The Assessment of the General Health Status of the Sarajevo Canton Residents Through General Biochemical Testing Results

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Orginal research

Abstract: *In this research, we will be assessing the general health status of the Sarajevo Canton residents by analyzing the biochemical test results for the samples from the study cohort collected in 2021 for the following testing panels: lipid panel, liver panel, thyroid panel, electrolyte panel, and prostate panel. Along with the biochemical components that are tested, their physiological importance and consequences of deregulation, we are introducing the reasons for ordering the tests, as well as potential findings and conclusions from the testing results. Devices that were used for this research are Gesan Chem 200 (Gesan Production, Campobello di Mazara, Italy) and Architect 1000 (Abbot, Chicago, IL), both operated according to manufacturer's instructions. The collection of demographic data and test results was performed through usage of Laboratory Information System (LIS). Test results of the study participants were compared with referent values, as provided for the population average. Initial results were summarized and compared through descriptive statistics, while the exact test of goodness-of-fit was used to assess the compliance of observed data with expected referent values. Demographic trends, in terms of which sex and/or age group are more likely to have any tested parameter deregulated, either increased or decreased, are presented and discussed in detail. Finally, recommendations for future testing and prophylaxis are given.*

Keywords: laboratory testing, biochemical blood testing, Sarajevo Canton, health status

1. Introduction

Blood circulates through the human body and delivers essential substances like oxygen and other nutrients to the body cells. Main blood functions are supporting the immune system, transporting oxygen and regulating body temperature (Stroncek et al., 2013). Straw-colored clear liquid is called plasma, and it makes around 55% of the blood. Cellular elements and dissolved substances are suspended in plasma. After removing fibrin from blood, serum is the fluid portion of blood which remains. Plasma consists of 8% of combination of inorganic and organic substance and 92% of water. Blood consists out of three elements, red blood cells (erythrocytes), white blood cells (leukocytes) and platelets (thrombocytes) (Stroncek et al., 2013).

Biochemical tests, which measure elements in blood and urine (such as protein, sugar, oxygen, etc.), are frequently used to diagnose illnesses and choose the best course of therapy (Joseph et. al., 2011). One or more of the specific biochemical indicators are impacted by the activity of each organ in the body. As a result, measuring concentrations and comparing biochemical indices in blood components can aid in the diagnosis of a wide range of illnesses (Joseph et. al., 2011).

Electrolytes are electrically charged minerals that aid in maintaining the proper balance of acids and bases in human body as well as fluid retention. They also support the regulation of heart rhythm, muscle and neuron activity, and other crucial processes (Gumz et al., 2015). A blood test called an electrolyte panel, often called a serum electrolyte test, analyzes the concentrations of the body's primary electrolytes: sodium, chloride, potassium, and bicarbonate. Any of these electrolyte imbalances may indicate a major health issue, such as kidney illness, hypertension, or a potentially fatal heart rhythm irregularity.

The term "renal" refers to the kidneys, which are the blood-filtering and -purifying organs. A panel test entails multiple measurements being taken from the same sample that offers detailed knowledge on the condition of the kidneys and can aid in the early identification, diagnosis, and monitoring of kidney issues (Boga et al., 2019). A blood sample is used by the thyroid panel to assess how well the thyroid gland is working, as well as to perform the diagnosis and management of thyroid diseases (Eggersten et al., 1988). The thyroid panel test, which is a collection of measurements, can give a thorough insight of how effectively the thyroid gland is functioning. It specifically calculates the body levels of thyroid hormones and thyroid-stimulating hormones, including TSH (thyroid-stimulating hormone), free T4 (thyroxine), and total T3 or T3 (triiodothyronine).

Blood tests called liver function tests, commonly referred to as liver panels, examine various enzymes, proteins, and other chemicals produced by the liver. These tests examine human liver overall condition, and may include the following components: albumin, total protein, bilirubin, lactate dehydrogenase, and prothrombin time.

