European Research Studies Journal
Volume XXV, Issue 2, 2022

pp. 530-542

Food Safety Delivered for Polish Military Cadets during the COVID-19 Pandemic

Submitted 12/05/22, 1st revision 13/06/22, 2nd revision 10/07/22, accepted 30/07/22

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Abstract:

Purpose: *Nutrition of cadets during the period of biological threat caused by SARS-CoV-2 is an important element shaping their combat readiness, however, scientific research in this area is scarce. The need to analyse this specific group has become the genesis of this article. The main purpose of the study was to verify the significance of the effect of selected factors on the assessment of the quality and quantity of meals provided to soldiers.*
Design/Methodology/Approach: *Due to the qualitative and multi-level form of the dependent variable, multinomial logistic regression was used, which allowed the evaluation of the effect of all selected predictors on the results.*
Findings: *Research involved students of 4 years of study. The article presents a discussion of the study group and the effect of selected factors on the opinions about meals received during the SARS-CoV-2 pandemic. An interesting question was the assessment of whether and how a surveyed cadet's year of study, BMI and gender affected their decisions regarding the qualitative and quantitative assessment of food consumed during this period.*
Practical Implications: *The analysis showed that there are factors related to the characteristics of the respondents which significantly affect their assessment of nutrition, and thus it is important to select the right study sample. The answers obtained in the survey differed depending on the respondent's gender, BMI level or year of study. The results of the study provide a basis for further research aimed at optimizing nutrition for students of military universities.*
Originality/Value: *The results of the study showed that there are factors related to the characteristics of the respondents, such as gender, year of study or the BMI, which significantly affect their final value. The ratings given by women were definitely higher than those of men. Perhaps this was due to a greater tendency to show empathy and appreciate the effort associated with preparing meals.*

Keywords: *Nutrition of officer cadets, multinomial logistic regression, BMI, combat readiness, food security, SARS-CoV-2.*

JEL Classification: *C02, C12, C13, I12.*

Paper type: *Research article.*

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1. Introduction

Food security is one of the most important determinants affecting the proper functioning of the human body. Providing the right amount of energy, taking into account the right proportions of the main components, i.e., carbohydrates, fat and protein, as well as microelements and vitamins forms the basis of a rational diet. Many factors, such as social or professional groups, differentiate the nutritional requirements. Physical activity and daily routine are also important.

Therefore, officer cadets of military schools constitute a separate community, requiring a specific approach. The conditions in which they operate lead to the conclusion that proper nutrition of troops has a great impact on the performance of assigned tasks and, as a result, on the security of the armed forces (Tharion *et al*., 2005). This obvious fact is strongly emphasized in the literature, e.g. Hill *et al*. (2011). point to the importance of proper nutrition especially during the course of recovery and rehabilitation following combat injury. Purvis *et al*. (2013) indicate that meal times as well as eating habits and behaviours are key to soldiers' performance. Proportions of particular nutrients have also been analysed.

For example, studies deal with the effects of calcium and potassium supplementation, as well as effects of proper protein supply on bone fragility during initial military training (Nakayama *et al.*, 2019) or the problem of vitamin D deficiency in a group of Finnish soldiers (Laaksi *et al.*, 2007). Lieberman, on the other hand, studies the effects of the amino acids tryptophan and tyrosine, caffeine and carbohydrates on the cognitive functions of soldiers, such as alertness and stress resistance.

The relationship between the diet of soldiers and their stress levels has also been analysed in (Caldwell *et al*., 2017; Mason, 2018; Rahmani *et al.*, 2018). Pillsbury *et al*. present their extensive research on traumatic brain injury and the impact of nutrition on prevention and therapy in this regard (Purvis *et al*., 2013). Selected publications also signal the issue of gender and separate studies are focused on women (King *et al.*, 2003; McClung *et al*., 2009). Also in the present work, the gender factor proved to be significant.

A review of the literature has shown that the effect of nutrition on selected areas of soldiers' performance is most often studied, and various factors are selected for evaluation. Several of them are included in this article; in addition to the aforementioned gender, it is also the BMI. A similar issue has been analysed in (Packnett *et al*., 2011), however it concerns not cadets but military recruits in the US army. A simple logistic regression model is applied there, in which the dependent variable is the decision to dismiss from the army.

