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CIÊNCIAS DO CONSUMO ALIMENTAR E NUTRIÇÃO

FEEDcities: A Characterization of the Purchasing Patterns of Street Food in Cities from Eastern Europe and Central Asia

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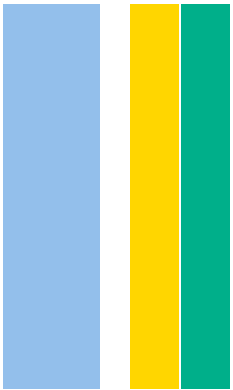

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Declaro que colaborei ativamente na definição dos objetivos de todos os manuscritos que constituem esta tese, conduzi a análise dos dados e colaborei na sua interpretação. Fui responsável pela redação da versão inicial e participei ativamente na elaboração das versões finais de todos os manuscritos aqui apresentados.

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TABLE OF CONTENTS

List of abbreviations.....vii

Abstract.....viii

Resumo.....xii

1. Introduction.....1

1.1 The evolution of societies: demographic, nutrition and epidemiologic transitions.....2

1.1.1. Urbanisation: a global process.....2
1.1.2. Demographic transition.....3
1.1.3. Nutrition transition.....5
1.1.4. Epidemiologic transition.....11
1.1.5. Implications for socioeconomic development.....14

1.2. Policy action towards healthy diets: the importance of food choices.....15

1.2.1. Factors influencing individual food choice.....15
1.2.2. The consumer as the centre of the food system.....16
1.2.3. Multisectoral action within the WHO European Region.....18

1.3. Away-from-home eating: a rising trend in transitional societies.....21

1.3.1. Street food.....21
1.3.2. Takeaway food.....28
1.3.3. Street food environment description in cities from Central Asia and Eastern Europe.....28

2. Objectives.....32

3. Methods.....34

4. Results.....44

Paper I – A Cross-Sectional Study of the Street Foods Purchased by Customers in Urban Areas of Central Asia.....45
Paper II – Nutritional Content of Street Food and Takeaway Food Purchased in Urban Bosnia and Herzegovina.....66
Paper III – Nutritional Content of the Street Food Purchased in Chișinău, Moldova: Opportunity for Policy Action.....86
Paper IV – Patterns of street food purchase in cities from Central Asia.....92
Paper V – Street Food and Takeaway Food Purchasing Patterns in Bosnia and Herzegovina.....106

5. Discussion and final conclusions.....126

6. References.....137

7. Annexes.....147

Annex 1 – FEEDcities Project: A Comprehensive Characterization of the Street Food Environment in Cities. Project protocol.....148
Annex 2 – Safe and healthy food in traditional food markets in the WHO European Region.....181

LIST OF ABBREVIATIONS

BMI - Body Mass Index

DALYs - Disability-Adjusted Life Years

FAO - Food and Agriculture Organization

FCNAUP - Faculty of Nutrition and Food Sciences of the University of Porto (Faculdade de Ciências da Nutrição e Alimentação da Universidade do Porto, in Portuguese)

FFUP - Faculty of Pharmacy of the University of Porto (Faculdade de Farmácia da Universidade do Porto, in Portuguese)

FMUP - Faculty of Medicine of the University of Porto (Faculdade de Medicina da Universidade do Porto, in Portuguese)

GPS - Global Positioning System

HIV/AIDS - Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome

ISPUP - Institute of Public Health of the University of Porto (Instituto de Saúde Pública da Universidade do Porto, in Portuguese)

LMIC - Low- and Middle-Income Countries

MUFA - Monounsaturated Fatty Acids

NCDs - Non-Communicable Diseases

PUFA - Polyunsaturated Fatty Acids

SDGs - Sustainable Development Goals

SFA - Saturated Fatty Acids

TFA - *Trans* Fatty Acids

USD – United States Dollars

WHO - World Health Organization

ABSTRACT

Countries from Central Asia and Eastern Europe have been going through demographic, nutrition and epidemiologic transitions closely interconnected with socioeconomic development and urbanisation processes, similarly to trends observed in other low- and middle-income countries. The nutrition transition, characterised by gradual shifts in diet and physical activity, has greatly contributed to change the health patterns of these populations, namely the increasing morbidity and mortality of diet-related non-communicable diseases such as obesity or cardiovascular diseases, among others. Arising from the growing globalisation of the food supply, a gradual replacement of the local dietary patterns by an increasingly westernized diet has been observed. In these regions, availability of staple foods such as cereals and starchy roots have been declining, whereas the supply of foods of animal origin and ultra-processed products, rich in energy, fat, saturated fatty acids, salt and sugar, have been increasing.

One of the changes in eating habits observed in low- and middle-income countries has been the increase in out-of-home food consumption. In this context, street-vended food has been described as an important source of cheap, convenient and fulfilling meals, especially for urban populations. Out-of-home food consumption has been associated with poorer dietary quality and a higher risk of chronic disease. However, until very recently, few studies have caracterised aspects related to the consumption and nutritional quality of street food.

This thesis aimed to characterise street food purchasing patterns in seven cities from Central Asia (*Dushanbe*, Tajikistan; *Bishkek*, Kyrgyzstan; *Ashgabat*, Turkmenistan; and *Almaty*, Kazakhstan) and Eastern Europe (*Sarajevo* and *Banja Luka*, Bosnia and Herzegovina; and *Chișinău*, Moldova), specifically the customers, their food purchases and respective nutritional composition. The specific objectives were as follows: (1) to describe street food customers' characteristics (sex, age, and weight status) and their purchases, including foods and beverages bought and their quantities; (2) to estimate the street food purchases' energy content and nutritional value, namely macronutrients, including protein, carbohydrates, total fat and lipid profile, as well as sodium and potassium contents, and to compare these values with the respective international population nutrient intake goals; and (3) to assess patterns of

purchase, considering both temporal (throughout the day) and spatial (city centre *versus* periphery) distributions.

To achieve these goals, data from the FEEDcities research project were used. This is a multi-centre cross-sectional study, whose main objective is to characterise the street food environment in cities from Central Asia and Eastern Europe. Between 2016 and 2017, studies were conducted in seven cities from these regions, comprising three steps: (1) characterization of the vending sites and food offer; (2) assessment of the customers and their purchases; and (3) collection of food samples for chemical analysis. For the purpose of this thesis, data was retrieved from steps 2 and 3 of these evaluations.

Eligible vending sites were selected through random and systematic sampling procedures, which were carried out in accordance with the distribution and density of vending sites in each city. In each selected vending site, up to four customers were observed, while they were buying ready-to-eat foods and/or beverages. Data on the customers' characteristics (estimated sex, age and weight status), the foods and beverages bought, and respective quantities were collected through direct observation by trained field researchers. Geographic location and time of purchase were also recorded. The food items purchased were classified into homemade or industrial, and in food groups. Each purchase was also classified according to its location (city centre or periphery) and time period in which it occurred (on an hourly basis). The nutritional composition of each purchase (comprising energy, macronutrients including lipid profile, sodium and potassium) was estimated using data either from chemical analyses, food labels and/or food composition tables using standardized recipes. Overall, data from 1620 customers and their respective purchases were included in this thesis.

In all cities, the purchase of industrial food products ranged from 26.2% of customers in *Bishkek*, Kyrgyzstan to 66.9% in *Chișinău*, Moldova, concurrently with the acquisition of traditional homemade foods and beverages. The most commonly purchased homemade food options were, in general, savoury pastries, main dishes, breads and sweet pastries, whereas the most popular industrially-produced foods were savoury snacks, confectionery and industrial bread. Ready-to-eat fruit was rarely purchased, reaching the highest frequency in *Dushanbe*, Tajikistan (4.9%). Soft drinks, industrial fruit juices, tea, coffee and water were amongst the most commonly bought beverages.

Regarding the nutritional value of the purchases, these were generally energy-dense (medians exceeding 300 kcal/100 g in most cities studied), with a higher contribution from carbohydrates and fat (frequently above 50% and 30% of total energy value, respectively) over protein. In terms of lipid profile, purchases were rich in saturated fatty acids (reaching 40% of maximum daily intake recommendation in cities from Turkmenistan and Bosnia and Herzegovina) and *trans* fatty acids (frequently surpassing the limit of 2% of total fat). High amounts of sodium (at around or above one third of maximum daily intake recommendation), together with low potassium values (below 10% of minimum daily intake recommendation), were also found, resulting in sodium-to-potassium ratios way above the recommended value of 1 in all cities studied (ranging from 4.3 in *Almaty*, Kazakhstan to 6.6 in *Dushanbe*, Tajikistan).

Purchases comprising industrial food items tended to present a worse lipid profile, with higher contents of saturated and *trans* fatty acids, as well as lower amounts of unsaturated fats, than those containing exclusively homemade food items. Conversely, the homemade food items purchased generally showed higher sodium-to-potassium ratios when compared to industrial ones. Male customers, as well as those with overweight or obesity, presented purchases with a less healthy nutritional profile, in general with higher values of energy, saturated and *trans* fatty acids and/or sodium than their female and under- or normal-weighted counterparts.

Higher customer influx (customers observed per 10 minutes) and buying rates (food items purchased per 10 minutes) were observed in the city centres and around lunchtime. In general, tea and coffee were mostly bought in the early morning, and bread, savoury pastries and main dishes during the morning period or at lunchtime. Purchase of industrial foods and beverages was generally more frequent in the city centres, mostly in the context of mid-morning and mid-afternoon snacks. In cities from Bosnia and Herzegovina, takeaway food establishments largely surpassed traditional street food vending sites, both in terms of customer influx and food items buying rate, especially in the city centres.

The findings arising from this thesis indicate that the phenomenon of nutrition transition that countries from Central Asia and Eastern Europe are currently crossing is reflected in the food choices made at street level. The nutritional profile of the street food purchases in the cities studied shows a clear need for public health action. In this context, the specific patterns of purchase identified should contribute to a better understanding of the street food buying

habits in these cities, and therefore should be considered when designing public health strategies customised to the reality of these food environments and the persons that are influenced by them. The knowledge gathered under the scope of this work highlights opportunitties of action in order to improve these urban food environments, and to nudge consumers to make healthier food choices.

Keywords: Street food; Low- and middle-income countries; Nutritional value; Food choice; Nutrition transition.

RESUMO

Os países da Ásia Central e da Europa de Leste têm vindo a atravessar um conjunto de transições demográficas, nutricionais e epidemiológicas intimamente interligadas com processos de desenvolvimento económico e urbanização, à semelhança das tendências observadas em outros países de baixo e médio rendimento. A transição nutricional, caracterizada por mudanças graduais na alimentação e na atividade física, tem sido um fator determinante para a alteração dos padrões de saúde destas populações, nomeadamente o aumento da morbilidade e mortalidade por doenças não transmissíveis relacionadas com a alimentação, como a obesidade ou as doenças cardiovasculares, entre outras. Decorrente da crescente globalização do abastecimento alimentar, tem-se observado uma gradual substituição dos padrões alimentares locais por uma alimentação cada vez mais ocidentalizada. Nestas regiões, a disponibilidade de alimentos-base como cereais e raízes amiláceas tem vindo a diminuir, enquanto a oferta de alimentos de origem animal e produtos ultra-processados, ricos em energia, gordura, ácidos gordos saturados, sal e açúcar, tem vindo a aumentar.

Uma das alterações em termos de hábitos alimentares observadas em países de baixo e médio rendimento tem sido o aumento do consumo de alimentos fora de casa. Neste contexto, a comida vendida nas ruas tem sido descrita como uma importante fonte de refeições baratas, convenientes e saciantes, especialmente para as populações urbanas. O consumo de alimentos fora de casa tem sido associado a uma menor qualidade da alimentação e a um risco mais elevado de doenças crónicas. No entanto, até muito recentemente, poucos estudos caracterizaram aspetos relacionados com o consumo e a qualidade nutricional da comida de rua.

Esta tese teve como objetivo caracterizar os padrões de compra de comida de rua em sete cidades da Ásia Central (*Dushanbe*, Tajiquistão; *Bishkek*, Quirguistão; *Ashgabat*, Turquemenistão; e *Almaty*, Cazaquistão) e Europa de Leste (*Sarajevo* e *Banja Luka*, Bósnia e Herzegovina; e *Chișinău*, Moldávia), especificamente os compradores, as suas compras e a respetiva composição nutricional. Os objetivos específicos foram os seguintes: (1) descrever as características dos compradores de comida de rua (sexo, idade e estado ponderal) e as suas compras, incluindo os alimentos e bebidas comprados e suas quantidades; (2) estimar o valor

nutricional das compras de comida de rua, nomeadamente energia, macronutrientes, incluindo proteínas, hidratos de carbono, gordura total e perfil lipídico, bem como conteúdos em sódio e potássio, e comparar esses valores com as respetivas recomendações internacionais de ingestão de nutrientes; e (3) avaliar os padrões de compra, considerando distribuições temporais (ao longo do dia) e espaciais (centro da cidade *versus* periferia).

Para atingir estes objetivos, foram utilizados dados do projeto de investigação FEEDcities. Trata-se de um estudo transversal multicêntrico, cujo objetivo principal é o de caracterizar o ambiente de comida de rua em cidades da Ásia Central e da Europa de Leste. Entre 2016 e 2017, foram realizados estudos em sete cidades destas regiões, compreendendo três etapas: (1) caracterização dos pontos de venda e da sua oferta alimentar; (2) avaliação dos compradores e das suas compras; e (3) recolha de amostras de alimentos para análise química. No âmbito desta tese, foram utilizados dados referentes às etapas 2 e 3 destas avaliações.

Os locais de venda elegíveis foram selecionados por meio de procedimentos de amostragem aleatória e sistemática, realizados de acordo com a distribuição e densidade de locais de venda em cada cidade. Em cada local de venda selecionado, foram observados até quatro clientes, enquanto compravam alimentos e/ou bebidas prontos a consumir. Dados sobre as características dos compradores (sexo, idade e estado ponderal estimados), os alimentos e bebidas comprados e respetivas quantidades foram recolhidos através de observação direta por parte de investigadores de campo treinados. A localização geográfica e a hora da compra foram também registadas. Os alimentos adquiridos foram classificados em caseiros ou industriais, e em grupos alimentares. Cada compra foi também classificada de acordo com a sua localização (centro ou periferia da cidade) e período do dia no qual aconteceu (de hora em hora). A composição nutricional de cada compra (que compreendeu energia, macronutrientes incluindo perfil lipídico, sódio e potássio) foi estimada por meio de dados de análises químicas, rótulos alimentares e/ou tabelas de composição de alimentos utilizando receitas padronizadas. No total, foram incluídos nesta tese os dados de 1620 compradores e respetivas compras.

Em todas as cidades, a frequência da compra de produtos alimentares industrializados variou entre 26,2% dos compradores em *Bishkek*, Quirguistão e 66,9% em *Chișinău*, Moldávia, concomitantemente com a aquisição de alimentos e bebidas tradicionais e caseiros. Os

alimentos caseiros mais frequentemente adquiridos foram, em geral, pastéis salgados, pratos principais, pão e pastelaria, enquanto os alimentos industriais mais procurados foram os *snacks* salgados, as "guloseimas" e os pães industriais. A fruta pronta-a-consumir foi raramente adquirida, atingindo a maior frequência em *Dushanbe*, Tajiquistão (4,9%). Refrigerantes, sumos de fruta industriais, chá, café e água estiveram entre as bebidas mais compradas.

Em relação ao valor nutricional das compras realizadas, estas foram geralmente densas em energia (medianas superiores a 300 kcal / 100 g na maioria das cidades estudadas), com maior contribuição por parte dos hidratos de carbono e das gorduras (frequentemente acima de 50% e 30% do valor total de energia, respetivamente) em detrimento das proteínas. Em termos de perfil lipídico, as compras foram ricas em ácidos gordos saturados (atingindo os 40% da recomendação máxima de ingestão diária em cidades do Turquemenistão e da Bósnia e Herzegovina) e *trans* (frequentemente ultrapassando o limite de 2% da gordura total). Observaram-se ainda elevadas quantidades de sódio (em torno ou acima de um terço da recomendação máxima de ingestão diária), juntamente com baixos valores de potássio (abaixo de 10% da recomendação mínima de ingestão diária), resultando em rácios sódio/potássio muito acima do valor recomendado de 1 em todas as cidades estudadas (variando entre 4,3 em *Almaty*, Cazaquistão e 6,6 em *Dushanbe*, Tajiquistão).

As compras contendo alimentos industrializados tenderam a apresentar um pior perfil lipídico, com maiores teores de ácidos gordos saturados e *trans*, além de menores quantidades de gorduras insaturadas, do que aquelas que incluíram exclusivamente alimentos caseiros. Por outro lado, os alimentos caseiros adquiridos apresentaram no geral, um maior rácio sódio-potássio quando comparados com os industriais. Os compradores do sexo masculino, assim como os com excesso de peso ou obesidade, realizaram compras com um perfil nutricional menos saudável, em geral com valores mais elevados de energia, ácidos gordos saturados e *trans* e/ou sódio, comparativamente com as mulheres e os compradores com baixo peso ou peso normal.

Foi observada uma maior afluência de clientes (clientes observados por 10 minutos), bem como um ritmo de compra (itens alimentares comprados por 10 minutos) superior, nos centros das cidades e perto da hora de almoço. No geral, chá e café foram comprados principalmente no

início da manhã, e pão, pastéis salgados e pratos principais durante o período da manhã ou na hora de almoço. A compra de alimentos e bebidas industrializados foi geralmente mais frequente nos centros das cidades, principalmente no contexto de lanches da manhã e da tarde. Nas cidades da Bósnia e Herzegovina, os estabelecimentos de comida *takeaway* superaram largamente os tradicionais locais de venda de comida de rua, quer em termos de afluência de clientes, quer em termos de ritmo de compra de alimentos, especialmente nos centros das cidades.

Os resultados desta tese indicam que o fenómeno de transição nutricional que os países da Ásia Central e da Europa de Leste atravessam atualmente se reflete nas escolhas feitas ao nível da comida de rua. O perfil nutricional das compras de comida de rua nas cidades estudadas mostra uma clara necessidade de ação em termos de saúde pública. Nesse contexto, os padrões de compra identificados deverão contribuir para uma melhor compreensão dos hábitos de compra de comida de rua nestas cidades e, portanto, devem ser considerados no desenho de estratégias de saúde pública adaptadas à realidade desses ambientes alimentares e das pessoas que os mesmos influenciam. O conhecimento adquirido no âmbito deste trabalho evidencia oportunidades de ação, com o objetivo de melhorar esses ambientes alimentares urbanos, bem como incitar os consumidores a fazerem escolhas alimentares mais saudáveis.

Palavras-chave: Comida de rua; Países de baixo e médio rendimento; Valor nutricional; Escolha alimentar; Transição nutricional.

1. INTRODUCTION

1.1. THE EVOLUTION OF SOCIETIES: DEMOGRAPHIC, NUTRITION AND EPIDEMIOLOGIC TRANSITIONS

After World War II, several major economic and demographic shifts marked the history of many regions worldwide. Rapid economic growth and industrialisation was accompanied by a vast increase in urban agglomerations and remarkable changes in mortality and fertility patterns[1, 2]. The role of these demographic changes in the nutrition and epidemiologic transitions which occurred in higher-income countries has been long recognized by the scientific community. More recently, it has also been identified that similar changes are now occurring in low- and middle-income countries (LMIC), as they undergo socioeconomic development. These patterns of change are closely interconnected, forming a complex network which has direct consequences in the nutritional and health profiles of these populations[1].

1.1.1. Urbanisation: a global process

Urbanisation is a complex socio-economic phenomenon that is mainly characterized by the growing number of people living in urban areas, either through modifications in the spatial distribution of a population (migration from rural to urban areas), or transformations in the built environment (i.e. conversion of formerly rural into urban settlements)[3]. This process has consequences in the demographic, economic and social structure of populations, being considered as a major driver of a set of intertwined nutrition and epidemiologic transformations[4, 5].

The urbanisation process is happening globally, with rising trends in low-, middle- and high-income countries. According to data from the United Nations, in 1950, 30% of the world's population was urban, but today, more people live in urban than in rural areas, with around 55% of the global population being urban dwellers in 2018. In future years, the world will continue to urbanize, with a projected growth of 2.5 billion people living in cities between 2018 and 2050. By then, 68% of the world's population is projected to be urban[3].

In relative numbers, Asia presents a low level of urbanisation, now approximating 50%. However, because of its large population, this region has the largest number of people living in urban areas (2.3 billion in 2018). Asia also presents one of the highest urban population growth rates in the world: the number of city dwellers increased by nine-fold between 1950 and 2018, from 246 million to 2.3 billion. This growth is expected to continue in the future,

being estimated that by 2050, this region will have the largest number of urban dwellers in the world (3.5 billion), corresponding to 66.2% of the total Asian population. On the other hand, Europe underwent an earlier process of urbanisation during the 19th century, as unprecedented economic transformations occurred along with the Industrial Revolution. That way, this is already one of the most urbanized continents, with 74% of its population living in cities in 2018, being the second (following Asia) considering absolute numbers (553 million in 2018). Although the number of urban dwellers in Europe nearly doubled between 1950 and 2018, it is currently exhibiting slowing rates of urban growth, with an estimated yearly rate of urbanisation of 0.38% between 2030 and 2050. Even so, it is estimated that 83.7% of the European population will be city dwellers in 2050[3]. LMIC from Europe and Central Asia have been following the same trends: the proportion of urban population has been rising consistently over the decades, reaching 68% by 2019[3, 6] (**Figure 1**).

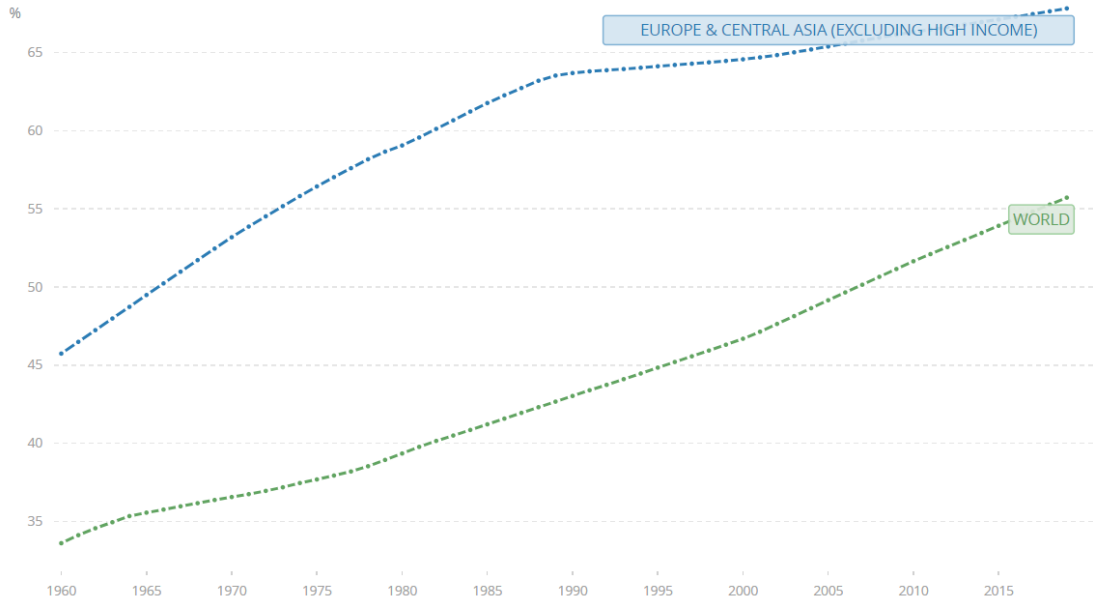


Figure 1. Urban population (% of total population) worldwide and in Europe and Central Asia, excluding high-income countries, between 1960 and 2019. Source: The World Bank, 2021[6].

1.1.2. Demographic transition

Concomitantly with urbanisation, industrialization and economic development, in LMIC the population is gradually growing, with decreasing fertility and mortality, a process that researchers call the demographic transition[2]. In accordance with data from the United Nations, a steep increase in the total population of Central Asia was observed between 1950 and 2020, from 17 million to 74 million people. In Eastern Europe, total population increased from around

220 million in 1950 to almost 310 million in 1990, year after which started to slowly decrease until the present (293 million). In both regions, mortality under the age of five years and total fertility have been decreasing, simultaneously with a growth in life expectancy, which is estimated to continue rising during the next decades[7] (**Figure 2**).

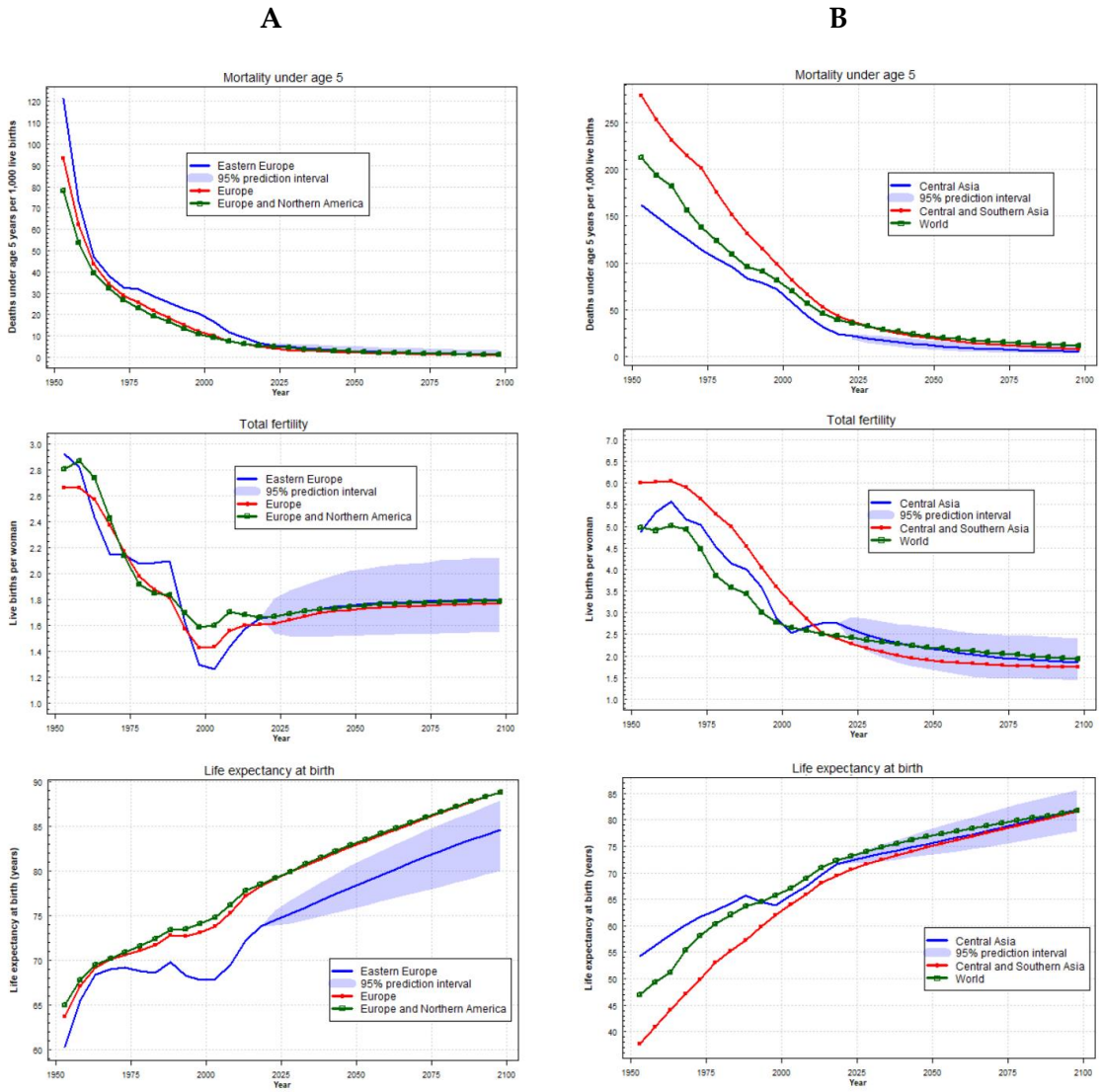


Figure 2. Mortality under age 5, total fertility and life expectancy at birth, in Eastern Europe **(A)** and Central Asia **(B)**, between 1950 and 2100. Source: United Nations, 2019[7].

The decline in death and birth rates, together with an increase in the human life span, had direct consequences in the age structures of these populations. Whereas in Central Asia population growth has been generally occurring across all age groups, in Eastern Europe it is possible to observe a decrease in the population below 25 years of age, and an overall increase in the population between 30 and 100 years. In both regions, an increase in the older groups of the population (above 65 years of age) is occurring[7] (**Figure 3**).

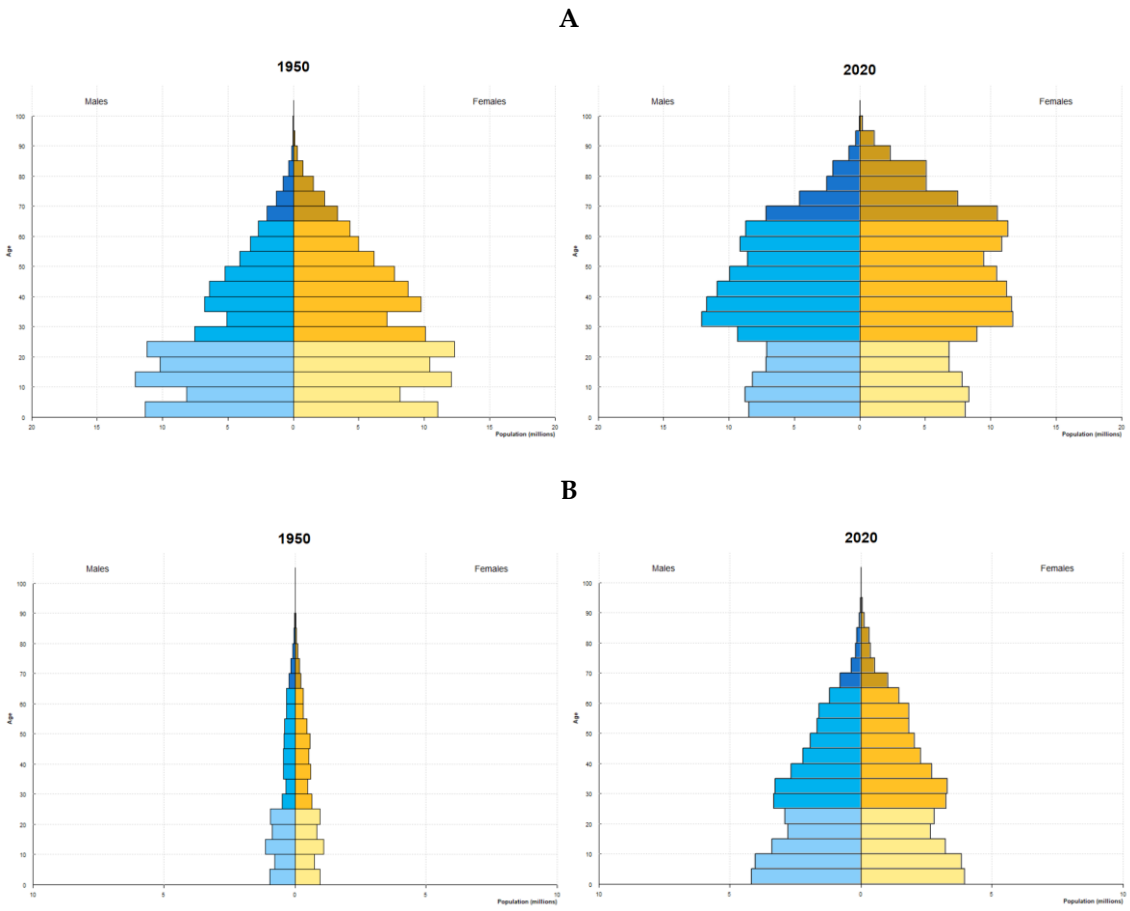


Figure 3. Population (millions) of Eastern Europe **(A)** and Central Asia **(B)**, by age and sex group, in 1950 and 2020. Source: United Nations, 2019[7].

