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ORGANIZING THE REGIME OF WORK AND REST OF DRIVERS ON MOUNTAIN ROADS

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Mountain roads in Kyrgyzstan are characterized a large difference in altitude above sea level. Above 2,000 meters above sea level, drivers develop symptoms of altitude sickness. The aim of the study is to study the effect of atmospheric pressure on the body of a vehicle driver in mountainous conditions. The Bishkek-Naryn-Torugart international highway was chosen as an object. Control point No. 1 is located on the Torugart pass near the border with China (altitude is 3752 meters above sea level). Checkpoint No. 2 is located near the village of At-Bashy (altitude above sea level is 2046 meters). Control point No. 3 is located near the village of Kemin (altitude 1120 meters above sea level). The results of the study showed that blood pressure indicators change along the considered route depending on the height above sea level. For example, pressure indicators of 140-159 / 90-99 were observed in 24% of drivers at point No. 1, 19% at point No. 2 and only 5% at point No. 3. Blood pressure 160-179 / 100-109 (moderate hypertension) was observed in 7% of drivers in point 1 and in 5% of drivers in point 2. The main reason for the increase in pressure was a violation of the mode of work and rest of drivers. As a result, standards for the work of drivers of international road transport in high altitude conditions were developed and measures were proposed for the mandatory organization of rest places for drivers on the Bishkek-Naryn-Torugart road.

Keywords: arterial pressure, atmosphere pressure, check point, mountain sickness, road bishkek-naryn-torugart

1 INTRODUCTION

Kyrgyzstan is located in Central Asia and about 90% of its territory is occupied by mountains over 1500 meters above sea level. Mountain roads have a complex terrain with frequent steep slopes and a large number of turns with small radii [1]. In addition to the difficult terrain, the mountain roads of Kyrgyzstan are characterized not only by limited visibility, difficult road topography, but also by a large difference in altitude above sea level. This has a strong impact on the potential of the vehicle itself [2-3] and on the driver's performance [4-5]. Most (70%) of all traffic accidents in the Republic of Kyrgyzstan occur on difficult sections of mountain roads [6].

The difference in altitude above sea level is accompanied by a difference in atmospheric pressure. Atmospheric pressure is created by the gravitational attraction of air to the Earth and decreases with increasing altitude. Driver develops altitude sickness symptoms above 2000 meters above sea level which often leads to severe accidents.

A decrease in atmospheric air pressure leads to an increase in human blood pressure. Blood pressure characterizes the work of the circulatory system. It is determined by the volume of blood pumped by the heart per unit of time and vascular resistance. Blood pressure is measured in millimeters of mercury (mm Hg). A person feels comfortable at an atmospheric pressure of 760 mm. rt. pillar.

The blood pressure indicator consists of two numbers: upper and lower. The upper number shows the pressure in the arteries at the moment when the heart contracts and pushes blood into the arteries and is called systolic. The lower number shows the pressure in the arteries at the moment o heart muscle relaxation and is called diastolic.

Stable increase in blood pressure above 140/90 mm. rt. artis hypertension. Hypertension is considered one of the most dangerous diseases of mankind. About 25% of people worldwide suffer from this disease, and the figure continues to increase [9]. The incidence of hypertension is a pandemic throughout the world. Its prevalence is: in Germany 55%, in Finland 49%, in the USA 28%, in Canada 27%. About 40% of the adult population of the Russian Federation has elevated blood pressure. Arterial hypertension remains a difficult condition to control. Only 27% of hypertensive patients in the USA, 24% in France, 9% in Italy, 6% in England, 2% in Poland are effectively treated. In Kyrgyzstan, this figure is 30-40% [10].

Driver hypertension creates a dangerous situation on the road and increases the number of road accidents. It has been hypothesis that factors other than height above sea level influence a driver's blood pressure.The aim of the study is to identify the causes of high blood pressure among vehicle drivers on the Bishkek-Naryn-Torugart mountain road.

2 MATERIALS AND METHODS

The research was carried out on the international mountain road Bishkek-Naryn-Torugart. The total length of the Bishkek-Naryn-Torugart highway is 539 km. The Torugart Pass of the Tien Shan mountain system is located on the border of the Naryn region of Kyrgyzstan and the Xinjiang Uygur Autonomous Region of the People's Republic of China. The study was conducted on June 6-7, 2022. Border, customs and weight control employees were informed in advance by the relevant services in writing.

Three control points were organized to monitor the health of drivers on the Bishkek-Naryn-Torugart international highway (Fig. 1).