A blood test called a lipid panel counts the number of certain fat molecules, or lipids, in human blood. The panel typically includes a test of human triglycerides, as well as four separate cholesterol measures, including total cholesterol, low-density lipoprotein (LDL), very low-density lipoprotein (VLDL), and high-density lipoprotein (HDL) (Grundy et al., 2019).

The prostate panel (PSA) test is a blood examination used primarily for prostate cancer screening. The prostate-specific antigen (PSA) level in the blood is determined by the test. The prostate is a tiny gland that resides underneath the bladder in males (Dvorácek et al., 2019). Both malignant and noncancerous cells in the prostate produces the protein known as PSA. Semen, which is also produced in the prostate, is primarily where PSA is discovered. PSA often circulates in the blood in small levels. The PSA test may be utilized in men who have already received a prostate cancer diagnosis to analyze a treatment efficacy and monitor possible cancer recurrence.

2. Materials and methods

Prior to starting with data analysis, ethical clearance for conducting the study was obtained from the Ethics Committee of the Faculty of Engineering and Natural Sciences, International Burch University in Sarajevo, Bosnia and Herzegovina. The permission to conduct the research was granted on December 7th, 2021, document number 04-116-1/21. Samples are anonymized and no-one except for the primary investigators on the project was familiar with participant identity.

Blood samples have been collected from 102 patients, from January until December 2021, and a total of 135 panel analyses has been performed with these samples (Table 1). Devices that were used for this research are Gesan Chem 200 (Gesan Production, Campobello di Mazara, Italy) and Architect 1000 (Abbott, Chicago, IL), both of them taking a basic blood sample as an input material.

Table 1. The number of samples tested per study panel.

Panel	Number of samples
Prostate panel	15
Electrolyte panel	20
Thyroid panel	30
Liver panel	30
Lipid panel	40

Depending on the type of analysis being performed, different sampling procedure is employed. All panels share certain similarity in process, whereby the amount of blood needed is 3.5 mL or 5 mL, depending on the amount of serum required. Collected sample should rest anywhere between 15 and 20 minutes for blood to coagulate. The sample is then centrifuged for 10 minutes on 3,000 rpm to get the serum. After this, we approach the analytical analysis of specimen. For the lipid, electrolyte, and liver panels, Gesan Chem 200 device and suitable reagents were used, according to manufacturer's instructions. Prostate and thyroid panel are performed on Architect 1000 device and using adequate reagents, according to manufacturer's instructions.

The collection of demographic data and test results were performed through usage of Laboratory Information System or LIS. Test results of the study participants were compared with referent values, as provided for the population average. Initial results were summarized and compared through descriptive statistics, while the exact test of goodness-of-fit was used to assess the compliance of observed data with expected referent values.

3. Results and Discussion

Thyroid Panel

For the analysis of this panel, 30 samples were collected, all of them from females. In order to examine the effect of age on the test results, study participants were divided into four groups (Figure 1) and data analyzed separately. The age of study participants ranges from 19 to 72, with the average age of 42.93. Samples were divided among four groups as follows: group 1, aged 19-30, n=6 (20%); group 2, aged 31-40, n=10 (33.33%); group 3, aged 41-50, n=6 (20%); and group 4, participants older than 50, n=8 (26.67%).

Regarding TSH analysis, participants in age groups 1 and 4 were not found to

have TSH levels outside of the reference range. In group 2, one participant was above and one was below the reference range. The same situation was observed in group 3. The exact test of goodness-of-fit has shown that there is no significant difference between age groups 2 and 3 (20% and 33.33%, respectively; p=0.098). Age groups 2 and 3 were also found to be significantly more likely outside of the reference range when compared to groups 1 and 4, with a p value of 1.91×10^{-6} for age group 2 when compared to groups 1 and 4 and a p value of 2.33×10^{-10} for age group 3 when compared to groups 1 and 4.