1.1.3. Nutrition transition

The socioeconomic and demographic changes occurring in LMIC have been closely linked to a process of nutrition transition, a concept first defined by Barry Popkin as "large changes over time in diet and physical activity, especially their structure and overall composition"[5]. According to the nutrition transition model proposed by this author, this phenomenon has followed five broad stages, which are not restricted to particular periods of human history, but instead characterize specific geographic and socioeconomic subpopulations: (1) collecting food; (2) famine; (3) receding famine; (4) degenerative disease; and (5) behavioural change[4, 5] (**Table 1**). Most LMIC seem to be transitioning from a period of receding famine towards a pattern where diet-related chronic diseases are rapidly emerging[5, 8].

Table 1. Summary of the main nutritional, economic and demographic features in each of the five stages of the nutrition transition model. Adapted from: Popkin, 1999[4].

	Collecting food	Famine	Receding famine	Degenerative disease	Behavioural change
Diet	Plants, low-fat wild animals; varied diet	Cereals predominant; diet less varied	Fewer starchy staples; more fruits, vegetables, animal protein; low variety continues	More fat (especially from animal products), sugar, and processed foods; less fiber	Less fat and processing; increased carbohydrates, fruits, and vegetables
Nutritional status	Robust, lean, few nutritional deficiencies	Children, women suffer most from low fat intake; nutritional deficiency diseases emerge; stature declines	Continued maternal and child nutrition problems; many deficiencies disappear; weaning diseases emerge; stature grows	Obesity; problems for elderly (bone health, etc.); many disabling conditions	Reduced body-fat levels and obesity; improved bone health
Food processing	Non-existent	Food storage begins	Storage process (drying, salting); canning and processing technologies; increased food refining and milling	Numerous food-transforming technologies	Technologies create foods and food constituent substitutes (e.g. macronutrient substitutes)
Economy	Hunter-gatherers	Agriculture, animal husbandry, homemaking begin; shift to monocultures	Second agricultural revolution (crop rotation, fertilizer) Industrial Revolution; women join labour force	Fewer jobs with heavy physical activity; service sector and mechanization; household technology revolution	Service sector mechanization, industrial robotization dominate; leisure exercise grows to offset sedentary jobs
Household production	Primitive; onset of fire	Labour-intensive, primitive technology begins (clay cooking vessels)	Primitive water systems; clay stoves; cooking technology advances	Household technology mechanizes and proliferates	Food preparation cost falls significantly with technological change
Income and assets	Subsistence; primitive stone tools	Subsistence; few tools	Increasing income disparity; agricultural tools; industrialization rises	Rapid growth in income and income disparities; technology proliferation	Income growth slows; home and leisure technologies increase
Mortality and fertility	Low fertility, high mortality, low life expectancy	High natural fertility, low life expectancy, high infant and maternal mortality	Slow mortality decline, later rapid; fertility static, then declines; small, cumulative population growth, later explodes	Life expectancy hits unique levels (60s–70s); huge fertility declines and fluctuations (e.g. post-war baby boom)	Life expectancy extends to 70s, 80s; disability-free period increases
Morbidity	Much infectious disease; no epidemics	Epidemics; endemic disease (plague, smallpox, polio, tuberculosis); deficiency disease begins; starving common	Tuberculosis, smallpox, infection, parasitic disease, polio, weaning disease (diarrhoea, retarded growth) expand, later decline	Chronic disease related to diet, pollution (heart disease, cancer); infectious disease declines	Increased health promotion (preventive and therapeutic); rapid decline in coronary heart disease, slower change in age-specific cancer profile
Age structure	Young population	Young; very few elderly	Chiefly young; shift to older population begins	Rapid fertility decline; elderly proportion increases rapidly	Increasing proportion of elderly > 75
Residency patterns	Rural, low density	Rural; a few small, crowded cities	Chiefly rural; move to cities increases; international migration begins; megacities develop	Urban population disperses; rural green space reduced	Lower-density cities rejuvenate; urbanization of rural areas encircling cities increases

Economic growth has caused major changes in the economic structures of LMIC, which have been transforming from a preindustrial agrarian profile to an industrialized cash economy[1, 4]. This shift implies the growth of service sectors and capital-intensive industrial production, which are rapidly replacing the previous pattern of subsistence agriculture, especially in the most urbanising regions[4]. In this new socioeconomic reality, patterns of employment change dramatically from activities such as farming or fishing, towards manufacturing and commercial jobs, and women start to play a much more important role in the labour market. Time allocation patterns change, as people spend more time working and less time at home, being less available for cooking or leisure activities. Life becomes much more work-oriented, which leads to major alterations in household management, as families get smaller and housework becomes less women-centered. Technologic development also plays a significant part on both dietary and activity patterns. Household appliances become indispensable, making domestic tasks such as house cleaning or food preparation much easier and faster. The food industry develops, increasing the availability of processed and ultra-processed food products, including pre-cooked meals and ready-to-eat snacks, which are highly convenient in an increasingly accelerated lifestyle. Enhancement of modern technology (e.g. motorized vehicles, television, computer, mobile phones, internet) profoundly changes activity patterns, characterized by a reduced use of human energy, as all activities, including work, transportation and leisure, become more and more sedentary. Finally, the expanding access to the modern mass media makes eating habits more influenceable by food advertising and marketing strategies[8-11] (**Figure 4**).

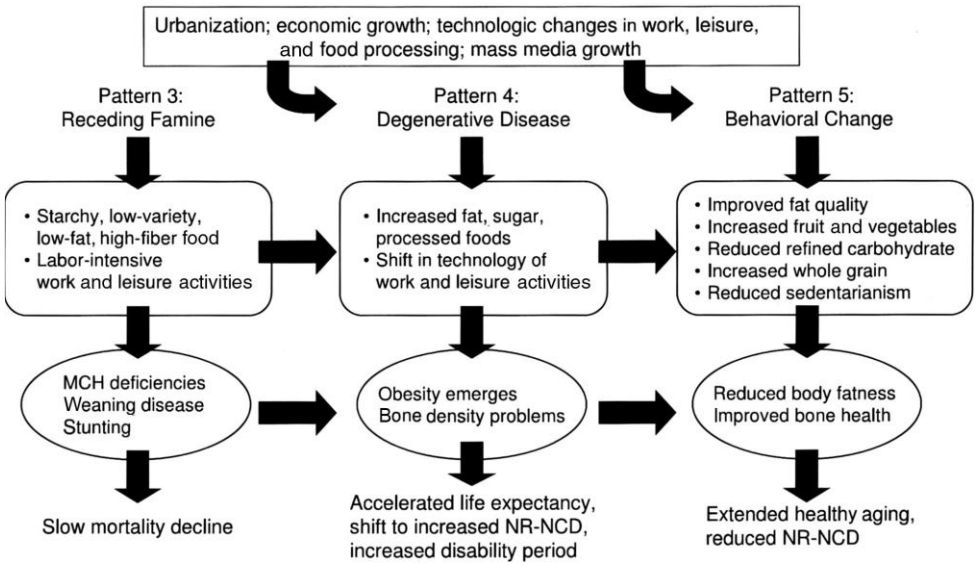


Figure 4. Patterns of the nutrition transition and main underlying socioeconomic and demographic factors. NR-NCD, nutrition-related non-communicable diseases; MCH, maternal and child health. Source: Popkin, 2006[8].

These social, economic and dietary transformations are now occurring in transitional LMIC much faster than they occurred in the past in modern high-income countries, because they are currently happening in the context of an already globalized and modernized world[12]. Globalisation of food trade, with the rapid spread of multi-national supermarket chains and fast food restaurants, further facilitates the so-called "westernisation" of food habits, by leading to a greater access to international suppliers and further promoting acculturation[9]. This evolution from a local and traditional diet towards a food consumption pattern characteristic of occidental developed regions generally involves a number of dietary changes: (1) decreasing intake of unprocessed or minimally-processed staple foods rich in micronutrients, starch, dietary fiber and/or vegetable protein, such as fruit, vegetables, whole grains and legumes; (2) increasing ingestion of foods from animal origin rich in total fat, mostly saturated (e.g. meat, meat products, dairy), as well as energy-dense ultra-processed foods (e.g. sweet or savoury snacks, soft drinks, alcoholic beverages), usually rich in added sugars, *trans* fatty acids (TFA) and/or sodium; and (3) modifications in culinary practices, such as the increasing frying of food and use of vegetable oils and other salt- and sugar-rich processed ingredients (e.g. sauces, stocks)[5, 8-10, 13].

These diets of low nutritional quality, coupled with a decrease in daily physical activity, cause problems at both ends of the malnutrition spectrum. In this context of changing dietary patterns, many LMIC are now facing a double burden of malnutrition, as conditions related with both undernutrition (e.g. wasting, stunting, micronutrient deficiencies) and overnutrition (e.g. overweight, obesity) often co-exist in the same region, country, household or person, and across the lifecourse[11, 14]. Inequalities regarding those outcomes have been documented, with food insecurity and malnutrition indicators being identified to affect more severely the most vulnerable groups, based on living and working conditions, income and education[15, 16].

The nutrition reality in Eastern Europe and Central Asia

At the end of the 20th century, the collapse of communism in the former Soviet Union and Yugoslavia triggered a set of economic, political and social changes, contributing to major shifts in dietary habits across most of the Eastern European and all Central Asian countries[17]. Data from the food balances between 2000 and 2018 showed a general increase in food availability in both Eastern Europe and Central Asia, with increasing energy (from 2980 to 3309 kcal/capita/day

and from 2461 to 2872 kcal/capita/day, respectively), protein (from 87 to 97 g/capita/day and from 73 to 87 g/capita/day, respectively) and fat supply (from 86 to 114 g/capita/day and from 63 to 87 g/capita/day, respectively)[18] (**Figure 5**). During the same time period, a diversification of the diet has been observed, with a stable or growing availability of almost all food groups. In Eastern Europe, availability of staple foods such as cereals and starchy roots have decreased, with relevant increases of vegetable oils, meat and animal fats. Similar changes have occurred in Central Asia, with decreasing availability of cereals and important increases in vegetable oils, meat and dairy[18] (**Figure 6**). Finally, recent studies show that in both regions, market sales of industrially processed and ultra-processed foods, such as sugar-sweetened beverages and packaged food products, have also increased markedly during the last two decades[19, 20].

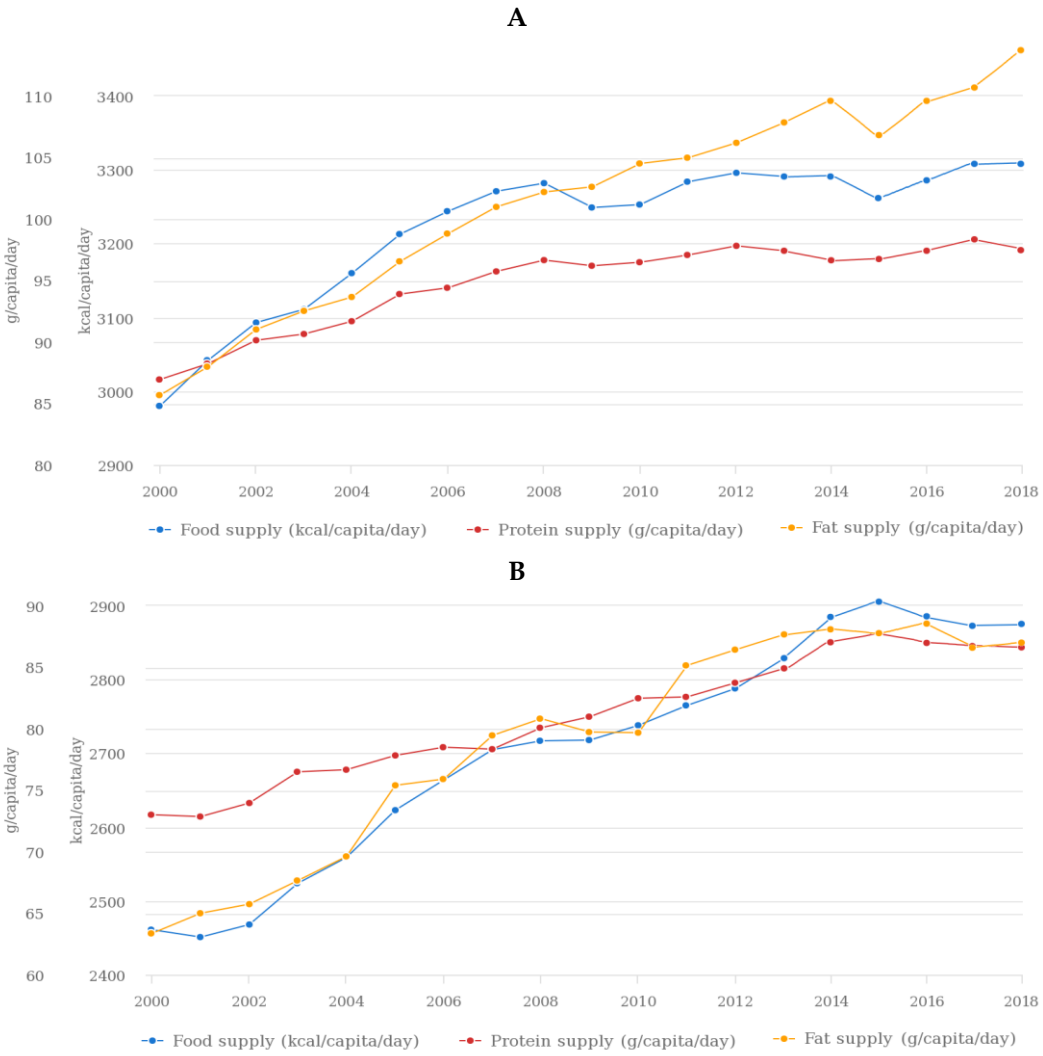


Figure 5. Per capita energy, protein and fat availability in Eastern Europe **(A)** and Central Asia **(B)**, between 2000 and 2018. Source: FAOSTAT, 2021[18].

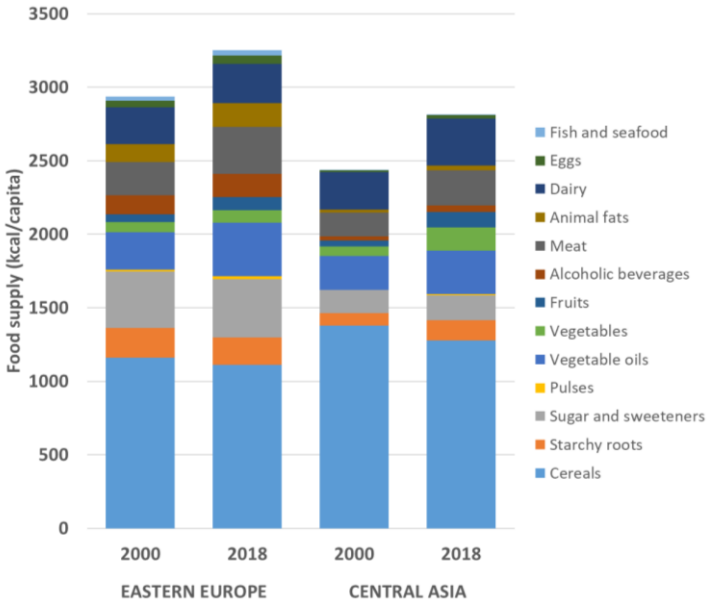


Figure 6. Changes in the energy availability in Eastern Europe and Central Asia, between 2000 and 2018, by food groups. Adapted from: FAOSTAT, 2021[18].

Despite the growing numbers regarding food supply, more than 100 million people in Europe and Central Asia (corresponding to 11% of its population) are currently exposed to moderate or severe food insecurity (based on the *Food Insecurity Experience Scale*, which assesses self-reported difficulties in accessing safe, nutritious and sufficient food)[16, 21]. Furthermore, and despite showing a general downward trend, many countries in this region continue to face relevant prevalence of various forms of undernutrition, such as stunting among children below five years of age and anaemia among women of reproductive age, as well as inadequate levels of exclusive breastfeeding during the first six months of life[16]. In Central Asia, data from 2019 show that anaemia affected an estimated 28.1% of women of reproductive age; 5.4% of infants had a low weight at birth; almost half of infants aged up to five months (44.8%) were not exclusively breastfed; and prevalence of stunting and wasting below five years of age was 10.0% and 2.3%, respectively[22]. Fewer data on undernutrition indicators exist for the Eastern European subregion, with only the prevalence of stunting under five years of age (6.6%) and anaemia among women of reproductive age (20.8%) being available[23]. Simultaneously, overweight, obesity and other diet-related chronic diseases also pose significant health concerns among children, adolescents and adults, reflecting the double burden of malnutrition in both subregions[16].

1.1.4. Epidemiologic transition

The theory of epidemiologic transition was first proposed in 1971 by Abdel Omran, who conceptualized it as "the complex change in patterns of health and disease (…) in which degenerative and man-made diseases displace pandemics of infection as the primary causes of morbidity and mortality"[24]. Nutrition transition, which is now occurring in the developing world, is having serious implications in the rapid rise of obesity and other diet-related chronic diseases in these settings, also leading to a gradual shift in the age patterns of mortality from younger to older groups[25]. While infectious diseases such as HIV/AIDS, respiratory and enteric infections, remain as unresolved health issues in many LMIC, new health problems related to diet and lifestyle, namely type 2 diabetes mellitus, cardiovascular diseases and certain types of cancer, have been increasing in prominence, causing a double burden of disease and having important effects for healthcare costs, especially in contexts of limited income and resources[25, 26].

Overweight and obesity trends

The combination of increased energy intake and reduced energy expenditure creates an energy imbalance, leading to changes in body composition towards overweight and obesity[10]. The World Health Organization (WHO) defines overweight and obesity as an "abnormal or excessive fat accumulation that may impair health", being classified for adults by values of Body Mass Index above 25 kg/m^2 and 30 kg/m^2, respectively. This problem has been growing across the globe, where the prevalence of obesity has nearly tripled since 1975. In 2016, an estimated 1.9 billion adults (corresponding to 39% of the world's population) were overweight and over 650 million (around 13%) were obese. Estimates for children and adolescents are lower than for adults but still worrisome: worldwide, 38.2 million children under the age of five years (16%) and 340 million children and adolescents aged five to nineteen years (18%) were overweight or obese, as estimated for 2019 and 2016, respectively. Furthermore, an upward trend remains across all age groups[27].

Once considered a problem exclusive to high-income countries, overweight and obesity are now on the rise in less developed economies, particularly its urban settings[27]. Currently, more than three-quarters of overweight or obese individuals live in LMIC[28]. In Central Asia and Eastern Europe, prevalence of overweight and obesity has also been increasing during the last

two decades. In Central Asia, this problem has evolved from a prevalence among adults (aged 20 years or more) near 40% in 2000, to values closer to 60% in 2015. On the other hand, Eastern Europe has shown a less marked increase among women (whose prevalence of overweight or obesity already exceeded 60% in 2000) and a steeper rise among men, from a prevalence around 50% in 2000 towards values closer to 60% in 2015[29] (**Figure 7**). According to data from the Global Nutrition Report 2021, in Central Asia, among adults, overweight affected 51.7% of women and 51.2% of men, while obesity affected 22.6% of women and 17.5% of men. In children and adolescents between 5 and 19 years, 19.0% and 6.4% of boys were overweight and obese, respectively, with similar numbers for girls (18.5% and 4.1%, respectively). In children under five years, the prevalence of overweight was 5.6%[22]. The Eastern European region presented higher numbers for both adult women (55.1% of overweight and 27.1% of obesity), adult men (63.1% of overweight and 23.2% of obesity), as well as children and adolescents, both female (28.2% of overweight and 11.4% of obesity) and male (20.1% of overweight and 5.5% of obesity). In this region, no data was available for children under five years[23].

Figure 7. Evolution of the prevalence of overweight plus obesity in adults (aged 20 years or more) from Eastern Europe **(A)** and Central Asia **(B)**, between 2000 and 2015. Adapted from: Institute for Health Metrics and Evaluation, 2017[29].

Diet-related non-communicable diseases

The term "non-communicable diseases" (NCDs) refers to a set of conditions that are not transmissible from person to person. They are also known as chronic diseases, as they generally tend to be of long duration and slow progression, usually requiring long-term treatment. Those include cardiovascular diseases, cancer, chronic respiratory diseases, diabetes, among others[30].

NCDs are by far the leading cause of mortality worldwide, being responsible for an estimated 41 million deaths in 2016, corresponding to 71% of the global mortality. The major causes of NCDs mortality were cardiovascular diseases (44% of all NCDs deaths), cancer (22%), respiratory diseases (9%) and diabetes (4%). In 2016, 78% of all NCDs mortality, and 85% of premature adult NCDs mortality (between 30 and 69 years) occurred in LMIC[31, 32]. In Eastern Europe and Central Asia, mortality due to NCDs have been continuously increasing during the last few decades: in 2000, NCDs were responsible for approximately 84% and 76% of total deaths in these two regions, respectively, reaching 89% and 85% of total mortality by 2019[33] (**Figure 8**).

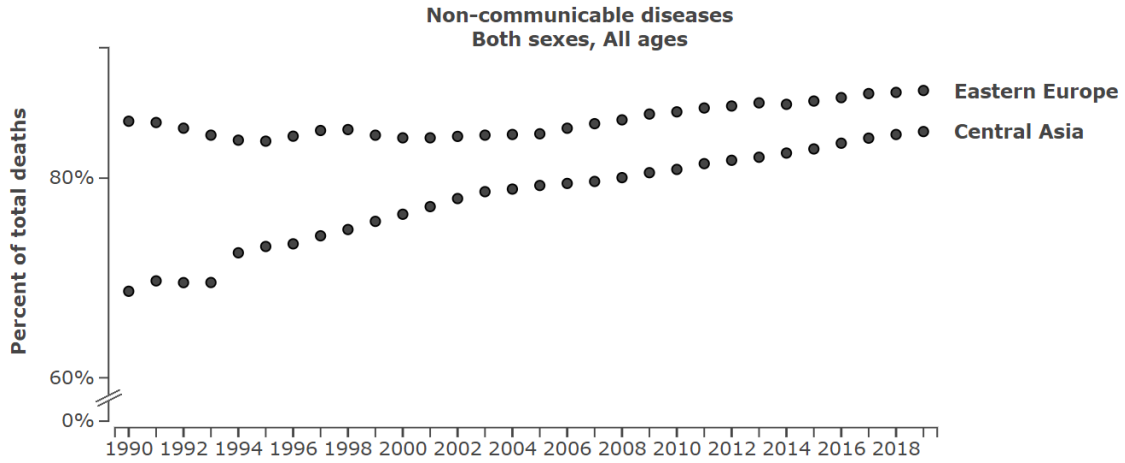


Figure 8. Evolution of non-communicable diseases mortality (% of total deaths) in Eastern Europe and Central Asia between 1990 and 2019. Adapted from: Institute for Health Metrics and Evaluation, 2019[33].

NCDs may result from a combination of genetic, physiological, environmental and behavioural determinants. Nevertheless, many leading risk factors, including high blood pressure, dietary risks (e.g. high sodium intake) and high body mass index (i.e. overweight and obesity) are diet-related[30, 33] (**Figure 9**). According to data from the Global Burden of Disease Study, in 2017 dietary risks were globally responsible for 11 million deaths and 255 million Disability-Adjusted Life Years (DALYs) among adults (corresponding to 22% of deaths and 15% of DALYs). Among all regions of the world, Central Asia and Eastern Europe showed the highest age-standardized proportions of deaths attributable to individual dietary risks (38% and 32%, respectively). Central Asia was also the region with the highest rates of diet-related cardiovascular disease mortality and disability[34]. These results reflect a very high weight of dietary factors to the burden of disease in these populations.

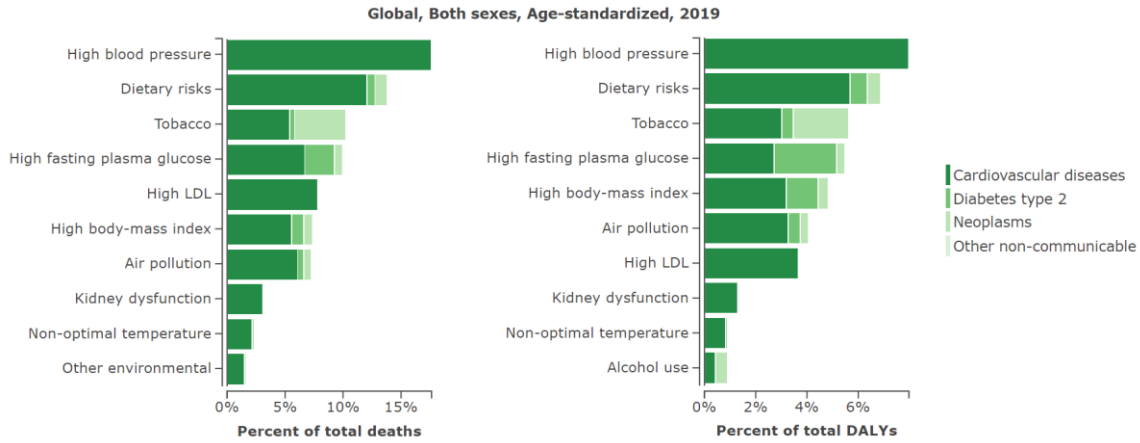


Figure 9. Age-standardized contribution to mortality and burden of disease attributable to the top 10 risk factors for non-communicable diseases in 2019. DALYs, disability-adjusted life years; LDL, low-density lipoprotein. Adapted from: Institute for Health Metrics and Evaluation, 2019[33].

1.1.5. Implications for socioeconomic development

The epidemic of obesity and NCDs poses a substantial economic burden worldwide, and may have a particularly negative impact on socioeconomic development of LMIC, by perpetuating poverty, hindering economic growth, and burdening already fragile healthcare systems[35, 36]. Overweight, obesity and other diet-related NCDs have been associated with reduction in productivity and increasing absenteeism and disability rates, as well as early retirement and premature death, that way contributing to a decrease in active life span, and consequently jeopardising the economy[28, 37]. In LMIC, where resources are scarcer and infectious diseases are still prevalent, healthcare systems face additional challenges with this rise of chronic diseases, which require prolonged treatment[28]. As a consequence, economic losses due to NCDs in LMIC are estimated to surpass US$ 500 billion/year[35, 36].

Overweight and NCDs also threaten progress towards the 2030 Agenda for Sustainable Development, which was adopted by all United Nations Member States in 2015. The Sustainable Development Goals (SDGs) are a set of 17 interlinked global goals, whose main objective is to call for urgent action by all countries to end poverty, improve health and education, reduce inequality, spur economic growth and tackle climate change. SDGs 2 ("Zero hunger") and 3 ("Good health and well-being") include specific targets to end all forms of malnutrition, including overweight and obesity by 2030 (SDG 2.2), and to reduce premature deaths from NCDs by one-third (relative to 2015) by 2030 (SDG 3.4)[38]. In 2016, the WHO Regional Office for Europe proposed similar targets on reduction of NCDs premature mortality and disability, including the SDG 3.4[39]. However, most countries, including those from Central Asia and Eastern Europe, are still not on track to achieve this target[40, 41].

1.2. POLICY ACTION TOWARDS HEALTHY DIETS: THE IMPORTANCE OF FOOD CHOICES

The unprecedented rise in the NCDs burden has been widely linked to unhealthy eating habits. As such, public health concerns have been redirecting towards changing diet-related behaviours, as well as other underlying variables affecting current food demand and consumption[42].

1.2.1. Factors influencing individual food choice

Food choices and diet-related behaviours are influenced by a complex and interrelated set of multiple factors, ranging from personal to global drivers. Although there are many conceptual models trying to explain food choice determinants and their relationships, a growing body of evidence is consensual in showing that food choices are determined by individual preferences and life experiences, in the context of a network of social, cultural and environmental determinants[43-49] (**Figure 10**).

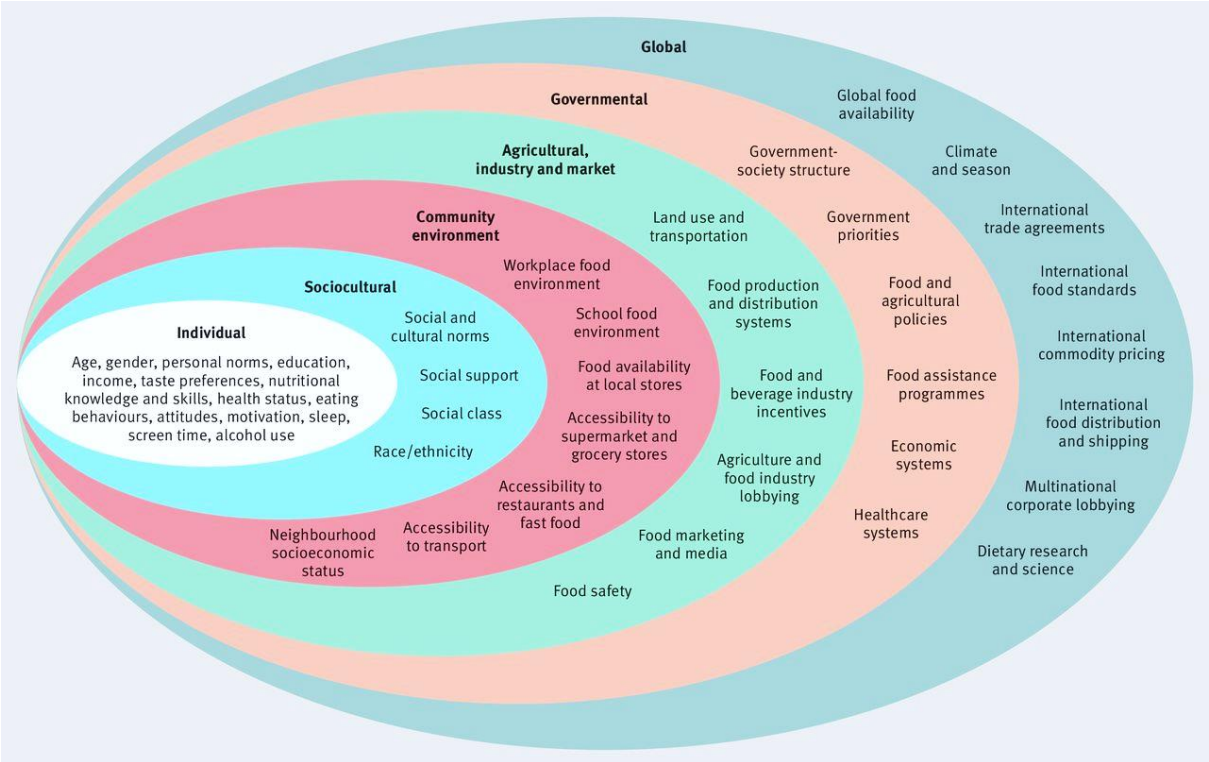


Figure 10. Multilayered influences on food choice. Source: Afshin *et al.*, 2014[49].