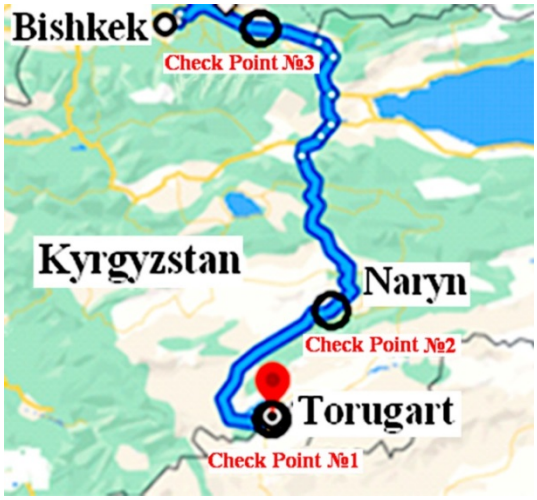

Fig. 1. Location of control points on a mountain road Bishkek-Naryn-Torugart

At each control point, weight control was carried out and blood pressure was measured. According to previous studies, it was found that blood pressure indicators make it possible to assess the degree of fatigue and the level of wakefulness [11]. To clarify possible deviations, a questionnaire was additionally conducted to record the age of the driver, the presence of diseases, smoking, and the organization of the work regime.

Point No. 1 is located on the Torugart pass. Its height above sea level was 3752 meters. There is a customs control at this control point. Drivers are forced to stand in line and sometimes wait for days for paperwork (Fig. 2).

Fig. 2. The queue for customs control at the pass Torugart

Previous studies [12] have shown that even a short-term acclimatization on the top of a mountain affects the efficiency of sleep, cardiovascular and respiratory responses of a person. Sleep disturbance increases the likelihood of traffic accidents [13-14]. Therefore, timely detection of driver drowsiness is an important measure to prevent traffic accidents [15-16].

Point No. 2 is located near the village of At-Bashy at a distance of 190 km from the Torugart pass. The height above sea level was 2046 meters. Some drivers take a break at this control point. Here you can eat and sleep. Other drivers continued on their way to their destination without rest. The lack of special resting places contributed to the violation of the work regime of drivers and affected their fatigue [17].

Increased driver fatigue contributes to a decrease in auditory, visual and tactile sensitivity, an increase in reaction time and a decrease in productivity [18-19]. The increase in the number of errors is one of the main causes of traffic accidents on mountain roads [20].

Point No. 3 is located near the village of Kemin at an altitude of 1120 meters above sea level. In total, the road from Torugart to Bishkek took an average of one to two days.

In point No. 1, the blood pressure of drivers was measured, the indicators were recorded in a table, and coupons with a number were issued. In subsequent points No. 2 and No. 3, each driver was received by the coupon number and repeated pressure measurements were taken (Fig. 3).

Fig. 3. Measurement of blood pressure at control points

The study involved two teams of medical workers of the At-Bashi Center for Public Medical Practice with an experience of 19 and 27 years. The blood pressure measurements of the drivers were carried out using a mechanical tonometer Adjutor IAD (Fig. 4). The measurement range of the tonometer was 300 millimeters of mercury. The division value of the tonometer scale is 2 millimeters of mercury. The measurement error of the tonometer was ±3 millimeters of mercury.

Fig. 4. Tonometer Adjutor IAD

The minimum number of measurements *n* was determined by the formula $n = q(t\omega/\varepsilon)^2$, where t is the coefficient for the confidence probability q, ε is the required accuracy of the result; ω is coefficient of variation. With a confidence level of $q = 0.9$ with an acceptable error of 10% ($\varepsilon = 0.1$), the number of measurements was $n = 100$.

During the study, the blood pressure of 101 drivers was measured at control point No. 1, 87 drivers at control point No. 2, and 81 drivers at control point No. 3. This was explained by the different time of paperwork at customs and different time of entry to the track.

3 RESULTS

An analysis of measured blood pressure indicators of drivers showed that only 5% of all drivers had normal blood pressure (90/60) (Fig. 5). The maximum indicators of blood pressure of drivers were observed among drivers at control points No. 1 and No. 2. As a result of the experiment, the speed characteristics of the fuel pump operating in the 4Ch11/12.5 (D-240) engine mode with serial and modernized injectors are shown (Fig. 5).