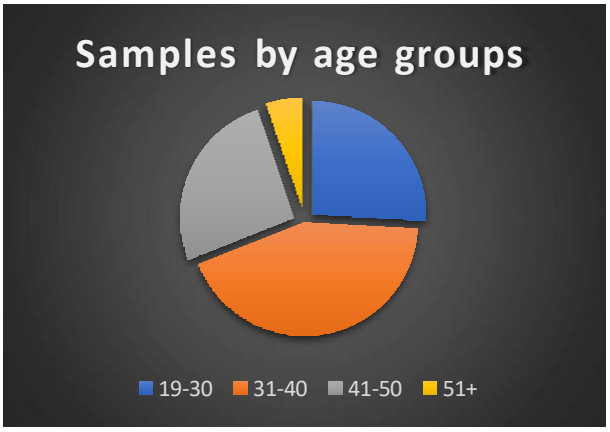

Figure 1. Samples analyzed for the thyroid panel divided into four age groups.

Regarding T3 and T4 analysis, the results were the same for these two parameters. There were no participants with results outside the reference range in groups 1, 2 and 4. In group 3, one participant had increased values for both T3 and T4 (16.67% of all participants in group 3). Therefore, group 3 participants were significantly more likely to have deregulated T3 and T4 levels when compared to any other study group (p=0.000031).

Prostate Panel

Opposite to the thyroid panel, all samples collected here came from male population, with a total of 15 samples being analyzed in the present study for total PSA and free PSA measurements. Their age was ranging from 31 to 89, with an average of 58.87 and standard deviation of 16.17 years. We approached this analysis by dividing samples by age groups, whereby group 1 consists of individuals aged between 31 and 40 (n=3, 20% of all participants), group 2 of individuals aged between 41 and 60 (n=4, 26.67%), group 3 contains individuals aged from 61 to 70 (n=4, 26.67%), while group 4 has individuals older than 70 (n=4, 26.67%) (Figure 2).

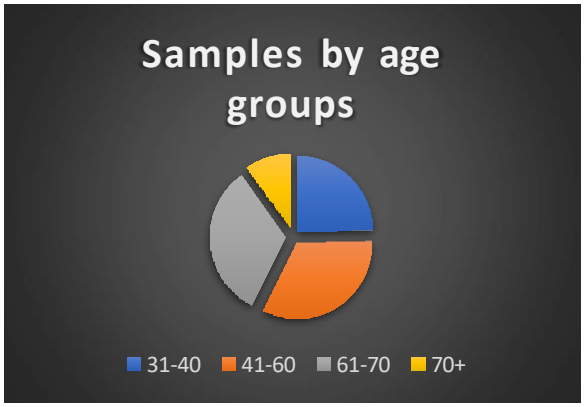

Figure 2. Samples analyzed in the prostate panel separated by age groups.

Regarding free PSA analysis, all participants had their results within optimum range. As for the total PSA, five participants had increased values, including one participant in each of groups 1, 3 and 4, as well as two participants in group 2. Therefore, in group 1, 33.33% of participants had increased total PSA, which is not statistically significant when compared to group 2 (p=0.078), or groups 3 and 4 (p=0.358). In group 2, 50% of participants had increased total PSA, which was not significantly more when compared to group 1 (p=0.078) but is when compared to both groups 3 and 4 (p=0.005228). Groups 3 and 4 had 25% participants each with increased total PSA (p=1 for group 3 vs. group 4) (Figure 3).