Cadets have also been analysed by Hoyt *et al.* (2006), however their study is based on a relatively small sample (16 people). A more complex form of logistic

regression (multinomial) has been applied in Rahmani *et al.* (2018), where the study sample is also larger (246 people), and the study itself concerns mental disorders, but only in a group of professional soldiers. Military school students are therefore not a frequent subject of research, probably because they are a narrow and specific group.

Few studies concern the assessment of their energy needs, including specific macronutrients (Edwards *et al.*, 2018; Glushkov *et al.*, 2018). Their knowledge of nutrition has also been analysed (Connell *et al*., 2017), although more often the research involves all military personnel (Bovill *et al.*, 2003; Kullen *et al*., 2016).

It should also be emphasized that the specificity resulting from geographical and cultural factors makes it necessary to conduct separate research for particular national groups, which also leaves room for comparisons. The time in which the research was conducted was also important - limitations resulting from the biological threat caused by the SARS-CoV-2 virus. Research on Polish soldiers is relatively scarce and is focused, among others, on diets of special forces (Bębnowicz *et al*., 2015; Tomczak *et al.*, 2014) as well as soldiers carrying out tasks in Polish military contingents (Bertrandt, 2005; Kłos *et al*., 1997). Moreover, most publications on the nutrition of Polish soldiers have been published in Polish, which significantly limits their dissemination.

The small number of publicly available publications and few studies on officer cadets, as well as the veritable need to analyse this specific group became the genesis of this article. Discussion is conducted against the background of a survey in which the students assessed the quality and quantity of meals they received. However, the study featured in this article focused not on the results of the survey, but rather on the evaluation of the sample. It was assumed that the year of study, the lifestyle reflected in the BMI, as well as gender could have a significant effect on the answers provided. Multinomial logistic regression was applied, allowing not only to verify the hypothesis, but also to calculate the probabilities of receiving particular survey results depending on the factors mentioned.

2. Research Methodology

Multinomial logistic regression is one of the regression methods used in statistics, which allows predicting the probability of various possible values of a dependent variable, expressed as several (more than two) categories (levels), based on independent variables. These variables can be categorical or continuous. Multinomial logistic regression is an extension of classic logistic regression (formulated for a binary dependent variable). The maximum likelihood method is used in each case for parameter estimation (Hosmer and Lemeshow, 2000; Kozłowski *et al*., 2019; T. Rymarczyk *et al.*, 2019).

In multinomial logistic regression, one of the levels of the dependent variable is taken as the reference level and each of the remaining levels is compared with it. In

addition to the possibility of describing multi-level qualitative variables, its advantage consists in the fact that it does not require compliance with the assumptions of normality, linearity or homoscedasticity of variables. However, it is necessary to assume the independence of the predictors. Logistic regression assumes a linear association between independent variables and the logarithm of the dependent variable. In addition, it requires large samples (at least 10 cases per independent variable) (Hastie *et al.*, 2009; Hosmer and Lemeshow, 2000).

In the case under consideration, a random variable $Y_n, n \in N$ describing student responses, can take k of possible realizations $k \in \{1,6\}$. Determining the probability values of providing the responses, depending on the factors that affect them (in this case BMI, gender and year of study) is enabled by multinomial logistic regression (Kozłowski *et al.*, 2019). In such a case, one of the levels is taken as a reference (typically the first, the last, or the value with the highest frequency) and conditional probabilities $P(y = k|x)$ are determined for each of the others, according to the equation:

$$P(y = k|x) = \frac{\exp\left(\beta_0^{(k)} + \beta_1^{(k)} x_1 + \cdots + \beta_p^{(k)} x_p\right)}{\sum_{j=1}^{K} \exp\left(\beta_0^{(k)} + \beta_1^{(k)} x_1 + \cdots + \beta_p^{(k)} x_p\right)} \quad (1)$$

for each $k = 1, \ldots, K-1$ the log of odds ratio for any two levels is:

$$ln \frac{P(y=j|x)}{P(y=k|x)} = \left(\beta_0^{(j)} - \beta_0^{(k)}\right) + \left(\beta_1^{(j)} - \beta_1^{(k)}\right) x_1 + \cdots + \left(\beta_p^{(j)} - \beta_p^{(k)}\right) x_p \quad (2)$$

However, for the reference level K we assume:

$$ln \frac{P(y=k|x)}{P(y=K|x)} = \beta_0^{(k)} + \beta_1^{(k)} x_1 + \cdots + \beta_p^{(k)} x_p \quad (3)$$