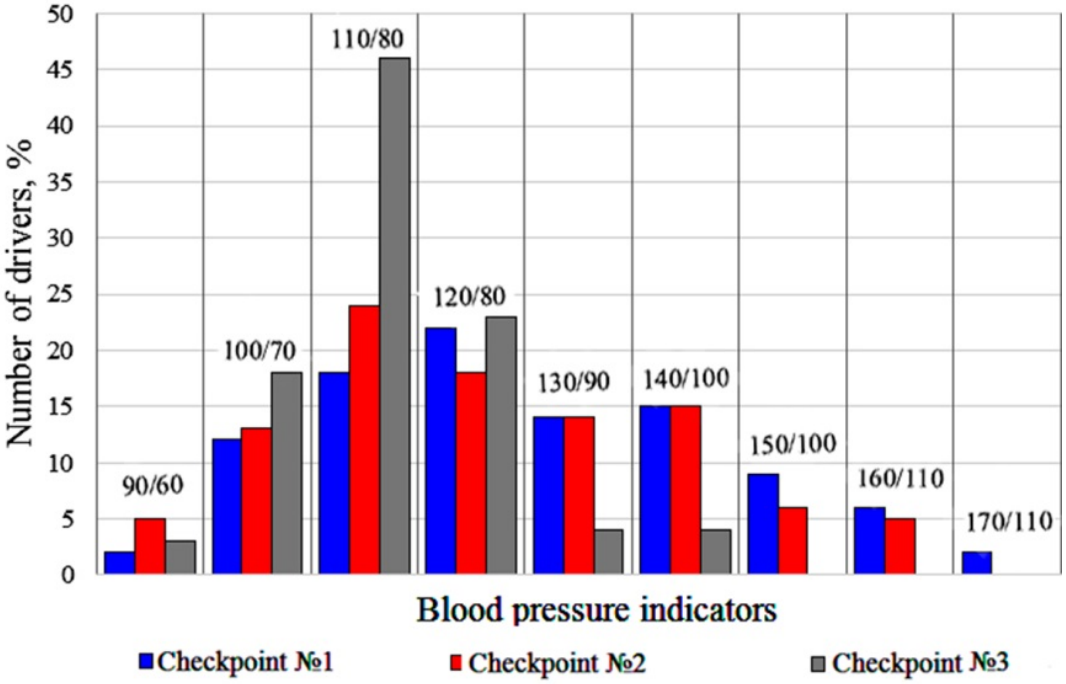

Fig. 5. Drivers blood pressure measurements

High blood pressure 140-159/90-99 was observed in 24% of drivers in control point No. 1. At control point No. 2, the number of drivers with such pressure was 19%, and at control point No. 3, only 5%. Blood pressure of 160-179/100-109 was observed in 7% of drivers at control point No. 1 and 5% at control point No 2 (Table 1).

Table 1 shows that blood pressure values change along the route under consideration depending on the altitude. Particularly alarming are the indicators in the lines “High normal blood pressure” (34%), “Moderate hypertension” (48%) and “Moderate hypertension” (12%).

Table 1. Number of drivers (%) according to the World Health Organization blood pressure classification

Category (blood pressure norms)	Upper blood pressure millimeters of mercury	Lower blood pressure millimeters of mercury	Control point No.1 (height 3752 m)	Control point No.2 (height 2046 m)	Control point No.3 (height 1120 m)
Hypotension (low)	below 100	below 60	1	5	3
Optimal pressure	100–119	60–79	32	38	64
Normal pressure	120–129	80–84	22	18	23
High normal pressure	130–139	85–89	14	15	5
Moderate hypertension (increased)	140–159	90–99	24	19	5
Moderate hypertension	160–179	100–109	7	5	–

The experiment involved 43% of drivers aged 31-40, 25% aged 41-50, 12% young drivers aged 23-30 and 19% older drivers 51-60. The age of the drivers participating in the study and their distribution by weight is presented in Fig. 6.

