

**Assessing the Relationship Between Food Intake, Lifestyle,
and Cardiometabolic Risk Factors in Kazakh Adults**

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Abstract

This cross-sectional study was conducted to assess the relationship between cardiometabolic risk factors and quality of diet among adults through a survey and a photo-based dietary diary analyzed using CaloScanAI. The survey was filled by 20 participants, 70% of whom were found to have a poor diet and 30% to have a diet that required improvement according to Healthy Eating Index (HEI)-2020. There were significant differences between these groups in their intake of total fruits and whole fruits with higher consumption in the “needs improvement” group. Numerical but not statistically significant differences were present in vegetable, dairy, and whole grain intake. Greens and beans intake were consistently low and potentially could have had an effect on overall diet quality. There were strong correlations established by Pearson's correlation analysis between macronutrient intake and total calorie intake. These findings underscore the need for enhanced dietary interventions focusing on fruit, vegetable, and dairy consumption. Future research involving larger and more diverse samples are recommended to validate and expand upon these results.

Introduction

1. CVD Rates Worldwide

Cardiovascular diseases (CVD) are the major cause of mortality worldwide, and it accounts for almost 17.9 million deaths yearly (World Health Organization: WHO, 2019). According to the Global Burden of Disease study, ischemic heart disease and stroke are the two principal causes of CVD death worldwide (Amini et al., 2021). This tendency has been exacerbated by aging of the population, urbanization, and the prevalence of risk factors such as obesity, hypertension, and diabetes during last decades (Amini et al., 2021). Furthermore, the economic burden of CVD is enormous: accounting for more than 75% of all CVD-related deaths, low income and middle income countries bear the major share of the cost (World Health Organization: WHO, 2021). These inequalities are explained by limited access to care, unhealthy lifestyle changes, and a higher prevalence of risk factors that are not properly addressed.

Global CVD mitigation has been aimed at prevention via public health initiatives, enhanced healthcare infrastructure, and food policy. However, the uniformity of the results is under a question. While high-income countries have experienced a decline in CVD mortality rates through improvements in medical care and management of risk factors, numerous low-income regions still demonstrate a rising trend (World Health Organization: WHO, 2021). The comprehension of the global distribution of CVD and its underlying causes represents a crucial basis for effective interventions relevant to regional demands.

Furthermore, the increasing prevalence of CVD is closely associated with globalization and urbanization processes that introduce essential alterations in dietary patterns, physical activity levels, and healthcare access (Da Costa et al., 2022). While these changes are continuing to proliferate, even regions earlier facing a low burden from CVD also reflect increased rates in incidence and mortality (Da Costa et al., 2022).

2. CVD in Central Asia

In this respect, cardiovascular disease remains a great public health burden in Central Asia, including Kazakhstan. Recent estimates demonstrated that ischemic heart disease and cerebrovascular diseases are the main causes of death in the region (Junusbekova et al., 2023). Age-standardized mortality of cardiovascular disease in Kazakhstan was estimated to be 219 deaths per 100,000 population in 2015, much higher than in many developed nations (Junusbekova et al., 2023). Additionally, increasing evidence suggests the involvement of genetics in the risk of obesity, with studies implicating the AA genotype in rs1800871 of the IL-10 gene to be significantly associated with increased risk of obesity in Kazakh individuals (Razbekova et al., 2021). Given that obesity is a leading cardiometabolic risk factor, this genetic susceptibility may be contributing to increasing cardiovascular disease burden in this population. In particular, the estimated obesity prevalence among adults increased from 6.10% in 1975 to 21.30% in 2016 (Obesity in Adults, 2024). Uzbekistan and Kyrgyzstan exhibit comparably high proportions of ischemic and hypertensive conditions of the heart, probably reflecting the general regional tendency (Usmanov et al., 2022; Farrington et al., 2017).

During the last decade, several health interventions for CVD burden reduction have been implemented in Kazakhstan: strengthening of the primary health services, early detection programs, and health promotions with a focus on reducing tobacco-related and unhealthy diet risk factors (Junusbekova et al., 2023). Nevertheless, the prevalence of CVD risk factors, including obesity, hypertension, and diabetes, continues to rise, prompted by urbanization, sedentary lifestyles, and dietary changes (Glushkova et al., 2023). This is increasingly affecting younger populations and evidences the dire need for dedicated campaigns to enhance health literacy in support of prevention care (Glushkova et al., 2023).

3. Cardiometabolic Risk Factors

Obesity, hypertension, insulin resistance, and dyslipidemia are cardiometabolic risk factors that are strongly associated with the onset of cardiovascular disease. These risks are established through lifestyle behaviors like diet, physical activity, sleep, and hormonal changes. The complex interplay of these factors may provide great comprehension about the prevention and treatment of cardiometabolic disorders.