Wald test is used to determine the significance of model parameters. The null hypothesis assumes no effect of the regression coefficient (predictor) value on the dependent variable. The Wald test statistics are calculated as the quotient of the estimated parameter $\hat{\beta}_i$ and standard error (SE) of the estimate (Hosmer and Lemeshow, 2000):

$$W = \frac{\hat{\beta}_i}{\widehat{SE}\left(\hat{\beta}_i\right)} \quad (4)$$

Wald statistics have approximately a chi-square distribution with one degree of freedom. If the calculated value of test statistics is less than the assumed level of significance α we reject the null hypothesis, while if it is greater, there are no grounds to reject the null hypothesis. An important step in the analysis is the assessment of predictors. Depending on the analysed variable, the present study used

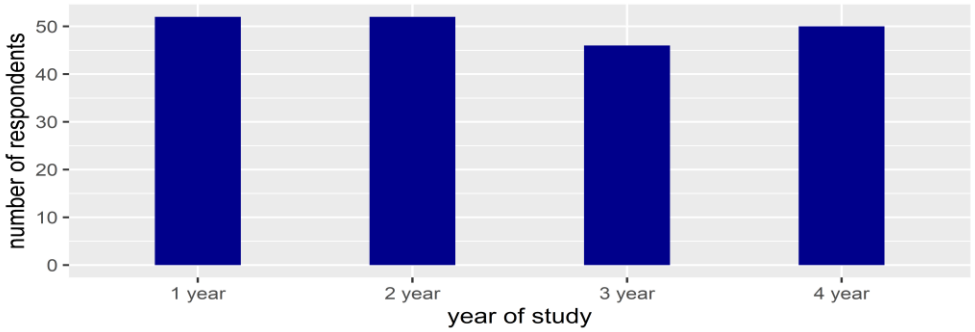
non-parametric Mann-Whitney, chi-square, and Kruskal-Wallis tests (Bruce and Bruce, 2017; Hastie *et al*., 2009).

3. Development of the Mathematical Model

3.1 Characteristics and Assessment of the Study Sample

The study included officer cadets of one of the Polish military schools. The sample was 200 students from four years of study. The number of individual groups was very similar, as shown in Figure 1.

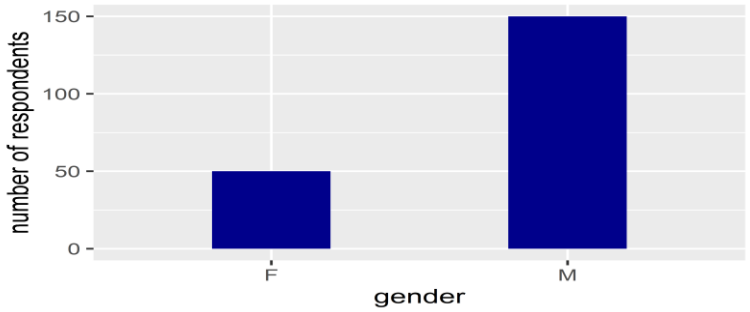
Figure 1. *Number of respondents for individual years of study*



Source: *Own study.*

The survey consisted of two parts. The first of these concerned the characteristics of the respondent, i.e. gender, weight and height. Due to the specificity of the university and occupation, which remains the domain of men in Poland, the vast majority of respondents (75%) were men (Figure 2).

Figure 2. *Number of women and men participating in the study*



Source: *Own study.*

BMI was calculated based on the weight and height of students. The basic descriptive statistics regarding this index are presented in Table 1.

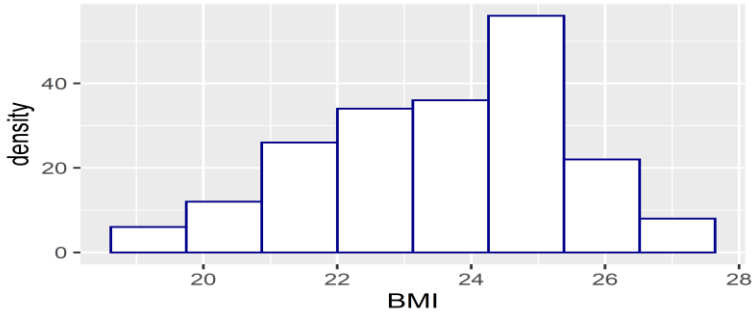
Table 1. *Basic descriptive statistics of the BMI*

	Descriptive statistics						
Variable	NOBS	Mean	Median	Minimum	Maximum	SD	CV
BMI	200	23.57	23.82	19.23	27.13	1.83	7.77

Source: *Own study.*

The mean and median values are slightly different, the distribution is not normal (Lilliefors test statistic D = 0.102, and p-value <0.0001), and there is also a clear left-hand asymmetry, there are more observations below the mean, which from the point of view of the analysis is a good result. The coefficient of variation is around 8%. The histogram of the distribution of the studied variable is presented in Figure 3.

