SHORT THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PHD)

# Nutrition and dietary profile of the Roma population living in segregated colonies

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UNIVERSITY OF DEBRECEN DOCTORAL SCHOOL OF HEALTH SCIENCES

DEBRECEN, 2021

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The PhD is held online and starts at 14:00 on 13<sup>th</sup> of July 2021. Publicity is provided online. If you wish to participate, please indicate it in a message sent to the e-mail address egdi@unideb.hu by 14:00 on 12 July 2021 latest. After the deadline, it is no longer possible to connect to the PhD defense due to technical reasons.

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# **INTRODUCTION**

The Roma population constitutes the largest ethnic minority in Europe (estimated to be between 10-12 million) and has been a major focus research in past decades. Historical migration has led to their dispersion over many European countries and they have been subjected to disadvantaged living conditions, food insecurity, high-risk health-related behaviors, as well as discrimination, stigmatization and barriers to accessing health service. Such exposures have resulted in a particularly poor health status marked by a relatively high prevalence of chronic morbidity, particularly diet-related noncommunicable diseases (NCDs), as well as an estimated life expectancy of almost a decade less, compared to the general population in Europe.

Survey results from different European countries, attempting to elucidate dietary aspects of Roma, have indicated detrimental dietary patterns, linked to the common hallmarks of diet-related NCDs, namely inadequate and infrequent consumption of fruits, vegetables and dairy products, unfavorable consumption of fast foods, animal fats, sugar-sweetened beverages, as well as confectionery. Apart from attempts to describe dietary intake of Roma, nutrient intake patterns and data among Roma are not available yet in Hungary or elsewhere. The dietary profile of the Hungarian adult population has been extensively investigated and is largely characterized by intake of immoderate amount of fats, meats (mainly processed), salt and sugar.

However, dietary intake and nutrient patterns of HR adults (nor Roma adults in other countries) has never been quantified. Therefore, it is timely and highly relevant to address malnutrition in all its forms and its implications not only with regards to nutrition and health, but sustainability aspects it affects as well.

To the best of our knowledge, this is the first study of this kind and depth among Roma, addressing the relevance of diet for human and planetary health, as well as the first time that quantified, extensive dietary intake data and comprehensive nutritional estimates for Roma adults, in comparison with not only general population's data as reference, but with data specified in established guidelines/recommendations for healthy and sustainable nutrition as well.

## **OBJECTIVES**

The main aim of this work was to investigate and elucidate the state of diet, nutrition and dietary profiles of the Roma population living in segregated colonies in North East Hungary, while considering HG population as reference.

Our specific objectives were to:

- (1) Determine the current dietary profile and nutritional status and
- (2) Assess the dietary patterns shown to strongly influence health and environmental sustainability, of Roma population living in segregated colonies.

# **METHODS**

#### STUDY DESIGN AND SAMPLING

All data used in my work were obtained in a cross-sectional survey carried out between May and August 2018, as a three-pillar (i.e., questionnaire-based, physical examination and laboratory examination) complex (i.e., health behavior and examination) survey. Individuals aged 20 to 64 years, were selected randomly, to be representative of the adult HR population living in segregated colonies of North-East Hungary (Hajdú-Bihar and Szabolcs-Szatmár-Bereg counties), where a great proportion of HR population resides, as well as that of the HG population living in the same counties. In addition to the demographic, anthropometric, health behavior, physical and laboratory data collection in the three pillars of the survey two 24-hour recalls were also obtained to quantify dietary intake. The intended sample size was 500 participants for both study groups, but the final study sample, with full recall data, included 797 participants, of which 410 subjects of the HG and 387 individuals of HR population.

## DIETARY AND ANTHROPOMETRIC DATA COLLECTION AND QUALITY APPRAISAL

Dietary intake data were obtained in case of each participant through a double (i.e., one non-consecutive weekday and one weekend day) interviewer-assisted multiple-pass 24-hour dietary recall protocol developed and validated previously. The consecutive steps used to determine food intake were the following: (i) listing of foods consumed by the respondent during a 24-hour period, including one weekday and one weekend day, before the interview, (ii) additional recall of nine categories of foods that are often forgotten, such as non-alcoholic and alcoholic beverages, sweets, savory snacks, fruits, vegetables, cheeses, bread and rolls, etc., (iii) assessment of meal time and occasion, (iv) detailed description of each item reported, and (v) a final opportunity to amend or recall any other unreported item. All subjects were eligible to report their intake if the weekday and the weekend day were considered '*typical*', which meant that: (i) intake represented what they usually consume, (ii) there was no special event (birthday, party, etc.) on the day assessed, (iii) no disease was diagnosed prior or during the days recorded, (iv) nutritional supplements of any kind were taken and (v) a diet regime of any kind was applied.