4. Links Between Diet and CVD Risk Factors

Dietary patterns play a vital role in the modulation of CVD risk factors. Fruits, vegetables, whole grains, nuts, and legumes are related to reduced risks of hypertension, dyslipidemia, and obesity, all of which are important risk factors for CVD (Martínez-González et al., 2019). Saturated fat, refined sugar, and high sodium diets, however, are related to elevated cardiovascular risks (Martínez-González et al., 2019). Meta-analyses and observational studies indicated that dietary patterns with cardiovascular health adherence, including the Mediterranean and DASH diets are inversely related to CVD prevalence (Martínez-González et al., 2019). Both diets are high in plant foods, low in sodium, and healthy fats, thereby demonstrating a protective effect against hypertension and atherosclerosis (Martínez-González et al., 2019).

In Central Asia, traditional diets consisting of mostly fermented milk foods, grains, and moderate intake of meat have shifted to Westernized eating patterns (Zhao, 2021). These dietary transitions that are defined by the higher intake of processed and energy-dense foods are associated with the increasing burden of CVD in Central Asia (Zhao, 2021).

Other mechanisms by which food components influence CVD include modulation of inflammatory responses, oxidative stress, and lipid metabolism (Jiang et al., 2021). In particular, foods high in saturated and trans fats increase LDL cholesterol and consequently promote the formation of arterial plaques (Jiang et al., 2021). On the contrary, antioxidant and omega-3 fatty acid-rich diets are linked with reduced systemic inflammation and enhanced endothelial function (Jiang et al., 2021). Moreover, added plant protein like pea, buckwheat, lentils, and soybeans integrated into the diet is a major step towards enhanced overall health (Auyeskan et al., 2024). It provides scientific justification for dietetic intervention on CVD risk reduction.

5. Links Between Meal Timing and Hunger and Satiety Levels and CVD Risk Factors

Meal frequency and timing during the day are considered to correlate with cardiometabolic well-being. Irregular meal timing has been linked with abnormal glucose metabolism, greater insulin

resistance, and increased obesity, all of which raise cardiovascular disease risk (St-Onge et al., 2017). Also, there is evidence that time-restricted dietary patterns as well as circadian cycles enhance cardiometabolic risk factors and reduce body weight (Panagiotou et al., 2024). These results demonstrate the significance of timing of meals in minimizing the risk of CVD onset. Besides that, psychological variables such as mood and self-reported hunger or satiety, also maximize the influence of eating patterns on cardiometabolic well-being. Stress or negative sensations evoked emotional eating is associated with increased intake of energy-dense foods that are nutrient-poor, which leads to increased risk of obesity and negatively affects cardiometabolic health (Konttinen, 2020). On the other hand, the development of mindfulness and sensitivity to internal satiety and hunger cues can enhance food choices and facilitate healthier eating (Warren et al., 2017).

6. Links Between Lifestyle Factors and CVD Risk Factors

Physical activity has a critical role in cardiometabolic health. Consistent physical activity is known to increase insulin sensitivity, enhance lipid profiles, and lower blood pressure: all these reduce cardiometabolic risk factors (Nystoriak & Bhatnagar, 2018). Physical activity also lowers visceral adiposity and systemic inflammation, both of which are key determinants of CVD (Tao et al., 2024; Wärnberg et al., 2010). Conversely, there is evidence that sedentary life with lower level of physical activity is linked with the high incidence of cardiovascular disease, cancer, and type-2 diabetes progression (World Health Organization: WHO, 2024). Furthermore, sleep quality and quantity are being identified more as significant predictors of cardiometabolic health. Restorative sleep maintains hormonal equilibrium, glucose regulation, and vascular health, whereas chronic disordered sleep is associated with obesity, insulin resistance, and hypertension (St-Onge et al., 2016). In addition, sleep deprivation also increased inflammatory mechanisms and autonomic neuropathy and promoted CVD risk (St-Onge et al., 2016).

Central Asia, including Kazakhstan, has a high rate of CVD, calling for local dietary intervention. Due to the scarcity of Central Asian food classification along with the high rate of CVD, investigating the relationship of diet patterns, lifestyle factors, and cardio-metabolic risk factors among adult Central Asians may provide valuable insights into the development of public health policies (Karabay et al., 2023). Identification of the relationship between diet, lifestyle behavior, and such risk factors is crucial to framing effective measures to mitigate these health conditions. Hence, the primary goal of this study is to determine the association between diet and lifestyle habits on cardiometabolic risk factors among Kazakhstani adults.