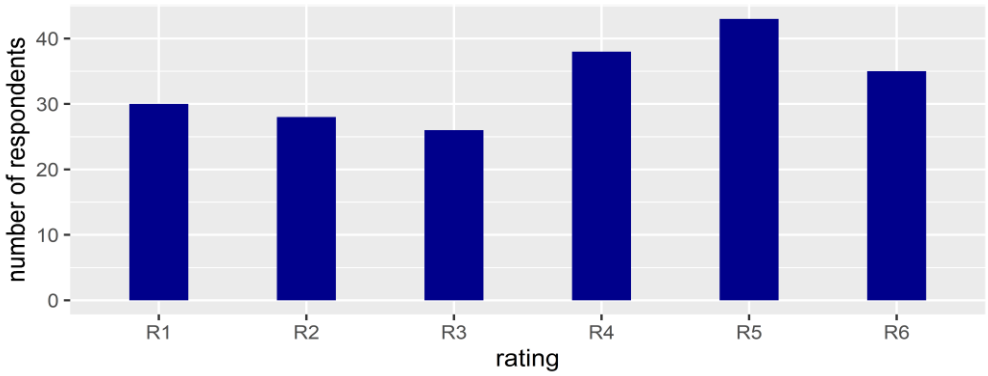
Figure 3. *Histogram of the BMI variable distribution*



Source: *Own study.*

The second part of the survey was an extended study on the quality and quantity of meals offered by the military canteen. The end result was an overall rating presented on a six-point scale. The number of results obtained within each of the possible categories is presented in Figure 4.

Figure 4. *Survey results*

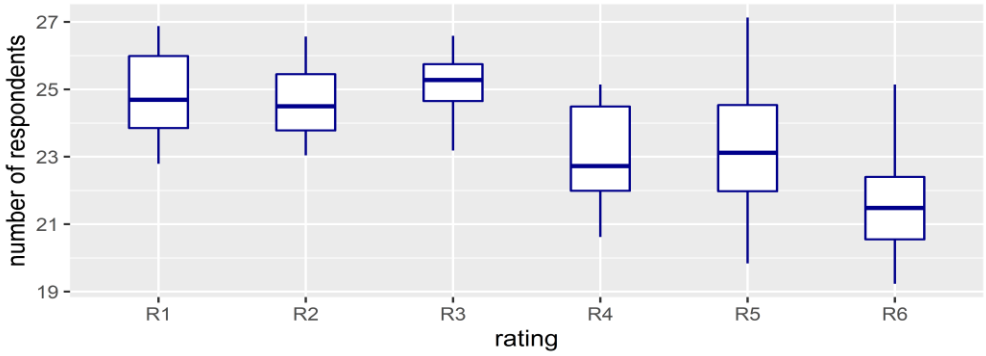


Source: *Own study.*

The results of the survey were varied and will be covered by a separate study. The present article aims to analyse and assess the impact of factors such as gender, year of study or BMI on the opinions on the quality of meals consumed. Due to the form of the dependent variable and its multi-level characteristics (six possible assessment results) multiple multinomial regression was used. The estimation of regression model parameters was preceded by testing the effect of individual predictors on the dependent variable.

For the BMI quantitative variable, due to the lack of compliance with the normal distribution, the non-parametric Kruskal-Walis test was used. Chi-square test statistics = 76.54 and p-value <0.0001, which means the need to reject the working hypothesis about the equality of means in individual groups. Therefore, the BMI is a statistically significant predictor. The box plot of this variable in individual groups is presented in Figure 5.

Figure 5. *Box plot of the BMI variable relative to the assessment made*



Source: *Own study.*

In the group of qualitative variables, the analysis was carried out based on contingency tables and by gauging association significance using the independence test χ^2. In addition, Cramer's V coefficient was calculated to assess the strength of this association. For the gender variable, the results obtained are presented (Table 2).