Environmental factors include macro- and microenvironments, both interacting with individual factors to influence dietary options and nutritional status. Macroenvironments, which include global and governmental structures, economic systems, agriculture, food industry and marketing, determine populations' diets in a more indirect way, by affecting food production, distribution, availability and pricing at a societal level. On the other hand, microenvironments (e.g. local food environments, sociocultural context, family and social networks) influence food availability, accessibility and social desirability within a person's community and household. These external factors together with individual determinants, including sociodemographic (e.g. age, sex, income), physiological (e.g. hunger, appetite, taste), psychological (e.g. emotions, motivation, personality), cognitive (e.g. knowledge, skills, attitudes) and experiential (e.g. familiarity, affective bond, memory), are responsible for continuously shaping food choices throughout the life course[43-48]. Finally, many authors also highlight food-related features, both intrinsic (e.g. sensory properties, portion size, nutritional value) and extrinsic (e.g. nutritional information, health claims, packaging) as important factors to the consumer's decision-making process[43].

1.2.2. The consumer as the centre of the food system

According to the High Level Panel of Experts on Food Security and Nutrition, "A food system gathers all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the output of these activities, including socio-economic and environmental outcomes"[50]. Situated within this concept, food environments have been described as "the interface where people interact with the wider food system to acquire and consume foods"[51]. In this context, the final consumer has been identified as an important feature of the food system, interacting with food environments in a complex, bi-directional way[42, 50, 51, 52]. It is not only the food system and the food environments that influence food choices; consumers' behaviours also shape food systems, through direct action in the food environments with which they interact, which have repercussions across the whole food supply chain (**Figure 11**).

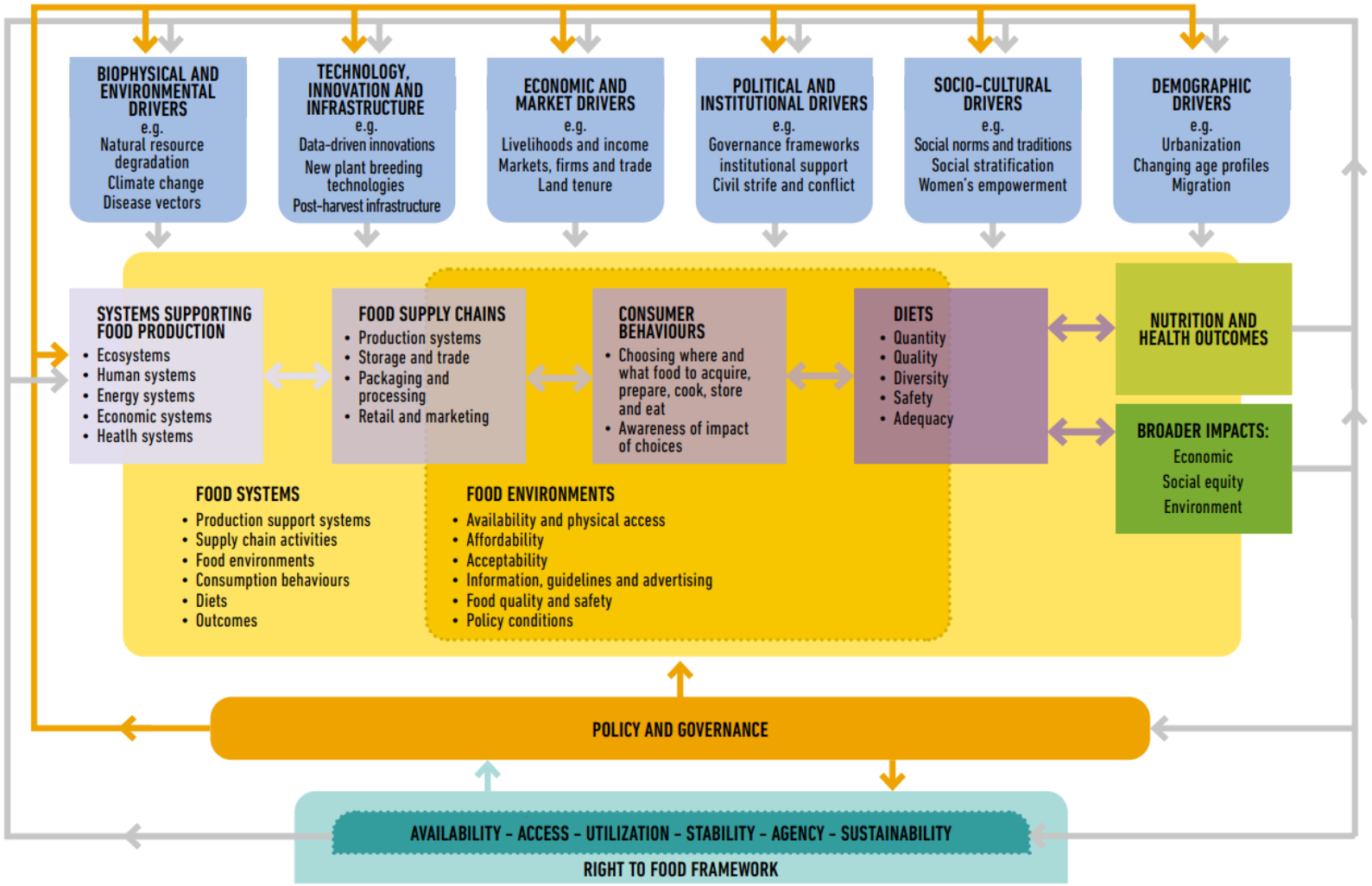


Figure 11. Sustainable food system framework, showing bi-directional interactions between consumer behaviours and food supply chains, diets and nutrition and health outcomes. Source: High Level Panel of Experts on Food Security and Nutrition (HLPE), 2020[50].

Consumers' decisions on what foods to buy and where to buy them, have effects on the demand for certain foods from retailers, which in turn has the potential to modulate their offer considering food desirability. This interconnection between demand and supply may have repercussions not only on food availability, but ultimately can lead to changes in food production. Thus, consumers' food purchases and dietary behaviours have the potential to influence both directly and indirectly all food system stakeholders, from producers and food industry, to small manufacturers and distributors[42, 52].

Individual food choice has been clearly recognized as an important feature which should be addressed when tackling the current nutrition crisis[42, 53]. Furthermore, the European Commission has recently placed consumer's food choice as one of the central targets for achieving a healthy and sustainable food system[54]. Current evidence supports multicomponent policies, comprising a set of complementary and synergic strategies at different levels of the food chain (e.g. food product reformulation, fiscal measures, nutrition education, food labelling, among others). This multi-strategical approach should be integrated in a unifying goal of facilitating food choices that are consistent with healthy diets. The involvement of all stakeholders is also crucial for the endorsement of policy efforts[42, 55]. Thus, the holistic characterisation of food environments, including both availability and consumption dimensions, seems essential for the identification of needs and priorities of action, ultimately targeting the improvement of food choices to successfully and effectively transform human health and nutrition[43].

1.2.3. Multisectoral action within the WHO European Region

The WHO European Region is comprised of 53 countries[56], which are very diverse not only regarding socioeconomic development, but also in terms of gastronomic and cultural characteristics. Despite these differences, unhealthy diets, including energy imbalance and excessive intakes of TFA, sugars and salt, seem to be a common challenge[41].

In 2014, the WHO Europe created the European Food and Nutrition Action Plan for 2015–2020, with the general goal of supporting the implementation of comprehensive and multisectoral policies to promote healthy diets and prevent obesity and other diet-related NCDs[41, 57]. The five specific objectives of the action plan were: (1) Create healthy food and drink environments; (2) Promote the gains of a healthy diet throughout life, especially for the most vulnerable

groups; (3) Reinforce health systems to promote healthy diets; (4) Support surveillance, monitoring, evaluation and research; and (5) Strengthen governance, alliances and networks to ensure a health-in-all-policies approach[57]. Main actions were delineated in a wide range of domains, and included: the promotion of easy-to-understand, consumer-friendly labelling on the fronts of packages and healthy retail environments; the improvement of the nutritional quality of foods and beverages available through product reformulation, including salt reduction programmes and TFA ban from the food supply; limitations on all forms of marketing of foods high in energy, saturated fatty acids (SFA), TFA, sugar or salt to children; creation of fiscal measures (e.g. taxes, subsidies on fruits, vegetables or other healthy foods) and pricing policies to influence diets; and strategic communication with the public to improve the ability of citizens to make healthy food choices and lifestyles (e.g. nutrition education, media campaigns, dietary guidelines, social media)[41, 57]. More recently, the Action Plan for the Prevention and Control of Noncommunicable Diseases in the WHO European Region 2016-2025 has been developed in order to achieve regional and global commitments to reduce NCDs premature mortality and disease burden, improve quality of life and promote equitable health. This action plan supported similar priority interventions, that way strengthening previous policy frameworks[39].

These action plans were adopted by all member states of the WHO European Region. Much progress is being made in the Region regarding nutrition labelling, especially on the implementation of mandatory ingredient list (98% of countries) and nutrient declarations in pre-packaged foods (90%). There has been less progress in the use of interpretative front-of-package labelling (27% of countries, mostly from northern Europe), which has been increasingly recognized as one important feature for influencing consumers' food choice. More than half of countries had energy, protein, carbohydrate, total fat, SFA, salt/sodium and total sugars as mandatory nutrients provided in nutrition declarations, but a much lower proportion imposed the display of TFA (6% of countries), added sugars (8%) and dietary fiber (8%)[58].

In 2010, Central Asia and Eastern Europe were among the regions with the highest mean sodium intakes (5.51 g/day and 4.18 g/day, respectively)[59], corresponding to more than twice the daily intake recommendations[60], and no updated data on these regions were published ever since. However, great efforts have been made on salt reduction, as almost half (47%) of

the countries within the WHO European Region have fully adopted national policies to reduce population salt consumption[61]; and more than half (55%) have already implemented mandatory or voluntary product reformulation measures regarding this nutrient. Less countries reported product reformulations on other relevant nutrients, namely sugar (37%) and TFA (24%)[58]. Taking into account the example of salt reduction, it has been proposed that similar strategies on product reformulation to reduce sugar content could be effective in reducing sugar intake in populations[62]. In 2015, the WHO Regional Office for Europe released a policy brief towards the elimination of TFA (which are mostly industrially-produced) from the food supply, through replacement with unsaturated fats[63]. In 2017, 62% of countries from the WHO European Region have implemented national policies to virtually eliminate industrially-produced TFA from the food supply[61]. However, most countries, including those from Eastern Europe and Central Asia, still did not have implemented a legislative ban on TFA in food products[58]. Those mandatory policies have already been adopted by the Eurasian Economic Union and the European Union, limiting the TFA content in foods to a maximum of 2% of total fat[64, 65].

Many countries in the WHO European Region have also taken steps to regulate or guide marketing of food products to children, especially through television (43% of countries), radio (39%) or the internet (29%), although monitoring was still not widespread (11%). Regarding fiscal policies, only 10 countries, mostly from western and northern Europe, reported the adoption of health-related taxes applied to foods or drinks, targeting most frequently sugar-sweetened soft drinks. The majority of countries (82%) reported launching media campaigns to promote healthier diets, the most common objectives being to raise awareness on the health effects of high intake of fats, sugars and salt/sodium (39%) and how to include more fruits and vegetables into the diet (37%)[58]. Regarding the existence of national nutrition surveillance systems, in 2017, more than one-third of the WHO Europe countries (36%) had no nationally representative survey, the main gaps occurring in Central and Eastern European countries[66].

1.3. AWAY-FROM-HOME EATING: A RISING TREND IN TRANSITIONAL SOCIETIES

In urban settings from LMIC, one of the biggest changes in lifestyle-associated eating patterns has been the increase of food consumption outside the home[67]. In this new socio-demographic and economic paradigm, factors such as the increasing number of women in the labour market (who in the past were entirely dedicated to housework), the growing number of working hours and the long commutes to work (often from peri-urban areas to urban centres), have limited the time available to prepare and cook meals at home[68-73]. This has made away-from-home food sources, such as street-vended and takeaway foods, to be seen by the urban dwellers as excellent options either for their main meals or mid-day snacks. However, frequent consumption of food outside the home has been associated with lower dietary quality, higher energy, total fat and SFA intake, and lower micronutrient intake[74], being also reported as a risk factor for weight gain[75], overweight and obesity[76]. This justifies the importance of the assessment of out-of-home food environments in settings that are under epidemiologic and nutrition transitions.

1.3.1. Street food

Street food has important historical roots, which remain since the ancient times. This phenomenon has been evolving concomitantly with the social and economic transformations of various civilisations throughout global history. In Eastern Europe and Central Asia, street food carries a legacy with centuries of existence. The first traces of street food on the European continent date back to the 6th century B.C. in ancient Rome, appearing together with the development of the first primordial cities[77]. In some ancient Asian countries, eating foods prepared by persons of another caste was forbidden. Thus, street food in Asia is a more recent phenomenon, the concept proliferating from the 1940s until the present days[78].

Street foods were defined by Food and Agriculture Organization (FAO) in 1988 as "ready-to-eat foods and beverages prepared and/or sold by vendors and hawkers especially in streets and other similar places"[79], this definition being reiterated by the WHO a few years later[80]. Street-vended foods can be highly heterogeneous (encompassing from drinks and small snacks to main dishes), this being one of their main characteristics. A great variation in terms of their ingredients, portion sizes, methods of preparation and cooking used, as well as the

degree of processing (ranging from unprocessed or minimally processed to ultra-processed food items), makes their nutritional value very diverse, as well[68-70, 81, 82]. The nature of the foods and beverages sold also varies greatly by country (and sometimes by city) due to cultural, ethnic and religious differences, thus justifying location-specific characteristics of offer and consumption. On the other hand, some industrialized foods and beverages can be widely found, due to the modern globalisation of the food supply chain and westernisation of food habits[68, 71]. Street food vending sites are mostly located in busy streets, in the vicinity of people-gathering places (e.g. bus stops, railway stations, schools, workplaces, hospitals), aiming to be as convenient to its customers as possible[68, 71, 83]. They usually present quite rudimentary physical setups, with foods and beverages being sold from pushcarts, bicycles, food stands or stalls without permanent walls, among others. Vendors can be mobile, in which case they change their position (continuously or not) throughout the day or week, or stationary, in which case they have a fixed location[68, 70].

In 2007, street food was estimated to be consumed each day by 2.5 billion people globally, being most commonly sold in urban areas from LMIC[68]. In Bamako, capital city of Mali, it was estimated that 19-27% of the average family budget was spent on street food[84]. In a study conducted in Turkey featuring high school and university students, 40.1% reported eating street food two to three times per week, and 23.3% every day[85]. A study conducted in the schools of two municipalities of Dar es Salaam, Tanzania, showed that 97% of schoolchildren purchased food from street vendors, of which 67.5% purchased it every day[86]. A national cross-sectional survey of South African adults found that 11.3% of population bought street food two or more times a week[87]. In Cape Town, the capital city of South Africa, a study on street food consumers reported that 43.3% consumed this type of foods two to three times a week, while 38% consumed it almost daily[83]. In Nairobi, data showed that in 78% and 53% of households in Korogocho and Dandora, respectively, street food was consumed at least once a week[72]. In another cross-sectional study, conducted in the market circle area of Takoradi, in Ghana, the reported frequency of consumption of street food was 6.76 ± 4.844 times per week (mean ± standard deviation)[81]. Finally, in a sample of Nigerian urban market women, street food provided 63% of the weight of total food consumed[88]. Street food is low in cost when compared to more formal food services like restaurants, still offering appealing alternatives to home-cooked food. Relatively low prices are set due to the consumers' limited purchasing

power, together with high competition from numerous fellow vendors. Since ingredients are frequently bought from vendors at the cheapest markets and in large quantities, and they have low or no rent to pay, the cost of a single serving can be very competitive even in comparison to home-cooking (especially taking into account not only the cost of food, but also the time, energy and cooking equipment needed)[68-70, 72, 81]. Although street food is consistently and regularly consumed across all income groups, it has been reported that many people from the lowest socio-economic strata (who often lack proper housing and cooking facilities) depend almost exclusively on street-vended meals in their daily diets[68, 70, 72].

One of the main advantages of the street food sector is its importance as a source of employment and livelihood for millions of people with little or no income and low educational level. Starting a street food business is attractive to vendors, since it requires a very low initial capital investment, and no special skills and training other than experience preparing and cooking foods are needed[68-70, 89]. For this reason, and as reported by various studies conducted in LMIC, the majority of street food vendors are poor, unskilled women[68, 70, 82, 88, 90] with limited formal education[68, 82, 90-92], and street food enterprises are commonly individual- or family-based[68, 70, 89]. However, street food's importance for the economy is not limited to its vendors and their families, as this business presents a beneficial impact for all other stakeholders involved. Since many of the ingredients used by the vendors are bought from local markets, which in turn are supplied by local farmers, street food vending supports local production and retail, contributing to small-scale and sustainable food supply chains. On the other hand, the street sale of industrially-produced ready-to-eat foods and beverages also provides support for more formal large-scale food processing industries. However, mostly due to the informal nature of the street food trade, its positive contributions to developing economies have been greatly underestimated and neglected[68, 70]. From the consumer's point of view, besides the benefits of being a source of economical, accessible, convenient, tasty and satisfying meals, street food also provides a set of culturally and socially appropriate food options. Street food trade reflects traditional and regional cultures and culinary practices, that way contributing to keep gastronomic heritage alive[68-70, 87]. Furthermore, with the recent rise of gastronomic tourism, street food is also becoming a great attraction to foreigners seeking to experience the unique and authentic flavours of the local cuisine, increasingly valued by travellers as an important dimension of the culture of a given country, city or region[69, 71, 87, 93].

From a nutrition-related standpoint, street food makes a significant contribution to the diet of many dwellers in LMIC, particularly in urban areas. A systematic review by Steyn *et al.* evaluated a total of twenty-three studies conducted in developing countries that included data on the nutritional value of street food. This review reported that street food's contribution to total energy intake ranged from 13% to 50% in adults, and from 13% to 40% in children. The majority of studies with protein data revealed a contribution to protein intake equal to or higher than 50% of its Recommended Dietary Allowance. Only a few studies provided information on micronutrients, and those showed that street food contributed significantly to the intakes of iron and vitamin A, and to a lesser extent, of calcium, thiamine and vitamin C[69]. In fact, it has been recognized by many authors street food's great potential for reducing urban food insecurity, especially in the most vulnerable populations. The provision of varied, affordable and fulfilling meals for people who otherwise would not have access to foods, may help them meet their nutritional needs. Furthermore, by generating significant employment and income, street food has an important role in alleviating poverty, a major causative factor of food insecurity[68, 71, 82, 87]. One work have also identified street food as a promising vehicle for micronutrient supplementation, which would aim to further improve food security and reduce prevalence of malnutrition-related diseases in developing settings[94]. Still, street food generally presents an inadequate nutritional profile, characterized by a high content of nutrients that, when consumed in excess, are harmful to health. Results from the same systematic review indicated that street food made a high contribution to the intakes of total fat (particularly SFA and TFA), sugar and salt[69], which is in line with more recent studies. A study conducted in Maputo, capital city of Mozambique, which assessed the nutritional value of homemade street foods, found a high energy density (reaching 430kcal/100g) and fat content (reaching 21.0g/100g) in some popular food options. It also found that almost all food samples analysed had high values of sodium (ranging from 90 to 455mg/100g) and sodium to potassium ratio (ranging from 1.89 to 11.95)[95]. Another work conducted in Kampala city, Uganda, which evaluated the contribution of street food to the diet of habitual consumers, showed a very high contribution to the daily intakes of total fat and sodium, with mean values of 49.1% and 38.4%, respectively[96]. In India, a study on the nutritional content of snacks sold by street vendors showed a high mean total fat content in both rural and urban settings (28.8g/100g and 29.6g/100g, respectively). The authors also analysed the fatty acid profile of

frying oils, and found high levels of SFA and TFA (reaching levels of 69% and 30% of total fat, respectively)[97]. Studies describing the types of street-vended foods and beverages available identified a high frequency of ultra-processed food products, mostly chips, candies, chocolates, cookies and soft drinks[69, 83, 87, 91, 95], which are usually rich in fat (SFA and TFA), sugar and/or salt. Unhealthy culinary practices, as well as the widespread utilisation of ingredients rich in these nutrients, such as TFA-rich fats and oils and sodium-rich powdered chicken stocks, have also been reported[97, 98]. This demonstrates the influence of the nutrition transition process occurring in LMIC on their street food environments, which is especially concerning if we take into account the double burden of disease that LMIC are currently going through. A set of three studies conducted in Palermo, Italy, found associations between habitual street food consumption and cardiovascular risk factors, namely higher body mass index and uric acid levels, lower high-density lipoprotein cholesterol levels, hypertension and endothelial dysfunction[99-101]. Although these results are from a high-income country, whose street food offer, dietary habits and epidemiologic reality could be very distinct, current evidence on nutritional composition of street food from LMIC suggests that its frequent consumption may lead to similar negative health outcomes.

Another important issue regarding street food is related to its hygiene and safety. Street food vending sites frequently lack appropriate layout and facilities for the preparation and sale of foods, such as access to clean water to sanitize hands and utensils, as well as electric power and equipment for storage and maintenance of food at correct temperatures. Even its own location (close to busy streets) exposes foods to a higher risk of contamination by physical, chemical and biological agents. More importantly, it has been reported that both vendors and customers have low understanding on proper hygiene and food handling techniques, and are not aware of its importance in the prevention of foodborne diseases[69-71, 102]. Street vending usually belongs to the informal sector, which typically describes loosely organized economic activities, without any official registration formalized near competent authorities. This sector often includes features such as self-employment, employees who are not legalized, and casual, unorganized labour. Street vendors have been known to regularly face problems with local authorities, since their activity is usually not licensed. The exponential and uncoordinated growth of clusters of vending sites has been frequently considered as hazardous to urban planning and public health. Vendors often obstruct both pedestrian and motorized traffic, impairing the normal and correct

functioning of increasingly congested cities[68, 70, 71]. This informal organisation makes it particularly difficult to introduce any type of official initiative, such as regulation and monitoring of the conditions of the premises, the hygiene and food handling practices of the vendors and food contamination, as well as the assessment and interventions in terms of the nutritional value of the foods and beverages sold. However, eliminating vendors from the streets may not be an appropriate solution, due to the widely known benefits of the street food trade to the economy and nutrition of populations. Instead, governments should legalize, regulate and support street vendors[103] as a valuable part of the local food supply chain, while attempting to minimize its health-related issues, in order to provide safe and healthy street-vended food for all.

Global research on street food has been increasing over the past few decades (**Figure 12**), reflecting the growing interest of this subject for public health and nutrition researchers. However, studies have been more focused on aspects of food safety (mostly microbial contamination analysis and food handling practices). Meanwhile, studies focusing on topics related to street food availability and consumption, especially those including data on its nutritional composition, remain very scarce (**Figure 13**). Furthermore, the majority of research have been conducted in countries from Africa and southern Asia (**Figure 14**)[104].

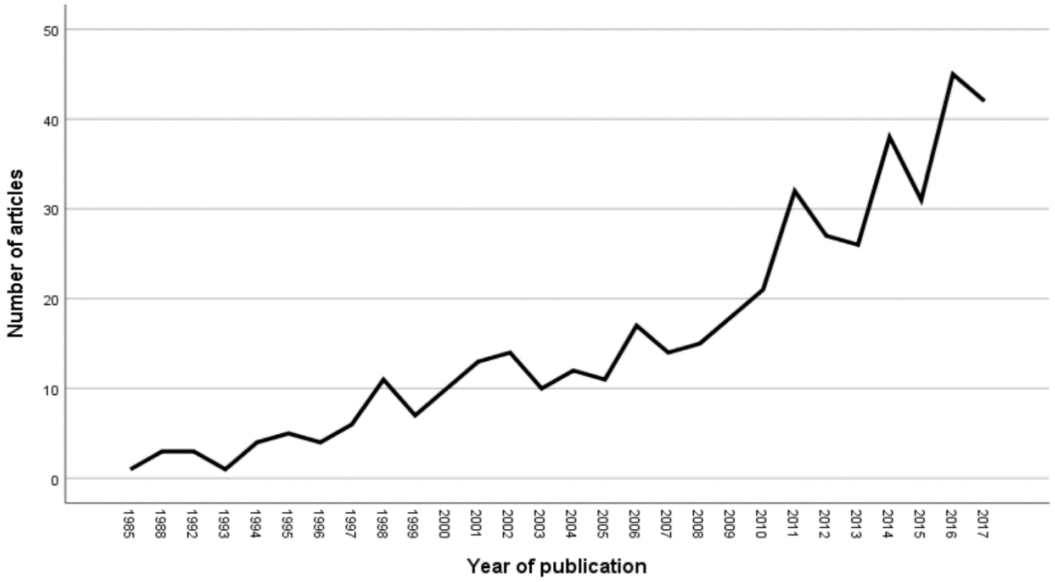


Figure 12. Temporal evolution of the number of articles addressing street food, published from inception to 16 October 2017 (n = 441). Source: Abrahale *et al.*, 2019[104].

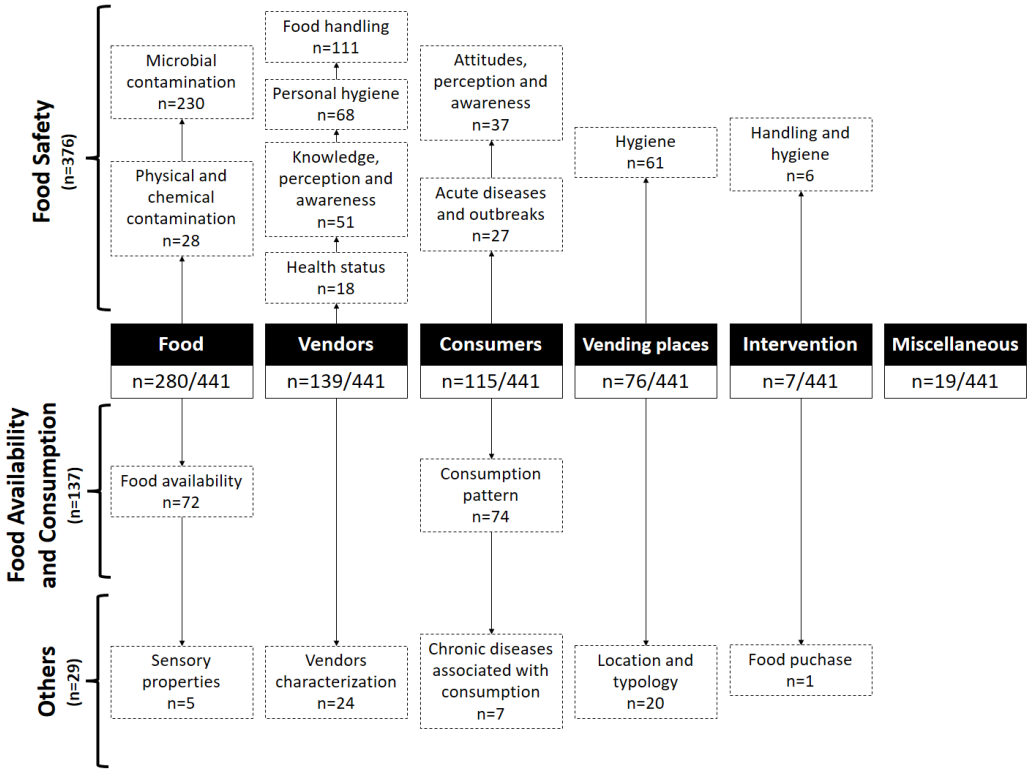


Figure 13. Main focus of the articles addressing street food, published from inception to 16 October 2017 (n = 441), by main category (black background) and sub-category (dotted line), according to the major subject covered (food safety, food availability/consumption, others). Source: Abrahale *et al.*, 2019[104].

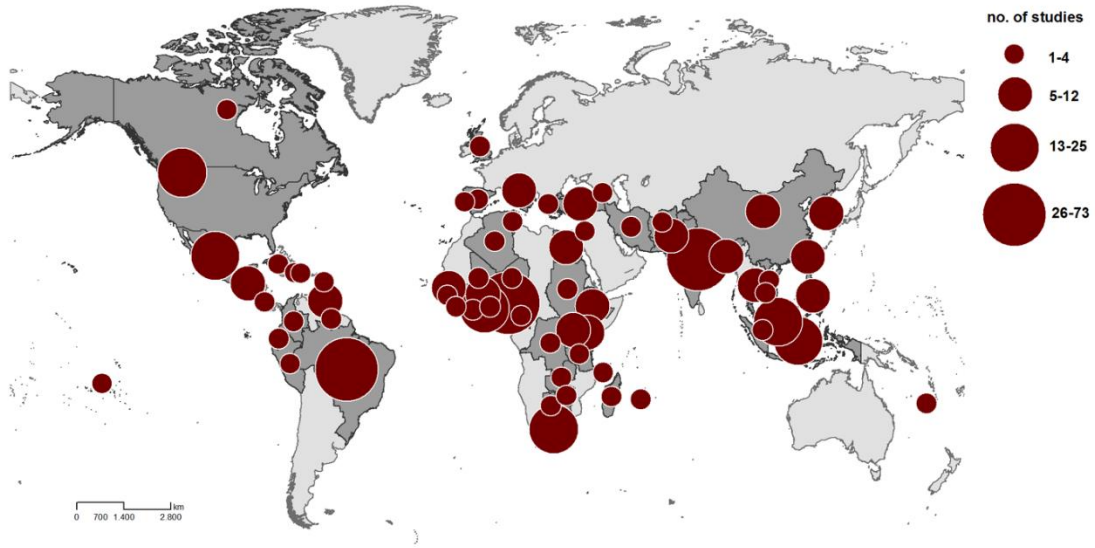


Figure 14. Geographical distribution of articles addressing street food (n = 456*). *The total number of studies considered includes multicentre studies. Source: Abrahale *et al.*, 2019[104].