Materials and Methods

Study design and participants

The cross-sectional study was conducted on 20 adults (16 females and 4 males) aged 20 to 33 years. The data collection utilized an online survey and a food consumption diary to encompass all pertinent variables. The participation was on a voluntary basis. Inclusion criteria for subjects were adults aged 18 years and older residing in Kazakhstan. The exclusion criteria encompassed significant cognitive impairment, incapacity to provide informed consent, and medical disorders that significantly modify nutritional consumption. Participants signed informed consent. The ethics approval was acquired from Nazarbayev University School of Medicine Institutional Research Ethics Committee (reference number assigned: 2024Nov#13).

The 18 to 65 years age range was selected to cover a broad spectrum of individuals in Kazakhstan, reflecting variations in dietary practices, lifestyle behaviors, and socio-demographic factors affecting cardiometabolic health. Furthermore, alcohol intake was included for its correlation as a recognized risk factor with cardiometabolic health to ascertain whether it may exacerbate the prevalence of such problems.

Data Collection Methods

Data collection was implemented through an online survey and food intake diary.

1. Survey Data Collection

The first step of data collection was an online survey conducted via Qualtrics. The data from the survey included:

- Socio-demographic data: age, gender, educational background, occupation, socio-economic status.
- Anthropometric measurements: weight, height, waist and neck circumferences.
- Lifestyle Habits: physical activity, level of stress, sleep pattern, eating habits of the participants.

This questionnaire was specifically designed in a way that it is user-friendly and will take approximately 10-15 minutes to complete.

2. Diet and Lifestyle Tracking

For three days, including two weekdays and one weekend day, the respondents tracked their food intake. Data collection was implemented through the diary. The respondents logged their food intake, physical activities, and sleeping patterns. Respondents were asked to save a photo of each meal they consumed during three days for the accuracy of the data. The photos were further

analyzed using a mobile phone app named CaloScanAI that provided the nutritional breakdown of each meal.

Data Analysis

Descriptive analysis was applied to examine the central tendency and dispersion of collected data in order to represent essential information about individuals' nutritional consumption, physical activity levels, and health metrics. Body mass index (BMI) calculation was implemented by dividing weight to height squared. The Healthy Eating Index—2020 (HEI-220) was employed to evaluate the quality of subjects' diet based on the information from the diary. HEI is a measure of diet quality developed by US Department of Agriculture (USDA) (Healthy Eating Index (HEI) | Food and Nutrition Service, n.d.). The HEI- 2020 version consists of 13 components scored from 0 to 5 or 10 (How The HEI Is Scored | Food and Nutrition Service, n.d.). The final score for HEI ranges from 0 to 100, establishing three categories: score under than or equal to 50 indicates “poor diet”; score between 50 to 80 inclusive indicates “needs improvement”; score higher than 80 for “good diet”(Hurley et al., 2008).

Regarding the statistical analysis, 5% significance level was applied for all tests. The Kolmogorov-Smirnov test was applied to test the normality of data. T-test was further used on normally distributed data. The Pearson's correlation test was performed to determine the correlation between intake of macronutrients such as carbs, fats, protein, and fiber reported by the CaloScanAI app and participants' BMI.

Results

The aim of the pilot study was to examine the correlation of dietary intake (carbohydrate, fat, protein, fiber) and Body Mass Index (BMI) in 20 adult Kazakh individuals. Pearson's correlation analysis was applied to compare various macronutrients — particularly, carbohydrates, fat, protein, and fiber — and calories with BMI of the participants. Data on calories and the macronutrient composition — particularly, carbohydrates, fat, protein, and fiber — of participants' meals were gathered using the CaloScanAI app, which analyzes meal photos to provide detailed information on the nutritional content of each meal. The following results are derived from the analysis, incorporating demographic information obtained from a participant survey.

Demographic Information

The study sample consisted of 20 participants, with a mean age of 21.8 years; range: 20 to 33 years (Table 1). Of the total sample, 16 participants were female constituting 80%, and 4 participants were male accounting for 20% of study participants (Table 1). Under anthropometric measurements, the average BMI of the total sample was 24.8 kg/m² (Table 1). The female respondents had an average BMI of 22.7 kg/m², whereas the male respondents had an average BMI of 26.8 kg/m² (Table 1).

