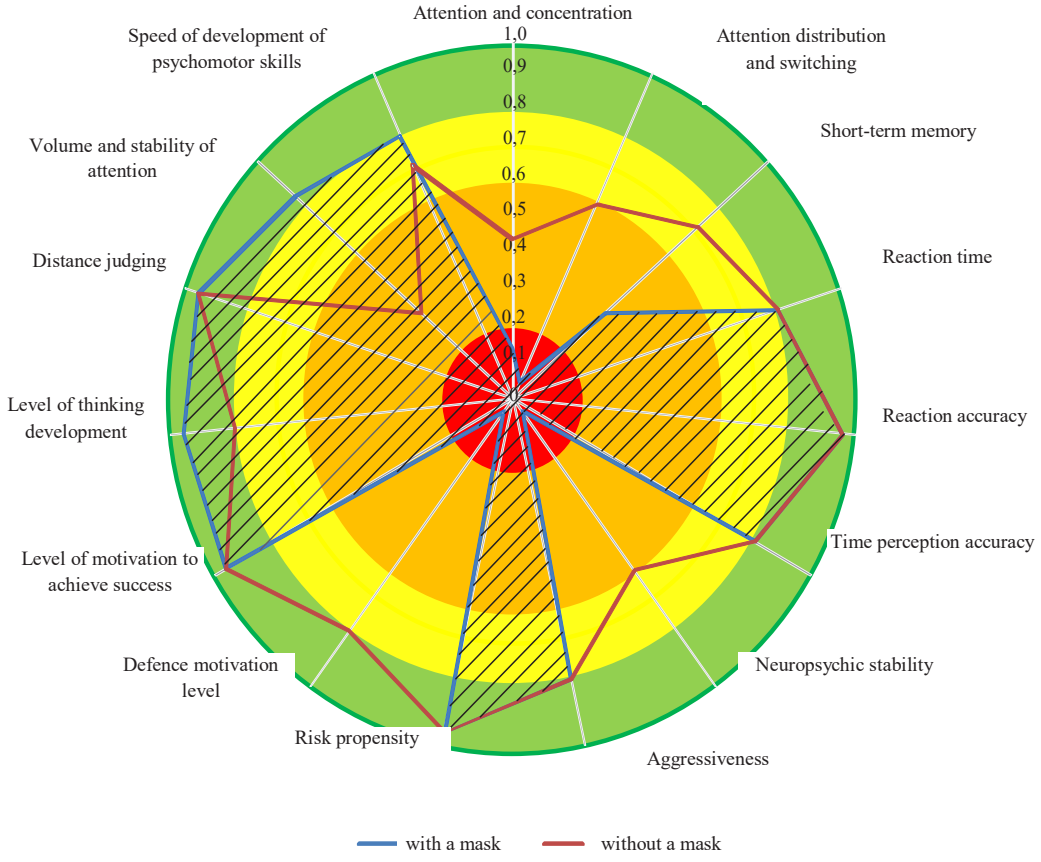
Pic. 1 shows the generalised test data for determining the level of psychophysiological qualities and the established parameters of the studied group of drivers with and without FPM. Each evaluated parameter in the diagram corresponds to a separate ray. Depending on the importance, the diagram is conventionally divided into four zones: threshold – from 0 to 0.19, satisfactory – from 0,2 to 0,59, good – from 0,6 to 0,79, and excellent – from 0,8 to 1,0.

Analysing the generalised results of an automated psychophysiological examination, it was found that the psychophysiological qualities of drivers wearing the masks showed lower values for certain professionally important qualities in comparison with the results of the same test passed by them without a mask, namely:

• The level of concentration and attention is reduced by 69 %. The driver is not able to concentrate on important elements of road traffic and vehicle controls for a long time (on instrument readings, road signs and markings, traffic signals, etc.). He is often distracted by extraneous factors and irritants (by his own thoughts not related to driving a vehicle, which reduce safety of driving a vehicle, by the environment, by using gadgets, by sounds and emotional conversations). He cannot concentrate in difficult road situations (driving during peak hours, difficult road, and weather conditions).

• The indicator of attention switching is reduced by 92 %. The driver is not attentive to road signs and instrument readings, misses road landmarks, is often unable to evaluate combinations of road signs, regularly demonstrates a slow reaction to switching attention from the traffic situation to external stimuli, is constantly distracted. He demonstrates confusion, a tendency to create emergency situations due to the slowed down ability to adequately assess them and the delayed control decision-making (especially in an unfamiliar road situation or terrain).