1.3.2. Takeaway food

Takeaway food is another important source of out-of-home ready-to-eat foods and beverages, commonly available in some urban settings. Although there is no formal, standardized definition, a takeaway food vending site was defined by the United Kingdom authorities, as "an outlet whose primary business is the sale of ready-to-eat food and beverages for consumption off the premises"[105]. Takeaway meals can be bought either from small independent outlets, or from national/multinational fast-food chains, and may include a variety of different foods (e.g. main dishes, sandwiches, cakes, savoury pastries). Unlike street food, takeaway food has a relatively recent history, and is usually sold in more formal venues, thus being more popular in developed western societies[106, 107]. Nevertheless, LMIC under nutrition transition have been facing increasing trends in takeaway food consumption, as well[108].

Frequent consumption of takeaway ready-to-eat meals have been associated with poorer dietary quality, including lower intakes of fruits, vegetables, low-fat dairy, whole cereals and lean meat[109-111] and higher intake of sugar-sweetened beverages[109, 110], as well as higher cardio-metabolic risk factors[112], increased prevalence of abdominal obesity[111], higher body mass index and greater odds of obesity[113]. Takeaway foods have also shown an unfavourable nutritional profile, with high levels of energy, total fat, SFA and TFA, sugars and sodium being reported[114-119]. Still, it is crucial to underline that the majority of studies performed to date investigating takeaway food have been conducted in high-income countries, and mostly directed towards fast-food restaurants, while takeaway meals from small independent outlets have been overlooked[107]. Additionally, evidence suggests that takeaway foods can differ greatly in their nutrient content depending on the type of foods being sold (e.g. Indian, Chinese, pizza, kebab)[114, 115, 118]. Therefore, research on the nutritional value of foods and beverages from takeaway food outlets in low- and middle-income settings where their consumption is common would be an important step in fulfilling this paucity of data.

1.3.3. Street food environment description in cities from Central Asia and Eastern Europe

Street trade has always been a well-developed sector of activity in central Asian urban areas. The majority of street food vendors are located in typical public markets (*Bazaars*) or near the main bus terminals. In cities from Central Asia, food availability and gastronomy reflect the

influence of the Silk Road (an ancient network of trade routes connecting Asia and Europe) and, more recently, the westernisation of food habits. As such, although local traditional foods remain widely available, food products by large-scale manufacturers are becoming increasingly popular. Some typical dishes, such as *Plov* (rice cooked in a seasoned broth with a mixture of spices, vegetables and other ingredients, such as meat, fish and/or dried fruit), *Lagman* (noodle dish made of chopped peppers and other vegetables, served in a spicy, vinegary sauce) and *Shashlik* (skewered grilled cubes of meat, alone or with alternating pieces of fat and vegetables) are very popular street foods in Central Asia. Savoury pastries, like *Pirozhki* (baked yeast pastry commonly stuffed with meat and/or vegetables), *Chebureki* (fried savoury pastry generally filled with ground or minced meat and onions) and *Samsa* (baked puff pastry usually filled with ground meat and vegetables) are also frequent. *Kurut* (salty snack made by straining and drying sour milk or yoghurt) and boiled corn cob are other examples of traditional foods. Traditional beverages, such as *Kvass* (fermented beverage made from rye bread) and *Kompot* (homemade beverage obtained by cooking fruit in a large volume of water, often with sugar or raisins) are also characteristic of these street food environments. Finally, availability of hamburgers, hot-dogs, pizza, french fries, ice-cream, popcorn, cakes, pancakes, soft drinks and fruit juices is a common feature[120-124].

In cities from Eastern Europe, street vending sites are either concentrated close to city centres, or widespread throughout the whole urban areas, usually near public transport stops. In this region, the food environments appear to be transitioning to a more mixed offer, with supermarkets, fast food outlets and takeaway food vending sites also taking part of the urban food panorama, in addition to street food vendors in the traditional sense[125-127]. In cities from Bosnia and Herzegovina, for example, both street food and more formal takeaway food establishments, such as *Buregdžinica*s (places selling savoury pies), *Ćevabdžinicas* (places selling barbecue) and *Pekaras* (bakeries), seem to play an important role in the urban foodscape. In these closed or semi-closed establishments, customers may purchase ready-to-eat foods through a window selling directly to the street, or they may be required to enter the premises. Either way, foods and beverages are bought to be consumed off the premises. As such, although these types of vending site do not fall within the classic definition of street food[79, 80], they have been reported as major sources of ready-to-eat foods and beverages available for consumption in the streets[125, 126]. Amongst the most popular street foods in the eastern

European region are *Burek* (savoury pie, usually filled with meat or, in other versions, vegetables, potato or cheese) and *Cévapi* (beef or lamb minced meat rolled into small sausages seasoned with spices, usually served with onions in a traditional flatbread, *Somun* or *Lepinja*). *Fornetti* (individual puff pastries with a sweet of savoury filling, namely jam, chocolate, cheese, vegetables or meat) is another popular food option. Both traditional and westernized sweet and savoury snacks are common, and comprise a variety of cakes, ice-cream, popcorn and confectionery, as well as pretzels, nuts and seeds. Food products such as pizza, hamburger, hot-dog and french fries are also commonly present, reflecting influences from the globalisation of the food supply. Regarding beverages, a coexistence of both traditional fermented drinks, including *Ayran* (dairy-based fermented beverage made from sheep's milk) and *Boza* (fermented low-alcoholic beverage made from wheat and/or corn, millet or barley), and more westernized options such as soft drinks and industrial fruit juices, is likewise observed[120, 125-127].

Until very recently, no quantitative data on ready-to-eat food availability, consumption and nutritional value in the regions of Eastern Europe and Central Asia existed. Results from the FEEDcities project came to bridge this gap of knowledge, and showed high availability of a wide variety of both homemade and industrial food items. In all cities assessed, it was reported that the most common foods available were generally energy-dense and rich in total, SFA and TFA, and sodium, frequently reaching or even exceeding their respective maximum daily dietary recommendations in one single serving, while presenting low contents of potassium. Although free sugars content was not analysed, it was also probably high, due to very frequent availability of sugary foods and beverages, such as cakes, cookies, candies and sugar-sweetened drinks. While industrial food products expectedly showed unhealthy nutritional profiles, homemade foods were also frequently reported as rich sources of both sodium and TFA, suggesting the common use of unhealthy fats and cooking methods such as frying, as well as the excessive addition of salt and salt-rich processed ingredients (e.g. sauces)[121-130]. These findings raise concerns regarding the potential impact of these food environments in the nutritional and health status of these urban populations. However, although food availability is an important factor influencing consumption, there are other determinants, including individual factors, which also play an important role in shaping food choices (as described in more detail in chapter 1.2), the same being observable in out-of-home food

settings[106]. Therefore, the study of street food availability shall be complemented with the assessment of the consumers and their purchasing behaviours, in order to have a much more comprehensive view of both environmental and individual dimensions of these street food environments.

2. OBJECTIVES

2.1. General Objective

This thesis aimed to characterize street food purchasing patterns in seven cities from Central Asia (*Dushanbe*, Tajikistan; *Bishkek*, Kyrgyzstan; *Ashgabat*, Turkmenistan; and *Almaty*, Kazakhstan) and Eastern Europe (*Sarajevo* and *Banja Luka*, Bosnia and Herzegovina; and *Chișinău*, Moldova), specifically the customers, their purchases and respective nutritional composition.

2.2. Specific Objectives

To achieve the general goal of this thesis, the following specific objectives were delineated:

1. To describe street food customers' characteristics (sex, age, and weight status) and their purchases, including types of foods and beverages bought and their quantities; **[Papers I to III]**
2. To estimate the street food purchases' nutritional value, namely energy, macronutrients, including protein, carbohydrates, total fat and lipid profile (SFA, monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA) and TFA), as well as sodium and potassium contents, and to compare these values with international population nutrient intake goals; **[Papers I to III]**
3. To assess patterns of purchase, considering both temporal (throughout the day) and spatial (city centre *versus* periphery) distributions. **[Papers IV and V]**

3. METHODS

3.1. THE FEEDCITIES PROJECT

In order to achieve the goals of this thesis, data from the FEEDcities (Food Environment Description in cities from Central Asia and Eastern Europe) research project, whose main objective is to characterize the street food environment in cities from Central Asia and Eastern Europe, were used. This project resulted from bilateral partnership between the WHO-Europe and the Institute of Public Health of the University of Porto (ISPUP), in strict collaboration with other organic units from this University: Faculty of Medicine (FMUP), Faculty of Nutrition and Food Sciences (FCNAUP) and Faculty of Pharmacy (FFUP).

This is a multi-country cross-sectional study, which has been already implemented in seven cities. In 2016, four assessments were conducted, in *Dushanbe*, Tajikistan (April and May), *Bishkek*, Kyrgyzstan (June and July), *Chișinău*, Moldova (between June and August) and *Ashgabat*, Turkmenistan (October); and in 2017, three studies were further implemented, in *Sarajevo* and *Banja* Luka, Bosnia and Herzegovina (between June and August) and *Almaty*, Kazakhstan (July and August).

The methodology of this research project is based on a stepwise, standardized framework, comprising three steps: step 1 corresponds to the characterization of the vending sites and food offer; step 2 corresponds to the description of the customers and their purchasing patterns; and step 3 corresponds to the collection of food samples for chemical analysis. The present thesis will focus on data retrieved from steps 2 and 3 of these evaluations. The FEEDcities general methodology was described in a previously published protocol[131] (**Annex 1**) and the specific methods implemented in the studies of this thesis will be detailed below. For the purpose of this thesis, a cross-sectional evaluation of street food customers and the food and beverages purchased, as well as the estimation of the nutritional composition of these purchases, were conducted in each of the seven cities studied.

3.2. ELIGIBILITY CRITERIA

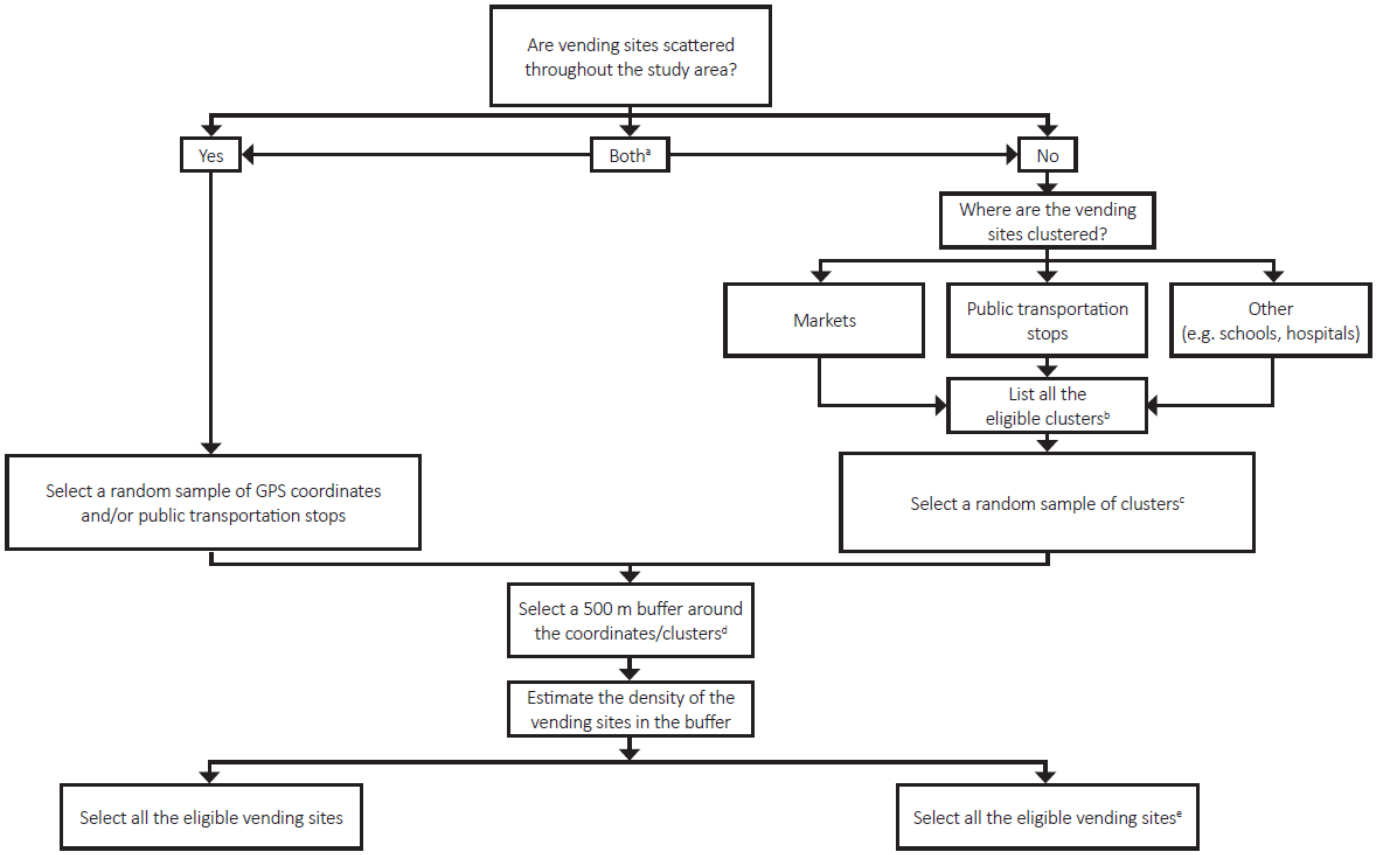
The definition of "street foods" proposed by FAO and WHO, as "ready-to-eat foods and beverages prepared and/or sold by vendors or hawkers especially in the streets and other

similar places"[79, 80], was adopted in order to select the street food vending sites where participants were selected. In Bosnia and Herzegovina, takeaway food vending sites were also identified as common sources of ready-to-eat foods to be eaten on the street, and therefore were also considered eligible for the study. As such, for this country the definition of a takeaway food vending site proposed by the United Kingdom authorities, as "an outlet whose primary business is the sale of ready-to-eat food and beverages for consumption off the premises"[105] was also used. These definitions included both stationary (street food and takeaway) and mobile (street food) vending units selling foods and beverages (hereafter referred to as food items) ready to be consumed immediately without needing further preparation. Eligible food items comprised both cooked (e.g. main dishes, savoury pastries) and uncooked (e.g. salads, sandwiches) options, and ranged from *in natura* (e.g. fruits, nuts) to ultra-processed (e.g. soft drinks, candies) food products. Vending sites selling exclusively non-prepared fruit and vegetables or other not ready-to-eat raw foods (e.g. meat, fish) were not eligible.

Any customer approaching one selected vending site to buy ready-to-eat food items during a pre-specified observation period was eligible.

3.3. SAMPLING PROCEDURES

Sampling was carried out in accordance with the specificities of each city, regarding geographic distribution and density of vending sites, and was defined for each of the settings after a preliminary field visit and taking into account information provided by the respective WHO country offices and local authorities. In each city, a set of decision rules for the definition of the study areas and selection of the vending sites was followed (**Figure 15**).



[a] In this case, follow both left-hand and right-hand arms.
b Samples of one or more types of cluster may be considered; exclusion criteria may be defined according to the characteristics of each cluster (e.g. restriction to major public transportation hubs).
[c] A stratified sample may be appropriate to ensure equitable representation of specific places (e.g. districts, markets of different sizes).
[d] The proposed buffer dimension is based on our previous experience, but it may have to be adjusted to the density of vending sites or the size of clusters (for example, when vendors concentrate in places that occupy a larger area, such as markets, buffers with a larger area may be more appropriate).
[e] Define the number of vending sites to be invited to participate (e.g. all, every two, every five) according to the density of vending sites and the intended sample size.

Figure 15. Decision rules for the selection of the vending sites. GPS, Global Positioning System. Source: World Health Organization Regional Office for Europe, 2019[131].

In all cities except *Banja Luka*, the vending sites were clustered in and around public markets. As such, a sample of the markets identified in each of those cities was selected. In *Dushanbe* (Tajikistan), *Bishkek* (Kyrgyzstan) and *Almaty* (Kazahkstan), a total of ten markets were randomly selected. In *Ashgabat* (Turkmenistan) and in *Sarajevo* (Bosnia and Herzegovina), four and ten markets, respectively, were chosen by local authorities. To define the study areas, buffers with a 500-meter diameter were defined around each of the selected markets (in *Sarajevo*, exceptionally, a 1500-meter diameter buffer was needed for the main city market, *Markale*). In *Chișinău* (Moldova), since most vending sites were concentrated in and around the central market, only this market was selected, and a 1000-meter diameter buffer zone was drawn from its centroid. Each buffer's diameter was defined in order to cover the entire market and its surroundings.

Unlike other cities, in *Banja Luka* (Bosnia and Herzegovina) the vending sites were not only clustered in and around the main city market (*Gradska tržnica*), but also distributed around public transportation stops (bus stations). In this case, this market was selected, along with 10 bus stops, each of which corresponded to the main station of the city bus routes. To define the study area, a 1500-meter diameter buffer was drawn around the centroid of the main city market, and for each bus stop, the buffer diameter was 100 meters.

Within the study areas defined for each city, local field researchers working in pairs canvassed all publicly accessible streets, and identified all eligible vending sites. Then, a systematic selection of the vending sites was performed, based on the estimated density of vending sites in each study area and the expected overall number of customers, in which one out of every ten (*Dushanbe*), one out of every four (*Bishkek*, *Almaty* and *Chișinău*) and all vending sites (*Ashgabat*, *Sarajevo* and *Banja Luka*) identified in each city were selected.

In each selected vending site, customers buying any food or beverage meeting the abovementioned criteria, were observed. The observation period started at the next multiple of five minutes and ended after 10 minutes (in *Sarajevo*, *Banja Luka* and *Chișinău*) or 15 minutes (in *Dushanbe*, *Bishkek*, *Ashgabat* and *Almaty*), or when a maximum of four customers were observed, whichever came first. If no customer was observed during this time period, field researchers would move on to the next vending site. Observations were made over consecutive days of the week and/or weekend, and covering the normal businesses' working hours in each city.

3.4. DATA COLLECTION

Data on customers' characteristics and their purchases were collected by direct observation of each selected vending site. Observations were performed by trained local field researchers located at a distance sufficient for not interfering with the vendors' businesses or the normal behaviour of the customers.

For each customer observed, the two researchers independently described the food items purchased and their quantities, as well as the customers' sex and estimated age (in years: <18, 18-24, 25-34, 35-44, 45-64 or ≥65) and body mass index (BMI)-based weight status (underweight, normal weight, overweight or obese). Disagreements on the food items purchased or their quantities were eliminated using a set of standardized criteria (**Table 2**). Regarding age or weight status, customers in which there was no agreement between observers were excluded from any analysis involving these two variables. No disagreements occurred regarding customers' sex.

Table 2. Decision rules for the elimination of conflicts of observation regarding food items and quantities purchased.

Type of disagreement	Criteria used	Example
Disagreements on the food items purchased		
The two observers registered two different food items	Conflicting food items were checked for its availability on the corresponding vending site*	Observer A registered "coffee" and observer B registered "tea". The corresponding vending site did not have coffee available. It was assumed that the customer purchased tea.
The two observers registered the same food item, but with different degrees of specificity	The broadest observation was assumed	Observer A registered "samosa" and observer B registered "chicken samosa". It was assumed that the customer purchased samosa.
The two observers registered a different number of food items	The most complete observation was assumed, unless the conflicting item was not available in the corresponding vending site	Observer A registered "samosa" and observer B registered "samosa" and "tea". It was assumed that the customer purchased samosa and tea. If the corresponding vending site did not have tea available, it would be assumed that the customer purchased samosa.
Disagreements on the quantity purchased		
The two observers registered the same food item, but different quantities	The average quantity between the two observations was assumed	Observer A registered 200mL of tea and observer B registered 300mL of tea. It was assumed that the customer purchased 250mL of tea.

*Observations should be excluded in the cases where the availability criterion does not solve the conflict: (1) if the conflicting food items are both available at the corresponding vending site; or (2) if none of the conflicting food items are available at the corresponding vending site. These particular situations did not occur in any of the cities studied.

The food items purchased were classified according to their nature as: homemade (foods and beverages that were prepared and/or cooked at home or in the street, even if using industrial ingredients) or industrial (foods and beverages that were produced by the food industry and sold as such, with no further preparation). Based on the WHO nutrient profile model[132], and taking into account similarities of composition, the food items purchased in each city were also categorized into food groups.

Geographic location, using Global Positioning System (GPS) coordinates, as well as time of beginning and end of observation, were recorded for each vending site observed. Each selected market/bus stop was classified as central or peripheral, according to their distance to the city centre reference point, assigned in each setting taking into account information provided by the respective WHO Country Offices and local authorities. Then, vending sites were classified as central or peripheral depending on whether they were located in or near central or peripheral markets/bus stops, respectively. The duration of the observation was also calculated for each vending site, as well as the customer influx (which was computed as the number of customers observed per 10 minutes of observation) and the food items buying rate (number of food items purchased per 10 minutes of observation). Purchases were categorized taking into account city location (city centre *versus* periphery) and time of the day, on an hourly basis (i.e. [09:00-10:00[, [10:00-11:00[, etc.).

3.5. NUTRITIONAL COMPOSITION ESTIMATION

The food items most frequently available in each city were identified during step 1 of the FEEDcities project, which assessed food availability. Taking this information into account, the nutritional composition of the food items purchased was estimated using data either from chemical analyses (for a pre-selected group of the most frequently available food items in each city) or food labels, standardized recipes or food composition tables (for the less commonly available).

For the collection of the food samples for chemical analysis, in most cities the 20 homemade and the 10 industrial food items most commonly available, excluding those whose nutritional composition was considered to be well documented (i.e. tea, coffee, soft drinks, water and fruit), were selected. These numbers varied in some cities, depending on the variability of food

items of unkown composition encountered. Then, in each city, four samples of each selected food item were collected in different randomly selected vending sites. A total of 794 food samples were collected: 134 from *Dushanbe*, Tajikistan; 120 from *Bishkek*, Kyrgyzstan; 128 from *Ashgabat*, Turkmenistan; 121 from *Almaty*, Kazahkstan; 52 from *Chișinău*, Moldova; 119 from *Sarajevo* and 120 from *Banja Luka*, Bosnia and Herzegovina. Chemical analyses included protein, total fat, fatty acids (SFA, MUFA, PUFA, n-3, n-6 and TFA), sodium and potassium. All these procedures followed standardized methodology by the Association of Official Analytical Chemists[133] and are described in more detail elsewhere[121-127]. Total carbohydrates were estimated by difference, and energy values were calculated using the Atwater general factors (protein and carbohydrates: 4 kcal/g; fat: 9 kcal/g). In cities from Turkmenistan and Bosnia and Herzegovina, exceptionally, chemical analysis only included total fat, fatty acids, sodium and potassium.

For the food items which were not sampled and subjected to chemical analysis, nutritional composition was estimated using: (1) food labels of the brands most commonly available in each city, in the case of industrial food items (e.g. chocolate, soft drinks); (2) standardized local recipes, in the case of prepared and/or cooked homemade food items (e.g. beef steak with rice, cabbage salad); and (3) food composition tables, selected taking into account geographical and cultural proximity, in the case of *in natura* foods or beverages (e.g. fruits, nuts) or recipe ingredients. Estimations using these sources comprised energy and macronutrients, and also sodium in the case of industrial and *in natura* food items. In *Ashgabat* (Turkmenistan), protein, carbohydrates and energy contents were also estimated using food labels and food composition tables.

The nutritional value of the purchases was then computed by adding up the available estimated energy, macro- and micronutrients contents of all food items purchased by the same customer in a single occasion. Purchases not having complete information for all items regarding one specific nutrient were considered as missing values for this nutrient.

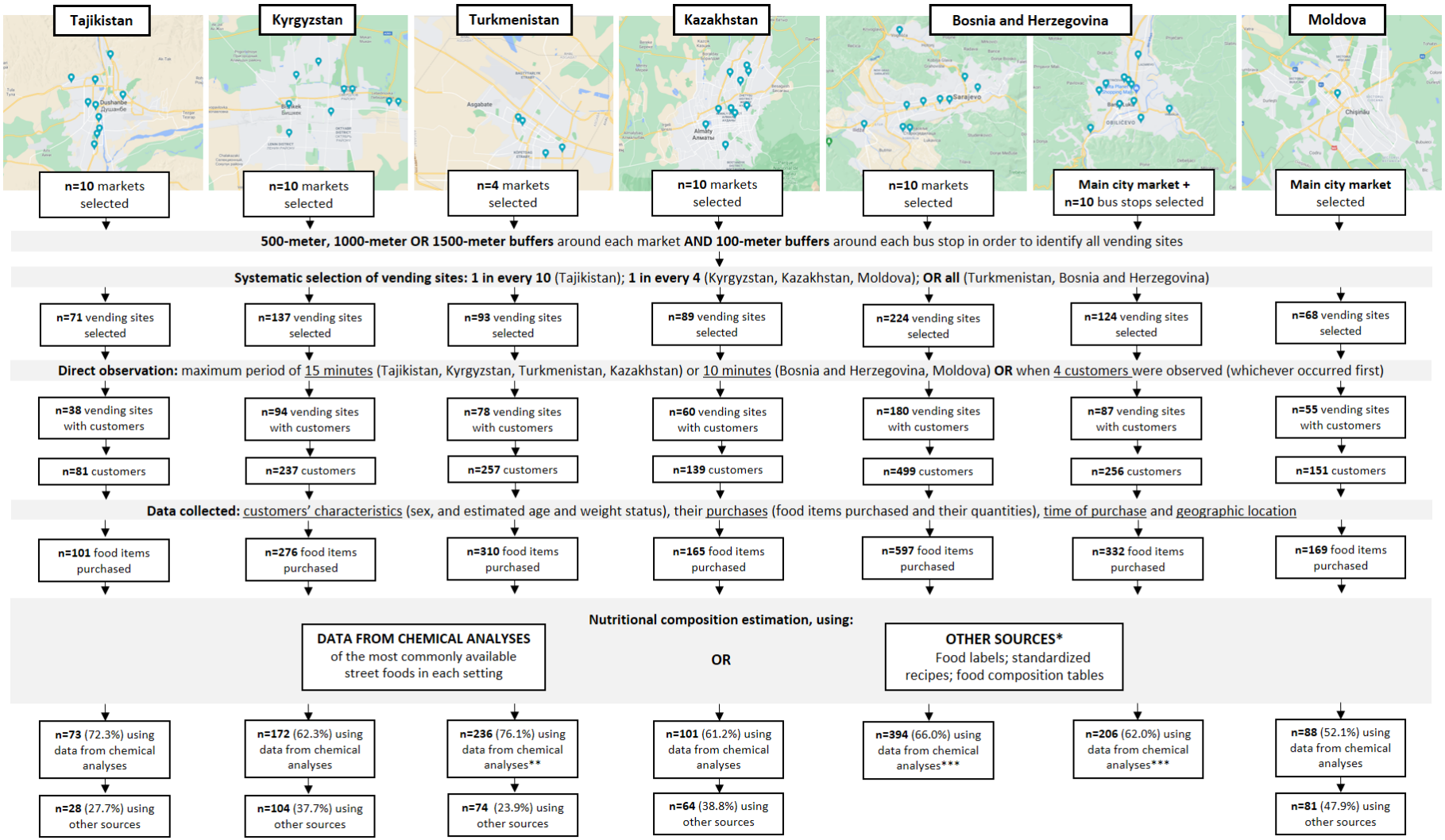
A flow chart summarizing the sampling procedures, data collection and nutritional composition estimation (previously described in subheadings 3.3, 3.4 and 3.5, respectively) is presented in **Figure 16**.

3.6. TRAINING TO FIELD RESEARCHERS

To ensure standardization of procedures and maximize reliability of the collected data, all field researchers underwent extensive training prior to field work. Training to researchers included theoretical lectures, demonstrations, practical exercices and application on field. The theoretical part of the training sessions was taught through presentations, and started with an overview of the research project, namely its rationale, objectives, general methodology (including the definition of the study areas, sampling procedures and eligibility criteria), tasks and timeline. Then, specific lectures including in-depth information on the methodology of each step of the research project were given. Those encompassed all procedures related to the observation of customers, including evaluation of their characteristics and registration of their purchases, as well as the collection of food samples. In order to standardize and improve the accuracy of the anthropometric evaluation by direct observation, further training was given using the BMI-based body size guides for women and men by Harris *et al.*[134]. Theoretical sessions were followed by the practical application of the knowledge acquired, in which each field researcher was asked to observe and evaluate all other members of the research team. Finally, field training was performed, in which field researchers had the opportunity to apply the methodology learned, under constant supervision and evaluation.

3.7. ETHICAL CONSIDERATIONS

The FEEDcities study was approved by the ISPUP Ethics Committee (reference CE16058), as well as by local authorities in each country. Verbal informed consent was obtained from all vendors. No consent was required for the collection of the food samples, since these were bought by field researchers as part of a regular transaction.



*For the least commonly available foods and beverages in each setting, or those whose nutritional composition was considered to be well documented (i.e. tea, coffee, soft drinks, water and fruit).
**In Turkmenistan, exceptionally, the samples collected for chemical analysis were not analysed for protein and carbohydrates contents, those nutrients being estimated using food labels, standardized recipes or food composition tables.
***In cities from Bosnia and Herzegovina, only data from chemical analyses were used.

Figure 16. Flow chart of the sampling procedures, data collection and nutritional composition estimation in each city studied.

4. Results

PAPER I

Sousa S., Lança de Morais I., Albuquerque G., Gelormini M., Casal S., Pinho O., Motta C., Damasceno A., Moreira P., Breda J., Lunet N., Padrão P.

A Cross-Sectional Study of the Street Foods Purchased by Customers in Urban Areas of Central Asia

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Article

A Cross-Sectional Study of the Street Foods Purchased by Customers in Urban Areas of Central Asia

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Abstract: This study aimed to describe street food purchases in cities from Central Asia, considering customers' characteristics and the nutritional composition of the foods and beverages. Cross-sectional studies were conducted in 2016/2017 in Dushanbe (Tajikistan), Bishkek (Kyrgyzstan), Ashgabat (Turkmenistan) and Almaty (Kazakhstan). Direct observation was used to collect data on the purchases made by street food customers, selected by random and systematic sampling. Nutritional composition was estimated using data from chemical analyses, food composition tables or food labels. A total of 714 customers (56.6% females, 55.5% aged ≥35 years, 23.3% overweight/obese) were observed, who bought 852 foods and beverages, the most frequent being savoury pastries/snacks (23.2%), main dishes (19.0%), sweet pastries/confectionery (17.9%), tea/coffee (11.3%) and soft drinks/juices (9.8%). Fruit was the least purchased food (1.1%). Nearly one-third of customers purchased industrial food items (31.9%). The median energy content of a street food purchase was 529 kcal/serving. Saturated and *trans*-fat median contents were 4.7 g/serving and 0.36 g/serving (21.4% and 16.5% of maximum daily intake recommendations, respectively). Median sodium and potassium contents were 745 mg/serving (37.3% of maximum recommendation) and 304 mg/serving (8.7% of minimum recommendation), respectively. In general, the purchases observed presented high contents of energy, saturated-fat, *trans*-fat and sodium, and low levels of potassium. Policies towards the improvement of these urban food environments should be encouraged.