If one of these conditions was not satisfied, subjects were not eligible and hence the recall was not recorded. The two dietary recalls were administered to all survey participants. Generalized obesity and obesity classes were estimated based on body mass index (BMI) according to WHO's criteria. Abdominal obesity was determined using waist circumference (WC) standards defined for females and males by the International Diabetes Federation (IDF) for European (IDF<sub>EURO</sub>) population. In addition, anthropometric indices that estimate percentage of body fat (PBF) were defined, using four different anthropometric equations for estimating PBF. These equations were considered suitable and potential alternatives in estimating whole-body fat percentage in subjects 20 years of age and older, independently of the ethnic background and sex.

Eventually, the proportion of those with metabolically healthy obesity (MHO) was determined among subjects suffering from obesity (i.e., BMI $\geq$ 30 kg/m<sup>2</sup>). MHO was defined in our study if participants fulfilled the following criteria: (1) no diagnosed pre-existing cardiometabolic diseases, (2) a healthy cardiometabolic blood profile (i.e. fasting triglycerides <1.07 mmol/L, HDL-C  $\geq$  1.04 mmol/L (men) and  $\geq$  1.29 mmol/L (women) and fasting glucose < 5.55 mmol/L) and (3) normal BP (i.e. blood pressure < 130/85 mmHg). After applying these criteria, we used four different approaches to further determine proportion of MHO.

#### DIETARY PATTERNS INDEXES

We used four different nutrient-based dietary quality indexes: HDI, DII, the EAT-Lancet and DASH. EAT-Lancet and DASH are considered environmentally sustainable dietary regimes, in addition to being beneficial to health. The World Health Organization (WHO) guidelines for the prevention of chronic diseases and the 2020 updated healthy diet fact sheet were used to construct a modified version of the HDI. Our HDI used seven nutrient standards and a dichotomous variable was generated for each nutrient according to prespecified coding criteria. Our DASH diet index, was an entirely nutrient-based version, constructed on the basis of target nutrient values from the DASH diet used in 2 clinical trials. The nine nutrients were those expected to be higher (protein, fiber, magnesium, calcium, and potassium) or lower (total fat, saturated fatty acids (SFAs), sodium, and cholesterol). To evaluate the adherence of our subjects to the reference diet of the EAT-Lancet Commission on Healthy diets from the sustainable food systems, we constructed a novel, nutrient-based EAT index (NB-EAT), based on the nutrient composition of the original EAT-Lancet reference diet. Our NB-EAT included twelve nutrient reference intakes (i.e.  $\alpha$ -linolenic acid, carbohydrates, cholesterol, dietary fibers, monoand poly-unsaturated fats, proteins, saturated fats, total fat, calcium, added sugar, magnesium and potassium). A total of 27 nutrients were available to calculate the DII for our study population. The overall index obtained by summing the 27 dietary parameters (total energy, carbohydrate, protein, total fat, alcohol, fiber, cholesterol, SFAs, caffeine, monounsaturated fatty acids (MUFAs), polyunsaturated fatty acids (PUFAs), omega-3 and omega-6 fatty acids, niacin, thiamine, riboflavin, vitamin B12, vitamin B6, iron, magnesium, zinc, vitamin A, vitamin C, vitamin D, vitamin E, folic acid, and beta-carotene).

## DATA ANALYSIS

Dietary data were processed with *NutriComp Étrend ver. 3.03* (https://www.nutricomp.hu/) software which has been used previously in *Hungarian Diet and Nutritional Status* surveys, as it contains detailed food composition information on 1328 food items and 1823 recipes. Additional recipes were created, or existing ones were modified in the software's database, if a food item was missing or had additional/fewer ingredients accordingly. Comparisons of characteristics between the study groups were made using chi-square ( $\chi^2$ ) test for categorical variables and t-test or ANOVA for continuous variables, as appropriate. Assumptions for normality were checked and regression coefficients were adjusted for all relevant covariates.

