Urban and rural differences in frequency of fruit, vegetable, and soft drink consumption among 6–9-year-old children from 19 countries from the WHO European region

Heinen, Mirjam M.; Bel-Serrat, Silvia; Kelleher, Cecily C.; Buoncristiano, Marta; Spinelli, Angela; Nardone, Paola; Musić Milanović, Sanja; Rito, Ana Isabel; Bosi, A. Tülay Bağci; Gutiérrrez-González, Enrique; ...

Source / Izvornik: **Obesity Reviews, 2021, 22**

Journal article, Published version
Rad u časopisu, Objavljena verzija rada (izdavačev PDF)

https://doi.org/10.1111/obr.13207

Permanent link / Trajna poveznica: https://urn.nsk.hr/urn:nbn:hr:105:338780

Received: 29 December 2020 | Accepted: 30 December 2020

DOI: 10.1111/obr.13207

SUPPLEMENT ARTICLE

OBESITY Reviews WILEY

Urban and rural differences in frequency of fruit, vegetable, and soft drink consumption among 6–9-year-old children from 19 countries from the WHO European region

Mirjam M. Heinen[1] | Silvia Bel-Serrat[1] | Cecily C. Kelleher[2] | Marta Buoncristiano[3] | Angela Spinelli[4] | Paola Nardone[4] | Sanja Musić Milanović[5,6] | Ana Isabel Rito[7] | A. Tülay Bağci Bosi[8] | Enrique Gutiérrrez-González[9] | Iveta Pudule[10] | Shynar Abdrakhmanova[11,12] | Zulfiya Abdurrahmonova[13] | Lacramioara Aurelia Brinduse[14,15] | Alexandra Cucu[15,16] | Vesselka Duleva[17] | Anna Fijałkowska[18] | Andrea Gualtieri[19] | Tatjana Hejgaard[20] | Jolanda Hyska[21] | Enisa Kujundžić[22] | Ausra Petrauskiene[23] | Elena Sacchini[19] | Lela Shengelia[24] | Maya Tanrygulyyeva[25] | Zhamilya Usupova[26] | Ingunn Holden Bergh[27] | Daniel Weghuber[28] | Radka Taxová Braunerová[29] | Marie Kunešová[29] | Victoria Farrugia Sant'Angelo[30] | Eha Nurk[31] | Sergej M. Ostojic[32] | Igor Spiroski[33,34] | Ľubica Tichá[35] | Harry Rutter[36] | Julianne Williams[3] | Khadichamo Boymatova[37] | Ivo Rakovac[3] | Martin W. Weber[38] | João Breda[3]

[1]National Nutrition Surveillance Centre, School of Public Health, Physiotherapy and Sports Science, University College Dublin, Dublin, Ireland

[2]College of Health and Agricultural Sciences, University College Dublin, Dublin, Ireland

[3]World Health Organization (WHO) European Office for the Prevention and Control of Noncommunicable Diseases, Division of Country Health Programmes, WHO Regional Office for Europe, Moscow, Russian Federation

[4]National Centre for Disease Prevention and Health Promotion, Italian National Institute of Health (Istituto Superiore di Sanità), Rome, Italy

[5]Croatian Institute of Public Health, Zagreb, Croatia

[6]School of Medicine, University of Zagreb, Zagreb, Croatia

[7]WHO/Europe Collaborating Center for Nutrition and Childhood Obesity - Food and Nutrition Department, National Institute of Health Dr. Ricardo Jorge, Lisbon, Portugal

[8]Medical Faculty, Department of Public Health, Hacettepe University, Ankara, Turkey

[9]Spanish Agency for Food Safety and Nutrition, Ministry of Consumer Affairs, Madrid, Spain

[10]Department of Research and Health Statistics, Centre for Disease and Prevention Control, Riga, Latvia

[11]Department of Science and Professional Development, National Center of Public Health of the Ministry of Health of the Republic of Kazakhstan, Almaty, Kazakhstan

[12]Kazakhstan School of Public Health, Kazakhstan's Medical University, Almaty, Kazakhstan

[13]Republican Centre for Nutrition, Ministry of Health and Social Protection of Population, Duschanbe, Tajikistan

[14]Faculty of Medicine, Department of Public Health and Management, University of Medicine and Pharmacy Carol Davila Bucharest, Bucharest, Romania

[15]National Centre of Health Promotion and Health Evaluation, National Institute of Public Health, Bucharest, Romania

[16]Faculty of Midwifery and Nursing, Discipline of Public Health and Health Management, University of Medicine and Pharmacy Carol Davila Bucharest, Bucharest, Romania

[17]Department Food and Nutrition, National Centre of Public Health and Analyses, Sofia, Bulgaria

[18]Department of Cardiology, Institute of Mother and Child, Warsaw, Poland

Abbreviations: BMI, body mass index; CI, confidence interval; COSI, Childhood Obesity Surveillance Initiative; OR, odds ratio; SES, socioeconomic status; WHO, World Health Organization.

[19]Health Authority, Ministry of Health, San Marino, San Marino

[20]Health Promotion and Inequality, Danish Health Authority, Copenhagen, Denmark

[21]Nutrition and Food Safety Sector, Institute of Public Health, Tirana, Albania

[22]Center for Health Ecology, Institute of Public Health, Podgorica, Montenegro

[23]Department of Preventive Medicine, Lithuanian University of Health Sciences, Kaunas, Lithuania

[24]Maternal, Child and Reproductive Health, National Center for Disease Control and Public Health of Georgia, Tbilisi, Georgia

[25]Scientific Research Institute of Maternal and Child Health, Ashgabat, Turkmenistan

[26]Republican Center for Health Promotion and Mass Communication, Ministry of Health of the Kyrgyz Republic, Bishkek, Kyrgyzstan

[27]Department of Health and Inequality, Division of Mental and Physical Health, Norwegian Institute of Public Health, Oslo, Norway

[28]Department of Pediatrics, Paracelsus Medical University, Salzburg, Austria

[29]Obesity Management Centre, Institute of Endocrinology, Prague, Czech Republic

[30]Primary Child Health Unit, Primary Health Care, Floriana, Malta

[31]Department of Nutrition Research, National Institute for Health Development, Tallinn, Estonia

[32]Biomedical Sciences Department, Faculty of Sport and Physical Education, University of Novi Sad, Novi Sad, Serbia

[33]Institute of Public Health, Skopje, North Macedonia

[34]Faculty of Medicine, SS. Cyril and Methodius University, Skopje, North Macedonia

[35]Children's Hospital National Institute of Children's Diseases, Medical Faculty, Comenius University, Bratislava, Slovakia

[36]Department of Social and Policy Sciences, University of Bath, Bath, UK

[37]Division of Noncommunicable Diseases and Promoting Health Through the Life-Course, WHO Country Office for Tajikistan, Dushanbe, Tajikistan

[38]World Health Organization (WHO) Child and Adolescent Health and Development, WHO Regional Office for Europe, Copenhagen, Denmark

Correspondence
Dr Mirjam M. Heinen, National Nutrition Surveillance Centre, School of Public Health, Physiotherapy and Sports Science, University College Dublin, Woodview House, Belfield, Dublin 4, Ireland.
Email: mirjam.heinen@ucd.ie

Summary

In order to address the paucity of evidence on the association between childhood eating habits and urbanization, this cross-sectional study describes urban–rural differences in frequency of fruit, vegetable, and soft drink consumption in 123,100 children aged 6–9 years from 19 countries participating in the fourth round (2015–2017) of the WHO European Childhood Obesity Surveillance Initiative (COSI). Children's parents/caregivers completed food-frequency questionnaires. A multivariate multilevel logistic regression analysis was performed and revealed wide variability among countries and within macroregions for all indicators. The percentage of children attending rural schools ranged from 3% in Turkey to 70% in Turkmenistan. The prevalence of less healthy eating habits was high, with between 30–80% and 30–90% children not eating fruit or vegetables daily, respectively, and up to 45% consuming soft drinks on >3 days a week. For less than one third of the countries, children attending rural schools had higher odds (OR-range: 1.1–2.1) for not eating fruit or vegetables daily or consuming soft drinks >3 days a week compared to children attending urban schools. For the remainder of the countries no significant associations were observed. Both population-based interventions and policy strategies are necessary to improve access to healthy foods and increase healthy eating behaviors among children.