Keywords: street food; nutritional value; nutrition transition; central Asia

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1. Introduction

Non-communicable diseases (NCD) are the first cause of mortality and disability in the world, and more than three-quarters of the NCD deaths (32 million) occur in low- and middle-income countries (LMIC) [1]. In Central Asian countries, NCD accounted for more than two-thirds of the deaths in 2016, mostly due to cardiovascular diseases and cancer [2]. The prevalence of obesity has been rising rapidly in this region, with a rate of increase between 2010 and 2016 ranging from 3.2% per year in Kazakhstan to 4.7% per year in Tajikistan. In 2016, obesity affected 12.6% of adults in Tajikistan, 15.4% in Kyrgyzstan, 17.5% in Turkmenistan and 21.3% in Kazakhstan [3]. High blood pressure affects one in every four adults in these populations [2].

The increasing prevalence of diet-related NCD in LMIC has been concurrent with the westernization of food habits and closely related to economic growth, rapid urbanization and globalization of the food supply [4,5]. In developing Asia, the consumption of soft drinks and high-fat processed foods has been increasing, and a growing proportion of dietary energy from fat and refined sugars has been reported [6]. Sodium intake is also high, corresponding to approximately three times the recommended amount [2]. These nutritional and epidemiological changes are expected to be even more pronounced in the most urbanized areas [7].

Street food is frequently consumed worldwide, with an estimated 2.5 billion people eating street food on a daily basis in 2007; the main reasons for consumption included low cost and convenience [8]. In LMIC, street food has a significant dietary contribution to the everyday diet, frequently serving as a replacement for home meals [9]. In Central Asia, there is a strong tradition of selling ready-to-eat foods on the streets, mostly in the context of organized public markets [10–13]. Although local traditional foods remain widely available, industrialized foods and ingredients are becoming more prevalent [8]. Recent studies from the World Health Organization (WHO) reported a wide availability of soft drinks, as well as concerning levels of sodium and *trans*-fat in both homemade and industrial street foods in cities from Central Asia [10–13].

Despite the importance of street foods in LMIC, scientific research covering its availability, consumption and nutritional value is scarce, and considered crucial to understand its implications for public health [14] and ultimately to design suitable policies towards diet-related NCD prevention. The FEEDCities project was created to bridge this gap of knowledge in urban areas from central Asian and eastern European LMIC, and have already provided valuable data regarding food availability, as well as the nutritional value of some highly available foods in these settings [10–13]. However, although food availability is an important feature of the food environments description, it does not directly reflect food choices. In addition, in this previously published work only data from chemical analyses of the most frequently available food items (approximately 30 foods and beverages out of 100 identified, with slight variations among cities) were reported. Thus, the assessment of street food customers and their purchases, including the nutritional composition of each purchase as a whole instead of individual food items, is essential to complement availability data, in order to have a much more comprehensive view of both environmental and individual dimensions of these street food environments. As such, the main objective of this study was to describe the street food purchases in urban areas of Tajikistan, Kyrgyzstan, Turkmenistan and Kazakhstan, taking into account customers' characteristics and the nutritional composition of the foods and beverages purchased. In this study, we go beyond the nutritional characterization of the most available foods, by assessing what was purchased by customers, regardless of the frequency in which the food is available for sale.

2. Materials and Methods

This study was implemented in the context of the FEEDCities (Food Environment Description in cities from Central Asia and Eastern Europe) project, which is based on a stepwise standardized characterization of the street food environment in cities from

Central Asia and Eastern Europe. For the purpose of this work, a cross-sectional evaluation of street food customers was conducted in *Dushanbe*, *Bishkek*, *Ashgabat* and *Almaty*, the largest and most urbanized cities of Tajikistan, Kyrgyzstan, Turkmenistan and Kazakhstan, respectively [15]. The surveys were conducted during April and May 2016 in *Dushanbe*, June and July 2016 in *Bishkek*, October 2016 in *Ashgabat*, and July and August 2017 in *Almaty*. The general methods were described in a previously published protocol [16] and detailed below. A flow chart summarizing the sampling procedures and data collection is presented in Figure 1.

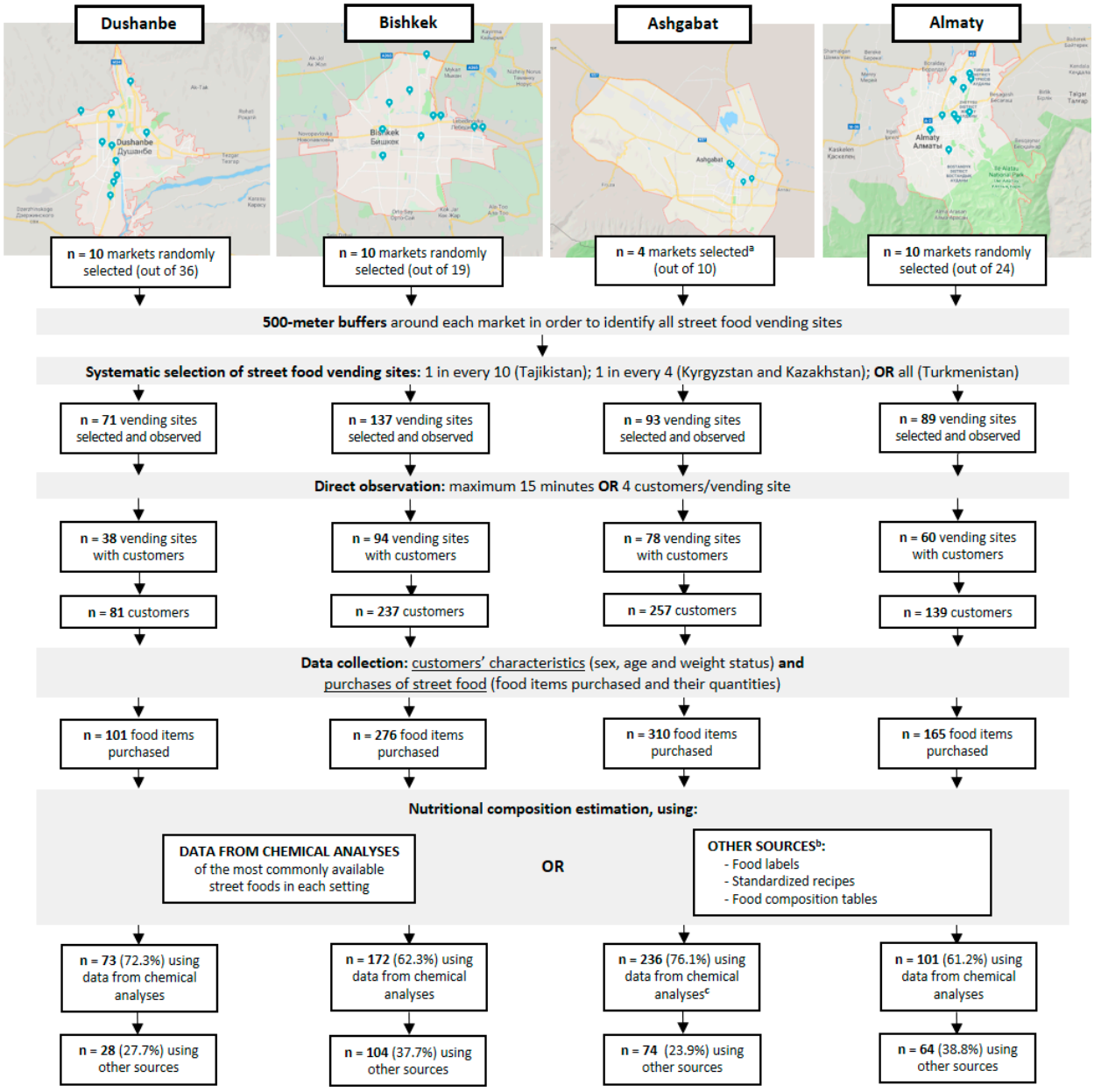

Figure 1. Flow chart of the sampling procedure and data collection conducted in *Dushanbe* (Tajikistan), *Bishkek* (Kyrgyzstan) *Ashgabat* (Turkmenistan) and *Almaty* (Kazakhstan). [a] In Turkmenistan, markets to be studied were selected by the public authorities in the country. [b] For the least commonly available street foods in each setting, or those whose nutritional composition was considered to be well documented (tea, coffee, soft drinks, water and fruit). [c] In Turkmenistan, exceptionally, the samples collected for chemical analysis were not analysed for protein and carbohydrates contents, those being estimated using food composition tables, standardized recipes or food labels.

2.1. Eligibility Criteria

The definition of street food proposed by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), as "ready-to-eat foods and beverages prepared and/or sold by vendors or hawkers especially in the streets and other similar places" [17,18], was adopted in order to select the street food vending sites where participants were selected. This includes both stationary and mobile vending units selling, directly to the street, food products ready to be consumed immediately without needing further preparation, comprising prepared (e.g., sandwiches), cooked (e.g., main dishes), *in natura* (e.g., fruits) or industrial foods (e.g., soft drinks, candies).

The exclusion criteria were as follows: (1) food establishments within four permanent walls or permanent storefront business not selling directly to the street; (2) vending sites selling exclusively non-prepared fresh fruits and vegetables or other raw foods not ready-to-eat (e.g., fish, meat); (3) food stalls and carts that are part of permanent stores or licensed establishments.

Customers buying ready-to-eat foods and/or beverages in the selected street food vending sites during pre-specified periods were eligible for the study.

2.2. Sampling Procedure

All public markets in *Dushanbe* (n = 36), *Bishkek* (n = 19), *Ashgabat* (n = 10) and *Almaty* (n = 24) were identified, with information provided by local authorities and gathered during preliminary field visits, as previously described [10–13,19,20]. In each city, a total of 10 markets were randomly selected (in *Ashgabat*, exceptionally, four markets were chosen by local authorities). Around the centroid of each selected market, a 500-m buffer was defined to represent the study area, covering the markets and their surroundings. Field researchers, operating in pairs, canvassed all publicly accessible streets within the study areas of each city, identifying all eligible street food vending sites. Finally, a systematic selection of the vending sites was performed, based on the number of vending sites encountered in each study area and the expected overall number of customers, in which one out of every 10 (Tajikistan), one out of every four (Kyrgyzstan and Kazakhstan) and all vending sites (Turkmenistan) identified in each city were observed.

In each selected vending site, all customers buying any food or beverage which meets the abovementioned definition of street food were observed. The observation period started at the next multiple of five minutes and ended after 15 minutes or when four customers were observed, whichever came first. If no customer was observed during this period, field researchers would move on to the next selected vending site. Observations were performed both on weekdays and weekends and covering all businesses' working hours (from 8 a.m. to 5 p.m.).

2.3. Data Collection

Data on customers' characterization and street food purchase were collected by direct observation of each selected street food vending site during its regular activity, by local field researchers, who were located at a distance sufficient for not interfering with the vendors' businesses or the normal behaviour of the customers. The body mass index (BMI)-based body size guides for women and men by Harris et al. [21] were used for training of the observers, aiming to improve and standardize the anthropometric evaluation by observation.

For each customer buying street food, two observers independently described the foods and beverages purchased (hereafter referred to as food items) and their quantities, as well as the customers' sex and estimated age and BMI-based weight status, in broad categories. Inter-observer concordance was high to very high, regarding both the customers' characteristics and the street food items purchased, as well as its quantities (Supplementary Table S1). For age and weight status, only data corresponding to the customers in which there was agreement between observers [n = 642 (89.9%) and n = 656 (91.9%), respectively]

were used for data analysis. Regarding the food items and quantities purchased, a set of criteria was used in order to eliminate observation conflicts (Supplementary Table S2).

The purchased food items were classified according to their nature as: *homemade* (foods and beverages that were prepared and/or cooked at home or in the street, even if using industrial ingredients) or *industrial* (foods and beverages that were produced by the food industry and sold as such, with no further preparation). Ready-to-eat in natura foods (e.g., fruits, nuts) were also classified as homemade. Both foods and beverages were further grouped into six sub-categories each, considering similarities of nature or composition, based on the WHO nutrient profile model [22], namely: (1) main dishes, (2) breads, (3) savoury pastries and snacks, (4) sweet pastries and confectionery, (5) sandwiches, and (6) fruit. Beverages were divided into: (1) tea and coffee, (2) soft drinks and juices, (3) non-alcoholic fermented traditional beverages, (4) alcoholic beverages, (5) milk, and (6) water. For example, rice- and noodles-based dishes (e.g., *plov*, *lagman*) were grouped into the "main dishes" group and were also classified as "homemade", since they were all cooked by vendors at home or in the street.

2.4. Nutritional Composition Estimation

The nutritional composition of all food items purchased was estimated using data either from chemical analyses (for the most commonly available food items in each setting) or from food labels, standardized recipes or food composition tables. The nutritional parameters estimated comprised energy, protein, carbohydrates, total fat, saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), $n-6$ and $n-3$ fatty acids, trans fatty acids (TFA), sodium and potassium.

During the first step of the research project, which assessed street food availability, the most commonly available street foods and beverages in each setting were documented [10–13,19,20]. The 20 (*Bishkek* and *Almaty*), 21 (*Ashgabat*) or 25 (*Dushanbe*) most common homemade foods and the 10 (*Bishkek*, *Almaty* and *Dushanbe*) or 11 (*Ashgabat*) most common industrial foods were selected for chemical analysis, excluding tea, coffee, soft drinks, water and fruit, as their nutritional composition was considered to be well documented. Then, four samples of each food were collected in different randomly selected vending sites in each city. Chemical analyses, including macronutrients, fatty acids, sodium and potassium, were performed for all collected samples, and energy values were calculated using the Atwater general factors, all in accordance with the Association of The Official Analytical Chemists recommendations [23], as described elsewhere [10–13,19,20]. In *Ashgabat*, exceptionally, the samples collected were not analysed for protein and carbohydrates contents, those being estimated using food composition tables, standardized recipes or food labels, as described in detail below.

For the food items which were not sampled for chemical analysis, nutritional composition was estimated using food labels, standardized recipes or food composition tables. For industrial food items, nutritional information was gathered from food labels of the brands most commonly available in each setting. For prepared and/or cooked homemade food items, standardized local recipes were gathered in each country. In the case of in natura food items (e.g., fruits, nuts) as well as for recipe ingredients, nutritional composition was obtained from the Food Composition Table for Pakistan [24] or from the Turkish National Food Composition Database [25], selected due to geographical and cultural proximity. Information from food labels and food composition tables did not include fatty acids and, in most cases (80.8% and 98.2%, respectively), sodium and potassium contents. As such, only energy, protein, carbohydrates and total fat were estimated for all food items which were not subjected to chemical analysis. Whereas sodium content was estimated for industrial and in natura food items using food labels and food composition tables, in the case of prepared/cooked homemade foods and beverages, it was not estimated using these sources, since the amount of salt added during their preparation and/or cooking was considered to vary greatly, being exclusively estimated by chemical analysis.

The nutritional value of the street food purchases of each customer was then computed by adding up the estimated energy, macro- and micro-nutrients of all foods and beverages purchased by the same customer on a single occasion. Purchases not having the complete information of all food items regarding one specific nutrient, were considered as missing values for that nutrient.

WHO daily population nutrient intake goals were then computed: SFA, <10% of total energy value (TEV) [26]; TFA, <1% TEV [27]; sodium, <2000 mg [28]; potassium, ≥3510 mg [29]; and sodium to potassium molar ratio, 1 [28,29]. In order to estimate the nutritional contribution in relation to the maximum daily intake recommendations, a daily reference intake of 2000 kcal was considered.

2.5. Statistical Analysis

Statistical analysis was performed using *Stata*® version 15.0 for *Windows*®. Absolute and relative frequencies were used to characterize street food customers and the food items purchased. The nutritional composition of the purchases was described through median and percentiles 25 and 75. Inter-observer concordance for the demographic and anthropometric characteristics of the customers, as well as for the food items purchased and their quantities, were analyzed through the percentage of agreement and Cohen's kappa coefficient with 95% confidence interval. Pearson's Chi-squared test, Mann–Whitney's U test and Kruskal–Wallis test were used to compare the frequencies of the food items and the nutritional composition of the purchases regarding demographic and anthropometric characteristics of the customers observed. Differences were considered statistically significant when the critical level of significance (p) was less than 0.05.

3. Results

A total of 714 customers were identified, 81 in Tajikistan, 237 in Kyrgyzstan, 257 in Turkmenistan and 139 in Kazakhstan. Slightly more than half were female (56.6%) and aged 35 years and older (55.5%), and almost one-quarter (23.3%) were classified as overweight or obese. A total of 852 food items were purchased, corresponding to an average of 1.2 food items per customer and 3.8 food items per 10 minutes of observation. Most customers (83.3%) purchased only one food item, and more than two-thirds (69.1%) purchased only foods. Most customers purchased only homemade food items (68.1%), although nearly one-third purchased at least one industrial food or beverage (31.9%); this proportion was highest in Kazakhstan (43.2%) (Table 1).

Overall, the most commonly purchased foods were savoury pastries and snacks (23.2% of all customers), mostly *sambusa* and *piroshky*; main dishes (19.0%), mostly meat dishes (*plov* and *shashlik*); and sweet pastries and confectionery (17.9%), mostly cookies, buns and candies. The most frequently purchased beverages were tea and coffee (11.3% of all customers), soft drinks and juices (9.8%) and non-alcoholic fermented traditional beverages (4.6%). Fruit and milk were the least frequently purchased food items (1.1% and 0.4% of all customers, respectively). Frequencies of the foods and beverages purchased in each country are presented in Figure 2. Purchases of sweets pastries and confectionery, as well as sandwiches, were more frequently observed in Turkmenistan; bread, fruit, soft drinks and juices in Tajikistan; tea, coffee, traditional beverages and alcoholic beverages in Kyrgyzstan; and water in Kazakhstan. No statistically significant differences amongst cities were found in the frequency of purchase of savoury pastries and snacks, main dishes or milk. Supplementary Table S3 presents the food items purchased by sex, age and weight status of the customers observed.

Table 1. Demographic and anthropometric characteristics and items purchased by the customers observed in street food vending sites of Dushanbe (Tajikistan), Bishkek (Kyrgyzstan), Ashgabat (Turkmenistan) and Almaty (Kazakhstan).

	Total *n* **= 714**	**Dushanbe** *n* **= 81**	**Bishkek** *n* **= 237**	**Ashgabat** *n* **= 257**	**Almaty** *n* **= 139**	***p***
			***n* (%)**			
Sex						
Male	310 (43.4)	53 (34.6)	96 (40.5)	119 (46.3)	42 (30.2)	**<0.001**
Female	404 (56.6)	28 (65.4)	141 (59.5)	138 (53.7)	97 (69.8)	
Age [a]						
<35 years	286 (44.5)	38 (56.7)	101 (47.9)	97 (41.8)	50 (37.9)	**0.045**
≥35 years	356 (55.5)	29 (43.3)	110 (52.1)	135 (58.2)	82 (62.1)	
Weight status [a]						
Underweight/normal weight	503 (76.7)	52 (76.5)	178 (82.8)	178 (73.6)	95 (72.5)	0.069
Overweight/obesity	153 (23.3)	16 (23.5)	37 (17.2)	64 (26.4)	36 (27.5)	
Number of items purchased						
1 (median)	595 (83.3)	66 (81.5)	203 (85.7)	213 (82.9)	113 (81.3)	0.666
>1	119 (16.7)	15 (18.5)	34 (14.3)	44 (17.1)	26 (18.7)	
Purchased foods or beverages?						
Only foods	493 (69.1)	55 (67.9)	131 (55.3)	222 (86.4)	85 (61.2)	**<0.001**
Only beverages	150 (21.0)	19 (23.5)	79 (33.3)	15 (5.8)	37 (26.6)	
Foods and beverages	71 (9.9)	7 (8.6)	27 (11.4)	20 (7.8)	17 (12.2)	
Purchased homemade or industrial?						
Only homemade	486 (68.1)	58 (71.6)	175 (73.8)	174 (67.7)	79 (56.8)	**0.003**
Only industrial	201 (28.1)	23 (28.4)	58 (24.5)	71 (27.6)	49 (35.3)	
Homemade and industrial	27 (3.8)	0 (0.0)	4 (1.7)	12 (4.7)	11 (7.9)	

Values in bold represent statistically significant differences according to Pearson's Chi-squared test with a significance level of 0.05. [a] For the variables age and weight status, the data presented corresponds to the customers in which there was agreement between observers (total: $n = 642$ and $n = 656$; Tajikistan: $n = 67$ and $n = 68$; Kyrgyzstan: $n = 211$ and $n = 215$; Turkmenistan: $n = 232$ and $n = 242$; Kazakhstan: $n = 132$ and $n = 131$).

The median energy content of a street food purchase was 529 kcal, with the highest contribution to the TEV from carbohydrates (56.6%), followed by total fat (33.5%) and protein (12.0%). SFA and TFA median contents were 4.7 g and 0.36 g, corresponding to 21.4% and 16.5% of the maximum daily intake recommendations for these nutrients, respectively. The purchases presented a median sodium content of 745 mg, which accounted for 37.3% of its maximum daily intake recommendation, while supplying 304 mg of potassium (8.7% of its minimum recommendation). The median energy density was 308 kcal/100 g, ranging from 274/275 kcal/100 g in Tajikistan/Kyrgyzstan to 432 kcal/100 g in Turkmenistan. Purchases presented similar median densities of SFA (2.7 g/100 g), MUFA (2.8 g/100 g) and PUFA (2.7 g/100 g), and median TFA ranged from 0.08 g/100 g in Tajikistan to 0.32 g/100 g in Kazakhstan. The median sodium to potassium ratio was higher than 1 in all settings, ranging from 4.3 in Kazakhstan to 6.6 in Tajikistan (Table 2). Purchases containing at least one industrial food item showed higher energy density (518 vs. 286 kcal/100 g, $p < 0.001$), SFA (5.6 vs. 2.6 g/100 g, $p < 0.001$) and TFA contents per 100 g (0.23 vs. 0.19 g/100 g, $p = 0.001$) than those with no industrial food items.

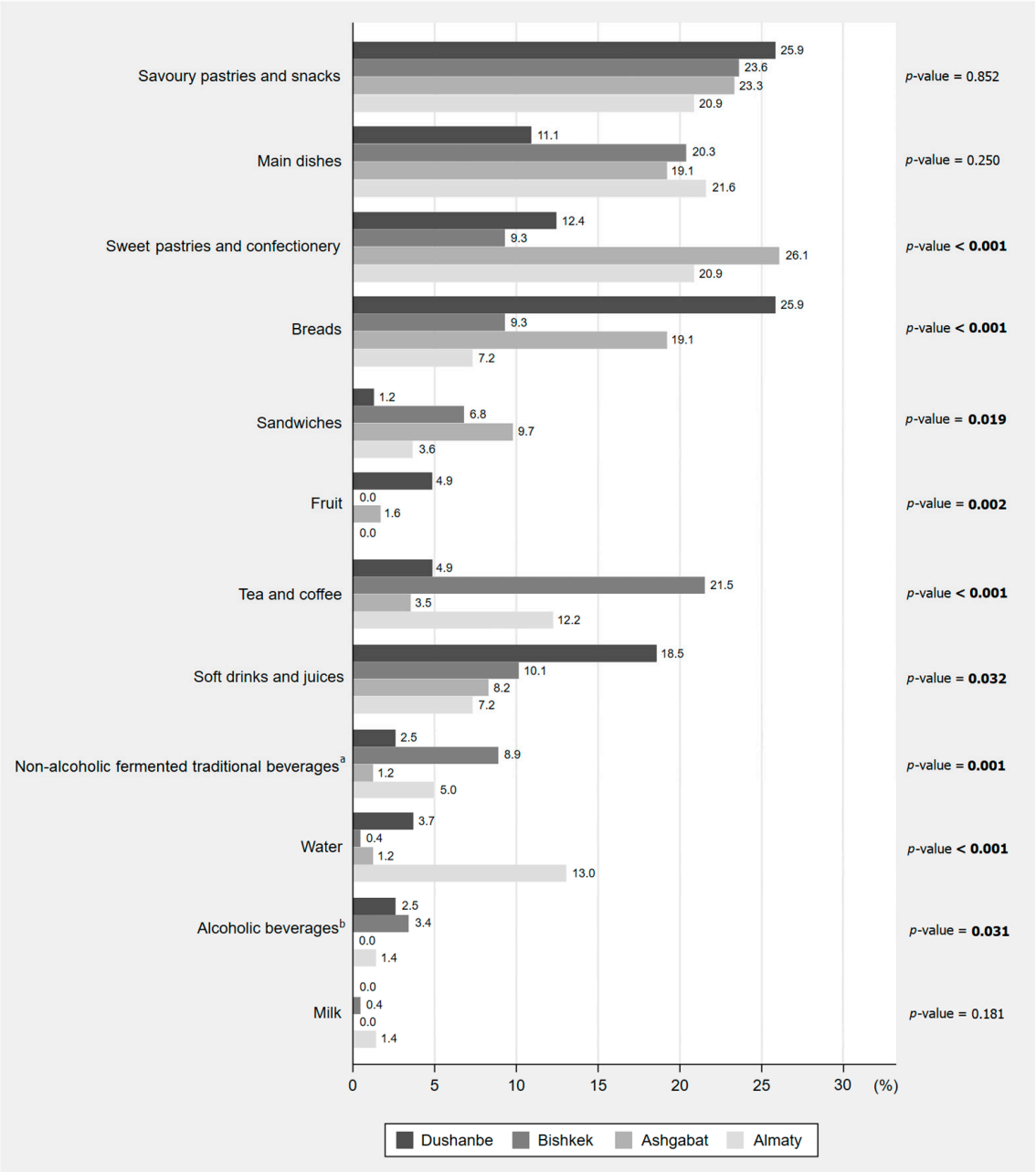

Figure 2. Ready-to-eat foods and beverages purchased by the customers observed in street food vending sites of Dushanbe (Tajikistan), Bishkek (Kyrgyzstan) Ashgabat (Turkmenistan) and Almaty (Kazakhstan) (n = 714). The proportions presented are relative to the total number of customers observed in each country (Tajikistan, n = 81; Kyrgyzstan, n = 237; Turkmenistan, n = 257; Kazakhstan, n = 139). The sum of the percentages from each country may exceed 100% because the same customer could buy more than one food item. Values in bold represent statistically significant differences according to Pearson's Chi-squared test with a significance level of 0.05. [a] Non-alcoholic fermented traditional beverages included *ayran* (dairy-based fermented beverage made from sheep's milk), *chalap* (beverage made from fermented milk, salt and carbonated water;), *dugob* (fermented beverage made with sour milk or buttermilk), *kefir* (fermented milk drink prepared by inoculating cow, goat or sheep milk with kefir grains), *maksym* (fermented beverage made from grain, usually malt), *tamshan* (mix of *maksym* and *chalap*), *kozhe* (cold drink made by boiling rice, millet or pearl barley with a mixture of dairy products such as *ayran* or *kefir*) and yoghurt. [b] Alcoholic beverages included beer, vodka and some traditional beverages with a low alcohol content, such as *kvass* (a fermented beverage made from rye bread), *bozo* (a fermented beverage made from millet) and *kymyz* (a fermented product made from mare's milk).

Table 2. Estimated nutritional composition of the purchases made by the street food customers observed in Dushanbe (Tajikistan), Bishkek (Kyrgyzstan), Ashgabat (Turkmenistan) and Almaty (Kazakhstan).

	Total (*n* = 564 [a])	**Dushanbe** (*n* = 62 [a])	**Bishkek** (*n* = 158 [a])	**Ashgabat** (*n* = 242 [a])	**Almaty** (*n* = 102 [a])	*p*
	Median (P25–P75)					
Amount purchased (g)	120 (95–278)	120 (58–281)	176 (100–306)	120 (99–265)	103 (90–296)	0.062
Per total purchase						
Energy (kcal)	529 (329–850)	352 (311–816)	451 (314–615)	568 (343–993)	557 (326–915)	**<0.001**
Protein (g)	13.4 (8.5–25.6)	12.7 (8.6–23.7)	18.1 (10.6–23.4)	13.2 (7.2–29.7)	13.5 (7.0–25.5)	0.267
CHO (g)	68.1 (42.6–107.6)	69.1 (33.0–91.3)	60.0 (44.7–73.9)	70.5 (54.5–130.3)	69.5 (40.3–101.8)	**<0.001**
Total fat (g)	20.1 (5.3–32.6)	11.1 (0.9–25.6)	16.2 (5.3–28.8)	22.8 (9.0–44.4)	21.5 (7.9–40.5)	**<0.001**
SFA (g) [b]	4.7 (1.2–12.4)	2.5 (0.5–9.9)	3.4 (1.1–12.3)	9.0 (1.1–15.7)	4.6 (1.7–11.1)	**<0.001**
MUFA (g) [b]	5.3 (1.6–9.4)	3.7 (0.3–7.9)	3.8 (1.4–9.3)	5.9 (2.0–11.3)	5.3 (2.5–10.7)	**<0.001**
PUFA (g) [b]	5.0 (1.3–9.1)	2.9 (0.2–9.6)	4.0 (0.7–7.8)	6.5 (1.7–9.8)	4.2 (1.9–8.9)	**<0.001**
n−6 (g) [b]	4.3 (1.2–8.6)	2.7 (0.2–8.8)	3.9 (0.6–7.6)	6.3 (1.4–9.5)	3.6 (1.9–8.9)	**<0.001**
n−3 (g) [b]	0.1 (0.0–0.2)	0.0 (0.0–0.1)	0.1 (0.0–0.4)	0.1 (0.1–0.3)	0.1 (0.0–0.2)	**0.002**
TFA (g) [b]	0.36 (0.06–0.86)	0.08 (0.02–0.38)	0.29 (0.02–1.38)	0.36 (0.06–0.55)	0.60 (0.20–2.14)	**<0.001**
Na (mg) [c]	745 (475–1783)	723 (479–1708)	861 (561–1411)	851 (477–2314)	681 (316–2085)	0.209
K (mg) [d]	304 (180–713)	226 (121–527)	282 (149–571)	414 (245–850)	288 (174–651)	**<0.001**
Per 100 g of purchase						
Energy (kcal)	308 (212–605)	274 (174–484)	275 (158–419)	432 (276–663)	315 (212–621)	**<0.001**
Protein (g)	10.6 (5.5–17.2)	10.0 (6.0–14.1)	10.6 (5.5–14.8)	11.0 (5.4–19.5)	8.9 (5.6–16.9)	0.154
CHO (g)	53.5 (25.2–74.8)	49.9 (25.2–58.9)	31.0 (17.3–57.6)	56.8 (29.6–108.9)	42.8 (30.2–75.2)	**<0.001**
Total fat (g)	10.1 (3.3–22.7)	5.2 (1.8–14.9)	7.7 (2.3–14.9)	17.3 (4.1–30.1)	11.4 (4.7–24.1)	**<0.001**
SFA (g) [b]	2.7 (0.7–7.2)	1.8 (0.7–4.3)	2.1 (0.4–5.2)	3.9 (0.7–11.0)	2.7 (1.4–7.9)	**<0.001**
MUFA (g) [b]	2.8 (0.9–6.8)	1.5 (0.6–4.7)	2.2 (0.7–3.9)	4.1 (1.2–9.6)	3.2 (1.4–6.8)	**<0.001**
PUFA (g) [b]	2.7 (1.1–6.4)	1.5 (0.3–5.0)	1.5 (0.8–3.8)	3.6 (1.3–7.1)	3.7 (1.5–6.7)	**<0.001**
n−6 (g) [b]	2.7 (1.0–6.0)	1.3 (0.3–4.1)	1.4 (0.7–3.4)	3.5 (1.2–6.7)	3.6 (1.2–6.5)	**<0.001**
n−3 (g) [b]	0.1 (0.0–0.2)	0.0 (0.0–0.1)	0.1 (0.0–0.1)	0.1 (0.0–0.2)	0.1 (0.0–0.2)	**<0.001**
TFA (g) [b]	0.21 (0.05–0.51)	0.08 (0.03–0.15)	0.22 (0.02–0.55)	0.21 (0.04–0.46)	0.32 (0.18–1.45)	**<0.001**
Na (mg) [c]	514 (411–1042)	467 (348–657)	508 (325–740)	611 (467–1216)	519 (324–1027)	**0.005**
K (mg) [d]	247 (150–474)	145 (114–250)	205 (124–303)	328 (150–631)	286 (166–461)	**<0.001**
Na/K ratio [d]	4.7 (2.7–6.3)	6.6 (4.1–8.0)	5.2 (3.1–8.7)	4.4 (2.6–5.6)	4.3 (2.3–5.6)	**<0.001**

CHO, carbohydrates; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; TFA, trans fatty acids; Na, sodium; K, potassium. Values in bold represent statistically significant differences according to Kruskal–Wallis test with a significance level of 0.05. [a] Data on customers purchasing only beverages were not included. [b] For these variables, the sample size is lower (*n* = 494) due to missing values. [c] For this variable, the sample size is lower (*n* = 473) due to missing values. [d] For these variables, the sample size is lower (*n* = 457) due to missing values.