Table 1. Age distribution and anthropometric measurements of study participants (N=20)

	Total (N=20)	Female (N=16)	Male (N=4)
Age (years)	21.8 ± 3.6	21.4 ± 2.7	23.5 ± 6.4
Height (cm)	169.9 ± 8.5	167.7 ± 7.7	178.5 ± 6.1
Weight (kg)	66.5 ± 14.4	61.7 ± 9.9	85.8 ± 14.6
BMI (kg/m ²)	24.8 ± 3.5	22.7 ± 2.8	26.8 ± 3.0
Waist circumference (cm)	73.7 ± 12.2	70.8 ± 10.1	85.0 ± 14.5

Healthy Eating Index

The quality of participants' diet was assessed by Healthy Eating Index. 20 participants were evaluated using the Healthy Eating Index (HEI), of which 14 — 70% of participants — were categorized into the “poor diet” group, and 6 — 30% — as “needing improvement”; no participants had scores corresponding to the good diet category (Table 2). The derived HEI-2020 scores were evaluated for normality. Kolmogorov-Smirnov test showed that data was normally distributed ($p=0.91$). Therefore, independent samples t-tests and descriptive statistics (mean± standard deviation) were employed to contrast dietary component scores between groups. Statistically significant disparities were observed in the total fruit and whole fruit components. The “needs improvement” group had a much higher intake of total fruits than the “poor diet” group ($p = 0.0024$). Likewise, whole fruit intake was higher in the “needs improvement” group ($p = 0.0097$) (Table 2).

Table 2. Daily food groups intakes by diet categories according to HEI-2020.

Component	Poor Diet (n = 14) Mean $\pm$ SD	Needs improvement (n = 6) Mean $\pm$ SD	P
Total Fruits	0.81 $\pm$ 1.67	3.78 $\pm$ 1.86	0.0024
Whole Fruits	1.07 $\pm$ 1.94	3.89 $\pm$ 2.14	0.0097
Total Vegetables	2.29 $\pm$ 1.52	2.17 $\pm$ 1.86	0.8811
Greens and Beans	0.98 $\pm$ 1.63	0.33 $\pm$ 1.19	0.3926
Whole Grains	1.41 $\pm$ 3.44	4.56 $\pm$ 4.80	0.1123
Dairy	2.52 $\pm$ 2.99	3.22 $\pm$ 3.77	0.6618
Total Protein Foods	4.98 $\pm$ 0.15	4.89 $\pm$ 0.47	0.0900
Seafood and Plant Proteins	3.33 $\pm$ 1.98	3.33 $\pm$ 1.85	1.0000
Fatty Acids	2.62 $\pm$ 3.41	5.06 $\pm$ 3.54	0.1640
Refined Grains	0.48 $\pm$ 1.84	2.28 $\pm$ 3.77	0.1618
Sodium	4.48 $\pm$ 4.12	6.17 $\pm$ 4.06	0.4097
Added Sugars	8.24 $\pm$ 2.69	9.72 $\pm$ 0.57	0.2049
Saturated Fats	4.62 $\pm$ 3.72	6.06 $\pm$ 3.70	0.4373
Mean Score	37.81 $\pm$ 2.21	55.44 $\pm$ 2.31	0.0027

For other components of the diet, there were no differences between the two groups (all $p > 0.05$). These are total vegetables ($p = 0.8811$), beans and greens ($p = 0.3926$), whole grains ($p = 0.1123$), dairy ($p = 0.6618$), total protein foods ($p = 0.0900$), seafood and plant proteins ($p = 1.0000$), fatty acids ($p = 0.1640$), refined grains ($p = 0.1618$), sodium ($p = 0.4097$), added sugars ($p = 0.2049$), and saturated fats ($p = 0.4373$) (Table 2).

Dietary Intake and Cardiometabolic Health

Pearson's correlation matrix indicated some significant correlations between dietary intake and BMI. 17 diaries were selected for the correlation test since 3 diaries were excluded due to the absence of meal photos for analysis by the app. To determine the correlation between HEI-2020 scores and BMI, all 20 participant reports were evaluated. The most important findings are summarized in Table 3 with the Pearson r value for the relationship between BMI and macronutrient consumption and the respective p values to identify statistically significant association between BMI and HEI-2020 score and macronutrient consumption.

Table 3. The relationship between BMI of the participants and HEI-2020 score and energy-macronutrients consumption by Pearson's Correlation.

BMI (kg/m ²)	r	P
HEI score	0.0976	0.6851
Calories (kcal)	0.2092	0.4203
Carbs (g)	0.1037	0.6921
Fats (g)	0.1506	0.5639
Protein (g)	0.3149	0.2183
Fiber (g)	0.1049	0.6886

The HEI-2020 score and BMI of participants were positively related, though the relationship is weak. The p value ($p=0.6851$) demonstrates that correlation does not present statistical significance ($p>0.05$). Carbohydrates, fats, fiber, and protein intakes were positively related to BMI (Table 4). Similarly, the correlation was not statistically significant ($p>0.05$) (Table 4). Correlation test showed identical results for the fiber consumption and calorie consumption.