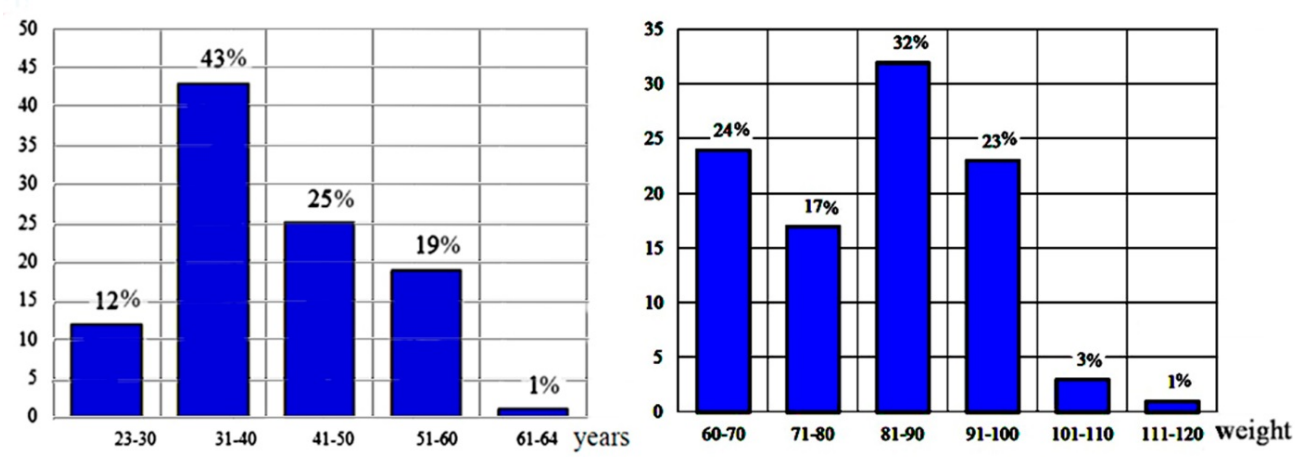

Fig. 6. Age of drivers and their weight distribution

Normal blood pressure of 110/80-120/80 was observed in drivers aged 26-50 years. Blood pressure 130/80-140/100 was measured in drivers aged 28-58. Older drivers aged 40-64 had, as a rule, high blood pressure 150/100-160/110. This is explained by sleep disturbance in older drivers [21], the presence of age-related diseases in them [22] and, as a result, an increase in possible accidents [23].

In 2018, the European Society of Cardiology introduced new recommendations on blood pressure norms that allow recognizing a person's wakefulness and sleepiness [24]. According to their recommendations, blood pressure should not exceed:

- 129/80 millimeters of mercury for people under 65;
- 139/80 millimeters of mercury for older people.

The cause of high blood pressure can be stress [25], physical overwork [26], the duration of intellectual work, weather changes, and overweight. To find out the cause of the increased pressure, a questionnaire analysis was carried out (Table 2).

Table 2. Results of the survey of drivers on the Bishkek-Naryn-Torugart international highway (06.06.2022)

Question	Answer
What is your working blood pressure?	73% of drivers do not know their working pressure
Are there any chronic diseases?	13% suffer from a chronic disease
Do you use medication while driving?	Use constantly 13%, use sometimes 40%, do not use medicines 47%
Do you smoke?	54% smoke, 13% smoke occasionally, 33% don't smoke
Does drowsiness occur while driving on the highway?	Constantly sleepy on the track 27%, occasionally sleepy on the track 60%, not sleepy on the track 13%
How many hours do you sleep before a trip?	4-5 hours - 40%, 6-7 hours 20%, 8-9 hours - 40%
How many hours do you spend driving a day?	8-10 hours - 47%, 11-12 hours - 40%, more than 12 hours - 13%
Are you very tired at work?	Feels constantly tired 40%, sometimes feel tired 40%, do not feel tired 20%
Do you have problems driving at night?	Sometimes it happens - 31%, it doesn't happen - 69%
Is it necessary to conduct a medical examination before leaving the track?	Feel the need for a medical examination 45%, feel no need 55%
Do drivers need periodic retraining?	Retraining needed 60%, no need 40%
Do you need places for drivers to rest on the highway?	It is necessary to organize places for the driver to rest on the track - 100%
What problems do you see on the Bishkek-Torugart route?	Delay in paperwork at customs posts and destruction of road surfaces

4 DISCUSSION

As a result of the questionnaire survey (Table 2), it turned out that 13% of drivers take medication constantly, and another 40% of drivers take medication occasionally. H makes up the majority of the drivers surveyed (53%). About 69% of drivers smoke. Almost half of the drivers (45%) supported the need for a medical examination before leaving the track.

At high mountains, drivers experience a lack of oxygen, which leads to a change in the function of the higher parts of the central nervous system [27]. There is a violation of mental and mental activity. The threshold of emotional excitability often rises in drivers, critical thinking and judgments about current events decrease [28].