Table 3 presents the estimated nutritional composition of the purchases by sex, age and weight status of the customers. Men presented purchases significantly richer in energy, protein, total fat, SFA, MUFA, TFA and sodium. No differences regarding sex were found for the nutritional composition per 100 g of purchase. Purchases from younger customers had a higher content of TFA, sodium and sodium to potassium ratio; while purchases from older customers showed higher energy density and higher contents per 100 g of protein and carbohydrates. Overweight/obese customers presented purchases with higher energy, total fat and TFA contents. Considering nutrient density (per 100 g), purchases from overweight/obese customers were also richer in energy, carbohydrates, PUFA, *n*−6 and sodium.

Table 3. Estimated nutritional composition of the purchases made by the street food customers observed in Dushanbe (Tajikistan), Bishkek (Kyrgyzstan), Ashgabat (Turkmenistan) and Almaty (Kazakhstan), by sex, age and weight status.

	Sex			**Age**			**Weight Status**		
	Male (n = 242 [a])	**Female (n = 322 [a])**	p	**<35 years (n = 226 [a])**	**≥35 years (n = 281 [a])**	p	**Underweight /Normal Weight (n = 398 [a])**	**Overweight /Obesity (n = 122 [a])**	p
	Median (P25–P75)			**Median (P25–P75)**			**Median (P25–P75)**		
Amount purchased (g)	120 (96–317)	120 (90–265)	0.051	132 (96–296)	120 (68.1–265.0)	**0.029**	120 (96–278)	120 (81–265)	0.411
Per total purchase									
Energy (kcal)	555 (337–930)	509 (311–717)	**0.018**	500 (327–893)	557 (329–750)	0.957	488 (324–730)	570 (343–978)	**0.020**
Protein (g)	15.9 (9.6–30.7)	13.2 (7.6–13.2)	**0.004**	15.3 (8.6–26.2)	13.2 (8.5–24.2)	0.292	13.2 (8.5–24.2)	13.6 (8.5–26.2)	0.529
CHO (g)	68.1 (45.1–122.3)	68.1 (40.5–100.1)	0.271	68.1 (41.5–118.3)	68.1 (42.8–100.1)	0.992	68.1 (41.5–100.1)	72.3 (49.3–122.3)	0.051
Total fat (g)	22.8 (6.5–35.2)	16.0 (5.3–30.9)	**0.002**	20.9 (7.6–35.1)	18.5 (5.2–31.8)	0.317	19.4 (5.3–31.2)	22.8 (6.3–43.9)	**0.006**
SFA (g) [b]	7.3 (1.5–12.8)	3.2 (1.1–11.1)	**0.025**	5.8 (1.5–12.3)	3.7 (1.0–12.3)	0.149	4.6 (1.1–12.3)	4.6 (1.3–12.8)	0.475
MUFA (g) [b]	6.3 (1.7–9.7)	4.4 (1.5–9.3)	**0.041**	5.9 (1.9–9.5)	4.4 (1.1–9.3)	0.119	4.9 (1.6–9.3)	5.7 (1.5–11.0)	0.237
PUFA (g) [b]	5.6 (1.3–9.5)	4.5 (1.3–8.4)	0.429	5.6 (1.4–9.6)	4.0 (1.3–8.3)	0.111	4.5 (1.3–9.1)	5.2 (1.4–9.6)	0.441
$n-6$ (g) [b]	4.7 (1.2–9.0)	4.2 (1.3–8.3)	0.559	5.1 (1.2–9.5)	3.5 (1.2–7.6)	0.126	4.3 (1.2–8.4)	3.9 (1.4–9.5)	0.471
$n-3$ (g) [b]	0.1 (0.1–0.3)	0.1 (0.0–0.2)	0.105	0.1 (0.1–0.3)	0.1 (0.0–0.2)	0.120	0.1 (0.0–0.2)	0.1 (0.0–0.3)	0.891
TFA (g) [b]	0.38 (0.05–1.15)	0.31 (0.06–0.67)	**0.002**	0.38 (0.11–0.86)	0.32 (0.03–0.76)	**0.036**	0.31 (0.05–0.73)	0.40 (0.06–1.00)	**0.025**
Na (mg) [c]	906 (560–2165)	672 (470–1687)	**0.030**	1062 (560–1943)	561 (416–1653)	**0.001**	753 (470–1750)	709 (470–2042)	0.937
K (mg) [d]	343 (180–718)	291 (180–691)	0.239	340 (180–777)	250 (175–648)	0.078	313 (180–691)	288 (180–778)	0.931
Per 100 g of purchase									
Energy (kcal)	286 (210–552)	314 (212–638)	0.370	287 (185–531)	314 (228–663)	**0.016**	306 (210–552)	382 (253–674)	**0.025**
Protein (g)	10.6 (5.5–17.1)	10.6 (5.5–17.4)	0.929	8.7 (5.2–15.0)	11.0 (6.4–18.2)	**0.003**	10.6 (5.4–17.1)	10.8 (6.5–19.5)	0.132
CHO (g)	53.5 (24.2–67.4)	53.1 (25.5–77.1)	0.325	40.2 (20.6–63.7)	56.8 (26.3–106.9)	**<0.001**	50.9 (22.7–70.5)	56.8 (29.6–101.8)	**0.030**
Total fat (g)	9.3 (3.5–24.1)	10.8 (3.2–20.1)	0.926	10.0 (3.7–20.9)	10.0 (3.3–24.0)	0.554	10.0 (2.5–20.1)	13.2 (4.3–30.1)	0.065
SFA (g) [b]	3.2 (0.7–9.0)	2.6 (0.7–7.0)	0.277	3.0 (1.3–7.1)	2.6 (0.7–8.9)	0.438	2.7 (0.7–7.1)	2.7 (0.7–10.9)	0.322
MUFA (g) [b]	2.6 (0.9–7.4)	3.0 (0.9–6.1)	0.619	2.8 (1.1–6.4)	2.5 (0.7–7.1)	0.971	2.8 (0.8–6.3)	3.4 (1.1–10.7)	0.111
PUFA (g) [b]	2.6 (1.1–5.6)	3.0 (1.1–6.6)	0.645	2.6 (0.9–5.4)	2.7 (1.1–6.4)	0.229	2.6 (1.1–5.8)	3.8 (1.3–6.6)	**0.023**
$n-6$ (g) [b]	2.5 (1.0–5.3)	2.7 (1.0–6.5)	0.572	2.4 (0.8–5.0)	2.7 (1.0–6.3)	0.243	2.5 (0.9–5.6)	3.3 (1.2–6.6)	**0.032**
$n-3$ (g) [b]	0.1 (0.0–0.2)	0.1 (0.0–0.1)	0.210	0.1 (0.0–0.1)	0.1 (0.0–0.2)	0.773	0.1 (0.0–0.1)	0.1 (0.0–0.2)	0.368
TFA (g) [b]	0.21 (0.04–0.57)	0.20 (0.05–0.48)	0.752	0.21 (0.08–0.46)	0.19 (0.03–0.52)	0.593	0.21 (0.05–0.46)	0.25 (0.04–0.76)	0.219
Na (mg) [c]	505 (412–1042)	521 (411–1065)	0.980	484 (345–1064)	525 (435–1042)	0.377	490 (388–1042)	620 (467–1136)	**0.045**
K (mg) [d]	246 (145–500)	249 (150–461)	0.337	244 (145–474)	264 (150–461)	0.266	244 (150–454)	305 (166–500)	0.060
Na/K ratio [d]	5.3 (3.1–6.3)	4.3 (2.6–5.9)	0.141	5.3 (2.7–6.6)	4.2 (3.0–5.8)	**0.046**	4.9 (2.6–6.3)	4.2 (3.0–5.8)	0.604

CHO, carbohydrates; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; TFA, *trans* fatty acids; Na, sodium; K, potassium. Values in bold represent statistically significant differences according to the Mann–Whitney's U test with a significance level of 0.05. [a] Data on customers purchasing only beverages were not included. In addition, regarding age and weight status, data presented corresponds to the customers in which there was agreement between observers. [b] For these variables, the sample size is lower (male: n = 206; female: n = 288; <35 years: n = 198; ≥35 years: n = 247; underweight/normal weight: n = 345; overweight/obese: n = 107) due to missing values. [c] For this variable, the sample size is lower (male: n = 200; female: n = 273; <35 years: n = 185; ≥35 years: n = 236; underweight/normal weight: n = 328; overweight/obese: n = 103) due to missing values. [d] For these variables, the sample size is lower (male: n = 191; female: n = 266; <35 years: n = 175; ≥35 years: n = 230; underweight/normal weight: n = 315; overweight/obese: n = 101) due to missing values.

4. Discussion

This study reports on relevant and innovative data regarding street food purchase and nutritional composition in four urban areas of Central Asia. Frequent purchase of street food was observed, demonstrated by the large number of food items bought within a limited observation period, and a wide variety of ready-to-eat foods and beverages was identified.

Traditional foods, such as *sambusa* (pastry with a savoury filling, usually meat or vegetables and spices), *lepyoshka* (traditional bread) and local main dishes, as well as tea and non-alcoholic fermented beverages, were commonly bought, indicating that local and traditional foods and beverages are important for the daily food consumption in these populations. However, it is noteworthy that almost one-third of the customers bought industrial foods items, mostly soft drinks, cookies and candies; it was also observed a high level of purchase of fried savoury pastries and meat-based dishes, coupled with a very low frequency of purchase of fruit. These results suggest that street food purchases in these settings have been directed towards a more Westernized consumption pattern, which is consistent with the nutrition transition process currently occurring in LMIC [3,30]. In *Almaty* and *Ashgabat*, the frequency of purchase of industrial foods and beverages was particularly concerning since this type of food items are usually energy-dense and rich in fat, SFA and TFA, sugars and salt [31]. In this study, we observed that the purchases containing at least one industrial food item showed higher energy density, SFA and TFA contents. The consumption of ultra-processed foods has been linked to a lower quality of the diet [32,33], and higher prevalence of obesity and other diet-related NCD [34–36], which makes urgent the implementation of efforts including information campaigns to raise consumers' awareness regarding the importance of choosing nutritional dense non-processed foods, as well as behaviour interventions to shape better food choices.

Overall, the median energy content of a street food purchase was 529 kcal; in all four cities, the highest contribution for TEV came from carbohydrates, followed by fat and protein, which was also reported in other settings [37–39]. A street food purchase provided considerable amounts of SFA and TFA, exceeding 40% of the WHO daily maximum recommendation for SFA [26] in Turkmenistan, and almost 30% of the WHO daily maximum recommendation for TFA [27] in Kazakhstan. It was also observed that, from a single street food purchase, almost one in every three customers (29.6%) exceeded 50% of the maximum recommendations for SFA, and one in every five (20.8%) exceeded 50% of the maximum recommendation for TFA. Both homemade and industrial foods have been identified as important sources of TFA in the street food context of these settings [10–13]. Another work in urban Delhi, India, showed high contents of total fat, SFA and TFA in street foods and oils used by street vendors [40]. High intakes of *trans* fats have been extensively associated with all-cause mortality and cardiovascular disease [41], and some countries in the WHO European Region have introduced legislation to limit its content in the food supply to a maximum of 2 g/100 g of fat [42]. The Eurasian Economic Commission adopted similar actions [43], enforcing Tajikistan, Kyrgyzstan and Kazakhstan to align with these practices up to 2018. However, according to our results, almost half (48.7%) of the industrial food items purchased with TFA information exceeded this limit, showing that progress must be made in order to achieve this goal, and repeated monitoring would be necessary to ensure compliance. Furthermore, high TFA levels in homemade foods suggest that its preparation commonly may include unhealthy cooking methods, such as frying, as well as the use of TFA-rich fats and shortenings. As such, to raise awareness of the street vendors for the importance of improving the quantity and quality of the fats added during preparation and cooking may help to reduce saturated and *trans* fats in homemade foods. Governmental support to street vendors and manufacturers for the substitution to healthier fats and improvement of the lipid profile of the food products should also be discussed.

Our results also showed that one single purchase provided more than one-third of the maximum daily intake recommendation for sodium [28]; furthermore, almost one-quarter (22.4%) of the customers exceeded its limit of 2000 mg in just one purchase. Sodium to

potassium ratio exceeded four times the recommendation [28,29] in purchases from all settings, being of even greater concern in the urban contexts of *Dushanbe* and *Bishkek*, in line with previous evidence [44]. The homemade food items purchased presented a median sodium to potassium ratio significantly higher than the industrial ones (5.20 vs. 3.29, $p < 0.001$), which could be attributed to the excessive use of added salt and/or sodium-rich ingredients (e.g., soy sauce) during homemade foods' preparation/cooking, as observed in other settings [45]. However, foods classified as homemade or industrial are heterogeneous in terms of the groups they belong to, and some are not sources of salt. Therefore, direct comparisons should be conducted with caution. For example, some food items classified as industrial (e.g., confectionery, soft drinks and juices), which usually have very low sodium contents, may contribute to explain these differences. The high sodium contents found in certain homemade foods may also reflect the influence of the "Silk Road" pattern, in which the use of salt as a food preservative remains a common tradition in Central Asian countries [46]. In 2010, diets high in sodium were among the leading risk factors for disease in Central Asia [47], and current evidence suggests that a reduction in dietary sodium decreases cardiovascular morbidity and mortality [48]. Public health strategies could include targets for salt reduction and/or mandatory maximum limits for industrial products, as well as the development of programmes targeting both vendors and consumers, to raise their awareness about the health hazards associated with adding too much salt to foods. Furthermore, and despite the protective effect of dietary potassium on cardiovascular disease risk [49], the street food purchases assessed in this study appeared to be a very poor source of this nutrient, in part due to a vestigial level of purchase of ready-to-eat fruits and vegetables by the customers observed. Results from the FEEDcities project have been clearly showing that availability of street-vended fruit is very low in all settings studied [10–13]. However, it should be pointed out that vending sites selling exclusively non-prepared fresh fruits and vegetables were excluded from this study, which may have underestimated the purchases of fruits and vegetables. However, this exclusion criterion was defined because these venues were mostly directed towards household food consumption, and not for immediate consumption, as the definition of 'street food' as 'ready-to-eat food' implies. Strategies aimed at increasing the availability of ready-to-eat fruits or improving the amounts of vegetables in some main dishes traditionally containing them as ingredients (e.g., *plov*, *lagman*), can help improve the consumption of these foods, which are nutrient-dense, rich in potassium and with low sodium content.

Regarding customers' characteristics, the street food purchases made by men and by overweight or obese customers presented a less healthy nutritional profile, showing in general higher levels of energy, fat (total, saturated and/or *trans*), sodium and sodium to potassium ratio than women and normal-weighted customers. Purchases from younger customers were also richer in *trans*-fat and sodium. These results can be useful in efforts to design targeted interventions towards diet-related NCD prevention.

Some limitations of this study should be acknowledged. Customers' weight status was estimated using direct observation, which is not yet validated for these populations. Although body measurement is the established gold standard, this method would bring a number of problems to achievable collection of data, namely: (1) the need for material and human resources; (2) large apparatus around the vendors, disturbing their activity and possibly causing the alteration of the customers' behaviour; and (3) cultural barriers to body measurement. A faster, more practical and culture-friendly approach to collect accurate anthropometric data in those settings has become essential. Self-report of height and weight has been extensively used; however, under-reporting of weight and over-reporting of height, leading to under-estimation of body mass index, have been documented [50]. As such, the validation of the estimation of weight status by direct observation by trained professionals in less developed contexts would be an important step in future work. Direct observation of purchases without interviewing also implies that we cannot ensure that all customers bought food items only for themselves, and for one single meal. However, the

number of food items purchased per customer, which was close to one, suggested that this assumption should be correct in the majority of cases.

Another limitation of the present research was the inability to discriminate sugars within carbohydrates. Nonetheless, it was observed that a significant proportion (27.6%) of our sample purchased sugar-rich food items, namely sweet pastries, confectionery, soft drinks and industrial juices. In line with this, frequent availability of soft drinks and other sugary foods in the streets of these cities was previously reported [10–13]. High intake of free sugars increases overall energy intake, leading to weight gain and increased risk of diet-related NCD [51,52], and WHO recommends reducing its intake to less than 10% of TEV [28]. As such, future work on the content of free sugars in the street foods available in these settings is recommended.

Among the strengths of this study, we highlight the collection of consumption data through observation of customers at distance rather than interview, which allowed us to minimize potential interference and, thus, potential behavioural or social desirability biases. A high level of concordance between observers, both on demographic and anthropometric characteristics of the customers, as well as on the food items purchased and their quantities, was observed. This was due to successful training, standardization of procedures and constant supervision, and resulted in reproducible observational data on street food purchase and customers' characteristics. Regarding nutritional composition, not only energy and macronutrients content was analysed, but also the lipid profile, as well as sodium and potassium contents. This represents a novel approach in relation to other studies on street food, providing a much more detailed view of the key nutrients for diet-related chronic disease. However, nutritional contents per 100 g may be diluted by the water content of the beverages that were purchased together with the foods, although we estimate that this effect should be minor, as only 9.9% of customers purchased foods with beverages (as shown in Table 1). However, these results should be interpreted carefully and in association with the contents per serving. Regarding fatty acids contents estimation (SFA, PUFA, $n-3$, $n-6$, MUFA and TFA), the lack of available data in the food composition tables and food labels used may have generated some error associated with the estimates of those specific nutrients. However, we assume that this error should be limited, since the majority of the purchases assessed (n = 494, 87.6%) had data available from chemical analyses. The inclusion of fatty acids data in both food composition tables and food labels would be a valuable contribution not only to research and policy, but also to the improvement of the information provided to the consumers. Finally, although generalizability is limited due to local cultural specificities, the FEEDCities methodology allows for standardized assessment, resulting in comparable results among different cities or countries.

5. Conclusions

In conclusion, street food purchase in these urban areas of Central Asia is frequent and characterized by the acquisition of local traditional foods and beverages concomitantly with industrialized food products. In general, street food purchases were energy-dense and rich in sodium, saturated and *trans* fats, and poor in potassium, which in the long term can have a negative impact on health. Further research on the prevalence, frequency and determinants of street food consumption in the general population, as well as practices among vendors, ingredients used and its determinants, using complementary methodology such as interviews, would contribute to deepen the knowledge regarding this issue. Our findings reinforce the importance of implementing public health strategies on healthier diets promotion and NCD prevention, on several fronts, such as public awareness, legislation, product reformulation and labelling improvement. Such policies could be integrated in existing national programmes on NCD, food security and nutrition, emphasizing mostly on sodium reduction, improvement of lipid profile and *trans* fat elimination.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/nu13103651/s1, Table S1: Inter-observer concordance on demographic and anthropometric characteristics and items purchased by the customers observed in street food vending sites of Dushanbe (Tajikistan), Bishkek (Kyrgyzstan), Ashgabat (Turkmenistan) and Almaty (Kazakhstan). Table S2: Decision rules for the elimination of conflicts of observation regarding food items and quantities purchased. Table S3: Ready-to-eat foods and beverages purchased by the street food customers observed in Dushanbe (Tajikistan), Bishkek (Kyrgyzstan), Ashgabat (Turkmenistan) and Almaty (Kazakhstan), overall and by sex, age and weight status.

Author Contributions: M.G., A.D., P.M., J.B., N.L. and P.P. designed the study. G.A., I.L.d.M. and M.G. supervised the study implementation and data collection. O.P. and S.C. were responsible for the laboratorial analyses of the food samples collected in Tajikistan, Kyrgyzstan and Kazakhstan. C.M. coordinated the laboratorial analyses in Turkmenistan. S.S., N.L. and P.P. performed the analysis and interpretation of the results. S.S. drafted the first version of the manuscript. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: This study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of the Institute of Public Health of the University of Porto (CE16058), as well as by local authorities in each country.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available upon request to the corresponding author.

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Supplementary Materials

Table S1. Inter-observer concordance on demographic and anthropometric characteristics and items purchased by the customers observed in street food vending sites of *Dushanbe* (Tajikistan), *Bishkek* (Kyrgyzstan), *Ashgabat* (Turkmenistan) and *Almaty* (Kazakhstan).

	Overall		Tajikistan		Kyrgyzstan		Turkmenistan		Kazakhstan	
	% agreement	Cohen's Kappa (95% CI)	% agreement	Cohen's Kappa (95% CI)	% agreement	Cohen's Kappa (95% CI)	% agreement	Cohen's Kappa (95% CI)	% agreement	Cohen's Kappa (95% CI)
CUSTOMERS	**n=714**		**n=81**		**n=237**		**n=257**		**n=139**	
Sex										
Male Female	100.0%	1.00 (0.93-1.00)	100.0%	1.00 (0.78-1.00)	100.0%	1.00 (0.87-1.00)	100.0%	1.00 (0.88-1.00)	100.0%	1.00 (0.83-1.00)
Age										
<35 years ≥35 years	89.9%	0.80 (0.72-0.87)	82.7%	0.65 (0.44-0.87)	89.0%	0.78 (0.65-0.91)	90.3%	0.80 (0.68-0.92)	94.7%	0.89 (0.73-1.00)
Weight status										
Underweight/Normal weight Overweight/obesity	91.9%	0.79 (0.71-0.86)	84.0%	0.60 (0.39-0.82)	90.7%	0.71 (0.59-0.84)	94.2%	0.86 (0.73-0.98)	94.2%	0.86 (0.69-1.00)
Purchased at least one food										
Yes No	100.0%	1.00 (0.93-1.00)	100.0%	1.00 (0.78-1.00)	100.0%	1.00 (0.87-1.00)	100.0%	1.00 (0.89-1.00)	100.0%	1.00 (0.83-1.00)
Purchased at least one beverage										
Yes No	99.2%	0.98 (0.91-1.00)	95.1%	0.88 (0.66-1.00)	99.2%	0.98 (0.86-1.00)	100.0%	1.00 (0.88-1.00)	100.0%	1.00 (0.83-1.00)
Number of items purchased										
One (median) More than one	99.7%	0.99 (0.93-1.00)	98.8%	0.96 (0.74-1.00)	100.0%	1.00 (0.87-1.00)	99.6%	0.99 (0.86-1.00)	100.0%	1.00 (0.83-1.00)
ITEMS	**n=852**		**n=101**		**n=276**		**n=310**		**n=165**	
Item purchased	97.6%	0.98 (0.97-0.99)	97.9%	0.98 (0.93-1.00)	94.5%	0.94 (0.92-0.96)	99.7%	1.00 (0.97-1.00)	98.8%	0.99 (0.96-1.00)
Quantity purchased	95.3%	0.94 (0.92-0.97)	92.6%	0.89 (0.79-0.99)	94.5%	0.93 (0.89-0.98)	96.8%	0.96 (0.92-1.00)	95.2%	0.94 (0.87-1.00)

95% CI: 95% confidence interval.

Table S2. Decision rules for the elimination of conflicts of observation regarding food items and quantities purchased.

Type of disagreement	Criteria used	Example
Disagreements on the food item purchased		
The two observers registered two different food items (n=5).	Conflicting food items were checked for its availability on the corresponding vending site.*	Observer A registered "coffee" and observer B registered "tea". The corresponding vending site did not have coffee available. It was assumed that the customer purchased tea.
The two observers registered the same food item, but with different degrees of specificity (n=15).	The broadest observation was assumed.	Observer A registered "samosa" and observer B registered "chicken samosa". It was assumed that the customer purchased samosa.
The two observers registered a different number of food items (n=10).	The most complete observation was assumed, unless the conflicting item was not available in the corresponding vending site.	Observer A registered "samosa" and observer B registered "samosa" and "tea". It was assumed that the customer purchased samosa and tea. If the corresponding vending site did not have tea available, it would be assumed that the customer purchased samosa.
Disagreements on the quantity purchased		
The two observers registered the same food item, but different quantities (n=40).	The average quantity between the two observations was assumed.	Observer A registered 200mL of tea and observer B registered 300mL of tea. It was assumed that the customer purchased 250mL of tea.

*Observations should be excluded in the cases where the availability criterion does not solve the conflict: (1) if the conflicting food items are both available at the corresponding vending site; or (2) if none of the conflicting food items are available at the corresponding vending site. These particular situations did not occur.

Table S3. Ready-to-eat foods and beverages purchased by the street food customers observed in *Dushanbe* (Tajikistan), *Bishkek* (Kyrgyzstan), *Ashgabat* (Turkmenistan) and *Almaty* (Kazakhstan), overall and by sex, age and weight status.