Beta coefficients ( $\beta$ ) and their corresponding 95% CI were calculated for explanatory parameters. In linear regression analyses, outcome variables with a non-normal distribution were normalized by Box–Cox transformation. Recommended intake values were obtained from WHO's official guidelines. In addition, recommended intake targets derived from the DASH, the EAT-Lancet reference diet and European Food Safety Authority (EFSA) dietary reference values were considered for benchmarking. Comparisons of intakes with the recommended/reference intakes have been made. All sociodemographic and nutritional covariates (age, sex, education, marital status, perceived financial situation, economic activity, BMI and energy intake) were included in the models by a stepwise manner to determine the Roma ethnicity effect independently from sociodemographic and anthropometric data. Statistical analyses were performed with IBM SPSS Statistics for Windows, Version 21.0 (IBM Corp., Armonk, NY, USA) and R Statistics (RStudio, Boston, MA, USA).

## **RESEARCH ETHICS**

Approval for the research protocols and methodology was provided by the Ethical Committee of the Hungarian Scientific Council on Health (61327-2017/EKU). Participants gave their written informed consent in each study population in accordance with the Declaration of Helsinki and the Science Ethics Code of The Hungarian Academy of Sciences.

# **RESULTS**

The final study sample comprised 797 participants, 410 in the HG and 387 in the HR population, with response rates of 91.0% and 77.4%, respectively. Those who had implausibly low or high estimated caloric intake (<800 or >4500 kcal/day for males, <700 or >3500 kcal/day for females), were excluded, i.e., 51 HG subjects (4 and 47 for implausibly low intake and high intake, respectively) and 43 HR subjects (4 and 39 for implausibly low intake and high intake, respectively) and 43 HR subjects (4 and 39 for and 344 HR) were included in the final analysis.

### ANTHROPOMETRIC CHARACTERISTICS OF PARTICIPANTS

Average WC and BMI values were not significantly different between the two groups (they fell within the range of overweight status in both populations), but the distribution of BMI categories showed significant difference. Abdominal obesity, based on IDF<sub>EURO</sub>, was significantly associated with ethnicity only among men ( $\Im$ n=66 (38.6%) for HG vs.  $\Im$ n=42 (43.8%) for HR, p<0.05). Both underweight and obesity were more prevalent among HR (n=10 (2.8%) and n=104 (29.0%) for HG vs. n=22 (6.4%) and 129 (37.5 %) for HR, respectively). WH*t*R was significantly higher among HR ( $\Im$ 0.56 and  $\Im$ 0.58 for HG vs.  $\Im$ 0.58 and  $\Im$ 0.60 for HR, p<0.05). There were significant differences between the two groups on PBF, regardless of the method used to estimate it – with HR having consistently higher estimates of PBF than HG (PBF%=32.7, 95%CI: 31.7-33.6 for HG vs. PBF%=35.1, 95%CI: 34.1-36.2 for HR).

The representation of MHO subjects was consistently, but not significantly lower in the HR group compared to HG, regardless of the classifying criteria applied (MHO%=21.2, 95%CI: 17.1-25.8 for HG vs. MHO%=16.9, 95%CI: 13.1-21.2 for HR).

#### DIETARY INTAKE PATTERNS

Energy intake estimation was found to be not significantly different between HG and HR (E=2188 kcal, 95% CI: 2111.2-2265.3 for H vs. E=2114.1, 95% CI: 2042.3-2185.8 for HR, p=0.166). Males had higher energy intake compared to females, regardless of ethnicity, but this difference was found statistically not significant. Total carbohydrate daily intake, as energy percentage, was significantly higher among HR (%E=46.2, 95% CI: 45.3-47.1 for HG vs. %E=48.2, 95% CI: 47.2-49.2 for HR,  $\beta$ =2.8, 95% CI: 0.9-4.8, p<0.05), but still significantly lower than the recommended range in both groups (i.e., 55-75 %E). Sugar intake did not differ significantly between HR and HG (20.3g, 95% CI: 19.3-21.3 for HG vs. 20.4 g, 95% CI: 19.1-21.6, p>0.05), but it was significantly higher than the recommended daily intake, in terms of %E (i.e., 10%E), and even higher than the 5%E intake recommended by WHO for additional health benefits (%E=17.0, 95% CI: 16.0-18.0 for HG vs. %E=18.8, 95% CI: 17.7-19.8 for HR,  $\beta$ =0.03, 95% CI: 0.01-0.05, p<0.05).