KEYWORDS
children, fruit, rural, soft drinks, urban, vegetables

1 | INTRODUCTION

Childhood obesity is a major public health challenge.[1] According to the latest round of the WHO European Childhood Obesity Surveillance Initiative (COSI) conducted in 2015–2017, 29% and 27% of 6–9-year-old boys and girls, respectively, had overweight or obesity.[2] These overall figures hide a great variability among countries. The prevalence ranged from 9% to 43% in boys and from 5% to 43%

in girls, respectively. Obesity is caused by multiple factors, with unhealthy diets—particularly high consumption of fat- and sugar-rich foods—and low levels of physical activity, the main drivers of the high global prevalence and rising trends in childhood overweight and obesity.[3] Dietary habits established during childhood and adolescence tend to persist into adulthood.[4,5] Therefore, acquiring healthy dietary habits at early ages is crucial to prevent the development of obesity and other chronic diseases during both childhood and at later ages. A healthy diet includes the consumption of high amounts of fruits, vegetables, legumes, whole grains, and nuts, together with limited consumption of total and saturated fat, and sugars.[6] Information on children's eating habits and how they are distributed across different populations is crucial to develop effective obesity prevention strategies. In recent decades, researchers have made huge efforts to study modifiable factors associated with excess bodyweight in young populations.

The association between socioeconomic status (SES) and diet quality is well documented in the literature. In high-income countries, both adults and children with higher SES tend to have healthier diets than those with lower SES.[7–10] Furthermore, studies show differences in obesity prevalence by urbanization levels among children younger than 5 years and adults.[11,12] Among children, those living in urban areas in low- and middle-income countries are taller and heavier compared to those living in rural areas.[12] Globally, the opposite was observed in adults, with BMI rising at the same rate or faster in rural areas compared to cities and a persistent higher BMI in rural areas in high-income countries.[11] Evidence available on the difference between eating habits in urban and rural areas in adolescents and school-aged children is scarce and inconsistent. Among adolescents, several studies showed no differences by urbanization for fruit,[13–15] vegetable,[13–16] or soft drink[15,16] consumption. Studies in Greenlandic or Polish adolescents observed that rural adolescents ate less fruit compared to urban adolescents.[16,17] On the other hand, rural Indonesian 10–18-year-old males consumed more fruits and vegetables compared with urban males and soft drinks were consumed less by both rural males and females compared to their urban peers.[18] For school-aged children, a narrative review on the diet in rural versus urban children in the United States only found few studies that investigated this topic.[19] Among these, two studies did not observe differences between rural and urban children[20,21] and two studies reported rural children eating fewer vegetables[22] and fruit and more dairy.[23] On the other hand, Australian preschool children from rural areas had healthier weight-related behaviors than their peers from urban areas.[9] Studies conducted in Europe have also reported inconclusive findings. While Colić-Barić et al.[24] have observed that energy and nutrient intakes were more adequate among urban than rural 12-year-old Croatian children, another study conducted in a sample of Croatian adolescents aged 12–17 years did not observe differences in total daily energy intake and other nutritional characteristics, except for fat intake.[25] In addition, those from rural areas consumed significantly less fast food and more fruits than those from urban areas.[25] Similarly, Lazarou and Kalavana[26] found that Cypriot children aged 9–13 years from rural areas consumed more traditional foods and were less likely to eat fast food. Finally, a study among Italian 8-year-olds did not observe any difference by urbanization level for fruit and vegetable consumption.[27] To the best of our knowledge, no previous studies have investigated rural versus urban differences in primary school-aged children's eating habits involving comparisons among countries. This study aims to investigate urban–rural differences in frequency of fresh fruit, vegetable, and soft drink consumption in a large sample of primary school-aged children aged 6 to 9 years from 19 European countries.

2 | METHODS

This study used data from the fourth round of COSI conducted in 2015–2017. The COSI study routinely estimates overweight and obesity prevalence of primary schoolchildren aged 6–9 years old.[28,29]

It allows countries to monitor the progress of the obesity epidemic in this population group and allows between-country comparisons within the WHO European Region to generate necessary knowledge to inform policy-makers to take action to reverse the trend.[30] In addition to the anthropometric examinations, data on simple indicators of energy balance-related behaviors—including dietary intake, physical activity, and screen time use—and of household sociodemographic information including parental education and urbanization level, are collected through an optional family record form.[28,29,31,32] This study focuses on data obtained in 19 of 23 countries that collected data on children's fresh fruit, vegetable, and soft drink consumption: Albania, Bulgaria, Croatia, Denmark, Georgia, Ireland, Italy, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Montenegro, Poland, Portugal, Romania, Spain, Tajikistan, Turkey, and Turkmenistan. Data from Malta, San Marino, and the Russian Federation (where the data collection took place only in Moscow) were not included because all children lived in areas with the same level of urbanization. Data from Czechia were excluded because it was not possible to determine the level of urbanization of the schools attended by children in the study. Children were included in this study if they (a) were 6–9 years old, (b) had information on at least one of the investigated dietary habits (i.e., consumption of fresh fruit, vegetables, and sugar-sweetened soft drinks), and (c) had data on the level of urbanization of the location of the schools attended by the children.

More details on data collection procedures can be found elsewhere.[28,29,31,32]

2.1 | Sampling of children

Two-stage cluster sampling was used in most of the countries with school as primary sampling unit and school class as the secondary sampling unit to draw nationally representative samples of children, with a few countries adopting a cluster design.[32] Bulgaria and Ireland followed a sentinel approach; the same schools measured in previous rounds were included and classes were randomly selected at each site. Lithuania followed a sentinel approach combined with the selection of new schools by region and by level of urbanization. Further details about the sampling characteristics have been described

elsewhere.[29,31–33]. All children registered in the sampled classes were invited to take part in the study and those who had parental consent received the family record form. Paper and online versions of the family record form were available for completion. Each country selected the approach that was most convenient for them.

2.2 | Measurements

2.2.1 | Urbanization level of children's residence place and of the place where the school was located

The categorization of the "urbanization level" of the child's place of residence was collected through the child's record form: the examiner, together with school staff (school principal, teacher, or administrative staff), registered this information as "urban," "semiurban," or "ural." The definition of these three categories was established at country level (see Table 1).

Seven countries collected the urbanization level of the place where the school was located as a proxy of the urbanization level of children's place of residence. In order to increase the comparability among countries, the urbanization level of the place where the school was located was used in the statistical analysis instead of the urbanization level of the children's residence place. For the purposes of this study, a school was defined as "rural" if at least 55% of the children from that school were residents of rural areas. Similarly, if at least 55% of children lived in "urban" or "semiurban" areas the school was defined as an "urban" school. These percentages were calculated including all children with a completed child's record form, regardless of whether the information about the urbanization level of child's place of residence was available or not. Those schools that did not meet any of the two abovementioned definitions—because of a high level of missing data or because the children were equally distributed between rural and urban areas—were excluded from the analysis. In most of the schools, the percentage of children living in areas with the same urbanization level was much greater than the threshold of 55% (between 80% and 100%), so the number of children resident in places with an urbanization level different from that of the school location was limited (Table 1). The percentage of "misclassified" children—children who were living in rural areas but attending schools in urban areas or vice-versa—is below 5% in all countries except Denmark (9.5%) and Lithuania (6.4%), suggesting that children in the age groups targeted by COSI mainly attended schools near their home. For the purposes of this study, "urban" and "semiurban" categories were combined.