• The indicator of short-term memory is reduced by 50 %. The driver is not always able to retain operational information in his memory: road signs with prolonged action, for example, speed limits, stop bans, signs of settlements, etc. Sometimes he can forget routes, addresses, nature of road surface. He is not always able to stably maintain his behavioural motives when driving through a known road, depending on its load at



Pic. 1. The influence of the mask on the level of psychological qualities of drivers (compiled by the authors).

the time of day, on days of the week, when conditions of insufficient visibility occur. He may find it difficult to navigate the terrain. Because of the above, it can sometimes unknowingly violate traffic rules, create emergency situations.

• The level of neuropsychic stability decreases by 92 %, which indicates the occurrence of the likelihood of neuropsychic breakdowns directed at fellow travellers and (or) at the «culprits» who caused such a reaction. The driver is quick-tempered and unbalanced, behaves inappropriately while driving, often violates traffic rules, both involuntarily and intentionally. The driver is advised to consult a neuropsychiatrist.

• The level of motivation to avoid failure increases by 94 %. Such a driver has reduced skills for safe driving, which are a consequence of his inattention and low concentration, of low indicators of visual-motor reaction, inability to correctly assess the road situation. The foregoing often leads the driver to an extremely low self-esteem and level of aspirations, to a chronic fear of failures (unwillingness to get into an accident), which increases as the motivation for a high level of failure avoidance grows, and often increases their occurrence like an avalanche.

• The level of thinking development increases by 19 %. Such a driver is always reliable in controlling his vehicle, movement of other vehicles in the stream and the entire traffic situation in general, is able to qualitatively predict development of the traffic situation. He ensures high safety of vehicle control, adheres to a safe driving style with minimal risks.

• The level of monotony increases by 136 %. The driver in uniform, boring and monotonous traffic conditions gets tired, loses reaction speed, ability to control the traffic situation, may even fall asleep, which from time to time provokes an emergency.

A person as a link in the «driver–car–road–environment» (DCRE) system is not only basic, but also the most unstable element [10, p. 113]. By his nature, a person is characterised by inconstancy, the ability to change, and therefore, the problem of the driver's reliability when driving a car is complicated by its versatility [11, p. 14].

https://rozetked.me/images/uploads/eOGOhrvqLbwc.jpg

When all the links of the system are balanced, the probability of a road traffic accident is insignificant [12, p. 9; 13, p. 60]. But the imbalance of at least one link leads to an imbalance of the entire system and an increase in the likelihood of a road traffic accident. The reliability of a driver in the «driver–car–road–environment» system is determined by a very complex set of interrelated factors. Performance, knowledge, abilities, skills, motives are most important factors, which intensity is due to individual characteristics, the nature and health of the driver, as well as his driving style [14, p. 87].

The peculiarities of the driver's activity should also include external unfavourable factors affecting him: heat and cold, high air humidity, unsatisfactory road conditions (ice, snow, mud, etc.), noise and vibration, uncomfortable working posture, etc. [15, p. 770]. With absent-mindedness, irritability, decreased attention, drowsiness and other complaints affecting the level of performance, the likelihood of a traffic accident increases sharply (by 1,5–1,8 times) [16, p. 178]. Therefore, the requirement to drive a vehicle wearing a protective mask is another negative external irritant that negatively affects performance.

Thus, the mask is considered as an eventual environmental factor affecting the accident rate. The degree of influence is proposed to be estimated by the coefficient of eventuality of reducing road safety determined as the ratio of the area of the radar diagram, built according to the values of the indicators of the level of the professionally important qualities of the driver in the mask, to the area of the diagram obtained during testing without it.

$$k_{ev} = \frac{S_{\text{m}}}{S_{\text{no.m}}} = \frac{\sum_{1}^{n} k_{\text{piq, m}}}{\sum_{1}^{n} k_{\text{piq, no.m}}}. \quad (1)$$

The coefficient shows a quantitative assessment of the influence of the use of a protective mask in the process of driving a car on the level of psychophysiological qualities and personality traits of the driver, which in turn affect safety of driving. In the studied case

$$k_{ev} = \frac{9,531}{11,340} = 0,84.$$

The need to consider the eventuality coefficient arises when investigating a traffic accident, when there are assumptions about the presence of a causal relationship between wearing a protective mask and the emergence of a traffic conflict and emergency situations.

CONCLUSION

The results obtained indicate that the use of a face mask by the driver while driving leads to

a significant increase in the level of mental activity, the volume and stability of the driver's attention. However, psychological overstrain and discomfort from wearing the face mask result in a decrease in such important psychophysiological qualities of the driver as concentration and attention (by more than three times), the distribution of attention switching between static (road signs, traffic lights, markings, etc.) and dynamic (moving vehicles and pedestrians) objects on the road (by more than ten times).

To assess the effect of a face mask on a driver, a coefficient of eventuality of reducing road safety was proposed, which can be taken into account when developing recommendations on the use of face masks for drivers of cars and buses and when analysing the causes of road accidents in a situational pandemic situation.

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