Table 2. *Study on the effect of the gender variable on survey results*

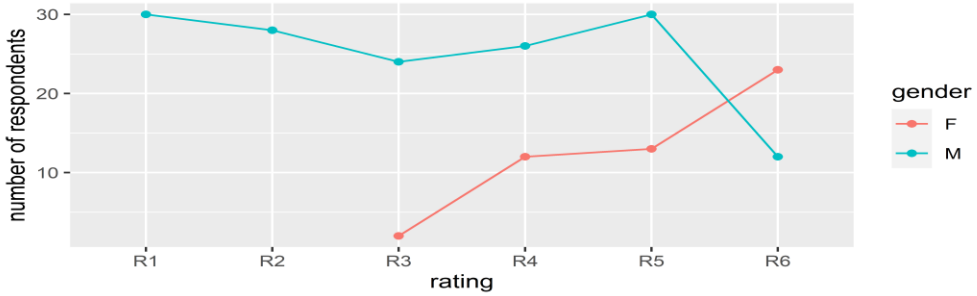
Statistics	**chi-square**	**Df**	**p-value**
Pearson's Chi^2	55.94	df=5	0.00
Chi^2 NW	65.73	df=5	0.00
Cramér's V	0.53		

Source: *Own study.*

The result indicates a significant difference between the groups defined by gender. The strength of this association is moderate. An additional interaction plot (Figure 6) clearly shows the varying effect of each category of the gender variable on the

dependent variable. In the absence of differences, the lines would be parallel to each other.

Figure 6. *Interaction graph for the gender variable*



Source: *Own study.*

The same analysis was conducted for the variable year of study. Contingency tables, χ^2 test and Cramer's V coefficient were used again. The results are presented in Table 3.

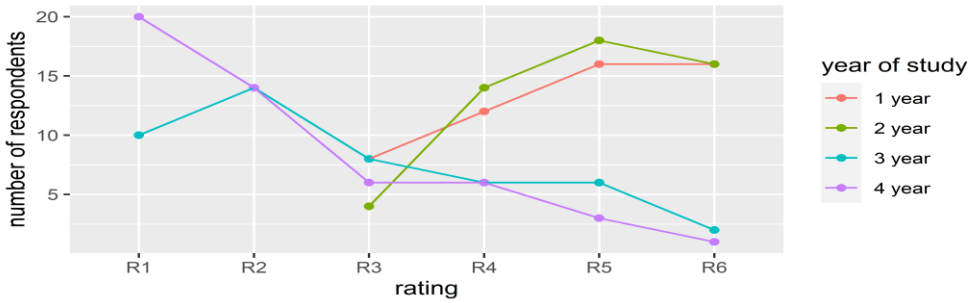
Table 3. *Study on the effect of the variable year of study on survey results*

Statistics	**chi-square**	**Df**	**p-value**
Pearson's Chi^2	109.89	df=15	0.00
Chi^2 NW	135.57	df=15	0.00
Cramér's V	0.43		

Source: *Own study.*

A significant association of moderate strength was confirmed. Interaction plots (Figure 7), however, showed some similarity for groups 1 and 2 of the year as well as 3 and 4, which suggests the possibility of combining these groups.

Figure 7. *Interaction plot for the variable year of study*



Source: *Own study.*

To investigate the associations between the groups designated by each category of the variable year of study, the Mann-Whitney U test was applied, the results of which for all pairs of groups are presented in Table 4.

Table 4. *Mann-Whitney U test results relative to the variable: year of study*

Year of study	Rank sum Group 1	Rank sum Group 2	U	p-value
2 and 1	2798	2662	1284	0.65
3 and 1	1453	3398	372	0.00
4 and 1	1511	3742	236	0.00
2 and 3	1413	3438	332	0.00
2 and 4	1478	3775	203	0.00
3 and 4	2497	2159	884	0.04

Source: *Own study.*

Because the test showed no significant difference in groups 1 and 2 of the year, further study was continued with the combination of these groups.

3.2 Estimation of Parameters of the Multinomial Logistic Regression Model

For each level of assessment, 5 logistic regression equations of the form (9) were determined, which describe associations for six possible assessments. The coefficient values were calculated using the maximum likelihood method, and their significance was tested using the Wald test. The calculations were made in the R environment. The results are presented Table 5.

Table 5. *Results of estimation of parameters of multinomial logistic regression*

Coef.	Intercept	BMI	Gender M	3rd year of study	4th year of study
R1	-50.86	1.32	12.26	12.70	12.21
R2	-47.29	1.14	12.58	13.54	12.39
R3	-47.28	1.14	12.58	13.55	12.39
R4	-8.46	0.31	1.87	2.6	2.77
R5	-39.36	1.43	5.15	5.05	3.77

Source: *Own study.*

Then, the odds ratios were calculated according to the equation (2), which allow to assess the effect of individual predictors on the dependent variable. The results are presented in Table 6.