2.2.2 | Eating habits

Frequency of fresh fruit, vegetable (excluding potatoes), and soft drink consumption during a normal week were reported by parents through food frequency questions included in the family record form. These food groups were selected based on the WHO recommendations for a healthy diet, to eat a plentiful amount of fruits and vegetables and to limit sugar-sweetened beverages.[34] Responses included four categories for frequency of consumption: "never or more than once a week," "some days (1–3 days)," "most days (4–6 days)," "every day" (Table S1 in the supporting information). The answers were dichotomized as "healthy" and "less healthy." The "less healthy" behaviors were as follows: not eating fresh fruit every day, not eating vegetables every day, and consuming sugar-containing soft drinks more than 3 days per week.[33]

2.2.3 | Parental educational attainment

The socioeconomic status of families was included as a confounder in the regression models and was assessed through the parents' educational attainment which was categorized as follows: (1) low parental education level (both parents with lower education); (2) medium parental education level (one parent with lower education, one parent with higher education); (3) high parental education level (both parents with higher education). Lower education level was defined by grouping together the following answer options: "primary school or less," "secondary or high school" and "vocational school." Higher education level includes "undergraduate or bachelor's degree" and "master's degree or higher". The COSI family form asked about the education of the respondent's caregiver and his/her partner/spouse. If the caregiver filling in the form was not the parent, they were excluded from the current analysis. In Bulgaria, Italy, Spain, and Turkey, education level of the parents was gathered irrespective of who completed the form. Finally, only children with available information on education level of both parents were included in the analysis.

2.3 | Statistical analysis

For each country, we estimated the distribution of children by sex, age, and urbanization level of the school location. The country-specific percentages of having a "less healthy" behavior were estimated for fresh fruit, vegetable, and soft drink consumption by the urbanization level of the school location. To take into account the clustering sampling design in the analysis, a design-adjusted version of the Pearson's $\chi 2$ test, the Rao-Scott method, was used to determine the statistical significance of differences in the percentages among children that attended urban or rural schools.

For each dietary behavior, we estimated a country-specific multivariate multilevel logistic regression model to examine the association between having a "less healthy" behaviour (compared to not having it) and the level of urbanization of the school location. The odds ratio (OR) for attending a rural school versus an urban school was estimated, along with its 95% confidence interval (CI), by adjusting for children's sex and age, parental education, and the region/administrative division where the child lived. Further adjustment for weight status (overweight/obesity) and family perceived wealth did not change the models, hence it was decided not to include these in the final models.

TABLE 1 Definitions of urban, semiurban, and rural areas as defined by each country and percentage of children misclassified for urbanization level of the school location. COSI/WHO Europe round 4 (2015–17)

Country	Definition of "urban," "semiurban," and "rural" areas	Unit to which the urbanization level refers	Misclassified children[a] (%)
ALB	Based on administrative division which takes into account population density and infrastructure level.	Child's place of residence	0.0
BUL	*Based on the law on administrative-territorial structure of the Republic of Bulgaria and the unified classifier of administrative-territorial and territorial units* **Urban areas**: Areas with 3500 or above inhabitants **Semi-urban areas**: Not applied **Rural areas**: Areas with less than 3,500 inhabitants	Child's place of residence	3.1
CRO	*Based on the Croatian Bureau of Statistics. Census of Population, Households and Dwellings in 2011. The model for the differentiation of urban, rural and semi-urban settlements in the Republic of Croatia. Available from:* https://www.dzs.hr/hrv/publication/metodologije/metod_67.pdf The following variables were used to define urban, rural and semi-urban settlements: 1. Administrative status of settlement (settlement as the seat of administrative town) 2. Settlement size (expressed in the number of inhabitants) 3. Socio-economic structure of population and employment function of settlement (expressed as the percentage of employed population working in their place of residence, in the secondary and tertiary sector) 4. Morphological-physiognomical characteristics of settlement (expressed in the percentage of non-agricultural households)	School location	0.0
DEN	**Urban areas**: City or large city with >10,000 inhabitants **Semi-urban areas**: Smaller city with ≥1,000 inhabitants or suburban city with ≤10,000 inhabitants **Rural areas**: Village or countryside area with <1,000 inhabitants	Child's place of residence	9.5
GEO	**Urban areas:** A "City" is defined as a territory where industrial capitals of the country, manufactured goods, socio-cultural centres are situated. The number of citizens might be >5,000. A geographical place with a population <5,000 population might be defined as a "City" if it is the Centre of the region. In cities, there is no infrastructure that is related to agriculture. **Rural areas:** A "village" is a place where <2,000 people live, who are mostly involved in agriculture. A "small town" is a place where a comparably small size of manufactured goods and socio-cultural centres are situated.	School location	1.3
IRE	**Urban area** is defined as having population clusters of 1,500 or more inhabitants **Rural area** refers to areas outside clusters of less than 1,500 inhabitants	School location	0.0
ITA	*The following levels of urbanization were used: i) less than 10,000 inhabitants, ii) from 10,001 to 100,000 inhabitants, iii) from 100,001 to 500,000 inhabitants and iv) more than 500,000 inhabitants. For the purpose of the paper, these categories were grouped as follows:* **Urban areas**: Settlements with at least 10,000 inhabitants **Semi-urban areas**: Not applied **Rural areas**: Areas or settlements with less than 10,000 inhabitants	School location	0.0

(Continues)

TABLE 1 (Continued)

Country	Definition of "urban," "semiurban," and "rural" areas	Unit to which the urbanization level refers	Misclassified children[a] (%)
KAZ	*Based on the administrative and territorial structure of the Republic of Kazakhstan* **Urban areas**: Cities **Semi-urban areas**: Settlements with at least 2,000 inhabitants **Rural areas**: Settlements with less than 2,000 inhabitants	Child's place of residence	0.1
KGZ	Based on the administrative and territorial structure under the law of the Kyrgyz Republic: **Urban areas:** a city/urban unit is an administrative-territorial unit in the form of city of republican, regional and district significance as well as an urban-type settlement in which the local community exercises local self-government in the manner outlined in the constitution and Laws of the Kyrgyz Republic. **Rural areas:** Village/rural unit is a settlement that has reached a certain level of provision of amenities with a population of at least 50 people of which those employed in agricultural production and their family members make up at least half of the population.	Child's place of residence	1.4
LTU	*According to Lithuania's 'law of administrative units of the territory and their boundaries (1994, 2010, 2014, 2019)' residential areas of the Republic of Lithuania are divided into urban and rural residential areas. Urban settlements include cities, rural settlements include smaller towns, villages and detached homesteads.* **Urban areas:** Lithuania's bigger cities (with 91,000 or more inhabitants); Vilnius (capital), Kaunas, Klaipėda, Šiauliai, Panevėžys. **Semi-urban areas:** Towns and campuses with a population of 3,000–91,000 or from 500 to 3,000 inhabitants, but historically considered as towns. **Rural areas:** Including villages and homesteads. Villages are residential areas that do not have the features of a city, town, or detached homesteads. Homesteads are historically-formed residential areas, usually composed of or originating from a single homestead and having no more than 20 objects at different addresses.	Child's place of residence	6.4
LVA	*According to the administrative division of territories in the country, the following levels of urbanization were used: i) Riga – Capital city; ii) other cities; iii) towns and iv) rural areas. For the purpose of the paper, these categories were grouped as follows:* **Urban areas**: Capital city, other cities and towns **Semi-urban areas**: Not applied **Rural areas**: Rural areas	Child's place of residence	2.1
MNE	Based on population size and density definition	School location	2.7
POL	**Urban areas**: Big town (over 100,000 inhabitants) **Semi-urban areas**: Small town (up to 100,000 inhabitants) **Rural areas**: Rural areas or village	Child's place of residence	4.2
POR	*Based on categorization used by the National Statistics Institute* **Urban areas**: Areas with a population density greater than 500 inhabitants/km2 or that integrates localities with more than 5,000 inhabitants. **Semi-urban areas**: Areas with population density greater than 100 inhabitants/km2 or that integrate localities with population between 2000 and 5,000 residents. **Rural areas**: Remaining areas	Child's place of residence	3.4

TABLE 1 (Continued)

Country	Definition of "urban," "semiurban," and "rural" areas	Unit to which the urbanization level refers	Misclassified children[a] (%)
ROM	**Urban areas**: Cities with at least 10,000 inhabitants **Semi-urban areas**: Not applied **Rural areas**: Areas or settlements with less than 10,000 inhabitants	Child's place of residence	2.0
SPA	*The following levels of urbanization were used: (i) less than 10,000 inhabitants, (ii) from 10,001 to 100,000 inhabitants, (iii) from 100,001 to 500,000 inhabitants and iv) more than 500,000 inhabitants. For the purpose of the paper, these categories were grouped as follows:* **Urban areas**: Settlements with at least 10,000 inhabitants **Semi-urban areas**: Not applied **Rural areas**: Areas or settlements with less than 10,000 inhabitants	School location	0.0
TJK	*Based on the administrative division of the territories in the country.* **Urban areas**: Cities and regional centers **Semi-urban areas**: Not applied **Rural areas**: Villages or rural areas	Child's place of residence	0.8
TKM	Based on the administrative division of the territories in the country	Child's place of residence	1.0
TUR	Based on administrative considerations	School location	0.8

[a]Percentage (%) of children living in areas with an urbanization level which was different from the one where the school was located.