	Total		Sex					Age[a]					Weight status[a]				
			Male		Female		p	<35 years		≥35 years		p	Underweight /normal		Overweight /obesity		p
	n	%	n	%	n	%		n	%	n	%		n	%	n	%	
Tajikistan	n=81		n=53		n=28			n=38		n=29			n=52		n=16		
Foods[b]	62	76.5	40	75.5	22	78.6	0.754	31	81.6	21	72.4	0.373	41	78.8	10	62.5	0.187
Savoury pastries and snacks	21	25.9	13	24.5	8	28.6	0.693	13	34.2	3	10.3	**0.023**	15	28.8	2	12.5	0.187
Main dishes	9	11.1	5	9.4	4	14.3	0.509	4	10.5	5	17.2	0.425	4	7.7	2	12.5	0.553
Sweet pastries and confectionery	10	12.4	8	15.1	2	7.2	0.301	8	21.1	2	6.9	0.107	9	17.3	0	0.0	0.074
Breads	21	25.9	13	24.5	8	28.6	0.693	7	18.4	13	44.8	**0.019**	10	19.2	7	43.8	**0.048**
Sandwiches	1	1.2	1	1.9	0	0.0	0.465	1	2.6	0	0.0	0.379	1	1.9	0	0.0	0.576
Fruit	4	4.9	3	5.7	1	3.6	0.680	0	0.0	0	0.0	-	4	7.7	0	0.0	0.253
Beverages[b]	26	32.1	18	34.0	8	28.6	0.621	13	34.2	8	27.6	0.562	16	30.8	8	50.0	0.159
Tea and coffee	4	4.9	2	3.8	2	7.1	0.506	4	10.5	0	0.0	0.072	4	7.7	0	0.0	0.253
Soft drinks and juices	15	18.5	11	20.8	4	14.3	0.476	6	15.8	6	20.7	0.604	7	13.5	7	43.8	**0.009**
Fermented traditional beverages[c]	2	2.5	2	3.8	0	0.0	0.298	2	5.3	0	0.0	0.210	2	3.8	0	0.0	0.426
Water	3	3.7	1	1.9	2	7.1	0.234	1	2.6	1	3.4	0.846	2	3.8	0	0.0	0.426
Alcoholic beverages[d]	2	2.5	2	3.8	0	0.0	0.298	0	0.0	1	3.4	0.249	1	1.9	1	6.3	0.370
Milk	0	0.0	0	0.0	0	0.0	-	0	0.0	0	0.0	-	0	0.0	0	0.0	-
Kyrgyzstan	n=237		n=96		n=141			n=101		n=110			n=178		n=37		
Foods[b]	158	66.7	59	61.5	99	70.2	0.160	68	67.3	72	65.5	0.774	121	68.0	25	67.6	0.961
Savoury pastries and snacks	56	23.6	19	19.8	37	26.2	0.251	24	23.8	26	23.6	0.983	42	23.6	11	29.7	0.431
Main dishes	48	20.3	22	22.9	26	18.4	0.400	24	23.8	17	15.5	0.128	42	23.6	3	8.1	**0.035**
Sweet pastries and confectionery	22	9.3	5	5.2	17	12.1	0.075	9	8.9	12	10.9	0.628	13	7.3	8	21.6	**0.008**
Breads	22	9.3	6	6.3	16	11.3	0.184	4	4.0	14	12.7	**0.023**	17	9.6	3	8.1	0.783
Sandwiches	16	6.8	9	9.4	7	5.0	0.184	10	9.9	5	4.5	0.130	12	6.7	1	2.7	0.348
Fruit	0	0.0	0	0.0	0	0.0	-	0	0.0	0	0.0	-	0	0.0	0	0.0	-
Beverages[b]	106	44.7	51	53.1	55	39.0	**0.032**	47	46.5	50	45.5	0.875	78	43.8	16	43.2	0.949
Tea and coffee	51	21.5	21	21.9	30	21.3	0.912	23	22.8	24	21.8	0.868	37	20.8	8	21.6	0.910
Soft drinks and juices	24	10.1	13	13.5	11	7.8	0.150	13	12.9	9	8.2	0.266	19	10.7	1	2.7	0.129
Fermented traditional beverages[c]	21	8.9	11	11.5	10	7.1	0.246	8	7.9	13	11.8	0.345	16	9.0	3	8.1	0.864
Water	1	0.4	0	0.0	1	0.7	0.408	1	1.0	0	0.0	0.296	0	0.0	1	2.7	**0.028**
Alcoholic beverages[d]	8	3.4	5	5.2	3	2.1	0.197	2	2.0	4	3.6	0.470	5	2.8	3	8.1	0.121
Milk	1	0.4	1	1.0	0	0.0	0.225	0	0.0	0	0.0	-	1	0.6	0	0.0	0.648
Turkmenistan	n=257		n=119		n=138			n=97		n=135			n=178		n=64		
Foods[b]	242	94.2	112	94.1	130	94.2	0.977	92	94.8	127	94.1	0.801	167	93.8	60	93.8	0.984
Savoury pastries and snacks	60	23.4	31	26.1	29	21.0	0.341	30	30.9	26	19.3	**0.040**	46	25.8	11	17.1	0.162

Main dishes	49	19.1	18	15.1	31	22.5	0.135	17	17.5	28	20.7	0.541	32	18.0	14	21.9	0.496
Sweet pastries and confectionery	67	26.1	26	21.9	41	29.7	0.152	23	23.7	40	29.6	0.317	44	24.7	19	29.7	0.437
Breads	49	19.1	28	23.5	21	15.2	0.091	15	15.5	29	21.5	0.249	34	19.1	12	18.8	0.951
Sandwiches	25	9.7	10	8.4	15	10.9	0.506	10	10.3	9	6.7	0.318	17	9.6	6	9.4	0.967
Fruit	4	1.6	2	1.7	2	1.5	0.881	2	2.1	2	1.5	0.738	3	1.7	1	1.6	0.947
Beverages[b]	35	13.6	19	16.0	16	11.6	0.308	17	17.5	16	11.9	0.222	26	14.6	8	12.5	0.677
Tea and coffee	9	3.5	6	5.0	3	2.2	0.212	4	4.1	5	3.7	0.870	7	3.9	1	1.6	0.363
Soft drinks and juices	21	8.2	12	10.1	9	6.5	0.299	13	13.4	6	4.4	**0.014**	16	9.0	5	7.8	0.774
Fermented traditional beverages[c]	3	1.2	1	0.8	2	1.5	0.650	0	0.0	3	2.2	0.139	1	0.6	2	3.1	0.112
Water	3	1.2	1	0.8	2	1.5	0.650	0	0.0	3	2.2	0.139	3	1.7	0	0.0	0.296
Alcoholic beverages[d]	0	0.0	0	0.0	0	0.0	-	0	0.0	0	0.0	-	0	0.0	0	0.0	-
Milk	0	0.0	0	0.0	0	0.0	-	0	0.0	0	0.0	-	0	0.0	0	0.0	-
Kazakhstan	n=139		n=42		n=97			n=50		n=82			n=95		n=36		
Foods[b]	102	73.4	31	73.8	71	73.2	0.940	35	70.0	61	74.4	0.583	69	72.6	27	75.0	0.784
Savoury pastries and snacks	29	20.7	6	14.3	23	23.7	0.209	13	26.0	14	17.1	0.217	21	22.1	7	19.4	0.740
Main dishes	30	21.6	12	28.6	18	18.6	0.188	8	16.0	20	24.4	0.253	15	15.8	11	30.6	0.059
Sweet pastries and confectionery	29	20.9	7	16.7	22	22.7	0.423	10	20.0	19	23.2	0.670	24	25.3	5	13.9	0.162
Breads	10	7.2	3	7.1	7	7.2	0.988	1	2.0	7	8.5	0.127	6	6.3	2	5.6	0.871
Sandwiches	5	3.6	4	9.5	1	1.0	**0.014**	4	8.0	1	1.2	**0.048**	3	3.2	2	5.6	0.523
Fruit	0	0.0	0	0.0	0	0.0	-	0	0.0	0	0.0	-	0	0.0	0	0.0	-
Beverages[b]	54	38.9	19	45.2	35	36.1	0.309	26	52.0	27	32.9	**0.030**	39	41.1	12	33.3	0.419
Tea and coffee	17	12.2	5	11.9	12	12.4	0.939	5	10.0	12	14.6	0.441	10	10.5	5	13.9	0.589
Soft drinks and juices	10	7.2	3	7.1	7	7.2	0.988	4	8.0	6	7.3	0.886	8	8.4	2	5.6	0.581
Fermented traditional beverages[c]	7	5.0	3	7.1	4	4.1	0.455	5	10.0	2	2.4	0.060	5	5.3	2	5.6	0.947
Water	18	13.0	7	16.7	11	11.3	0.390	12	24.0	5	6.1	**0.003**	15	15.8	3	8.3	0.268
Alcoholic beverages[d]	2	1.4	1	2.4	1	1.0	0.539	0	0.0	2	2.4	0.266	1	1.1	0	0.0	0.537
Milk	2	1.4	0	0.0	2	2.1	0.349	0	0.0	2	2.4	0.266	2	2.1	0	0.0	0.380

Values in bold represent statistically significant differences according to Chi-squared test with a significance level of 0.05.

[a]For the variables age and weight status, the data presented corresponds to the customers in which there was agreement between observers (Tajikistan: n=67 and n=68; Kyrgyzstan: n=211 and n=215; Turkmenistan: n=232 and n=242; Kazakhstan: n=132 and n=131).

[b]The sum of the values for each sub-category may be higher than the total N of the respective category, because the same customer could buy more than one food item.

[c]Fermented traditional beverages included *ayran* (dairy-based fermented beverage made from sheep's milk), *chalap* (beverage made from fermented milk, salt and carbonated water;), *dugob* (fermented beverage made with sour milk or buttermilk), *kefir* (fermented milk drink prepared by inoculating cow, goat or sheep milk with kefir grains), *maksym* (fermented beverage made from grain, usually malt), *tamshan* (mix of *maksym* and *chalap*), k*ozhe* (cold drink made by boiling rice, millet or pearl barley with a mixture of dairy products such as *ayran* or *kefir*) and Yoghurt.

[d]Alcoholic beverages included beer, vodka and some traditional beverages with a low alcohol content, such as *kvass* (a fermented beverage made from rye bread), *bozo* (a fermented beverage made from millet) and *kymyz* (a fermented product made from mare's milk).

PAPER II

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Nutritional Content of Street Food and Takeaway Food Purchased in Urban Bosnia and Herzegovina

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Abstract: Street food (SF) and takeaway food (TAF) are important sources of out-of-home meals in urban Bosnia and Herzegovina, where diet-related non-communicable diseases are growing rapidly. This study aimed to characterise SF and TAF purchased in urban areas of Bosnia and Herzegovina, regarding customers' characteristics and the nutritional composition of the foods and beverages. A cross-sectional study was conducted in Sarajevo and Banja Luka in 2017. SF (n = 194) and TAF vending sites (n = 154) were selected through random and systematic sampling. Data on the food items purchased and customers' characteristics were collected by direct observation. Nutritional composition was estimated using data from chemical analyses of the foods most commonly available. Two-thirds of the customers observed (n = 755) were aged ≥35 years, half were women and 27.7% were overweight/obese. A total of 929 food items were purchased. The most commonly bought SFs were confectionery (30.5%), water (27.9%) and soft drinks/juices (22.2%). TAF customers purchased mostly savoury pastries (39.8%), breads (27.1%) and main dishes (21.4%). Almost half of customers purchased industrial food (i.e., pre-packaged foods and beverages produced by the food industry). The purchases presented median contents of 18.7 g of fat (39.6% saturated, 32.3% monounsaturated, 22.1% polyunsaturated, 1.5% trans), 838 mg of sodium and 285 mg of potassium. Saturated-fat contribution was higher in SF purchases (60.4% vs. 30.2%, $p < 0.001$), whereas TAF purchases presented higher trans-fat proportion (1.8% vs. 0.6%, $p < 0.001$), sodium (1241 vs. 89 mg, $p < 0.001$) and sodium-potassium ratio (6.1 vs. 0.6, $p < 0.001$). Generally, SF and TAF bought in Sarajevo and Banja Luka were rich in saturated and trans fatty-acids and sodium, and poor in potassium.

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Nutrition policies promoting use of healthier fats and salt reduction in SF and TAF may contribute to the prevention of diet-related diseases in these settings.

Keywords: street food; takeaway food; nutritional value; nutrition transition; Eastern Europe

1. Introduction

Non-communicable diseases (NCD) are the leading cause of mortality and morbidity worldwide, representing one of the major threats to global sustainable development in the 21st century [1]. In Eastern Europe, NCD are estimated to account for approximately 90% of all deaths in the region, mostly cardiovascular diseases and cancer [2]. The prevalence of obesity in South-Eastern Europe is the highest when compared to the rest of the European sub-regions, with a 30% growth between 2000 and 2014 [3]. In Bosnia and Herzegovina, overweight and obesity affects 60.7% and 26.5% of adults aged 20 years or older, respectively [4] and over one-third are estimated to present high blood pressure [2].

The prevalence of diet-related NCD is rising steeply in low- and middle-income countries (LMIC) [5,6], where Western dietary patterns rich in calorie-dense industrialized foods and beverages are supplanting traditional local diets [7]. In Eastern European countries, the supply of sugar-sweetened beverages and packaged processed foods have increased abruptly [8], as well as the availability of dietary energy, animal fats and sugar [6]. Salt intake is also high in the region, corresponding to approximately twice its maximum dietary recommendation [2].

Nutrition and epidemiological transitions are particularly evident in the most urbanized populations [5,9], where out-of-home eating has become one of the major changes in dietary habits over the last decades [10]. In LMIC, rapid urbanization and economic development have led to a great shift in the lifestyle paradigm of these populations, characterized by physical activity decline, increasing number of hours spent away from home and limited time available for preparation of homemade meals [9]. Eating away from home has been associated with higher energy and fat intake and lower micronutrient ingestion [10], as well as higher risk of becoming overweight or obese [11].

Street food and takeaway food were reported as major sources of ready-to-eat foods and beverages available for consumption away from home, and may play an important role in the foodscape of Bosnia and Herzegovina [12,13]. However, the characterization of nutrition-related research on this type of food sources has been mostly conducted in high-income countries [14,15]. Studies in LMIC are still more centered on hygiene and food safety issues [14,16], and research focusing on consumption of street food and takeaway food in these settings is necessary to support evidence-based nutrition policies. Therefore, this study aims to describe the street food and takeaway food purchases in urban areas of Bosnia and Herzegovina, namely regarding the customers' characteristics and the nutritional composition of the foods and beverages sold in these venues.

2. Methods

This study was implemented in the context of the FEEDCities project, which is based on a stepwise standardized characterization of the food environment in cities from Eastern Europe and Central Asia, as described before [17]. For the purpose of this work, a cross-sectional evaluation of street food and takeaway food customers was carried out between June and August 2017 in Sarajevo and Banja Luka, the two largest urban centres of Bosnia and Herzegovina [18,19].

2.1. Eligibility Criteria

In order to select the food vending sites for the study, we adopted the definition of street food proposed by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), as "ready-to-eat foods and beverages prepared and/or sold

by vendors or hawkers especially in the streets and other similar places" [20,21], as well as the definition of a takeaway food vending site proposed by the United Kingdom authorities, as "an outlet whose primary business is the sale of ready-to-eat food and beverages for consumption off the premises" [22]. These included both stationary (street food and takeaway) and mobile (street food) vending units selling food products ready to be consumed immediately without needing further preparation, comprising prepared (e.g., sandwiches), cooked (e.g., main dishes), in natura (e.g., fruits) or industrial foods (e.g., soft drinks, candies). Vending sites selling exclusively non-prepared fruit and vegetables or other not ready-to-eat raw foods (e.g., meat, fish) were not included in the study.

Customers approaching eligible street food or takeaway food vending sites to buy ready-to-eat foods and/or beverages were eligible for the study.

2.2. Sampling Procedure

Sampling procedures were designed taking into account the specificities of each city, namely the distribution patterns of street food and takeaway food vending sites observed during preliminary field visits, as previously described in detail [12,13]. In Sarajevo, vending sites were identified within 10 public markets selected in collaboration with local authorities. A study area was defined within each market, corresponding to 500 m diameter buffers around the centre of the selected markets, with the exception of the larger main city market (*Markale*), where a 1500 m diameter was defined, to accommodate its wider distribution of vending sites. In Banja Luka, the vending sites were mainly clustered in the main city market (*Gradska tržnica*), as well as around public transportation stops (bus stations). Thus, the main city market was selected along with 10 bus stops, each of which corresponded to the main station of the city bus routes. To define the study area, a 1500 m buffer was drawn around the centroid of the main city market; and for each bus stop, the buffer diameter was 100 m.

Field researchers working in pairs canvassed all publicly accessible streets within the study areas of each city in order to identify eligible vending sites. All vending sites identified in each city were selected for this study.

In each vending site, all customers buying any food or beverage meeting the above-mentioned criteria, were observed; the period of observation started at the next multiple of five minutes and ended after 10 min or when four customers were observed, whichever came first. If no customer was observed during this period, field researchers would move on to the next vending site. Observations were performed both on week days and weekends and covering all businesses' working hours (from 8 a.m. to 6 p.m.).

2.3. Data Collection

Data on customers' characteristics and their street food or takeaway food purchases were collected through direct observation, at each identified vending site and performed independently by two local researchers, placed at a distance considered sufficient not to compromise the normal behaviour of the customers nor the regular activity of the vending sites. To standardize and improve the accuracy of the anthropometric evaluation by direct observation, the observers were trained using the Body Mass Index (BMI)-based body size guides for women and men by Harris et al. [23].

The two observers registered the type of vending site (street food or takeaway) and described, for each customer approaching the venue, the foods and/or beverages purchased (hereafter referred to as food items) and their quantities, as well as customers' characteristics, including sex and estimated age (in years: <18, (18–25), (25–35), (35–45), (45–65) or ≥65) and BMI-based weight status (underweight, normal weight, overweight or obese). The inter-observer concordance was high to very high regarding both the customers' characteristics and the food items purchased (Supplementary Table S1). Data on age and weight status was considered for data analysis only for the customers regarding whom there was agreement between observers (n = 701 and n = 683, respectively). For the

food items and quantities purchased, a set of decision rules was implemented in order to eliminate conflicts of observation and uniform the purchases (Supplementary Table S2).

The food items purchased were classified into homemade (foods and beverages prepared and/or cooked at home or in the venue, even if using industrial ingredients) or industrial (foods and beverages produced by the food industry and sold as such, with no further preparation). Based on the WHO nutrient profile model [24], the food items were also grouped into seven sub-categories of foods (1) Main dishes; (2) Breads; (3) Savoury pastries; (4) Savoury snacks; (5) Buns, cakes and cookies; (6) Ice-cream, chocolate and confectionery; and (7) Sandwiches; and five sub-categories of beverages (1) Coffee; (2) Water; (3) Soft drinks and industrial juices; (4) Alcoholic beverages; and (5) Yoghurt.

2.4. Nutritional Composition Estimation

The foods and beverages most frequently available at street food and takeaway food vending sites from each city were identified in a preceding step of the FEEDCities project [12,13]. Then, in each setting, the 20 most frequently available homemade foods and the 10 most frequently available industrial foods were selected for laboratorial analysis. Common foods and beverages with known nutritional composition, such as coffee, soft drinks, water and fruit, were excluded from this selection.

In each city, four samples of each food were collected as part of a regular transaction in different randomly selected vending sites. Chemical analyses, including total fat, fatty acids, sodium and potassium, were performed in accordance with standardized and recommended procedures [25], and described elsewhere [12,13].

For the description of the nutritional composition of the purchases, it was considered a sub-sample (n = 474) of customers who purchased exclusively foods which were chemically analysed; customers who, in addition to those foods, bought one or more beverages of known composition (water, coffee and soft drinks) were also included in this sub-sample. A street food or takeaway food purchase was defined as an acquisition consisting of at least one food. As such, customers buying only beverages, as well as those who purchased at least one food item without nutritional composition data, were excluded. No statistically significant differences were found between the included and excluded customers, regarding sex, age or weight status.

The nutritional value of the street food and takeaway food purchases of each customer was then computed by adding up the estimated contents of total fat, fatty acids, sodium and potassium of all food items purchased by the same customer in a single occasion. For each purchase, percentages of the WHO daily recommendations were computed assuming an average adult with a daily reference intake of 2000 kcal of total energy value (TEV): saturated fatty acids (SFA), <10% TEV [26]; trans fatty acids (TFA), <1% TEV [27]; sodium, <2000 mg [28]; potassium, $\geq$3510 mg [29]; sodium to potassium molar ratio, 1 [28,29]. For all fatty acids, contents were also computed as proportions of the total amount of fat, and were expressed as g/100 g of total fat.

2.5. Data Analysis

Absolute and relative frequencies were used to describe the customers and their purchases, and the nutritional value of the purchases was described using medians and percentiles 25 and 75. For the description of the sample and the comparison of purchases between groups, the variables corresponding to the customers' characteristics were dichotomized (sex: male or female; age: <35 years or $\geq$35 years; weight status: underweight/normal weight or overweight/obesity). Inter-observer concordance for the demographic and anthropometric characteristics of the customers, as well as the food items purchased and its quantities, was assessed through percentage of agreement and Cohen's kappa coefficient with 95% confidence interval. Pearson's Chi-squared and Mann-Whitney's U tests were used to compare the frequencies of the food items purchased and the nutritional content of the purchases, respectively, regarding demographic and anthropometric characteristics of the customers observed and type of vending site fre-

quented. Differences were considered statistically significant when the critical level of significance (p) was less than 0.05. Statistical analyses were performed using Stata® version 15.0 (StataCorp., College Station, TX, USA).

3. Results

A total of 348 vending sites were observed (n = 194 street food; n = 154 takeaway), of which 267 (76.7%) had customers observed. A total of 755 customers were observed: 499 (66.1%) in Sarajevo and 457 (60.5%) takeaway food customers. Demographic and anthropometric characteristics of the individuals observed, as well as some main aspects regarding the food items purchased, are presented in Table 1. Approximately half of the customers (50.6%) were female, two-thirds (66.8%) were aged 35 years and older and almost one-third (27.7%) were overweight or obese. Most customers (79.1%) purchased only one food item and more than two-thirds (68.1%) purchased only foods. Almost half (43.7%) of the customers purchased at least one industrial food item; this frequency was significantly higher for street food customers (78.2% vs. 21.2%, $p < 0.001$).

Table 1. Customer's demographic and anthropometric characteristics, and items purchased, estimated by direct observation of street food and takeaway food vending sites in Sarajevo and Banja Luka, Bosnia and Herzegovina.

	Total n **= 755** n **(%)**	**Street Food Customers** n **= 298** n **(%)**	**Takeaway Food Customers** n **= 457** n **(%)**	p
Sex				
Male	373 (49.4)	130 (43.6)	243 (53.2)	**0.010**
Female	382 (50.6)	168 (56.4)	214 (46.8)	
Age [a]				
<35 years	233 (33.2)	120 (44.1)	113 (26.3)	**<0.001**
≥35 years	468 (66.8)	152 (55.9)	316 (73.7)	
Weight status [a]				
Underweight/Normal weight	494 (72.3)	206 (75.7)	288 (70.1)	0.105
Overweight/obesity	189 (27.7)	66 (24.3)	123 (29.9)	
Number of items purchased				
1 (median)	597 (79.1)	272 (91.3)	325 (71.1)	**<0.001**
>1	158 (20.9)	26 (8.7)	132 (28.9)	
Purchased foods or beverages?				
Only foods	514 (68.1)	150 (50.3)	364 (79.7)	**<0.001**
Only beverages	153 (20.3)	130 (43.6)	23 (5.0)	
Foods and beverages	88 (11.6)	18 (6.0)	70 (15.3)	
Purchased homemade or industrial?				
Only homemade	425 (56.3)	65 (21.8)	360 (78.8)	**<0.001**
Only industrial	257 (34.0)	231 (77.5)	26 (5.7)	
Homemade and industrial	73 (9.7)	2 (0.7)	71 (15.5)	

[a] For the variables age and weight status, the data presented corresponds to the customers in which there was agreement between observers (n = 701 and n = 683, respectively). Values in bold represent statistically significant differences according to Pearson's Chi-squared test with a significance level of 0.05.

A total of 929 food items were purchased, corresponding to an average of 1.2 food items per customer and 5.8 food items per 10 min of observation. The most commonly purchased takeaway foods were savoury pastries (39.8% of all takeaway customers), breads (27.1%) and main dishes (21.4%), while street food customers bought mostly ice-cream, chocolate and confectionery (30.5% of all street food customers), water (27.9%) and soft drinks and industrial juices (22.2%) (Figure 1). The frequencies of foods and beverages purchased by sex, age and weight status of the customers observed are presented in Supplementary Table S3.

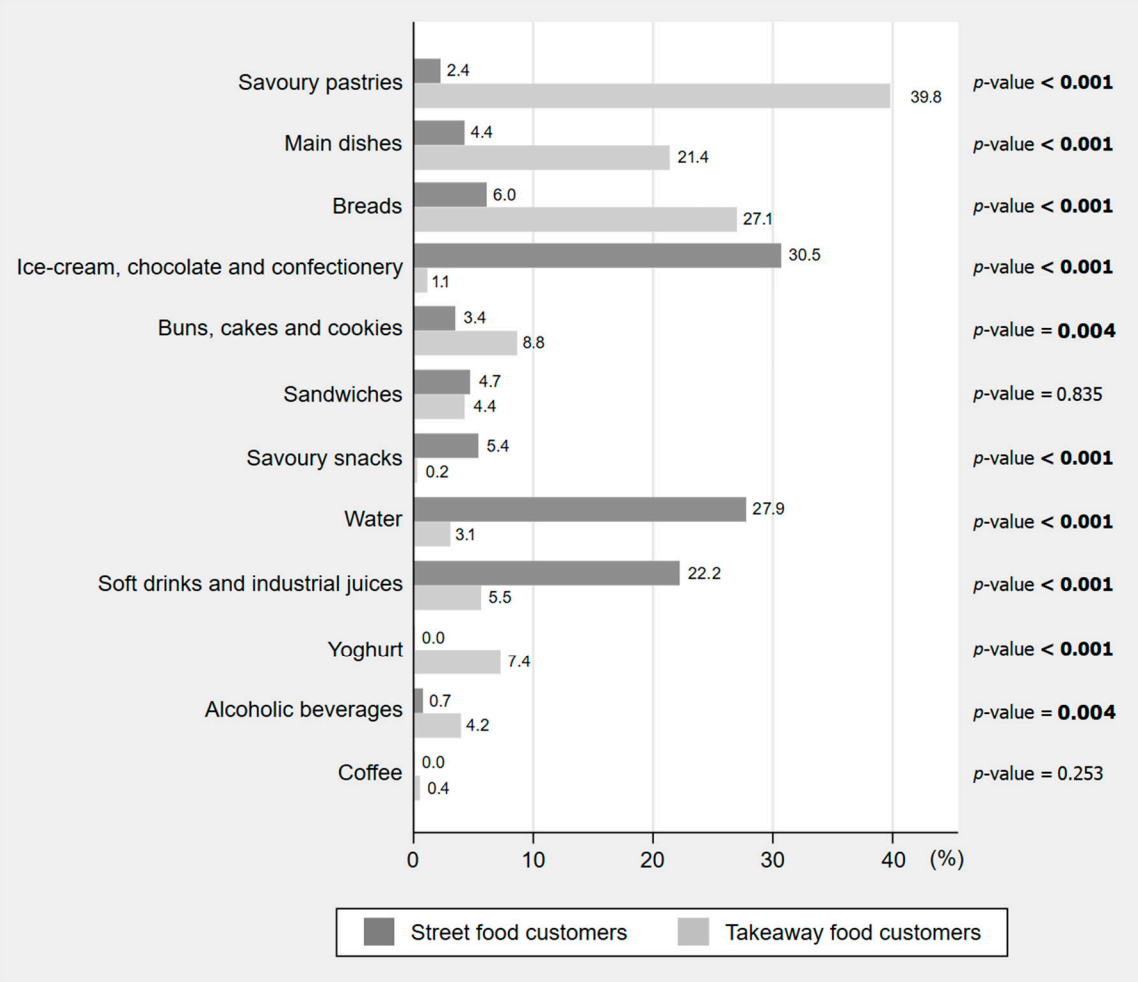

Figure 1. Ready-to-eat foods and beverages purchased by the customers observed in street food and takeaway food vending sites in Sarajevo and Banja Luka, Bosnia and Herzegovina (n = 755). The proportions presented are relative to the total number of customers from each type of vending site (street food: n = 298; takeaway food: n = 457). The sum of the percentages may exceed 100% because the same customer could buy more than one food or beverage. Values in bold represent statistically significant differences according to Pearson's Chi-squared test with a significance level of 0.05.

The median total fat content of one purchase was 18.7 g, with SFA and TFA median contents accounting for 38.0% and 8.1% of their recommendations, respectively. The median sodium content was 838 mg, which accounted for 41.9% of its maximum daily intake recommendation, while supplying 285 mg of potassium (8.1% of its minimum recommendation). In comparison to street food, takeaway food purchases presented higher median contents of total fat (22.0 vs. 13.9 g, $p < 0.001$) as well as all fatty acids. SFA and TFA median contents in takeaway food purchases accounted for 39.7% and 21.4% of their maximum daily intake recommendations, respectively. Takeaway food customers also presented purchases with higher median contents of sodium (1241 vs. 89 mg, $p < 0.001$) and potassium (323 vs. 162 mg, $p < 0.001$). Regarding nutrient density (per 100 g), street food purchases presented higher total fat (12.6 vs. 8.8 g/100 g, $p < 0.001$), SFA (8.9 vs. 3.0 g/100 g, $p < 0.001$) and potassium (216 vs. 161 mg/100 g, $p < 0.001$), while takeaway food customers presented purchases with higher polyunsaturated fatty acids (PUFA) (1.9 vs. 1.0 g/100 g, $p < 0.001$), TFA (0.19 vs. 0.11 g/100 g, $p < 0.001$) and sodium levels (565 vs. 117 mg/100 g, $p < 0.001$). Sodium to potassium ratio was significantly higher in takeaway food purchases (6.1 vs. 0.6, $p < 0.001$) (Table 2).

Table 2. Estimated fatty acids, sodium and potassium contents of the purchases made by a sub-sample (*n* = 474 [a]) of street food and takeaway food customers observed in Sarajevo and Banja Luka, Bosnia and Herzegovina.

	Total ***n* = 474** **Median (P25–P75)**	**Street Food Customers** ***n* = 127** **Median (P25–P75)**	**Takeaway Food Customers** ***n* = 347** **Median (P25–P75)**	***p***
Amount purchased (g)	159 (83–294)	66 (66–192)	179 (96–318)	**<0.001**
Per total purchase				
Total fat (g)	18.7 (7.7–32.0)	13.9 (8.2–18.9)	22.0 (6.6–37.2)	**<0.001**
SFA (g)	8.4 (1.9–12.5)	7.4 (4.0–9.2)	8.8 (1.2–14.4)	0.546
MUFA (g)	5.7 (1.6–10.3)	3.3 (1.6–6.6)	7.7 (1.8–12.5)	**<0.001**
PUFA (g)	2.6 (1.4–6.0)	0.8 (0.6–1.6)	4.0 (1.7–6.7)	**<0.001**
n-6 (g)	2.5 (1.3–5.8)	0.8 (0.6–1.5)	3.8 (1.4–6.6)	**<0.001**
n-3 (g)	0.1 (0.1–0.2)	0.1 (0.0–0.1)	0.1 (0.1–0.3)	**<0.001**
TFA (g)	0.18 (0.05–0.92)	0.08 (0.04–0.17)	0.47 (0.05–1.16)	**<0.001**
Na (mg)	838 (365–1934)	89 (39–490)	1241 (540–2140)	**<0.001**
K (mg)	285 (154–500)	162 (143–292)	323 (154–536)	**<0.001**
Per 100 g of purchase				
Total fat (g)	9.5 (6.0–17.6)	12.6 (7.1–21.1)	8.8 (5.5–15.0)	**<0.001**
SFA (g)	3.3 (1.6–7.0)	8.9 (2.7–14.0)	3.0 (1.2–5.3)	**<0.001**
MUFA (g)	3.0 (1.9–5.0)	3.0 (2.1–5.0)	3.0 (1.8–4.8)	0.352
PUFA (g)	1.8 (1.0–3.0)	1.0 (0.4–2.0)	1.9 (1.1–3.6)	**<0.001**
n-6 (g)	1.5 (0.9–2.9)	0.9 (0.4–1.7)	1.8 (1.0–3.3)	**<0.001**
n-3 (g)	0.1 (0.0–0.1)	0.1 (0.0–0.1)	0.1 (0.0–0.2)	**0.030**
TFA (g)	0.16 (0.06–0.28)	0.11 (0.03–0.19)	0.19 (0.07–0.32)	**<0.001**
Na (mg)	562 (357–674)	117 (59–523)	565 (451–758)	**<0.001**
K (mg)	169 (118–232)	216 (144–273)	161 (116–201)	**<0.001**
Na/K ratio	5.9 (4.8–7.2)	0.6 (0.5–5.8)	6.1 (5.6–7.4)	**<0.001**

SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; TFA, trans fatty acids; Na, sodium; K, potassium. Values in bold represent statistically significant differences according to Mann-Whitney's U test with a significance level of 0.05. [a] Only customers purchasing foods with laboratorial data and beverages (when applicable) of known composition (i.e., water, coffee and soft drinks) were included. Customers purchasing only beverages were not included.

Regarding lipid profile, the highest median contribution to total fat came from SFA (39.6 g/100 g total fat), followed by monounsaturated fatty acids (MUFA) (32.3 g/100 g total fat), PUFA (22.1 g/100 g total fat) and TFA (1.5 g/100 g total fat). Purchases from street food customers presented higher contribution from SFA (60.4 vs. 30.2 g/100 g total fat, $p < 0.001$) and lower proportions of PUFA (5.0 vs. 27.4 g/100 g total fat, $p < 0.001$), whereas takeaway food customers presented purchases with higher TFA levels (1.8 vs. 0.6 g/100 g total fat, $p < 0.001$) (Figure 2). Purchases containing at least one industrial food item had a higher proportion of SFA (58.9 vs. 30.0 g/100 g of total fat, $p < 0.001$) and lower contribution from PUFA (5.0 vs. 28.2 g/100 g of total fat, $p < 0.001$) and MUFA (30.2 vs. 32.5 g/100 g of total fat, $p = 0.034$) than those with no industrial food items.