Sleepiness while driving on a high mountain road was experienced by 87% of drivers (27% of drivers constantly and another 60% of drivers sometimes). A driver struggling with drowsiness and losing concentration is a threat to all road users [29].

Studies have shown that car drivers in conditions of rapid changes in atmospheric pressure have a decrease in attention by 32% and an increase in reaction time. The majority (88%) of traffic accidents occur due to the fault of car drivers [30]. Rollovers (42%) and vehicle collisions (37%) are the most common types of road traffic accidents on mountain roads. The main reasons are:

- 18% overspeeding,
- 62% exit into the oncoming lane and violation of the rules of overtaking,

- 6% non-observance of the distance,
- 13% fatigue and sleep at the wheel.

Analysis of the results of the study revealed the problem of non-compliance with work and rest regimes by drivers. Not all drivers fully rested before leaving the route (40% of drivers slept only 4-5 hours). Sleep disturbance is directly related to the risk of a traffic accident [31-32]. Many drivers (40%) constantly felt tired at work. Another 40% felt tired periodically. This is due to the fact that 47% of respondents were driving 8-10 hours, and another 40% worked 11-12 hours a day. 13% of drivers spend more than 12 hours behind the wheel. An increase in the duration of driving a vehicle reduced the vigilance and performance of the driver [33]. 31% of drivers had problems driving a vehicle at night.

Studies by various scientists show that after 4–5 hours of continuous driving, drivers experience fatigue, which contributes to a significant decrease in their performance [34-35]. According to the authors of [26], at an altitude of 2000–3000 meters above sea level (atmospheric pressure 125–105 mm Hg), human performance decreases by 18%. In high altitude conditions (3800–4200 meters above sea level) (atmospheric pressure 95–85 mm Hg), performance is reduced by 46%.

In Kyrgyzstan, one of the main causes of road traffic accidents is non-compliance with the work and rest regime of drivers. This applies to drivers of all vehicles engaged in freight and passenger transportation [36]. In Europe, fines have even been introduced for violating the condition of rest for drivers, which can be a quarter of his earnings.

The time during which the employee performs his labor duties is called working time. It is determined in accordance with the internal labor regulations and the work schedule or the terms of the employment contract. Working time is normalized through the norms of the duration of the calendar (working) week and the working day (shift) [37].

5 CONCLUSIONS

As a result of the conducted studies of the condition of drivers on the Bishkek-Naryn-Torugart international highway, it was revealed that

high normal blood pressure 130-139/85-89 was observed in:

- 14% of drivers at control point No. 1 (height 3752 meters above sea level);
- 15% of drivers at control point No. 2 (altitude 2046 meters above sea level);
- 5% of drivers at control point No. 3 (altitude 1120 meters above sea level).

moderate hypertension (increased) with blood pressure 140-159/90-99 was observed in:

- 24% of drivers at control point No. 1 (height 3752 meters above sea level);
- 19% of drivers at control point No. 2 (altitude 2046 meters above sea level);
- 5% of drivers at control point No. 3 (altitude 1120 meters above sea level).

moderate hypertension with blood pressure 160-179/100-109 was observed in:

- 7% of drivers at control point No. 1 (height 3752 meters above sea level);
- 5% of drivers at control point No. 2 (altitude 2046 meters above sea level).

An increase in the number of traffic accidents due to heart failure while driving has been recorded. It has been established that the increase in blood pressure of drivers on high mountain roads is affected by: age; overweight; smoking; irrational nutrition; mode of work and rest; lifestyle and physical activity. The conducted research confirmed the fact of violation of the regime of work and rest of drivers.

According to the provisions of the European Agreement [38], working standards have been developed for drivers of international road transport (Table 3).

Table 3. Work standards for drivers of international road transport in high altitude conditions

Maximum continuous control time	Norm - 4.5 hours
Minimum break time	The norm is 45 minutes, it is allowed to divide into breaks of 15 and 30 minutes during the driving period
Maximum control time (per day)	Norm - 9 hours, allowed up to 10 hours no more than twice a week
Maximum driving time (per week)	The norm is 56 hours, up to 90 hours are allowed for any two consecutive weeks
Minimum rest time (per day)	The norm is 11 hours, division into two periods of 3 and 9 hours is allowed.
Minimum rest time (per week)	The norm is 45 hours, at least 24 hours are allowed

One of the reasons for these violations is the lack of organized rest areas for drivers on the Bishkek-Naryn-Torugart highway. As a result of the survey, it was revealed that 100% of drivers support the need to organize rest places for drivers along the way.

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