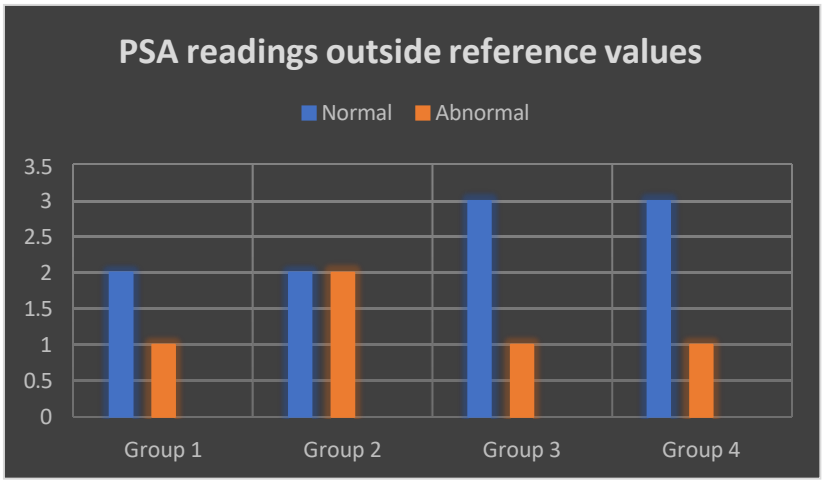

Figure 3. Total PSA readings within and outside the referent values, separated into four age groups.

Liver Panel

In liver panel, we performed 30 tests, with 15 male and 15 female participants. Mean age of all participants was 42.1, ranging from 24 to 82. Standard deviation was 14.47

years. When observing females only, average age was 44.1, while for males, average age was 40.13.

In female group, only one participant (6.67% of all females) had GGT increased, while the results for AST, ALT, ALP and LDH were all within the recommended range. For males, two participants (13.33% of all male participants) had increased AST, four (26.67%) had increased ALT, while three had increased each of ALP, GGT and LDH (20% for each parameter). Therefore, males were statistically more likely to have any of these parameters increased than females, with p values of 0.000224 for AST, 2.98×10^{-8} for ALT, 1.91×10^{-6} for ALP, 0.009355 for GGT, and 1.91×10^{-6} for LDH.

Next, we have divided all our participants in four age groups, regardless of sex, as follows: group 1 aged 30 and younger (n=6, 20%), group 2 aged 31-35 (n=9, 30%), group 3 aged 36-50 (n=7, 23.3%), and group 4 aged 51 and older (n=8, 26.67%) (Figure 4).

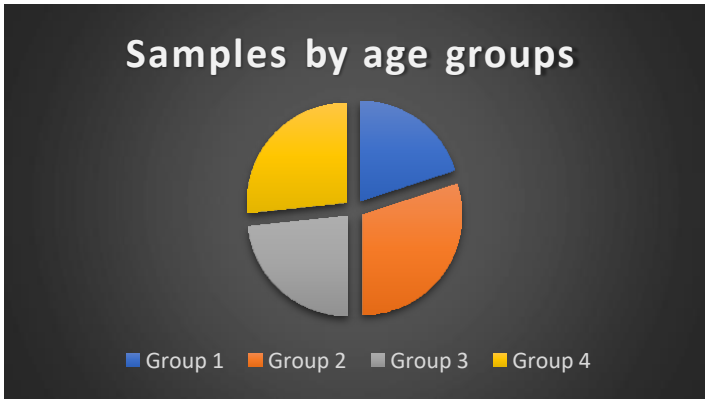

Figure 4. Liver panel samples by age groups.

For AST analysis, there was one increased result in each of groups 1 and 2 (16.67% for group 1 and 11.11% for group 2), which was not statistically significant (p=0.442). There were no increased results in groups 3 and 4. Therefore, group 1 was more likely to have increased AST when compared to groups 3 and 4 (p=0.000031), as well as group 2 when compared to groups 3 and 4 (p=0.000997). In ALT analysis, there were two increased values in each of groups 1 and 2 (33.33% for group 1 and 22.22% for group 2) and no results outside the reference range in groups 3 and 4. Groups 1 and 2 were not significantly different from each other (p=0.177). Group 1 participants were more likely to have increased ALT when compared to groups 3 and 4 ($p=2.33 \times 10^{-10}$), just like group 2 participants when compared to groups 3 and 4 ($p=4.77 \times 10^{-7}$). ALP and LDH