Total dietary fiber intake was much lower than the recommended daily amount (i.e.,  $\ge 24$  g) for both groups (20.3g, 95%CI: 19.3-21.3 for HG vs. 20.4g, 95%CI: 19.1-21.6 for HR,  $\beta$ =-2.35, 95%CI: -4.7-0.01, p>0.05). Total dietary protein intake was significantly higher compared against recommended intake ranges (i.e., 10-15 %E) among HG (%E=15.5, 95%CI: 15.2-15.9), but not among HR (%E=15.1, 95%CI: 14.7-15.4). Neither animal-based nor plant-based protein intake were significantly different between groups. Total and essential amino acids intake was significantly lower in the HR sample (71.1g, 95%CI: 68.5-73.7 and 26.4g, 95%CI: 25.4-27.4, respectively) compared to the HG group (76.8g, 95%CI: 73.9-79.7 and 28.7g, 95%CI: 27.6-29.8, respectively). There were no significant differences by type and source of fat between the two groups, but there were significantly higher intakes (in both groups) compared to the established dietary recommendations.

PUFAs' intake was significantly lower among HR (%E=9.0, 95%CI: 8.7-9.3 for HG vs. %E= 8.2, 95%CI: 7.9-8.5 for HR,  $\beta$ =-1.0, 95%CI: -1.6--0.4), but still within the recommended range (i.e., 6-10 %E) and both groups were characterized by a moderately excessive (below 10%) intake of SFAs (%E=10.7, 95%CI: 10.3-11.1 for HG vs. %E=10.7, 95%CI: 10.3-11.0 for HR). Cholesterol intake was very high compared to the reference limit in both groups, both as absolute intake and as adjusted value (i.e., mg/1000 kcal); while intake of beneficial fatty acids, such omega-3 fatty acids and alpha-linolenic acid, were very low, particularly among HR. Omega-6 intake was higher than the upper value of the recommended range among HG and significantly lower, but at the upper value among HR.

In case of minerals and trace elements, sodium intake in both groups was exceedingly higher (5644.0mg, 95%CI: 5351.9-5936.0 for HG vs. 5094.4mg, 95%CI: 4866.0-5322.8 for HR,  $\beta$ =765.0, 95%CI: -1304.5--225.5, p>0.05) compared to established international dietary recommendations (i.e.,  $\leq$ 2000 mg), while potassium and magnesium intakes were below the recommended intake, independently of the criteria used.

HR had consistently lower vitamin intake – particularly B vitamins - compared to recommendations. When examining the odds of the HR participants achieving the recommended daily nutrient intake ranges/values, compared to HG population as a reference, results showed that HR was less likely to achieve recommended intake targets, compared to HG. The odds were significantly lower for HR in general, regardless of the model accounted for (fixed: OR=0.81, 95%CI: 0.72-0.91 and random effects: OR=0.81, 95%CI: 0.67-0.97).

## DIETARY PATTERN SCORES AND QUALITY

Further, when accounting for dietary patterns quality, results showed a high representation of participants with poorer adherence levels for DASH, HDI and NB-EAT, independently of the dietary index used, ethnicity or sex. DII tertile and score distribution also showed a considerable representation in the two upper tertiles. Additionally, there was no observed statistical association between sex/ethnicity and the selected dietary indexes, with regards to score differences. Multivariable regression models, both adjusted and unadjusted for the indicated and relevant covariates, showed no significant effect of Roma ethnicity on DASH, NB-EAT and HDI scores ( $\beta$ =-0.049, 95% CI: -0.254 - 0.156,  $\beta$ =-0.017, 95% CI: -0.179 - 0.144 and  $\beta$ =-0.00, 95% CI: -0.231 - 0.230, respectively). On the other hand, DII score was significantly and inversely associated with Roma ethnicity in the adjusted models ( $\beta$ =-0.455, 95% CI: -0.720 - -0.191, p>0.05).

# **DISCUSSION**

Diet and nutrition are closely related to a number of NCDs and currently there has been a growing interest in characterizing their association with dietary patterns, particularly among disadvantaged minority populations, such a Roma. The unfavorable living conditions in which some Roma people live, frequently on the outskirts of towns and villages and in substandard settlements, allow relatively straightforward identification of locations in which Roma people are concentrated. This study has taken advantage of this opportunity, by sampling HR participants in Northeastern Hungary, where the Roma population is greatest and in identified settlements, in which the population was almost exclusively Roma. Below we discuss two themes that emerged while investigating dietary profile and nutritional status of Roma in Hungary, namely (1) dietary profile and general nutritional status and (2) adherence to healthy and sustainable dietary patterns. In addition, we provide a brief outlook of the relevance of our findings to the current COVID-19 pandemic.

# DIETARY PROFILE AND GENERAL NUTRITIONAL STATUS

With regards to nutritional status, HR appear to be particularly affected by malnutrition in many forms, with less favorable estimates of body composition coupled with greater perceived financial challenges and higher unemployment rates – factors which may affect access to better nutrition and dietary quality.