As the urbanization variable is a school-level variable and not a child-level variable, school was included as a random effect in all regression models. Due to the limited number of observations, regression analyses were not carried out for Ireland regarding soft drinks.

Differences in especially fruit and vegetable intake by season might influence the results. Especially in low- and middle-income countries that have a close connection to regional agricultural harvest, food consumption at any given time may be determined in part by the season of the year and food availability. Indeed, a systematic literature review showed some differences in fruit and vegetable intake by season among adults.[35] Therefore, we investigated whether there was a seasonality effect within countries. There appeared to be none, most probably because almost all countries collected their data within a few months and not across seasons. Hence, data collection period was not included in the final models.

We applied sampling weights for all countries to adjust for the sampling design, oversampling and children's nonresponse, except for Lithuania where the analysis was unweighted. A p-value of 0.05 was used to define statistical significance. All statistical analyses were performed in the statistical software package Stata version 15.1 (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC).

Results are presented in the tables by grouping countries in five macroregions according to United Nations Standard Country or Area Codes for Statistical Use.[36] Northern Europe (Denmark, Ireland, Latvia, and Lithuania); Eastern Europe (Bulgaria, Poland, and Romania); Southern Europe (Albania, Croatia, Italy, Montenegro, Portugal, and Spain); Central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, and Turkmenistan) and Western Asia (Georgia and Turkey).

3 | RESULTS

A total of 123,100 children from 19 countries were included in the analysis. The number of children participating per country varied widely, from 873 children in Ireland to 43,484 children in Italy (Table 2).

The mean age of the children was 7 or 8 years of age and approximately 50% were boys (Table 3). The percentage of children attending schools located in rural areas ranged from 3% in Turkey to 70% in Turkmenistan (Table 3).

In most of the countries, the proportion of children attending schools located in rural areas was less than a quarter, except for the countries in the Central Asia macroregion where more than 50% of children attended schools in rural areas.

3.1 | Differences in prevalence of less healthy eating habits between children attending schools located in rural versus urban areas

3.1.1 | Fresh fruit

The percentages of children not eating fresh fruit daily varied widely among countries; from 29% in Italy to 85% in Kyrgyzstan for rural

TABLE 2 Number of children and schools included in the analysis by country. COSI/WHO Europe round 4 (2015–17)

	Children aged 6–9 years whose parents or caregivers filled in the family form	Children included in the analysis[a]		Schools with children aged 6–9 whose parents or caregivers filled in the family form	Schools included in the analysis[b]
		Total	With data on children's sex, age, region of residence and parental education		
Northern Europe					
DEN	957	929	837	89	86
IRE	874	873	791	107	107
LTU	3,812	3,194	2,825	100	87
LVA	5,707	5,698	4,992	96	96
Eastern Europe					
BUL	3,400	3,347	3,142	199	196
POL	2,945	2,915	2,596	133	132
ROM	6,610	6,533	5,503	198	198
Southern Europe					
ALB	2,527	2,281	2,131	45	45
CRO	2,651	2,631	2,482	162	162
ITA	43,696	43,484	39,946	2,373	2,373
MNE	2,736	2,711	2,562	97	97
POR	6,391	6,147	5,173	230	224
SPA	10,453	10,452	9,407	164	164
Central Asia					
KAZ	4,311	4,130	3,340	141	141
KGZ	7,567	7,412	5,599	150	148
TJK	3,270	3,261	2,836	153	153
TKM	3,891	3,864	3,507	159	159
Western Asia					
GEO	3,246	3,193	2,820	242	242
TUR	10,502	10,045	9,720	578	576
Total	125,546	123,100	110,209	5,416	5,386

Abbreviations: Albania (ALB); Bulgaria (BUL); Croatia (CRO); Denmark (DEN); Georgia (GEO); Ireland (IRE); Italy (ITA); Kazakhstan (KAZ); Kyrgyzstan (KGZ); Latvia (LVA); Lithuania (LTU); Montenegro (MNE); Poland (POL); Portugal (POR); Romania (ROM); Spain (SPA); Tajikistan (TJK); Turkmenistan (TKM) and Turkey (TUR).

[a]All children aged between 6 and 9 years old, with available information on the frequency of consumption of either fresh fruit, vegetables, or soft drinks and on the urbanization level of the school location.

[b]Schools attended by children included in the analysis.

areas and from 27% in Italy to 82% in Lithuania for urban areas (Table 4).

This same wide variation was seen within the macroregions. For the majority of countries, the percentage of children not eating fresh fruit daily did not differ between rural versus urban areas. No differences were found for any of the countries in the Northern European region. For the other regions, some statistically significant differences were found. Bulgaria in the Eastern European region showed a statistically significantly higher percentage of children not eating fruit daily in rural versus urban areas. The same was observed for Albania, Italy, and Montenegro in Southern Europe, Kazakhstan, and Kyrgyzstan in Central Asia, and Turkey in Western Asia, all observing statistically significant higher percentages of not eating fruit daily in rural areas versus urban areas.

3.1.2 | Vegetables

The percentages of children not eating vegetables daily again varied widely among countries and was higher than for not eating fresh fruit daily for all countries except Kyrgyzstan and Tajikistan from the Central Asian region. The percentages varied from 33% and 31% in Turkmenistan for rural and urban areas, respectively to 92% and 91% in Spain (Table 4). This same variation was seen within the macroregions. For two thirds of the countries, the percentage of children not eating vegetables daily did not differ between rural versus urban areas. No differences were found for any of the countries in the Northern European and Central Asian region. For the other regions, some statistically significant differences were found. Bulgaria and Poland in the Eastern European region both

TABLE 3 Percentage of boys, mean, and standard deviation of children's age in years and percentage of children attending schools located in rural areas by country. COSI/WHO Europe round 4 (2015–17)

	Boys (%)	Children's age in years *Mean (Standard deviation)*	Children attending schools in rural areas (%)
Northern Europe			
DEN	53.0	7.2 (0.3)	14.7
IRE	52.7	7.1 (0.4)	22.6
LTU	51.1	7.8 (0.3)	14.0
LVA	48.3	8.3 (1.0)	14.0
Eastern Europe			
BUL	51.5	7.6 (0.2)	21.4
POL	50.1	8.4 (0.2)	22.9
ROM	49.2	8.5 (0.6)	44.0
Southern Europe			
ALB	52.4	8.5 (0.7)	20.1
CRO	50.9	8.5 (0.3)	11.4
ITA	51.5	8.8 (0.3)	27.5
MNE	52.6	7.4 (0.6)	20.1
POR	50.9	7.5 (0.6)	11.3
SPA	50.9	8.0 (1.1)	19.5
Central Asia			
KAZ	50.5	9.0 (0.5)	52.5
KGZ	50.8	7.9 (0.7)	65.1
TJK	51.7	7.4 (0.3)	69.9
TKM	49.9	7.7 (0.3)	56.6
Western Asia			
GEO	51.2	7.6 (0.4)	30.4
TUR	50.8	7.5 (0.4)	2.5

Note. For an explanation of the country abbreviations, see Table 2.

showed a statistically significant higher percentage of children not eating vegetables daily in rural versus urban areas. The same was observed for Montenegro and Portugal in Southern Europe, and Turkey in Western Asia, all observing statistically significant higher percentages of not eating vegetables daily in rural areas versus urban areas.