analysis offered the same results in that one participant (16.67%) from group 1 had both parameters increased, as well as two participants (22.22%) in group 2. There were no such measurements in groups 3 and 4. There was no significant difference in the frequency of increased ALP and LDH between groups 1 and 2 ($p=0.418$). There was, however, significantly more increased ALP and LDH in group 1 when compared to both groups 3 and 4 ($p=0.000031$), as well as in group 2 compared to groups 3 and 4 ($p=4.77 \times 10^{-7}$). Finally, when analyzing GGT, we observed one participant with increased value in groups 1 and 4 (16.67% for group 1 and 12.5% for group 4), two (22.22%) in group 2 and 0 (0%) in group 3. Group 1 did not significantly differ from group 2 ($p=0.418$) or group 4 ($p=0.458$) but did differ from group 3 ($p=0.000031$). Group 2 also did not differ from group 4 ($p=0.121$) but did differ from group 3 ($p=4.77 \times 10^{-7}$). Groups 3 and 4 did differ statistically ($p=0.000448$) in that group 4 participants were more likely to have increased GGT when compared to group 3.

Electrolyte Panel

Regarding electrolyte panel, total number of samples was 20, equally divided among males and females. Average age of panel participants was 49.95, ranging from 20 to 83 and with standard deviation of 19.06.

Regarding abnormal values in these readings, we only noticed that 10% of females (n=1, 73 years old) had decreased level of calcium, while all other readings were regular. When it comes to male population, we noticed that 10% had decreased sodium (n=1, 58 years old), chlorides (n=1, 63 years old), and calcium (n=1, 70 years old). Finally, one 57-year-old male (10% of all males) had slightly increased potassium levels.

Statistical overview of data outside of the expected range by sex and corresponding measurements, including p values is presented in Table 2 below. There is no significant difference between males and females when it comes to Ca ($p=1$), while males are more likely to have other parameters (Na, K, and chlorides) deregulated when compared to females ($p=0.001953$ in all three cases).

Table 2. Electrolyte panel samples with values outside the referent range and statistical significance between the sex groups.

Na	K	Chlorides	Ca	
0%	0%	0%	10%	Percent female
10%	10%	10%	10%	Percent male
0.001953	0.001953	0.001953	1	p value

This analysis also differs between two age groups, namely G1 with 9 samples with age below 50, and G2 with 11 samples and age above 51. Regarding the differences in electrolyte level deregulation between the age groups (Table 3), we can see the G2 is significantly more likely to have any of these individual measurements deregulated when compared to G1 ($p=0.003906$ for Na, K, and chlorides, and $p=7.63 \times 10^{-6}$ for Ca).

Table 3. Statistics comparison between measurements and age groups including p values.

Na	K	Chlorides	Ca	
0%	0%	0%	0%	G1
9.09%	9.09%	9.09%	18.18%	G2
0.003906	0.003906	0.003906	7.63×10^{-6}	p value

Lipid Panel

Lipid panel contained 40 samples, divided in two groups of 20 males and 20 females. Age was ranging from 24 to 85, with an average value of 51.1 years of life. We additionally divided samples into four age groups (Figure 5), whereby group 1 (G1) contains samples from individuals aged 40 or younger (n=10, 25% of all study participants), group 2 (G2) individuals from 41 to 45 years (n=12, 30%), group 3 (G3)

individuals from 46 to 65 (n=10, 25%), and group 4 (G2) individuals aged 66 or older (n=8, 20%).