Although statistical differences could not be detected for some anthropometric indices, estimates of body fatness were significantly and consistently (criteria-wise) higher among HR, indicating less healthy body composition compared to HG. Although not significantly different from HG, consistently lower MHO was showed among HR according to different classification criteria. Such results need to be confirmed via direct body composition measurements, but currently these findings are in line with results from recent analyses, where the distribution of BMI was shown to have significantly worsened among younger HR (in both sexes) between 2004 and 2015, with obesity becoming significantly more frequent. In addition, Roma had higher rates of underweight compared to HG.

With regards to nutrient patterns and intake, dietary fat composition among the study participants, was substandard considering the representation of beneficial fatty acids, such as PUFAs, omega-3 fatty acids and alpha-linolenic acid, particularly among HR. SFAs and cholesterol intake were excessively high in comparison with the recommended intake, with no significant differences between groups. These results are consistent with recent estimates by WHO, which show the adult population in Hungary with an estimated 11.8% of their total calorie intake coming from SFAs. It is reasonable to assume that such high SFAs' intakes can be partially explained by the traditional consumption of meat and SFAs-rich products, such as lard, tallow, cold cuts and sausages among Hungarian population. The current nutritional discourse and best dietary guidelines put no longer an emphasis on the reduction in total fat intake, but rather call for optimization of fat types in the diet, and specifically reduced intake of SFAs and trans-fats.

Therefore, given our results and the current evidence, dietary guidance should focus on optimizing dietary fat sources. Sugar intake was also significantly high for both groups (evaluated against WHO recommended intake) and previous data on HG adults have also shown similarly immoderate amounts of sugar intake. Sugar, coming predominantly from glucose- or fructose-sweetened beverages and confectionary, is a great public health challenge in Hungary.

However, given our results and the urgency to tackle the current '*sugar epidemic*', measures aimed at reducing excessive sugar consumption should go beyond legal actions and additional regulatory mechanisms should be introduced, particularly targeting early exposures in childhood and adolescence. Such mechanisms may include regulating and monitoring advertising of unhealthy foods and beverages, with special attention to child-directed food marketing. Moreover, sodium intake was observed to be exceedingly high for HR, both in terms of absolute and adjusted intake, and not significantly different from HG. It should be noted that the estimated intake in this analysis may be subject of a diluted underestimation effect, as sodium is typically underreported when using recall methods, such as ours. This means that the actual intake may be even higher.

Such results strengthen the importance of existing national targets to reduce sodium intake at the population level. Another critical aspect of diet composition, in both study groups, was the inadequate fiber intake, which has been linked to higher risk of colorectal cancer. This dietary aspect is highly relevant for Hungary as colorectal cancer is one of the most common causes of cancer-related death, for both males and females, in Hungary, making it the number one country in the world ranking list of age-standardized mortality (per 100,000) caused by colorectal cancer.

Considering the current evidence on the protective effect of dietary fibers, our findings have important public health implications and provide support for public health nutrition recommendations to increase intake of fiber especially in the prevention of colorectal cancer. Fiber intake, combined with potassium estimates, can be an indication of fruits and vegetables consumption, which seems to be low and this is also reflected in the lower micronutrient intake among HR (particularly B-vitamins). Such results are supported by our recent study among HR showing that the Roma participants reported significantly less frequent consumption of fresh fruits and vegetables than the Hungarian subjects. Public health nutrition interventions in addition to existing ones in Hungary, going beyond just legal and regulatory policies, while deliberately engaging minorities such as Roma, aiming at modifying current dietary patterns. Given the complexity of nutritional behaviors and the wide range of influences on diet, such efforts require active collaboration of a variety of actors throughout the food system, along with policies targeting multiple sectors. Many populations, as in the present case, are dynamically enriched by a range of ethnic groups and such minority groups should be key targets when tackling inequalities in health. Our results suggest that such actions should emphasize and reinforce the relevance of more plantbased proteins, higher fiber, fruit, vegetables, whole grains intake and substitution of detrimental fatty acids sources with beneficial fatty acids sources in energy balanced conditions. The present findings results can also imply the presence of dietary risk factors, and signify elevated risk for diet-related NCDs in both groups examined.

### ADHERENCE TO HEALTHY AND SUSTAINABLE DIETARY PATTERNS

In relation to the nutrient-based dietary patterns, our results further confirm the substandard adherence to established healthy and sustainable dietary guidelines, as accounted by the nutrient-based dietary indexes used in this work. Ethnicity did not have a strong influence on adherence to selected dietary guidelines.