Table 4. The relationship between energy consumption of the participants and macronutrients consumption by Pearson's Correlation.

Calories (kcal)	r	P
BMI (kg/m ²)	0.2092	0.4203
Carbs (g)	0.844	0.00002
Fats (g)	0.8935	0.00001
Protein (g)	0.873	0.00001
Fiber (g)	0.3628	0.1524

Carbohydrates, fats, and protein consumption had a significant positive relationship with calorie consumption (Table 4). The p-values of the correlations are 0.00001, which indicates statistical significance (Table 4).

Lifestyle Factors

Table 5 shows the outcome of chi-square test that examined the association between different lifestyle factors and diet quality. The factors examined are work schedule, sleep duration, exercise frequency, mood category, and stress level, while diet quality is divided into "poor diet" and "needs improvement" categories based on the HEI-2020 results. The number of participants in each category of each factor is shown along with the respective percentages.

Table 5. Association between lifestyle factors and diet quality among participants (Chi-Square Analysis)

	Poor diet (N=14)	Needs improvement (N=6)	Total (N=20) (%)	P
Work schedule				
Unemployed/student	5	4	9 (45.0)	0.414
9 to 5	3	1	4 (20.0)	
Flexible hours	6	1	7 (35.0)	
Sleep duration				
Some rest (≤ 6 hours)	8	2	10	0.329
Long and well (≥ 7 hours)	6	4	10	
Workout Frequency				
Less than 2 time per week	9	3	12 (60)	0.550
3 to 5 times a week	5	3	8 (40)	
Mood States				
Positive	5	4	9 (45)	0.414
Neutral	6	1	7 (35)	
Negative	3	1	4 (20)	
Stress Levels				
Mild stress	2	4	6 (30)	0.605
Moderate stress	8	1	9 (45)	
High stress	4	1	5 (25)	

Respondents had variable schedules, with 45% being unemployed, or students, 35% having flexible working hours, and 20% working with a 9 to 5 work schedule (Table 5). The pattern of sleep duration among the participants is that half of the participants registered that they slept up to 6 hours and the other half indicated sleeping for more than 7 hours at night (Table 5). With regard to physical activity, 40% of the patients exercised 3 to 5 times a week, showing a high to moderate level of physical activity (Table 5). Predominating 60% of the participants exercised less than two times a week, showing a low level of consistency in the pattern of their physical activity (Table 5). For mood states, 45% of the participants indicated they felt generally positive overall, reflecting an overall positive affective state (Table 5). Another 35% of participants indicated a mood as neutral (Table 5). However, 20% of the participants responded that they experienced a predominantly

negative mood. The stress levels that the participants reported were mixed, and 45% indicated medium levels of stress (Table 5). This was the most prevalent level of stress reported, which suggests a general moderate level of felt stress. In addition, 25% of the sample graded themselves as experiencing a great deal of stress, and another 30% graded themselves as having mild stress, indicating that the majority of the sample was experiencing some degree of stress, ranging from little to great (Table 5).

Discussion

The Healthy Eating Index questionnaire of the 20 participants indicated that most (70%) had a poor diet and a few (30%) had a diet in need of improvement. Notably, a significant difference was seen in the intakes of total fruits and whole fruits between groups. The subjects classified as “needing improvement” group were more likely to have higher intakes of total and whole fruits than those in the “poor diet” group. This acknowledgment identifies the position of fruit consumption as a possible differentiating characteristic in the quality of diet overall. Increased intake of fruits and vegetables has been associated with a reduced risk of CVD, various cancers, and overall mortality (Aune et al., 2016). Whereas there were numerical differences in dietary intake of other food groups such as vegetables, whole grains, dairy, and protein foods between the groups, these were not statistically significant. Regarding the vegetable consumption among study participants, “poor diet” group and “needs improvement” diet group scored 2.29 ± 1.52 and 2.17 ± 1.86 out of 5, respectively. It indicates the scarcity of vegetables in the diet is a considerable contributing factor to the lower HEI-2020 score and, ultimately, quality of diet. The identical trend can be observed for the dairy consumption, for which participants scored 2.52 ± 2.99 in “poor diet” group and 3.22 ± 3.77 in “needs improvement” diet category out of maximum of 10 points. According to Alexander et al. (2016), dairy consumption may be associated to a reduced risk of cardiovascular disease based on findings from a systematic review and meta-analysis. This suggests that the daily dairy consumption should be increased to get a higher HEI-2020 score and fundamentally enhance the quality of diet to prevent the progression of cardiovascular diseases. On the contrary to low scores in components, both diet groups scored equally high for protein consumption and added sugars component. In the case of HEI-2020, the higher score for the added sugars component represents lower consumption, while lower score is assigned for high consumption of added sugars, 8.24 ± 2.69 and 9.72 ± 0.57 for “poor diet” and “needs improvement” diet, respectively. The greens and beans intake was significantly low in both categories, detrimentally affecting the diet quality. Since green leafy and cruciferous vegetables as well as beans are rich in antioxidants such as lutein, increased consumption of greens can decrease the incidence of cardiovascular diseases (Pollock, 2016).