3.1.3 | Soft drinks

The percentages of children consuming soft drinks more than 3 days a week varied from under 2% in Ireland for rural and urban areas to 44% in Croatia and Tajikistan for rural areas and 45% in Tajikistan and Turkmenistan for urban areas (Table 4). As for fruit and vegetables, this same variation between countries was seen within the macro-regions. For about half of the countries, the percentage of children consuming soft drinks more than 3 days a week did not differ between rural versus urban areas. No differences were found for any of the countries in the Central Asian region. For the other regions, some statistically significant differences were found, with all but one showing a higher percentage of children consuming soft drinks more than 3 days a week in rural areas versus urban areas: Denmark in Northern Europe, all countries in Eastern Europe (Bulgaria, Poland, and Romania), Albania, and Croatia in Southern Europe, and Georgia in Western Asia. Only Portugal in Southern Europe showed a slightly lower but statistically significant percentage of children consuming soft drinks more than 3 days a week for rural vs urban areas (11% vs 15%, respectively; $p < 0.05$).

3.1.4 | Multivariate multilevel regression models on eating habits by level of urbanization

Figure 1 shows the results of the multivariate multilevel regression model investigating the association between having a less healthy eating habit (compared to not having it) related to the level of urbanization of the school location; random effects for schools were included in this analysis.

TABLE 4 Country-specific prevalence (%) of children with a "less healthy" behavior related to fresh fruit, vegetable, and soft drink consumption by the urbanization level of the school location (rural or urban). COSI/WHO Europe round 4 (2015–17)

	Not eating fresh fruit every day (%)			Not eating vegetables every day (%)			Consuming soft drinks more than 3 days a week (%)		
	Rural areas	*Urban areas*	*Total*	*Rural areas*	*Urban areas*	*Total*	*Rural areas*	*Urban areas*	*Total*
Northern Europe									
DEN[a]	40.1	39.9	39.9	56.6	46.2	47.7	14.7	6.7	7.9
IRE	45.8	36.9	38.9	50.5	54.9	53.9	0.8	1.6	1.4
LTU	82.9	82.4	82.5	86.2	86.5	86.5	12.0	9.0	9.4
LVA	79.0	76.5	76.9	82.8	82.1	82.2	13.8	11.8	12.0
Eastern Europe									
BUL[b,c,d]	73.1	62.3	64.6	82.2	70.1	72.7	30.8	14.1	17.7
POL[a,e]	66.7	62.5	63.5	83.2	75.0	76.9	34.1	28.0	29.4
ROM[d]	60.0	56.3	57.9	71.4	74.3	73.1	21.5	8.1	13.9
Southern Europe									
ALB[a,b]	52.1	39.1	41.6	72.3	73.4	73.2	19.2	13.3	14.5
CRO[d]	70.7	65.7	66.2	84.7	83.0	83.2	44.1	27.5	29.4
ITA[f]	28.7	27.0	27.4	45.6	46.3	46.1	n.a.	n.a.	n.a.
MNE[e,f]	59.8	52.9	54.3	75.7	69.0	70.3	37.1	31.2	32.4
POR[a,e]	38.2	36.8	36.9	67.0	61.5	62.1	11.4	15.3	14.9
SPA	73.3	70.5	71.1	91.6	90.8	90.9	3.0	3.8	3.7
Central Asia									
KAZ[f]	72.5	60.5	66.7	70.0	69.5	69.8	23.5	21.5	22.5
KGZ[b]	84.9	76.8	82.1	68.5	70.2	69.1	29.3	26.0	28.2
TJK	68.2	62.4	66.5	56.3	58.2	56.9	44.1	44.8	44.3
TKM	31.3	28.1	29.9	32.6	30.9	31.9	40.9	44.9	42.6
Western Asia									
GEO[d]	74.9	76.9	76.3	84.2	86.2	85.6	31.6	21.9	24.9
TUR[e,f]	57.2	49.0	49.2	81.5	88.3	88.1	22.2	17.6	17.7

For an explanation of the country abbreviations, see Table 2.
Abbreviation: n.a., not available.
[a]Statistically significant difference of percentages between children attending schools in urban areas and those attending schools in rural areas for consuming soft drinks more than 3 days a week—Pearson's chi-square corrected using Rao-Scott method, $p < 0.05$.
[b]Statistically significant difference of percentages between children attending schools in urban areas and those attending schools in rural areas for not eating fresh fruit every day—Pearson's chi-square corrected using Rao-Scott method, $p < 0.001$.
[c]Statistically significant difference of percentages between children attending schools in urban areas and those attending schools in rural areas for not eating vegetables every day—Pearson's chi-square corrected using Rao-Scott method, $p < 0.0001$.
[d]Statistically significant difference of percentages between children attending schools in urban areas and those attending schools in rural areas for consuming soft drinks more than 3 days a week—Pearson's chi-square corrected using Rao-Scott method, $p < 0.0001$.
[e]Statistically significant difference of percentages between children attending schools in urban areas and those attending schools in rural areas for not eating vegetables every day—Pearson's chi-square corrected using Rao-Scott method, $p < 0.001$.
[f]Statistically significant difference of percentages between children attending schools in urban areas and those attending schools in rural areas for not eating fresh fruit every day—Pearson's chi-square corrected using Rao-Scott method, $p < 0.05$.

Overall, results of the regression analysis were comparable to analysis on the differences in percentages. For fresh fruit, no significant associations were observed for included countries of Northern Europe, Central Asia, and Western Asia. Only for Bulgaria in Eastern Europe, and Albania in Southern Europe, children attending schools located in rural areas had statistically significantly higher odds (OR ≥ 1.4) for not eating fruit daily compared to children attending schools in urban areas. Statistically significant higher but small odds were observed for Italy (OR < 1.1). For vegetables, no significant associations were observed for Northern Europe and Central Asia. For the rest, results were slightly mixed, with children in rural areas being more likely to not eat vegetables daily compared to urban children in Bulgaria and Poland in Eastern Europe and Italy in Southern Europe, but statistically significantly less likely in Romania in Eastern Europe and Turkey in Western Asia. For the remainder of the countries in these regions, no significant associations were observed. For soft drinks, no associations were observed for Western Asian countries and for most other countries from the other macroregions. For