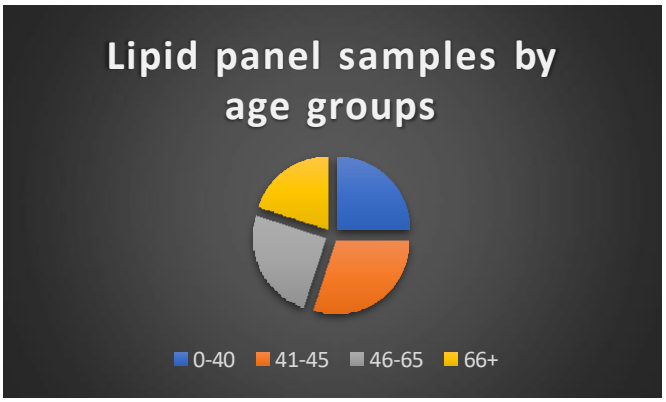

Figure 5. Lipid samples by age groups

For cholesterol measurement, G3 had most values out of expected range (90%), G1 showed 50% out of expected range, while G2 and G4 showed 41.67% and 25% values outside referent values, respectively. What we can notice for HDL statistics is that none of the values were higher than expected, only G1 and G2 in 10% and 16.67% cases, respectively, exhibited samples with value lover than referent ones. Opposite to the HDL readings, none of the samples in LDL data were lower than referent values, G4 and G3 in 50% of their samples showed results higher than expected, while G2 and G1 exhibited such samples in 41.67% and 20% of all cases, respectively. Similar to LDL data, none of the tested samples displayed triglyceride levels below the referent range. As for the readings above the referent range, G3 had the highest frequency of those readings (50% of all samples), followed by G4 (37.5%) and G1 (30%), while the lowest frequency was in G2 (25%). These results are shown in Table 4 below.

Table 4. Overview of lipid panel data separated by age groups.

Out of range	Higher	Lower	Group
Cholesterol			
50%	20%	30%	G1
41.67%	25%	16.67%	G2
90%	50%	40%	G3
25%	0%	25%	G4
HDL			
10%	0%	10%	G1
16.67%	0%	16.67%	G2
0%	0%	0%	G3
0%	0%	0%	G4

LDL			
20%	20%	0%	G1
41.67%	41.67%	0%	G2
50%	50%	0%	G3
50%	50%	0%	G4
Triglycerides			
30%	30%	0%	G1
25%	25%	0%	G2
50%	50%	0%	G3
37.5%	37.5%	0%	G4

Next, we separated our study population by sex, into male and female groups. Female samples had abnormal value readings in the following categories: cholesterol 55%, LDL 40% and triglycerides 35%. Regarding male samples, we calculated the following values: cholesterol 50%, HDL 15%, LDL 40%, and triglycerides 35%. If we reflect on p values, we come up with following results: p=0.696 for cholesterol, p=0.000061 for HDL, p=1 for LDL, and p=1 for triglycerides. This means that HDL was significantly more likely to be deregulated, either increased or decreased, in males when compared to females, while those differences for other parameters were not significant. Figure 6 displays comparison of normal readings and readings outside expected value for male samples, while Figure 7 shows the same data for female samples only.

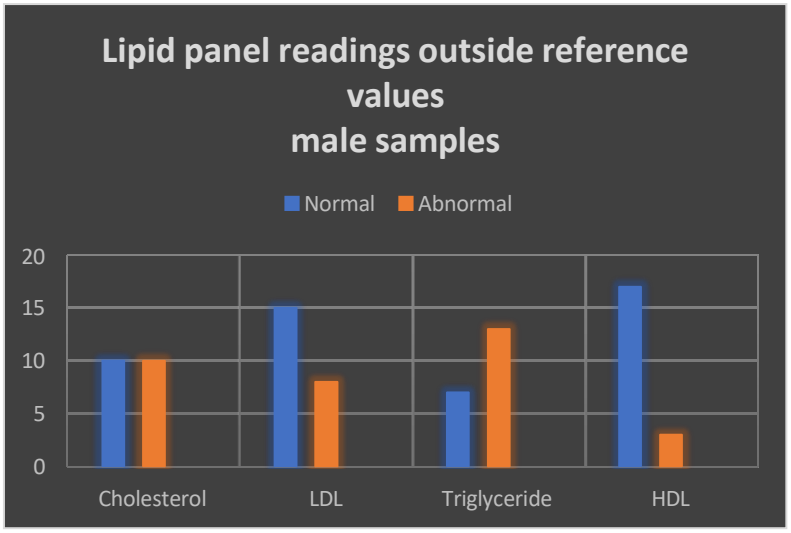

Figure 6. Lipid male samples with readings within and outside referent interval.