Overall, the findings highlight the importance of intensive dietary interventions, especially for increased fruit, vegetables, and leafy greens intake. Larger sample size studies in the future would be valuable to further elucidate these trends and establish the findings.

For the association between quality of the diet and cardiometabolic risk factors, a weak positive correlation between BMI and HEI-2020 scores was observed, but the association is not statistically significant. Conversely, the breakdown of dietary components in this sample reveals several trends. The strong correlation observed among carbohydrate, fat, protein, and calorie intakes underscores the role of macronutrients in determining total caloric consumption. Specifically, fat and protein intake appear to be more strongly associated with overall calorie levels, suggesting that diets higher in these macronutrients may be driving the higher caloric values observed.

These insights provide a useful basis for understanding how dietary composition correlates with energy intake and with health outcomes such as body mass index (BMI). However, further investigation is needed to establish causal links and to explore whether certain macronutrient profiles are more strongly associated with specific health outcomes across diverse populations.

The study did not indicate any statistically significant relationships between lifestyle factors (exercise frequency, work schedule, sleeping time, mood category, and stress level) and diet quality, as assessed by the chi-square test. This indicates that in this population, the considered lifestyle factors were not related to the quality of diet. However, the non-significance of results can be explained by a small sample size (N=20) to identify the low-level variations possible in a more heterogenous bigger population. Additional research with an increased sample size is recommended to examine these associations further and determine whether these factors do not have an impact on diet quality.

Limitations and Future Research

There are several limitations in this pilot study that are worthy of consideration. First of all, the small sample size of 20 participants limits the generalizability of the findings and restricts the potential for conducting more advanced statistical analyses. Additionally, only 17 food diaries were included in the Pearson's correlation analysis due to the exclusion of three diaries that lacked any usable photo data for processing by the CaloScanAI app.

Another key limitation was the inconsistent quality and format of photo submissions. CaloScanAI relies on clear, well-framed images taken under good lighting conditions and from a top-down perspective at a distance of approximately 20 cm to accurately identify foods and plate borders and calculate macronutrient content (Fig. 1).



Figure 1. Example of a suitable image for analysis.



Figure 2. Example of improperly formatted image.

However, several participants submitted photos that did not meet these criteria — for example, images taken at oblique angles, in poor lighting, or missing critical visual information about portion size or food type (Fig. 2). As a result, the app was unable to process some entries accurately and introduced noise into the dataset. Future versions of the study should incorporate clearer instructions and training materials for participants with examples of both acceptable and unacceptable photo formats to improve data quality.

Future studies should focus on replicating these findings on a larger and more demographically diverse sample. Expanding the participant pool would enable a more comprehensive statistical testing and the exploration of potential moderating factors such as sex, age, physical activity, and cultural dietary patterns. Additionally, incorporating longitudinal tracking could help assess changes in dietary intake over time and their relationship to health markers like BMI, blood sugar levels, and cholesterol.

Improving the integration of app-based dietary monitoring tools like CaloScanAI also holds promise for more accurate and scalable dietary analysis. However, ensuring that the participants are properly trained in data collection methods, particularly meal photography, will be critical to getting accurate results and maximizing the utility of such technologies.

Conclusion

The results of the present pilot study showed high prevalence of poor diet quality in Kazakhstani adults: the majority fall into the "poor diet" category according to HEI-2020. Fruits intake was the most prominent difference between moderate and poor diets, whereas vegetables, dairy consumption, and green consumption were low across the board. This eating pattern is especially important in the context of the established correlation between low fruit and vegetable consumption and elevated cardiometabolic risk, as well as elevated cardiovascular disease and obesity risks. CaloScanAI use offered a technology-based alternative to dietary assessment, but issues with data quality highlighted the need for greater support with electronic data collection. Overall, these results emphasize the importance of targeted nutritional interventions that promote increased consumption of fruits, vegetables, and dairy products. Future research with larger, more diverse populations and improved data collection methods is necessary to build on these insights and better inform health promotion strategies.