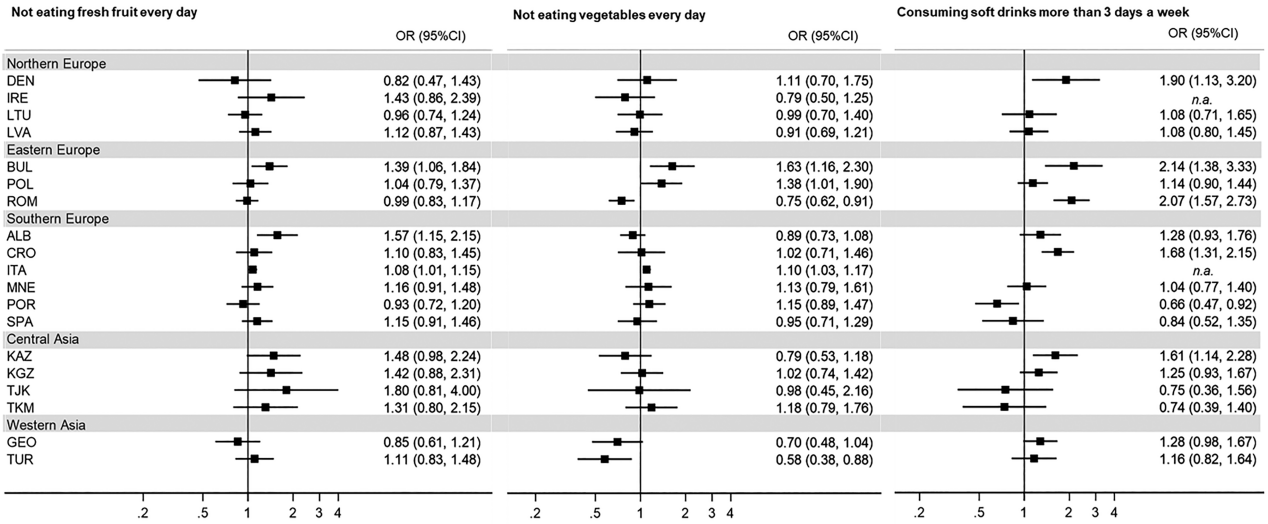

FIGURE 1 Country-specific adjusted odds ratios of having a "less healthy" eating habit (compared to not having) related to the urbanization level of the school location (rural *vs*. urban areas)[a]. COSI/WHO Europe round 4 (2015–17).
For an explanation of the country abbreviations, see Table 2.
Abbreviation: CI, confidence interval; n.a., not available; OR, odds ratio. [a]Adjusted ORs and 95% CI were estimated through a multilevel logistic regression analysis with random effects for schools. The adjustment was carried out for children, sex, age, region of residence and parental education.

Denmark in Northern Europe, Bulgaria and Romania in Eastern Europe, Croatia in Southern Europe, and Kazakhstan in Central Asia, statistically significantly higher odds were observed for children attending rural schools consuming soft drinks more than 3 days a week compared to children attending urban schools (OR > 1.6). Statistically significant lower odds were only observed for Portugal.

4 | DISCUSSION

This paper investigated whether there were urban and rural differences in some selected indicators of eating habits in a large sample of 123,100 children living in 19 European countries that participated in the fourth round of COSI data collection between 2015 and 2017. Overall, for the majority of countries included in the current analysis no difference was observed in fresh fruit, vegetable or soft drink consumption between children attending rural or urban schools. Where differences were observed between rural and urban, the odds were only slightly elevated or decreased. Only for Bulgaria in Eastern Europe and Albania and Italy in Southern Europe, children attending schools located in rural areas were more likely to not eat fruit daily compared to children attending schools in urban areas. For vegetable consumption, results were slightly mixed with two countries in Eastern Europe (Bulgaria and Poland) and one in Southern Europe (Italy) showing that children attending schools in rural areas were more likely to not eat vegetables daily, whereas the other country from Eastern Europe included in this analysis (Romania) and Turkey in Western Asia observed that children in rural schools were less likely to not eat vegetables daily. For soft drinks, again, just a few studies have observed higher odds for children attending rural schools consuming more soft drinks compared to children attending urban schools. These were Denmark in Northern Europe, Bulgaria and Romania in Eastern Europe, Croatia in Southern Europe, and Kazakhstan in Central Asia. Whereas children in Portuguese rural schools were less likely to consume soft drinks on more than 3 days a week. Overall, between 30% and 80% of primary school-aged children did not consume fresh fruit daily, 30% to 90% did not eat vegetables daily, and up to 45% consumed soft drinks more than 3 days a week.

There are few studies conducted in the WHO European region on children that have investigated urban and rural differences in eating habits among primary school-aged children[24–27] and half of these did not observe any differences by urbanization level for fruit, vegetable, or soft drink consumption.[26,27] For fruit intake, results from the literature are mixed. One U.S. study observed a lower percentage among adolescents living in rural areas consuming the recommended amount of fruit compared to those living in urban areas,[22] but this difference was not observed in primary school-aged children. In contrast, a Croatian study among children and adolescents has observed a higher percentage of energy contribution from fruit intake in participants living in rural area versus urban areas.[25] Among Australian preschoolers, 5-year-olds living in rural areas were more likely to meet the fruit recommendation than urban children.[9] Finally, five other studies did not observe a difference for fruit intake by urbanization level.[20,21,24,26,27] For vegetable intake, most studies have observed no difference by urbanization level.[9,21,22,25–27] Only one study, among Croatian children and adolescents, observed that a higher percentage of daily energy came from vegetables for students living in rural areas versus students living in urban areas.[24] For soft drinks, again most studies showed no difference by urbanization

level.[20–22,26] Only one Croatian study has observed children and adolescents living in urban areas significantly consuming a higher amount of soft drinks compared to students living in rural areas.[24] This was in contrast with the findings of the current study that showed Croatian children attending a school in rural areas having higher odds of consuming soft drinks more frequently than children at urban schools. As all studies— but one[20]—did either not include or poorly adjusted for confounders in their analysis, comparing our results with these studies is difficult. As most available data comes from the United States, more studies should be conducted on differences in eating patterns by urbanization in European children, including qualitative studies to explore the "why."

Globalization has led to urbanization as well as drastic changes to the food system (i.e., all processes and infrastructure involved in feeding a population, from farm to fork).[37] One of the consequences of this has been the "nutrition transition," whereby traditional diets shift to diets high in highly-processed food products and foods high in saturated or trans fats, refined sugars, and salt, low in fiber, and less nutrient-dense.[37] This transition happened at first in industrialized nations, but is currently occurring at an accelerated pace in low- and middle-income countries.[38] Furthermore, within countries these changes have affected urban areas first, but increasingly rural areas are also affected.[39] So, even though people in rural areas might be more likely to grow their own food (e.g., vegetables) and have fewer fast food outlets available, studies show that residents of rural communities have less access to healthy food due to limited infrastructure, types of outlets, long distances to food outlets, and fewer healthy options.[40–42] Powell et al.[43] have observed that in the United States all food store types and, in particular, chain supermarkets are significantly less available in rural areas. This was confirmed in another U.S. study that showed that most stores in a rural county were convenience stores with more unhealthy foods, and healthful foods being more expensive than the less healthful version.[44] A review on food access across small food stores found that small food stores in rural areas lacked healthy food options largely because store owners perceived that their customers would not purchase healthier items.[45] So, it seems that rural and urban populations might have different challenges to access healthier foods, and hence, different strategies will be needed to address these.[41]

This study has some limitations. The food frequency questionnaire we used was designed as an easily applicable monitoring tool to obtain an overall indication of a child's usual consumption frequencies of a food group; but it has not been validated. The cross-sectional design of this study does not allow us to make any causal inferences. We excluded children from the analysis for whom we had no parental education level information or only one of the parents because we were unable to distinguish between children living in single-parent households and those with missing information for one of the parents' education level. Hence, we might have underestimated the associations observed in the current analysis since children excluded may be more likely to come from more vulnerable families. The reliance on parental reports of children's diet behaviors may have limited accuracy and such reports are subject to measurement error, recall bias, selection bias, and social desirability bias.[46] This may have led to some degree of differential misreporting. Furthermore, for the current analysis, each country defined urban, semiurban and rural areas using their own national definition. In our study most countries used measures of population size and/or density (n = 10), administrative decisions (n = 4) or a combination of these (n = 4) for their national definition. There is currently no internationally accepted definition of rurality,[47] and although using an internationally accepted definition might be more transparent and make intercountry comparisons easier, using national definitions could be an advantage as these are more relevant to a country and its infrastructure, service provision, and food system. The current study also has no data on the level of service provided in rural areas of the countries included in the current analysis, which could have slightly confounded the results. Finally, we used the urbanization level of the school location instead of the children's place of residence as the latter information was not available for all included countries. However, of the 10 studies that had information of the child's place of residence, misclassification (children living in rural areas but attending schools in urban areas or vice versa) was less than 5% for eight countries and less than 10% for the other two countries; hence, it is unlikely that our results were affected by using the school location. This is because most primary schools tend to enroll children to their schools within a certain catchment area or distance to the school and, hence, most children tend to live close to their school. The main strengths of this study include the very large sample size of more than 123,000 children from diverse geographical areas of the WHO European Region, using country-based sampling strategies designed to yield nationally representative samples and a common protocol for collecting data which allows intercountry comparisons. Furthermore, our study has information about relevant confounders that were included in the multivariate analysis. This is in contrast with all previous studies on the same topic, which, with one exception,[20] were unadjusted or poorly adjusted.[9,21,22,24–27] Future studies should include relevant confounders when looking into differences in eating habits by urbanization level, including intake of macronutrients, such as saturated or trans-fats, and place of eating.