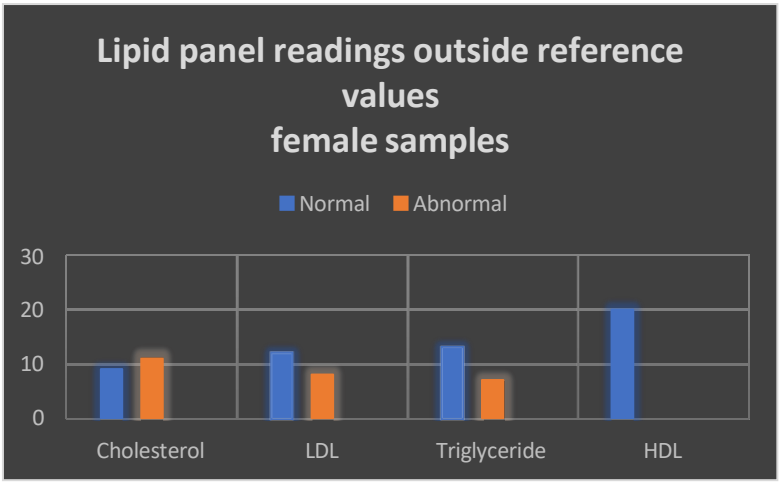

Figure 7. Lipid panel readings within and outside referent values for females.

If we only consider the case in which sample values were above the referent range, for male samples we get the following frequencies: cholesterol 25%, LDL 40%, triglycerides 35%; and for female samples cholesterol 25%, LDL 40%, and triglyceride 35%. Since p values in all cases are equal to 1, it means that there are no differences between male and female groups.

Opposite to previous observation, we next considered only those cases where readings were below the referent values. For female samples, we got that only cholesterol was below the referent values in 30% of cases. Regarding male samples, readings for cholesterol and HDL were in 25% and 15% cases below referent values, respectively. p values in these cases are: p=0.59 for cholesterol, p=0.000061 for HDL, and p=1 for both LDL and triglycerides. This means that males are significantly more likely to have HDL values below referent interval than females, while other differences did not reach statistical significance.

4. Discussion

To be able to assess the general health of a certain group or a general population, the number of samples, period in which samples were collected, and reason for testing, and demographic characteristics of a study cohort all play a major role in objectivity of results and determine how representative the study sample is of the general population. We should not neglect the fact that samples which were analyzed in the present study came from both patients who were referred to examination by their physician or self- initiated the testing. Improvements to the present study and better application of obtained results could be obtained by considering only those samples that came from patients that were analyzed based on self-initiative, because usually the patients which are referred by the medical doctors, are not the ones which represent general health in the best possible

manner. In addition, it would be beneficial to increase the number of samples per panel, achieve well-balanced sex and age group representation, as well as analyze additional blood parameters, in order to get more meaningful results. We should also keep in mind that samples were collected during the second year of COVID-19 pandemic, which potentially also influenced some of the obtained readings.

5. Conclusions

The general conclusion of the present research is that the citizens of the Canton Sarajevo are the most likely to be affected by problems regarding lipid components of blood, more precisely increased LDL, cholesterol and triglycerides in blood. We can conclude that Canton Sarajevo population should be monitoring their lipid levels more closely in order to avoid associated problems, such as cardiovascular disease and metabolic syndrome. Statistical data analysis also gave us information that males are more likely to have problem in any of the tested categories, except for thyroid gland hormone levels, which was tested in female participants only. Considering that only female samples were available for the thyroid panel, implies that males are not likely to get tested for those components, which is a practice that should be changed in close future.

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