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Appendix

Informed Consent

You are being invited to participate in a research study titled "Assessing the Relationship Between Food Intake, Lifestyle, and Cardio-Metabolic Risk Factors in Kazakh Adults." The aim of this study is to explore the association between food intake and lifestyle factors with cardio-metabolic risk factors in adults from Kazakhstan.

If you agree to participate in this study, you will be asked to complete several steps. First, in the Baseline Assessment, you will fill out an online questionnaire providing information about your medical history, dietary habits, lifestyle factors (physical activity, sleep, stress levels, and mood), and biological characteristics. The assessment will take about 10-15 minutes. Next, for the Dietary Recording, you will track your food intake using a paper diary and two mobile apps. You will be asked to provide information from your wearable devices, such as smartwatches, including data on physical activity and sleep patterns.

This study poses minimal risks to participants.

By participating in this study you will gain a better understanding of how your dietary and lifestyle habits influence your overall cardio-metabolic health. The insights gained from this study can contribute to improving the understanding of dietary and lifestyle impacts on cardio-metabolic health in Kazakhstan.

Your privacy and confidentiality will be maintained throughout the study. The results of this study may be published or presented in academic settings, but your identity will remain anonymous at all times.

Participation in this study is entirely on a voluntary basis. You have the right to refuse to participate or to withdraw from the study at any time without any negative consequences.

If you have any questions about the research, you can contact:

Investigator: Mei Yen Chan, PhD. Assistant Professor, Nazarbayev University School of Medicine, Department of Biomedical Sciences.

Email address: yen.chan@nu.edu.kz

By choosing "I agree" below you are indicating that you are above 18 years old, have read and understood this consent form and agree to participate in this research study.

– I Agree

– I Disagree

Appendix

Food Consumption Diary with Instructions

Instructions for Completing the Research Tasks

Thank you for participating in this study. Follow these step-by-step instructions to complete your research tasks. Please provide accurate and complete data for 3 days (2 weekdays and 1 weekend day).

Step 1: Complete the Online Survey

1. Access the survey using the provided link: https://nukz.qualtrics.com/jfe/form/SV_37ZtrkCuJHTj62G
2. Be ready to provide the following information:
 - Body Measurement: Waist circumference, neck circumference, and body weight.
 - Lifestyle Information: Details about your daily habits, physical activity levels, sleep patterns, stress, and mood.
3. Remember the assigned Participant ID.

Please complete the survey honestly to ensure data accuracy.

Step 2: Maintain a Daily Diary

Record your food intake, physical activities, mood, and sleep quality for each of the 3 days. Use the provided diary template and follow these instructions:

A. Food and Drink Log

For each meal or snack, record:

1. Time: The exact time (in hours and minutes) you consumed the food or drink.
2. Location: Where you ate or drank (e.g., home, work, restaurant).
3. Description of Food/Drink: Clearly describe the food or drink (e.g., plov, tea with sugar, salad).
4. Quantity/Amount: The portion size (e.g., 2 tablespoons, 1 cup, 150 g).
5. Additional Ingredients: List any extra ingredients added (e.g., sugar, honey, salt).
6. Mood and Hunger Feeling: Use the *Scale of Hunger and Satiety* to describe your hunger level before eating and your feeling of satiety after eating (e.g., "Before —3, After — 6").

B. Physical Activity Log

For each activity, record:

1. Activity Description: Note all physical activities throughout the day (e.g., walking, swimming, exercising, running).
2. Time and Duration: Record the start time and how long the activity lasted (e.g., "Walking—2:00 PM, 30 minutes").

C. Sleep Patterns

Each day, record the sleep duration and your sleep quality using the following terms:

1. Restorative Sleep: You woke up feeling fully rested, refreshed, and energized.
2. Moderate Restfulness Sleep: You felt rested, but not completely refreshed or energized.
3. Disturbed Sleep: You had trouble falling asleep, experienced interruptions, or woke up feeling tired and unrested.

D. Female Participants Only

Indicate whether you are currently having your period or not.

Step 3: Ensure Data Accuracy

- Double-check your diary entries to ensure they are complete and accurate.
- Record everything before eating or doing activities whenever possible to avoid missing details.

Step 4: Submission

After completing all 3 days, submit your diary to the research team.

If you have any questions or need clarification, please reach out to the research team. Thank you for your valuable contribution to this study!