Table 6. *Odds ratios for individual predictors*

	Intercept	BMI	Gender M	3rd year of study	4th year of study
R1	$8.18 * 10^{-23}$	3.73	$2.1* 10^{5}$	$3.29* 10^{5}$	$2.1 * 10^{5}$
R2	$2.91 * 10^{-21}$	3.12	$2.9* 10^{5}$	$7.65* 10^{5}$	$2.4 * 10^{5}$
R3	$8.06 * 10^{-18}$	4.17	$1.73* 10^{2}$	$1.56* 10^{2}$	43.46
R4	$2.11 * 10^{-04}$	1.37	6.48	$1.34* 10^{1}$	15.59
R5	$1.36 * 10^{-04}$	1.43	4.87	8.71	5.3

Source: *Own study.*

Table 6 presents the odds ratios associated with each predictor. An odds ratio of 1 means that there is no change, while a value greater than 1 means an increase, and a

smaller one means a decrease. In the study, the reference level for the dependent variable is the rating value of 6 ($R6$). For the BMI variable, each increase in its value by a unit increases the odds of giving a lower rating. The highest value concerns the odds of giving an R3 rating in relation to the R6 rating. This means that people with a higher BMI are more likely to criticize the quality and quantity of meals delivered. For the gender variable, the presented results are for men, and the reference point is women. As the rating scale increases, the odds for the rating to be given decreases among men compared to women. This means that women are more likely to give a higher rating.

The direction of the effect of the year of study is the same for years 3 and 4, assuming that the reference is the 1st year of study. A longer study period is conducive to disapproving ratings, with the highest odds ratios achieved for the transition from R6 to R1 and R2. The results correspond well with certain social issues regarding the analysed groups. People with a higher BMI can be associated with less physical activity and a greater propensity for unhealthy nutrition, which is why their assessment of balanced and healthy meals is lower, because it does not quite meet their expectations. Women are more willing to give higher ratings.

This may be due to a greater predisposition to a positive assessment of one's effort (empathy), as well as the fact that they care about their body shape and proper nutrition more than male respondents. Subsequent years of study are conducive to lower ratings, which might result from greater courage in expressing opinions, undoubtedly coming with longer experience of functioning in the military and student environment. First-year students are often intimidated by the new reality and are less likely to articulate negative feedback.

4. Conclusions

Candidates for professional soldiers are a specific group in which readiness to accept the proposed standards is often assumed. In addition, officer cadets, due to their position in the military hierarchy, are not willing to submit claims and comments—also regarding the consumed meals. Therefore, research concerning their assessment of nutrition should be carefully thought out, and the study group selected properly.

The analysis presented in the present article showed that there are factors related to the characteristics of the respondents, such as gender, year of study or the BMI, which significantly affect their final value. The ratings given by women were definitely higher than those of men. Perhaps this was due to a greater tendency to show empathy and appreciate the effort associated with preparing meals. Also, women's culinary knowledge (often greater than that of male respondents) may be relevant in making such an assessment.

Assuming that the BMI is an expression of care for health and physical fitness, the conclusion is that less concern for a proper lifestyle results in a higher BMI and a

more severe assessment of the meals received. This attitude may be connected with a greater propensity to prefer unhealthy foods rich in sugars and fats over a balanced, healthy diet.

The year of study also proved to be important. A longer period of education favoured more negative opinions about nutrition. This may be due to a prolonged experience with the offered diet, but it may also be the result of greater boldness in expressing opinions among students with a longer service in the military. First-year students who are beginning their military career are often affected by the new reality of discipline and subordination required in the army, and are therefore more likely to be positive in their assessments and accept the proposed standards. It is only in the course of teaching and getting used to the mode of functioning and atmosphere of a military unit that they become bolder in expressing their opinions.

The analysis shows that surveys on officer cadets' nutrition should take into account factors related to the characteristics of the respondents, such as gender, BMI or year of study, as the ratings obtained in individual groups may vary greatly and, as a result, provide erroneous aggregate results. In addition, studies have shown that the nutritional safety of cadets during the period of biological threat caused by the SARS-CoV-2 virus is not endangered, provided that sanitary and hygienic standards are met. The present findings provide a basis for further research aimed at optimizing nutrition for students of military universities, who are a unique group with special requirements.

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