5 | CONCLUSION

This large study has showed that children's frequency of fruits, vegetables, and soft drinks consumption did not differ between children attending schools located in rural areas versus urban areas across Europe and Central Asia. In both urban and rural areas, the studied eating behaviors were not optimal and need improvement. Both population-based interventions and targeted policy strategies are necessary to improve access to healthy foods and increase healthy eating behaviors among children, and different strategies may be needed for urban and rural areas depending on the national context.

ACKNOWLEDGMENTS

We gratefully acknowledge all participating, children, their parents, and the schoolteachers and principals for kindly volunteering to participate in the study. We also thank the examiners and regional and local supervisors/coordinators who collected the data in each country. We also gratefully acknowledge support from Liza Villas and Gerben Rienk for making the WHO European Childhood Obesity Surveillance Initiative (COSI) project possible. Additionally, we acknowledge the leadership of the principal investigators from Kyrgyzstan (Gulmira Aitmurzaeva), Romania (Constanta Huidimac Petrescu), Norway (Else Karin Grøholt), Spain (Mª*Ángeles Dal Re*), and Turkey (Nazan Yardim).

AUTHOR CONTRIBUTIONS

Conceptualization: J. B., M. B., C. C. K., S. B.-S., and M. H.; *Formal analysis*: M. B.; *data curation*: M. B., M. H., S. B.-S., and C. C. K.; *Writing-original draft preparation*: M. H., S. B.-S., and C. C. K.; *writing-review and editing*: M. H., S. B.-S., C. C. K., J. B., I. R., A. S., P. N., T. H., M. K., R. T. B., S. M. M., A. F., A. G., E. S., V. F. S., I. P., V. D., Z. U., L. S., J. H., M. T., A. P., E. K., A. C., L. A. B., A. I. R., I. S., S. M. O., A. T. B. B., I. H. B., E. N., D. W., S. A., H. R., K. B., L. T., E. G.-G., J. W., M. W., M. B., and J. B.; *Supervision*: J. B., J. H., C. K., S. A., A. G., A. I. R., A. S., T. H., S. M. M., A. F., I. P., V. D., L. S., M. T., A. P., Z. A., and E. K. All authors have read and agreed to the published version of the manuscript.

ETHICS STATEMENT

The COSI study follows the International Ethical Guidelines for Biomedical Research Involving Human Subjects. Local ethics approval was also granted.

CONFLICT OF INTERESTS

The authors declare no conflict of interest. The funders played no role in the design of the COSI protocol, the decision to write this paper, or its content.

DISCLAIMER

J. B., I. R., J. W., and M. W. are staff members of WHO and MB is a consultant with WHO. The authors alone are responsible for the views expressed in this article and they do not necessarily represent the views, decisions, or policies of the institutions with which they are affiliated.

FUNDING SOURCES

The authors gratefully acknowledge support from a grant from the Russian Government in the context of the WHO European Office for the Prevention and Control of NCDs.

Data collection in the countries was made possible through funding from Albania: WHO through the Joint Programme on Children, Food Security and Nutrition "Reducing Malnutrition in Children," funded by the Millennium Development Goals Achievement Fund, and the Institute of Public Health; Austria: Federal Ministry of Social Affairs, Health, Care and Consumer Protection, Republic of Austria; Bulgaria: Ministry of Health, National Center of Public Health and Analyses, WHO Regional Office for Europe; Croatia: Ministry of Health, Croatian Institute of Public Health and WHO Regional Office for Europe; Ministry of Health of the Czech Republic, grant nr. AZV MZČR 17-31670 A and MZČR–RVO EÚ 00023761; Denmark: Danish Ministry of Health; Estonia: Ministry of Social Affairs, Ministry of Education and Research (IUT 42-2), WHO Country Office, and National Institute for Health Development; Georgia: WHO; Ireland: Health Service Executive; Italy: Ministry of Health and Italian National Institute of Health; Kazakhstan: Ministry of Health of the Republic of Kazakhstan and WHO Country Office; Kyrgyzstan: World Health Organization; Latvia: Ministry of Health, Centre for Disease Prevention and Control; Lithuania: Science Foundation of Lithuanian University of Health Sciences and Lithuanian Science Council and WHO; Malta: Ministry of Health; Montenegro: WHO and Institute of Public Health of Montenegro; North Macedonia: COSI in North Macedonia is funded by the Government of North Macedonia through National Annual Program of Public Health and implemented by the Institute of Public Health and Centers of Public Health in the country. WHO country office provides support for training and data management; Norway: Ministry of Health and Norwegian Institute of Public Health; Poland: National Health Programme, Ministry of Health; Portugal: Ministry of Health Institutions, the National Institute of Health, Directorate General of Health, Regional Health Directorates and the kind technical support from the Center for Studies and Research on Social Dynamics and Health (CEIDSS); Romania: Ministry of Health; Serbia: This study was supported by the World Health Organization (Ref. File 2015-540940); Slovakia: Biennial Collaborative Agreement between WHO Regional Office for Europe and Ministry of Health SR; Spain: Spanish Agency for Food Safety and Nutrition (AESAN); Tajikistan: WHO Country Office in Tajikistan and Ministry of Health and Social Protection; Turkmenistan: WHO Country Office in Turkmenistan and Ministry of Health; Turkey: Turkish Ministry of Health and World Bank.

ORCID

Mirjam M. Heinen https://orcid.org/0000-0002-0876-1395
Marta Buoncristiano https://orcid.org/0000-0002-3978-8435
Angela Spinelli https://orcid.org/0000-0002-4068-3569
Sanja Musić Milanović https://orcid.org/0000-0003-4643-1052
Radka Taxová Braunerová https://orcid.org/0000-0003-1693-4951

REFERENCES

1. WHO. Childhood overweight and obesity. 2020; https://www.who.int/dietphysicalactivity/childhood/en/
2. Spinelli A, Buoncristiano M, Nardone P, et al. Thinness, overweight and obesity in 6–9-year-old children from 36 countries. *The WHO European Childhood Obesity Surveillance Initiative–COSI 2015–17*. Obesity Reviews, 2021:e13214.
3. WHO. What are the causes?. https://www.who.int/dietphysicalactivity/childhood_why/en/, 2020
4. Mikkila V, Rasanen L, Raitakari OT, Pietinen P, Viikari J. Consistent dietary patterns identified from childhood to adulthood: the cardiovascular risk in young Finns study. *Br J Nutr*. 2005;93(6):923-931.
5. Movassagh EZ, Baxter-Jones ADG, Kontulainen S, Whiting SJ, Vatanparast H. Tracking dietary patterns over 20 years from