Scale of Hunger and Satiety	
10	Extremely stuffed, nauseous
9	Stuffed, very uncomfortable
8	Overfull, somewhat uncomfortable
7	Full but not uncomfortable
6	Satisfied, but could eat a little more
5	Starting to feel hungry
4	Hungry, stomach growling
3	Uncomfortably hungry, distracted, irritable
2	Very hungry, low energy, weak and dizzy
1	Starving, no energy, very weak

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Your privacy and confidentiality will be maintained throughout the study. The results of this study may be published or presented in academic settings, but your identity will remain anonymous at all times.

Participation in this study is entirely on a voluntary basis. You have the right to refuse to participate or to withdraw from the study at any time without any negative consequences.

If you have any questions about the research, you can contact: Mei Yen Chan, PhD. Assistant Professor, Nazarbayev University School of Medicine, Department of Biomedical Sciences.
Email address: yen.chan@nu.edu.kz

By signing, it indicates that

- You have read the above information
- You voluntarily agree to participate
- You are 18 years of age or older

Signature: _____ Date: _____

Example

Participant ID _____

Date _____

Time	Location	Description of Food/Drink	Quantity/Amount	Mood and hunger feeling before every meal (use Scale of Hunger and Satiety)	Physical Activity (time & duration)	Sleep patterns and duration (restorative sleep/ moderate restfulness sleep/ disturbed sleep)	For females only: currently having periods or not (yes or no)
Breakfast 10:00 AM	Home	Boiled eggs Bread Cucumber	2 2 pieces 50g	Before — 3 After — 7	Running — 9:00 AM, 30 minutes	Moderate restfulness for 7 hours	No
Lunch							
Dinner							
Snacks							

Day 1

Participant ID _____

Date _____

Time	Location	Description of Food/Drink	Quantity/Amount	Mood and hunger feeling before every meal (use Scale of Hunger and Satiety)	Physical Activity (time & duration)	Sleep patterns and duration (restorative sleep/ moderate restfulness sleep/ disturbed sleep)	For females only: currently having periods or not (yes or no)
Breakfast							
Lunch							
Dinner							
Snacks							

Day 2

Participant ID _____

Date _____

Time	Location	Description of Food/Drink	Quantity/Amount	Mood and hunger feeling before every meal (use Scale of Hunger and Satiety)	Physical Activity (time & duration)	Sleep patterns and duration (restorative sleep/ moderate restfulness sleep/ disturbed sleep)	For females only: currently having periods or not (yes or no)
Breakfast							
Lunch							
Dinner							
Snacks							

Day 3

Participant ID _____

Date _____

Time	Location	Description of Food/Drink	Quantity/Amount	Mood and hunger feeling before every meal (use Scale of Hunger and Satiety)	Physical Activity (time & duration)	Sleep patterns and duration (restorative sleep/ moderate restfulness sleep/ disturbed sleep)	For females only: currently having periods or not (yes or no)
Breakfast							
Lunch							
Dinner							
Snacks							

Appendix

Healthy Eating Index - 2020 components and scoring standards

Component	Maximum points	Standard for maximum score	Standard for minimum score
Total Fruits	5	≥ 0.8 cup equiv. per 1,000 kcal	No Fruit
Whole Fruits	5	≥ 0.4 cup equiv. per 1,000 kcal	No Whole Fruit
Total Vegetables	5	≥ 1.1 cup equiv. per 1,000 kcal	No Vegetables
Greens and Beans	5	≥ 0.2 cup equiv. per 1,000 kcal	No Dark Green Vegetables or Legumes
Whole Grains	10	≥ 1.5 oz equiv. per 1,000 kcal	No Whole Grains
Dairy	10	≥ 1.3 cup equiv. per 1,000 kcal	No Dairy
Total Protein Foods	5	≥ 2.5 oz equiv. per 1,000 kcal	No Protein Foods
Seafood and Plant Proteins	5	≥ 0.8 oz equiv. per 1,000 kcal	No Seafood or Plant Proteins
Fatty Acids	10	$(\text{PUFAs} + \text{MUFAs})/\text{SFAs} \geq 2.5$	$(\text{PUFAs} + \text{MUFAs})/\text{SFAs} \leq 1.2$
Refined Grains	10	≤ 1.8 oz equiv. per 1,000 kcal	≥ 4.3 oz equiv. per 1,000 kcal
Sodium	10	≤ 1.1 grams per 1,000 kcal	≥ 2.0 grams per 1,000 kcal
Added Sugars	10	$< 6.5\%$ of energy	$\geq 26\%$ of energy
Saturated Fats	10	$\leq 8\%$ of energy	$\geq 16\%$ of energy