However, being Roma was associated with a lower DII score, i.e., lower dietary inflammatory potential. These findings are in line with our previous results and reinforce the fact that currently the Hungarian population is not close to meeting healthy diet targets – regardless of ethnic background. The cause of such a substandard quality of diet is highly likely to be multifactorial. A relevant contributor may be the lack of adequate dietary guidance/interventions, as nutrition services have not yet been mainstreamed into the Hungarian health care system. As a result, dietary patterns such as DASH, EAT-*Lancet* or dietary evaluation based on DII and HDI approach have not been widely promoted in Hungary.

At present, provision of general preventive services in primary health care in Hungary is challenging and not based on evidence-informed dietary guidance, i.e., trained dieticians, nutritional experts, etc. Additionally, there was a considerable representation of subjects in the upper tertile of the DII, hinting an elevated inflammatory potential of the current dietary patterns. Chronic inflammation plays an important role in the development of several chronic diseases. Since various nutrients and foods have been shown to modulate inflammation, dietary patterns play an important role in the regulation of chronic inflammation. Although the link between diet and disease outcomes needs additional studies to further confirm the health potential of current dietary patterns, longitudinal epidemiological data have already linked poor adherence to healthy dietary patterns to many NCDs and claiming an attributable global death toll of 11 million from diet-related NCDs. Therefore, there is a compelling case for urgently considering the inclusion of nutrition and dietary services as an integral component of primary healthcare. The Hungarian healthcare system has for decades focused on the clinical, pharmacological-oriented model of disease that may ignore fundamental causes, such as diet and lifestyle. The consequences of this approach can be observed in the poor dietary patterns reported here, with the potential to contribute to an elevated risk of diet-related NCDs and further supported by data showing a very high prevalence of metabolic syndrome in both HG and HR populations (i.e., 39.8% and 44.0%, respectively) with no significant difference between the two groups in either females or males.

Integrating and mainstreaming nutrition actions into the Hungarian health care system to promote healthier diet, and prevent and treat diet-related NCDs, has the potential to generate substantial health gains and be highly cost-effective. Furthermore, adherence to sustainable dietary patterns among our participants, can be viewed, not only as dietary marker, but as one of behavioral commitment towards addressing Climate Change as well. The vast majority of nutrient-based EAT-Lancet reference diet targets were not attained and none of the participants was in the third-upper category of adherence. Considering the detrimental environmental impact of current food systems, and concerns raised about their sustainability, there is a pressing need to promote diets that are healthy and have no or low destructive impact on the environmental in Hungary and globally. At present, the 'Nutritional recommendations for the adult population in Hungary' (i.e., national food-based dietary guideline) fails to include sustainability criteria, although there is mounting evidence linking overconsumption of, in particular, red and ultra-processed meat products with detrimental human and environmental health outcomes.

Recommending dietary shifts towards plant-based diets may be of great importance in achieving health and sustainability goals, as from a food systems point of view, down-right adoption of plant-based diets has the potential to all-at-once optimize food supply, improve health, increase environmental sustainability, and advance social justice outcomes. Apart from the established health benefits DASH diet is also considered an environmental-friendly dietary pattern. Our results indicate an extremely high 'non-accordance' to DASH pattern (95%), independently of ethnicity. This may be an epidemiological signature, which may signify increased risk for diet-related NCDs, as well as low potential of the current diet to contribute to climate targets.

Thus, our findings provide novel insights into dietary situation among HR and HG, as well as key dietary recommendations which might require special attention during nutrition/public health education. Such nutrition campaigns should strongly emphasize the importance of fiber, fruit, vegetable, and wholegrain intake and the substitution of saturated fats by mono/polyunsaturated fatty acid sources. Moreover, we advocate for nutrition education and research, to be integrated and mainstreamed into health sciences-related academic programs, with an overarching emphasis and regular reinforcement of the importance of higher fiber, fruit, vegetable and wholegrain intake and substitution of fat sources with beneficial ones, in an energy balanced manner.

In addition to the above-mentioned challenges, the actual nutrition situation is clearly neither a mere consequence of inappropriate quantity/quality of foods in the Hungarian diet, nor as a lack of willpower from the individual, but a consequence of a fundamental global challenge: food systems that have failed in providing healthy, safe, affordable, and sustainable diets. The economic, social, and environmental implications of further inaction can impact the growth and development of individuals and societies for decades to come. As the Lancet Series on the "*Double Burden of Malnutrition*" has shown, the intricate biological and social pathways of all forms of malnutrition cannot be disrupted through siloed interventions, therefore requiring society-wide and scalable behavioral shifts that can be sustained over time. Hence, more studies are warranted to determine the food system determinants, as well as social drivers of poor dietary intake in Hungary.