childhood through adolescence into young adulthood: the Saskatchewan pediatric bone mineral accrual study. *Nutrients*. 2017;9(9):990.
6. WHO. Children's diet. 2020; https://www.who.int/dietphysicalactivity/childhood_diet/en/
7. Crawford PB, Obarzanek E, Schreiber GB, et al. The effects of race, household income, and parental education on nutrient intakes of 9- and 10-year-old girls. NHLBI growth and health study. *Ann Epidemiol*. 1995;5(5):360-368.
8. Drewnowski A, Specter SE. Poverty and obesity: the role of energy density and energy costs. *Am J Clin Nutr*. 2004;79(1):6-16.
9. Hardy LL, Baur LA, Wen LM, Garnett SP, Mihrshahi S. Descriptive epidemiology of changes in weight and weight-related behaviours of Australian children aged 5 years: two population-based cross-sectional studies in 2010 and 2015. *BMJ Open*. 2018;8(4):e019391.
10. Lioret S, Touvier M, Lafay L, Volatier JL, Maire B. Dietary and physical activity patterns in French children are related to overweight and socioeconomic status. *J Nutr*. 2008;138(1):101-107.
11. NCD Risk Factor Collaboration (NCD-RisC). Rising rural body-mass index is the main driver of the global obesity epidemic in adults. *Nature*. 2019;569(7755):260-264.
12. Paciorek CJ, Stevens GA, Finucane MM, Ezzati M, Nutrition Impact Model Study G. Children's height and weight in rural and urban populations in low-income and middle-income countries: a systematic analysis of population-representative data. *Lancet Glob Health*. 2013;1(5):e300-e309.
13. Bell L, Ullah S, Olds T, et al. Prevalence and socio-economic distribution of eating, physical activity and sedentary behaviour among south Australian children in urban and rural communities: baseline findings from the OPAL evaluation. *Public Health*. 2016;140:196-205.
14. Euler R, Jimenez EY, Sanders S, et al. Rural-urban differences in baseline dietary intake and physical activity levels of adolescents. *Prev Chronic Dis*. 2019;16:E01.
15. Kelly C, Callaghan M, Molcho M, Nic Gabhainn S, Alforque TA. Food environments in and around post-primary schools in Ireland: associations with youth dietary habits. *Appetite*. 2019;132:182-189.
16. Sygit KM, Sygit M, Wojtyla-Buciora P, Lubiniec O, Stelmach W, Krakowiak J. Environmental variations of nutritional mistakes among polish school-age adolescents from urban and rural areas. *Ann Agric Environ Med*. 2019;26(3):483-488.
17. Niclasen B, Rasmussen M, Borup I, Schnohr C. The intake of fruit and sweets in rural and urban Greenland--development from 1994 to 2006. *Int J Circumpolar Health*. 2011;70(2):186-194.
18. Nurwanti E, Hadi H, Chang JS, et al. Rural-urban differences in dietary behavior and obesity: results of the Riskesdas study in 10–18-year-old Indonesian children and adolescents. *Nutrients*. 2019;11(11):2813.
19. McCormack LA, Meendering J. Diet and physical activity in rural vs urban children and adolescents in the United States: a narrative review. *J Acad Nutr Diet*. 2016;116(3):467-480.
20. Davis AM, Bennett KJ, Befort C, Nollen N. Obesity and related health behaviors among urban and rural children in the United States: data from the National Health and Nutrition Examination Survey 2003-2004 and 2005-2006. *J Pediatr Psychol*. 2011;36(6):669-676.
21. Davis AM, Boles RE, James RL, et al. Health behaviors and weight status among urban and rural children. *Rural Remote Health*. 2008;8(2):810.
22. Liu JH, Jones SJ, Sun H, Probst JC, Merchant AT, Cavicchia P. Diet, physical activity, and sedentary behaviors as risk factors for childhood obesity: an urban and rural comparison. *Child Obes*. 2012;8(5):440-448.
23. Ettienne-Gittens R, McKyer EL, Odum M, et al. Rural versus urban Texas WIC participants' fruit and vegetable consumption. *Am J Health Behav*. 2013;37(1):130-140.
24. Colic-Baric I, Kajfez R, Satalic Z, Cvjetic S. Comparison of dietary habits in the urban and rural Croatian schoolchildren. *Eur J Nutr*. 2004;43(3):169-174.
25. Sila S, Pavic AM, Hojsak I, Ilic A, Pavic I, Kolacek S. Comparison of obesity prevalence and dietary intake in school-aged children living in rural and urban area of Croatia. *Prev Nutr Food Sci*. 2018;23(4):282-287.
26. Lazarou C, Kalavana T. Urbanization influences dietary habits of Cypriot children: the CYKIDS study. *Int J Public Health*. 2009;54(2):69-77.
27. Tognarelli M, Picciolli P, Vezzosi S, et al. Nutritional status of 8-year-old rural and urban Italian children: a study in Pistoia, Tuscany. *Int J Food Sci Nutr*. 2004;55(5):381-387.
28. Wijnhoven TM, van Raaij JM, Breda J. *WHO European Childhood Obesity Surveillance Initiative. Implementation of Round 1 (2007/2008) and Round 2 (2009/2010)*. Copenhagen, Denmark 2014.
29. Wijnhoven TM, van Raaij JM, Spinelli A, et al. WHO European childhood obesity surveillance initiative 2008: weight, height and body mass index in 6–9-year-old children. *Pediatr Obes*. 2013;8(2):79-97.
30. Wijnhoven TM, van Raaij JM, Spinelli A, et al. WHO European childhood obesity surveillance initiative: body mass index and level of overweight among 6-9-year-old children from school year 2007/2008 to school year 2009/2010. *BMC Public Health*. 2014;14(1):806.
31. WHO European Childhood Obesity Surveillance Initiative. *Overweight and obesity among 6-to-9-year-old children. Results of the third round of data collection* 2012–2013. Copenhagen, Denmark; 2018.
32. Breda J, McColl K, Buoncristiano M, et al. Methodology and implementation of the WHO European Childhood Obesity Surveillance Initiative (COSI). Obesity Reviews. 2021:e13215.
33. Williams J, Buoncristiano M, Nardone P, et al. A snapshot of European children's eating habits: results from the fourth round of the WHO European childhood obesity surveillance initiative (COSI). *Nutrients*. 2020;12(8):2481.
34. WHO. Healthy diet: key facts. 2020; https://www.who.int/news-room/fact-sheets/detail/healthy-diet#:~:text=A%20healthy%20diet%20includes%20the,cassava%20and%20other%20starchy%20roots., 2020.
35. Stelmach-Mardas M, Kleiser C, Uzhova I, et al. Seasonality of food groups and total energy intake: a systematic review and meta-analysis. *Eur J Clin Nutr*. 2016;70(6):700-708.
36. *United Nations standard country code, series M: miscellaneous Statistical Papers, No. 49*. New York: United Nations. ST/-ESA/STAT/SER.M/49.
37. Cordain L, Eaton SB, Sebastian A, et al. Origins and evolution of the Western diet: health implications for the 21st century. *Am J Clin Nutr*. 2005;81(2):341-354.
38. Drewnowski A, Popkin BM. The nutrition transition: new trends in the global diet. *Nutr Rev*. 1997;55(2):31-43.
39. Popkin BM, Adair LS, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. *Nutr Rev*. 2012;70(1):3-21.
40. Caspi CE, Sorensen G, Subramanian SV, Kawachi I. The local food environment and diet: a systematic review. *Health Place*. 2012;18(5):1172-1187.
41. Johnson DB, Quinn E, Sitaker M, et al. Developing an agenda for research about policies to improve access to healthy foods in rural communities: a concept mapping study. *BMC Public Health*. 2014;14(1):592.
42. Walker RE, Keane CR, Burke JG. Disparities and access to healthy food in the United States: a review of food deserts literature. *Health Place*. 2010;16(5):876-884.

43. Powell LM, Slater S, Mirtcheva D, Bao Y, Chaloupka FJ. Food store availability and neighborhood characteristics in the United States. *Prev Med*. 2007;44(3):189-195.
44. Liese AD, Weis KE, Pluto D, Smith E, Lawson A. Food store types, availability, and cost of foods in a rural environment. *J am Diet Assoc*. 2007;107(11):1916-1923.
45. Pinard CA, Byker Shanks C, Harden SM, Yaroch AL. An integrative literature review of small food store research across urban and rural communities in the U.S. *Prev Med Rep*. 2016;3:324-332.
46. Burrows TL, Truby H, Morgan PJ, Callister R, Davies PS, Collins CE. A comparison and validation of child versus parent reporting of children's energy intake using food frequency questionnaires versus food records: who's an accurate reporter? *Clin Nutr*. 2013;32(4):613-618.
47. Larson NI. Nutritional problems in childhood and adolescence: a narrative review of identified disparities. *Nutr Res Rev*. 2020;1-31.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Heinen MM, Bel-Serrat S, Kelleher CC, et al. Urban and rural differences in frequency of fruit, vegetable, and soft drink consumption among 6–9-year-old children from 19 countries from the WHO European region. *Obesity Reviews*. 2021;22(S6):e13207. https://doi.org/10.1111/obr.13207