#### IMPLICATIONS OF FINDINGS FOR THE TRAJECTORY OF THE CURRENT PANDEMIC

Eventually, with relevance to the current Corona Virus Disease 2019 (COVID-19) situation, it is important to emphasize that research has showed that major risk factors for hospitalization, severity and mortality of COVID-19 include diet-related conditions, such as obesity, hypertension and type 2 diabetes.

Hence, nutritional well-being for all, particularly the most vulnerable, has heightened significance in the face of COVID-19 pandemic, thus addressing malnutrition in all its forms and diet-related NCDs are crucial in preparedness and building health resilience of populations for this and future public health threats. A streamlined response to COVID-19 in the context of nutrition and NCDs is important to optimize public health outcomes and reduce the impacts of this pandemic on individuals, vulnerable groups, minorities and societies.

Finally, the current COVID-19 pandemic has cast spotlight on longstanding costly and life-threatening inequities in global society. Those living in economically challenged communities, such as ethnic minorities, are bearing the heaviest burden of COVID-19 infections. It is now accepted that poor metabolic health is one of the most important immunity-impairing factors underlying cardiovascular disease, type 2 diabetes and obesity-related cancers, rendering many people vulnerable to COVID-19 severity and mortality.

However, while diet-related NCDs may increase vulnerability to the virus, limited attention has been paid in improving access to healthy and sustainable diets that can both sustain metabolic health, support a vigorous immune system and contribute to lessening the effect on the environment.

After this pandemic subsides, hopefully a lot more attention to the needs to be given to the potential of our diets have to ward off, not only future medical, economic and social calamities from whatever pathogen next comes down the pike, but to address bigger 'pandemic' as well: **Climate Change**! As governments embark on economic recovery plans in the wake of COVID-19, a great opportunity exists, within the framework of the UN Decade of Action on Nutrition (2016-2025), to invest in a green recovery plan that can tackle the health equity and environmental crises together, to ensure the most effective response to each.

Addressing these issues and building forward better starts with our 'plates'.

#### STRENGTHS, LIMITATIONS AND CONSIDERATIONS FOR FUTURE RESEARCH

Our work provides a comprehensive comparative dietary analysis, offering an opportunity to explore diet quality among Roma in relation to a variety of measures of nutritional quality and anthropometric status. However, even though our analysis may be the first comprehensive and detailed characterization for Roma's nutrition, there are some limitations to our observations that should be recognized. Observations are based on a double multiple-pass 24-hour dietary recall, and even though it is a valid approach to assess dietary intake patterns in epidemiological studies, findings need to be interpreted with caution, as long-term or seasonal variation of dietary patterns, in the populations under investigation, may not be fully captured. Further, the Roma study population can be considered representative only of HR living in segregated colonies of Northeast Hungary, but not representative of overall Roma population living in Hungary. Although diet is, no doubt, an important modulator of inflammation, it is by no means the only one. Other indexes, including physical activity and stress, should be derived using similar methods. If these could be integrated with the DII, then this could validate and confirm the inflammatory potential of the diet in the current population under investigation. It should be taken also into consideration that in our study the representation of females among HR was higher than among HG. This has also been the case in our previous surveys conducted among segregated Roma colonies in Hungary and also in Roma surveys in other countries. Although this is the first attempt, to the best of our knowledge, to present a nutrient-based index for healthy and sustainable diets based on the rigorous EAT-Lancet reference diet, we recognize that it may need further validation. Further work on drivers of poor dietary patterns should go beyond measuring the effect of prescribed, (but often not followed) dietary guidelines on population-averaged cohorts, towards quantifying the efficiency of dietary and lifestyle advice as well. Even the best dietary advice in the world may be indistinguishable from the worst, when individuals do not or cannot adhere to it due to specific circumstances, e.g. place of residence, access to healthy foods, employment conditions, income, etc. Despite the abovementioned challenges, findings offer novel nutritional insights on dietary aspects that require particular attention during potential interventions and monitoring their effects, when attempting to improve dietary quality among adults in Hungary. A food system's perspective is needed to address and transform the complex web of activities involving the production, processing, transport, and consumption of unhealthy diets.

## **CONCLUSION**

In summary, current dietary profile, intake patterns and nutritional status of HR living in segregated colonies in Northeastern Hungary, was found to be suboptimal, with inadequate nutrient composition and anthropometric status estimates, not strongly different than HG population, but occasionally worse among HR. Ethnic-specific differences exist with regard to meeting nutrient-based dietary recommendations, with Roma being less likely to comply, compared to HG population.

To date, this is the first study, to provide detailed and comparable (with the general population) data on nutrient patterns and intake, as well as extensive anthropometric indices in a relatively large sample of Roma. Unhealthy nutrient-based dietary patterns appear generally indiscriminate of ethnic background according to our analyses, with both populations (HG and HR) poorly adhering to healthy and sustainable dietary patterns. Such data are valuable for developing and implementing public health nutrition strategies to meet the national dietary recommendations, as well as for guiding nutrition education and intervention programs to reduce the risk malnutrition in all its forms and diet-related NCDs risk, in these high-risk population.

This study also demonstrates the data gaps on intake for key nutrients among HR, while highlighting the importance of establishing and integrating Roma nutrition in national surveillance and monitoring systems for key dietary risk factors. It is timely to reconsider dietary guidelines for Hungary, with incorporation of evidence on ethnicity-related and sustainability issues into these recommendations. Identifying dietary patterns that are nutrient-rich, affordable, healthy and sustainable for Hungarians should be a top public health research priority, as well as an opportunity to discern and address social inequalities in nutrition and health.

The current nutritional trajectory may not be in line with achieving the sustainable development goals in respect to multiple dietary targets for public health and environmental sustainability. Further research is warranted to elucidate drivers and ascertain food-based dietary patterns, with sustainability considerations in mind.

# **FUNDING**

This work was supported by the GINOP-2.3.2-15-2016-00005 project. The project is co-financed by the European Union under the European Social Fund and European Regional Development Fund, as well as by the Hungarian Academy of Sciences (TK2016-78). Project no. 135784 has also been implemented with the support provided from the National Research, Development and/Innovation Fund of Hungary, financed under the K\_20 funding scheme. An invaluable support was provided by Stipendium Hungaricum Scholarship Program (grant SHE-15651-001/2017 to ELL).

## **ACKNOWLEDGMENTS**

I would first like to thank my promoter, supervisor, mentor and 'academic mother' Prof. Dr. Róza Ádány, to whom I have looked up since my undergraduate studies and life mysteriously gave me the opportunity to work and learn with. Her door was always open whenever I ran into a trouble spot or had a question about my research or writing. She consistently allowed this project to be my own work, but steered me in the right the direction whenever she thought I needed it ... despite her countless encounters with my errors and typos!

Further, I had the good luck to work with a team and everyone else who were involved in the process of data collection, entry and organization of this research project: Gabika Koósné, Ferenc Vincze, Peter Piko, Zsigmond Kósa, János Sándor and the rest of the excellent team.

The gratitude for GINOP, Stipendium Hungaricum and Debrecen University could not go unwritten. Their trust invested in me, further supported my career and my professionality and character transcended. I am indebted for life. My very profound gratitude goes to Tea, for providing me with unfailing support and continuous encouragement throughout my studies and through the process of researching and writing this thesis.

Finally, I want to express my gratitude towards humanity and the numerous tireless scientists throughout all history on whose shoulders we all stand, including myself. There is a lot of goodness in this world, and more goodness every day, and this fantastic human-made fabric of excellence is genuinely responsible for the fact that I am here today.

They all are a worthy recipient of the gratitude I feel, and I want to celebrate that fact here and now, by being grateful to everyone equally and infinitely.



Registry number: Subject: DEENK/184/2021.PL PhD Publication List

Candidate: Erand Llanaj Doctoral School: Doctoral School of Health Sciences

# List of publications related to the dissertation

 Llanaj, E., Vincze, F., Kósa, Z., Bárdos, H., Diószegi, J., Sándor, J., Ádány, R.: Deteriorated Dietary Patterns with Regards to Health and Environmental Sustainability among Hungarian Roma Are Not Differentiated from Those of the General Population. *Nutrients. 13* (721), 1-15, 2021. DOI: http://dx.doi.org/10.3390/nu13030721 IF: 4.546 (2019)

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  DOI: http://dx.doi.org/10.1371/journal.pone.0197874
  IF: 2.776

Total IF of journals (all publications): 31,837 Total IF of journals (publications related to the dissertation): 9,092

The Candidate's publication data submitted to the iDEa Tudóstér have been validated by DEENK on the basis of the Journal Citation Report (Impact Factor) database.

08 April, 2021