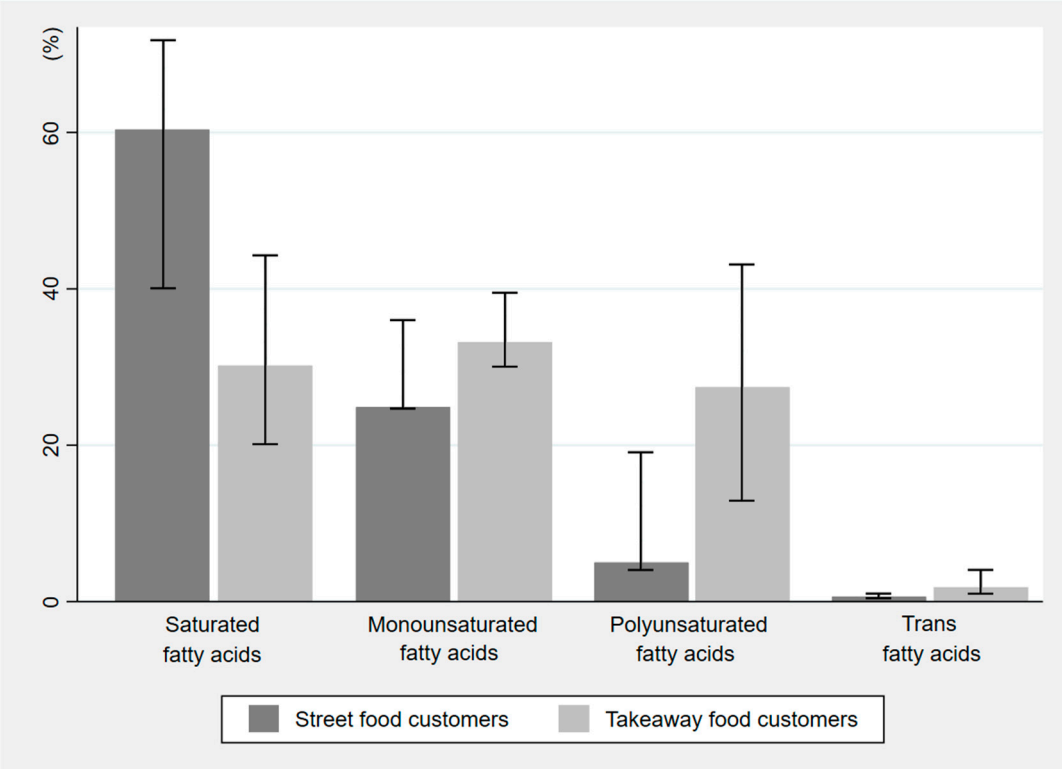

Figure 2. Estimated fatty-acid contents (g/100 g of total fat) of the purchases made by a sub-sample (n = 474) of street food and takeaway food customers observed in Sarajevo and Banja Luka, Bosnia and Herzegovina. The values shown are presented as median and inter-quartile range.

The nutritional composition of the purchases by sex, age and weight status of the customers is presented in Table 3. Male customers presented purchases with higher serving size, total fat, SFA, TFA, MUFA, sodium and potassium. Older customers presented purchases richer in PUFA, n-6 fatty acids and sodium. Purchases from overweight/obese customers showed higher level of TFA and sodium. Considering nutritional composition per 100 g, men and older customers presented purchases richer in sodium, while younger individuals presented purchases with higher levels of total fat, SFA and MUFA.

Table 3. Estimated fatty acids, sodium and potassium contents of the purchases made by a sub-sample (n = 474 [a]) of street food and takeaway food customers observed in Sarajevo and Banja Luka, Bosnia and Herzegovina, by sex, age and weight status.

	Sex			**Age** [b]			**Weight Status** [b]		
	Male n **= 229**	**Female** n **= 245**	p	**<35 Years** n **= 141**	**≥35 Years** n **= 308**	p	**Underweight/ Normal Weight** n **= 311**	**Overweight/ Obesity** n **= 120**	p
	Median (P25–P75)			**Median (P25–P75)**			**Median (P25–P75)**		
Amount purchased (g)	179 (89–318)	108 (66–247)	0.004	154 (66–247)	171 (83–318)	0.155	145 (82–247)	191 (83–318)	0.126
Per total purchase									
Total fat (g)	22.0 (8.8–35.7)	16.0 (6.9–27.9)	**0.017**	17.8 (9.1–27.8)	19.1 (6.6–32.3)	0.967	17.8 (8.0–30.6)	21.7 (7.7–34.0)	0.269
SFA (g)	9.1 (4.0–14.4)	7.3 (1.3–11.8)	**0.020**	9.1 (4.2–12.5)	8.1 (1.11–12.5)	0.254	8.4 (3.1–12.0)	8.8 (1.8–16.8)	0.263
MUFA (g)	7.1 (3.0–11.5)	4.8 (1.5–9.4)	**0.011**	5.6 (3.3–9.5)	6.6 (1.4–11.3)	0.912	5.6 (1.6–9.8)	6.6 (1.8–11.8)	0.341
PUFA (g)	2.9 (1.4–6.1)	2.0 (1.3–5.4)	0.192	1.9 (1.0–4.5)	3.0 (1.4–6.4)	**0.022**	2.4 (1.4–6.0)	2.7 (1.4–5.3)	0.745
n-6 (g)	2.8 (1.3–6.0)	1.9 (1.1–5.1)	0.211	1.9 (0.9–4.3)	2.8 (1.3–6.3)	**0.023**	2.2 (1.3–5.8)	2.5 (1.3–5.2)	0.649
n-3 (g)	0.1 (0.1–0.2)	0.1 (0.1–0.2)	0.726	0.1 (0.1–0.2)	0.1 (0.1–0.2)	0.145	0.1 (0.1–0.2)	0.1 (0.1–0.2)	0.751
TFA (g)	0.34 (0.05–0.93)	0.16 (0.04–0.88)	**0.013**	0.18 (0.05–0.78)	0.25 (0.04–0.92)	0.987	0.18 (0.04–0.92)	0.31 (0.05–1.06)	**0.021**
Na (mg)	1122 (459–2140)	540 (260–1561)	**<0.001**	548 (237–1416)	1080 (459–2085)	**0.010**	712 (308–1751)	1122 (412–2140)	**0.018**
K (mg)	308 (155–511)	235 (143–430)	**<0.001**	256 (150–437)	289 (154–507)	0.095	256 (154–471)	324 (158–509)	0.079
Per 100 g of purchase									
Total fat (g)	9.0 (6.0–17.6)	10.1 (5.5–17.0)	0.963	10.3 (7.2–20.3)	9.0 (4.9–15.1)	**0.018**	9.4 (6.0–18.1)	9.5 (5.5–15.3)	0.552
SFA (g)	3.3 (1.7–7.1)	3.3 (1.3–6.8)	0.589	4.5 (2.6–9.2)	3.1 (1.1–6.0)	**0.001**	3.3 (1.6–8.2)	3.3 (1.3–6.0)	0.561
MUFA (g)	3.0 (2.0–5.0)	2.9 (1.8–5.0)	0.529	3.3 (2.2–5.3)	2.7 (1.8–5.0)	**0.033**	2.9 (2.0–5.0)	3.0 (1.8–4.8)	0.663
PUFA (g)	1.8 (0.9–3.0)	1.8 (1.0–3.2)	0.389	1.5 (1.0–2.9)	1.8 (1.0–3.0)	0.155	1.8 (1.0–3.0)	1.7 (0.8–2.8)	0.489
n-6 (g)	1.5 (0.9–2.8)	1.5 (0.9–3.2)	0.433	1.5 (0.9–2.7)	1.6 (0.9–3.0)	0.190	1.5 (0.9–3.0)	1.5 (0.8–2.7)	0.529
n-3 (g)	0.1 (0.0–0.1)	0.1 (0.0–0.2)	0.080	0.1 (0.0–0.1)	0.1 (0.0–0.1)	0.863	0.1 (0.0–0.1)	0.0 (0.0–0.1)	0.124
TFA (g)	0.16 (0.06–0.31)	0.14 (0.05–0.26)	0.152	0.18 (0.07–0.26)	0.16 (0.05–0.30)	0.410	0.14 (0.06–0.26)	0.18 (0.05–0.31)	0.378
Na (mg)	565 (393–689)	517 (317–629)	**0.024**	522 (245–629)	562 (397–689)	**0.049**	541 (331–627)	562 (376–758)	0.181
K (mg)	169 (120–232)	169 (116–232)	0.709	172 (120–243)	169 (116–232)	0.429	167 (118–225)	172 (116–242)	0.657
Na/K ratio	6.0 (4.9–7.2)	5.8 (3.7–7.0)	0.063	5.8 (1.6–7.2)	5.9 (4.9–7.2)	0.065	5.9 (4.3–7.2)	5.9 (4.8–7.2)	0.425

SFA, saturated fatty acids; PUFA, polyunsaturated fatty acids; TFA, trans fatty acids; MUFA, monounsaturated fatty acids; K, potassium; Na, sodium. Values in bold represent statistically significant differences according to Mann Whitney's U test with a significance level of 0.05. [a] Only customers purchasing foods with laboratorial data and beverages (when applicable) of known composition (i.e., water, coffee and soft drinks) were included. Customers purchasing only beverages were not included; [b] For the variables age and weight status, the data presented corresponds to the customers in which there was agreement between observers (n = 449 and n = 431, respectively).

4. Discussion

In the two main urban areas of Bosnia and Herzegovina, the purchase of street food and takeaway food was frequent, as demonstrated by the large number of foods and beverages bought within a limited observation period. The food items identified varied according to the type of vending site: takeaway food purchases consisted mainly of pastries, bread and main dishes, whereas those from street food customers included mostly

industrial sweets and beverages. As a result, the nutritional composition of the purchases in each type of venue also differed. Generally, in takeaway food vending sites purchases presented higher total fat content, trans-fat proportion and sodium to potassium ratio, while street food purchases showed higher contribution from saturated fats.

The acquisition of homemade food items was commonly observed, with traditional foods such as *cevapi* (seasoned minced meat rolled into small sausages and served with onions in a traditional bread), *burek* and *sirnica* (traditional savoury baked pies, usually filled with beef and cheese, respectively) and *kifla* (local bread) being amongst the most frequently bought. This suggests that street-vended local foods continue to have cultural expression and dietary importance to these populations, as observed in other contexts [16,30]. However, it should be noted that almost half of the customers bought industrial food items, mostly ice-cream, chocolate and confectionery, chips and soft drinks. Purchases containing industrial food items presented a worse lipid profile than those with no industrial food items, which is in line with previous evidence showing that this type of food products is usually rich in fat, mostly saturated [31]. It has been observed that ultra-processed foods compromise the quality of the diet [32,33] and greatly contribute to excess weight gain and its comorbidities [34,35], and there is a margin for the food industry to improve the nutritional quality of its products, by using healthier recipes and ingredients. Also, promoting higher availability and affordability of healthier street-vended food options, such as ready-to-eat fruits, vegetables, legumes and whole grains, could contribute to counteract the widespread access to less healthy foods, ultimately influencing positively the consumers' choices, as seen in other contexts [36,37].

The street food and takeaway food purchases presented considerable quantities of total fat, SFA and TFA per serving. These values were particularly high in purchases from takeaway venues, reaching almost 40% of the WHO recommendation for SFA [26], and exceeding 20% of the WHO recommendation for TFA [27]. However, it is noteworthy that the amounts purchased by takeaway food customers were much larger when compared to those bought by street food customers. When analysing the nutritional value per 100 g of purchase, it was possible to observe that both total and saturated fat contents were significantly higher in street food, when compared to takeaway purchases. Considering the lipid profile per 100 g of total fat, it was observed that in both types of venue the highest contribution came from SFA rather than unsaturated fats; TFA also accounted for an important share of the purchases' total fat. In each type of vending site, it was possible to identify some concerning results: street food purchases presented very high proportions of SFA (exceeding 60% of total fat) as opposed to the very small contributions of PUFA, whereas takeaway customers presented purchases with high contents in TFA, with its median almost reaching the limit of 2 g/100 g of total fat recommended by the WHO Europe [38] and most recently legislated for the European Union [39]. From all food items analysed for TFA, approximately one in every three (33.8%) exceeded this limit, showing that efforts must be undertaken in order to lower contents of industrially-produced TFA through reformulation of industrial foods. This, coupled with continuous monitoring, would be essential in the achievement of this goal. It was also observed that, from a single purchase, more than half of the customers (53.4%) exceeded 50% of the maximum recommendation for SFA and almost half (46.4%) exceeded 50% of the maximum recommendation for TFA, suggesting that the customers observed are likely to surpass the daily recommended amounts for these fatty acids when consuming one or more meals from a street food or takeaway food vending site. In other settings, high contents of total, saturated and trans-fat have also been documented in both street [16,30,40] and takeaway food [41,42], and their frequent consumption have been associated with negative health outcomes [43,44]. In this study, homemade foods were identified as major sources of TFA, which might suggest a common use of cooking fats and shortenings containing trans-fat, or unhealthy cooking methods, such as frying, in the preparation and confection of these foods [12,13]. This underlines the need for interventions aimed at improving the ingredients and culinary techniques used, for example through price policies that

promote the purchase of healthier ingredients, or through nutrition education programmes aimed at increasing vendors' knowledge and skills related to healthier cooking practices. A systematic review by Downs et al., assessing the impact of policies to reduce trans-fat consumption, reported a reduction on cardiovascular mortality ranging from 1.3% to 6.4% attributable to TFA policies (including voluntary limits on TFA, TFA labelling and legislative bans) [45]. Although no study was conducted in Bosnia and Herzegovina, these results indicate that strategies aimed at TFA reduction from the food supply are expected to decrease the burden of diet-related disease.

Our findings also showed that one single purchase provided almost half of the maximum daily intake recommendation for sodium [28], with higher values in the case of takeaway food. The discrepancies in the nature of the foods available in each type of vending site justify the differences found, since the street food bought consisted mainly of industrial sweets and drinks, which are not relevant sources of sodium. It was also observed that nearly half the customers exceeded its limit of 2000 mg in a single purchase. On the other hand, both street food and takeaway food purchases appeared to be very poor sources of potassium, which can be attributed in part to the low content in fruits, vegetables and pulses of the foods purchased. Sodium to potassium ratio exceeded five times the WHO recommendation [28,29], and this was observed even in purchases containing foods which could be considered as main courses, where a higher amount of potassium would be expected. Homemade food items presented a median sodium to potassium ratio significantly higher than the industrial ones (6.8 vs. 0.5, $p < 0.001$), which can be explained by the excessive addition of salt and/or sodium-rich ingredients, as reported in other settings [46,47]. Results from the Global Burden of Disease study 2019 showed that high blood pressure is the leading risk factor for disease in Eastern Europe, also underscoring the disproportionately high burden of cardiovascular disease in this region [48]. Both reducing dietary sodium content and increasing potassium intake have shown documented benefits to cardiovascular health [49,50]. A study modelling the impact of salt reduction strategies in 23 LMIC showed that a reduction in salt intake to 5 g/day over 10 years could correspond to a potential impact of 23.7% of deaths averted due to cardiovascular disease [51,52]. Salt reduction policies have also been identified as one of the most cost-effective measures to improve populations' health [51]. However, to the best of our knowledge, no salt reduction initiatives have been implemented in this country [4], thus highlighting an opportunity for action. Public health strategies may include the development of interventions encouraging sellers and small manufacturers to use healthier ingredients and to adopt cooking practices for reducing the addition of salt into homemade foods, as well as the implementation of legislation limiting the amount of salt in the industrial ingredients used during preparation of these foods. Increasing the availability of fruits and vegetables as snacks ready for consumption, as well as encouraging the inclusion of more vegetables in the culinary preparations to be sold in the streets, could also help improve sodium to potassium balance of the street food and takeaway meals consumed in these settings.

Although we were unable to analyse sugar contents of the samples collected, it was possible to observe that sugary foods and beverages (i.e., sweet pastries, confectionery, soft drinks and industrial juices) were purchased by a relevant part of our sample (232 customers, 30.7% of total). Accordingly, a high availability of cookies, cakes, industrial sweets, soft drinks and fruit-juice based beverages has been previously reported in these cities [12,13]. The consumption of sugar-rich foods and beverages has been linked to a higher risk of obesity and other cardio-metabolic diseases [53,54]. WHO guidelines recommend adults and children to reduce their daily intake of free sugars to less than 10% of their total energy daily intake; and further reduction to below 5% would provide additional health benefits [55].

Regarding customers' characteristics, male customers and those classified as overweight/obese presented purchases with generally higher levels of fat (total, saturated and trans) and sodium than women and normal-weighted customers. Energy requirements

of men are generally higher than those of women, which may partly justify the higher amounts of food purchased, and consequently the higher contents of fats and sodium. However, high intakes of SFA, TFA and sodium have documented deleterious effects on health [27,28,50], being particularly concerning among individuals that already suffer from overweight or obesity. Strategies aimed at improving consumption patterns with a focus on the prevention of diet-related diseases would be of particular importance in these groups.

Some limitations and strengths of the present study should be discussed. Estimation of weight status was performed through direct observation, which still lacks validation in these populations. However, agreement between observers was high, regarding not only sex, age and weight status of the customers, but also the foods and beverages bought and their quantities, resulting in consistent and reliable observational data. This was achieved due to successful training, which included a clear definition of the research goals and standardized procedures, followed by practical application with continuous supervision. Although body measurement is currently used as the gold standard, it was considered that this method could pose some practical difficulties to data collection. The need for additional human and material resources, namely numerous calibrated body scales, stadiometers, as well as measurement rooms for individual privacy, could create a large apparatus around the vendors, disturbing their regular activity. Also, frequent refusal to participate would be expected due to individual and/or cultural barriers to body measurement. Future work should consider the validation of the estimation of weight status through direct observation by trained researchers, as this would constitute a more practical and culture-friendly method to collect accurate anthropometric data. Another factor which could present potential additional challenges to anthropometric evaluation was the weather, since climate variations throughout the study could lead to changes in the customers' clothing. In this study, both cities were assessed during summer, that way minimising errors associated to clothing. Also, in both cities, the specific tasks related to data collection were carried out in the month of July, during which weather conditions were favourable, with no rain and small temperature variations [56,57]. Another limitation of this study is the fact that we cannot ensure that all customers bought food items only for themselves, and for one single meal. However, the number of food items purchased per customer, which was close to one, suggested that this assumption should be correct in the majority of cases. Furthermore, the assessment of the purchases as a proxy measure to consumption, using direct observation rather than interview, allowed us to avoid potential behavioural or social desirability biases. Nutritional composition characterization included the lipid profile, sodium and potassium contents through laboratorial analysis of the most common foods available. This constitutes innovative and accurate information on these key nutrients for diet-related NCD, hence contributing to a better understanding of the health implications of street food and takeaway food frequent consumption in these cities. Finally, the methodology used in this study allows the standardization of the evaluations and, thus, valid comparisons among different cities or countries, although generalizability is limited due to local cultural specificities.

In conclusion, street and takeaway foods are commonly bought in these urban areas of Bosnia and Herzegovina. Purchases are characterized by the coexistence of globalized industrial food products with local and traditional foods and beverages. Customers presented purchases generally rich in SFA, TFA and sodium, and poor in potassium, which may impact negatively on health. Nutritional policies targeting the improvement of the nutritional profile identified in the street food and takeaway food purchased, namely towards the reduction of TFA, sodium and/or sugar contents, as well as the modulation of the availability of highly energy-dense foods, have the potential to reduce mortality from ischemic heart disease and stroke, which are the two leading causes of death in Bosnia and Herzegovina, and to reduce the burden of risk factors such as hyperglycaemia, high blood pressure, high BMI, dietary factors and dyslipidemia, which constitute five of the top seven risk factors for NCD mortality and disability in the country [48]. Political efforts should follow a multi-front approach, targeting simultaneously the urban food environment, the

food industry and the population. Environmental strategies in combination with policy and educational programmes have been documented as effective in preventing obesity and other diet-related chronic diseases in low-income settings [58]. Public health strategies should concern not only the consumers as the recipients of the foods, but also the vendors and manufacturers as the vectors of the nutritional quality of the foods publicly available for consumption, and could be incorporated into existing programmes towards nutrition-related NCD prevention.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/foods10112594/s1, Table S1: Inter-observer concordance on demographic and anthropometric characteristics and items purchased by the customers observed in street food and takeaway food vending sites in Bosnia and Herzegovina. Table S2: Decision rules for the elimination of conflicts of observation. Table S3: Ready-to-eat foods and beverages purchased by the customers observed in street food and takeaway food vending sites in Bosnia and Herzegovina, overall and by sex, age and weight status.

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Institutional Review Board Statement: This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Ethics Committee of the Institute of Public Health of the University of Porto (CE16058), as well as by local authorities in each city.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available upon request to the corresponding author.

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Supplementary Material

Supplementary Table S1. Inter-observer concordance on demographic and anthropometric characteristics and items purchased by the customers observed in street food and takeaway food vending sites in Bosnia and Herzegovina.

	Total		Street food		Takeaway food	
	% agreement	Cohen's Kappa (95% CI)	% agreement	Cohen's Kappa (95% CI)	% agreement	Cohen's Kappa (95% CI)
CUSTOMERS	***n* = 755**		***n* = 298**		***n* = 4 57**	
Sex						
Male Female	100.0%	1.00 (0.93-1.00)	100.0%	1.00 (0.89-1.00)	100.0%	1.00 (0.91-1.00)
Age						
<35 years ≥35 years	92.9%	0.84 (0.77-0.91)	91.3%	0.82 (0.71-0.94)	93.9%	0.85 (0.76-0.94)
Weight status						
Underweight/Normal weight Overweight/obesity	90.5%	0.77 (0.70-0.84)	91.3%	0.78 (0.66-0.89)	89.9%	0.77 (0.68-0.86)
Purchased at least one food						
Yes No	100.0%	1.00 (0.93-1.00)	100.0%	1.00 (0.89-1.00)	100.0%	1.00 (0.91-1.00)
Purchased at least one beverage						
Yes No	100.0%	1.00 (0.93-1.00)	100.0%	1.00 (0.89-1.00)	100.0%	1.00 (0.91-1.00)
Number of items purchased						
1 (median) >1	99.1%	0.97 (0.91-1.00)	99.7%	0.98 (0.87-1.00)	98.7%	0.97 (0.89-1.00)
ITEMS	***n* = 929**		***n* = 324**		***n* = 605**	
Item purchased	98.2%	0.98 (0.97-1.00)	96.3%	0.96 (0.93-0.99)	99.2%	0.99 (0.97-1.00)
Quantity purchased	92.0%	0.89 (0.86-0.92)	94.1%	0.91 (0.85-0.97)	90.8%	0.88 (0.85-0.91)

Supplementary Table S2. Decision rules for the elimination of conflicts of observation.

Type of disagreement	Criteria used	Example
Disagreement on the food item purchased		
The two observers registered two different food items (n = 4).	Conflicting food items were checked for its availability on the corresponding vending site.*	Observer A registered "coffee" and observer B registered "tea". The corresponding vending site did not have tea available. It was assumed that the customer purchased coffee.
The two observers registered the same food item, but with different degrees of specificity (n = 13).	The broadest observation was assumed.	Observer A registered "kebab" and observer B registered "chicken kebab". It was assumed that the customer purchased kebab.
The two observers registered a different number of food items (n = 7).	The most complete observation was assumed, unless the conflicting item was not available in the corresponding vending site.	Observer A registered "kebab" and observer B registered "kebab" and "coffee". It was assumed that the customer purchased kebab and coffee. If the corresponding vending site did not have coffee available, it would be assumed that the customer purchased kebab.
Disagreement on the quantity purchased		
The two observers registered the same food item, but different quantities (n = 74).	The average quantity between the two observations was assumed.	Observer A registered 200mL of coffee and observer B registered 150mL of coffee. It was assumed that the customer purchased 175mL of coffee.

*Observations should be excluded in the cases where the availability criterion does not solve the conflict: (1) if the conflicting food items are both available at the corresponding vending site; or (2) if none of the conflicting food items are available at the corresponding vending site. These particular situations did not occur.

Supplementary Table S3. Ready-to-eat foods and beverages purchased by the customers observed in street food and takeaway food vending sites in Bosnia and Herzegovina, overall and by sex, age and weight status.

	Total		Sex					Age[a]					Weight status[a]				
			Male		Female			<35 years		≥35 years			Underweight /normal		Overweight /obesity		
	n = 755		*n* = 373		*n* = 382		*p*	*n* = 233		*n* = 468		*p*	*n* = 494		*n* = 189		*p*
	n	%	*n*	%	*n*	%		*n*	%	*n*	%		*n*	%	*n*	%	
Foods[b]	602	79.7	291	78.0	311	81.4	0.246	177	76.0	382	81.6	0.079	391	79.2	155	82.0	0.404
Savoury pastries	189	25.0	106	28.4	83	21.7	**0.034**	44	18.9	131	28.0	**0.009**	120	24.3	51	27.0	0.467
Main dishes	111	14.7	60	16.1	51	13.4	0.289	38	16.3	68	14.5	0.536	69	14.0	34	18.0	0.189
Breads	142	18.8	59	15.8	83	21.7	**0.038**	29	12.4	105	22.4	**0.002**	88	17.8	38	20.1	0.490
Ice-cream, chocolate and confectionery	96	12.7	42	11.3	54	14.1	0.236	41	17.6	46	9.8	**0.003**	68	13.8	23	12.2	0.583
Buns, cakes and cookies	50	6.6	15	4.0	35	9.2	**0.005**	15	6.4	27	5.8	0.725	31	6.3	12	6.4	0.972
Sandwiches	34	4.5	19	5.1	15	3.9	0.439	16	6.9	16	3.4	**0.039**	24	4.9	5	2.7	0.199
Savoury snacks	17	2.3	6	1.6	11	2.9	0.239	6	2.6	10	2.1	0.714	13	2.6	4	2.1	0.699
Beverages[b]	241	31.9	135	36.2	106	27.8	**0.013**	79	33.9	144	30.8	0.401	160	32.4	58	30.7	0.670
Water	97	12.9	40	10.7	57	14.9	0.085	34	14.6	56	12.0	0.327	63	12.8	26	13.8	0.727
Soft drinks and industrial juices	91	12.1	54	14.5	37	9.7	**0.043**	41	17.6	41	8.8	**0.001**	65	13.2	18	9.5	0.193
Yoghurt	34	4.5	23	6.2	11	2.9	**0.029**	6	2.6	26	5.6	0.075	19	3.8	11	5.8	0.260
Alcoholic beverages	21	2.8	20	5.4	1	0.3	**<0.001**	0	0.0	21	4.5	**0.001**	13	2.6	5	2.6	0.992
Coffee	2	0.3	1	0.3	1	0.3	0.987	0	0.0	2	0.4	0.318	1	0.2	1	0.5	0.480

[a]For the variables age and weight status, the data presented corresponds to the customers in which there was agreement between observers: *n* = 701 and *n* = 683, respectively; [b]The sum of the values for each sub-category may be higher than the total of the respective category, because the same customer can buy more than one food and/or beverage.
Values in bold represent statistically significant differences according to Pearson's Chi-squared test with a significance level of 0.05.

PAPER III

Sousa S., Albuquerque G., Gelormini M., Casal S., Pinho O., Damasceno A., Moreira P., Breda J., Lunet N., Padrão P.

Street food purchased in Chișinău, Moldova: opportunity for public health policy action.

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Nutritional content of the street food purchased in Chișinău, Moldova: Opportunity for policy action

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ABSTRACT

This study aimed to describe the street food purchased and its nutritional value in Chișinău, Moldova. A cross-sectional study was conducted in 68 street food vending sites. Data on the food items purchased were collected through direct observation. Nutritional composition was estimated through chemical analyses, food composition tables or nutrition labels. From the 151 customers observed, two-thirds purchased industrial food items, most commonly buns/cakes/cookies (15.2%), soft drinks/industrial juices (15.2%) and confectionery (10.6%). The purchases were energy dense (median: 362 kcal/100g), rich in saturated fat (5.6 g), trans fat (0.43 g) and sodium (585 mg) and poor in potassium (212 mg).

1. Introduction

Street food is daily consumed by millions of people worldwide, having a strong gastronomic importance in low- and middle-income countries (LMIC) and reflecting traditional and regional cultures and culinary practices (Fellows and Hilmi. 2012). In Eastern Europe, recent socioeconomic development and urbanization led to eating habits modifications, namely the increasing consumption of energy-dense foods, such as sugar-sweetened beverages and packaged processed food products rich in sugar and salt (Ulijaszek and Koziel. 2007). Furthermore, physical inactivity, limited time to prepare homemade meals and increased consumption of foods away from home have also become common features of these populations. Simultaneously, a shift to high non-communicable disease (NCD) prevalence and mortality is rapidly occurring, which can be partly attributed to these dietary and lifestyle changes. In the Republic of Moldova, overweight and obesity is reported to affect, respectively, 50% and 21% of the adult population (20 years or older) (World Health Organization. 2018); also, approximately one-third is estimated to present raised blood pressure (World Health Organization. 2013).

Despite street food's importance for the foodscape of urban areas in many transitional societies (Fellows and Hilmi. 2012), research has been focusing mainly on hygiene and food safety issues related to street food consumption, whereas there is a current gap of knowledge concerning the nutritional composition of this type of food source (Abrahale et al., 2018). Here, we report on the foods and beverages purchased by street food customers in the main urban centre of Moldova, and the nutrition composition of their purchases.

2. Methods

This study was set in the context of the FEEDCities project, which is

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based on a stepwise standardized characterization of the food environment in cities from Eastern Europe and Central Asia, and whose protocol is published elsewhere (Lunet et al., 2019). For the purpose of this work, a cross-sectional evaluation of street food customers was conducted in Chișinău, capital city of Moldova, between June and August 2016.

The definition of street food proposed by the Food and Agriculture Organization (FAO) and World Health Organization (WHO), as "ready-to-eat foods and beverages prepared and/or sold by vendors or hawkers especially in the streets and other similar places" (Food and Agriculture Organization. 1989; World Health Organization. 1996) was adopted in order to select eligible street food vending sites. These included both stationary and mobile vending units selling food products ready to be consumed immediately without needing further preparation. Vending sites selling exclusively non-prepared fruits and vegetables or other not ready-to-eat raw foods (e.g. meat, fish) were excluded from the study. Customers approaching eligible street food vending sites to buy ready-to-eat foods and/or beverages were eligible for the study.

To define the study area, a 1-km diameter buffer was built around the centroid of the central market, that way covering both the market and its surroundings. Field researchers, operating in pairs, canvassed all publicly accessible streets within the study area, identifying all eligible street food vending sites. Finally, a systematic selection of the vending sites was performed, in which one out of every four vending sites were included in the study.

In all selected vending sites, data on the foods and/or beverages purchased (hereafter referred to as food items) and their quantities were collected through direct observation by trained local field researchers. In each vending site, up to four customers were observed, over a maximum period of 10 min, whichever occurred first (Fig. 1A). If no customer was observed during this period, field researchers would move on to the next selected vending site. Observations were performed both on week days and weekends and covering all businesses' working hours (from 8:00 to 16:00). The food items purchased were classified into homemade (foods and beverages that were prepared and/or cooked at home or in the street, even if using industrial ingredients) or industrial (foods and beverages that were produced by the food industry and sold as such, with no further preparation) and grouped into 8 sub-categories of foods and 6 sub-categories of beverages, according to similarities in nature and composition (World Health Organization. 2015a).

To estimate the nutritional composition of the street food purchases, a total of 52 samples of the most commonly available street-vended food items (identified during a previous step of the project (Albuquerque et al., 2020)) were collected for chemical analysis (Fig. 1B and C) in different randomly selected vending sites. All analyses (i.e. protein, total fat, fatty-acids, sodium and potassium) were conducted according to standard methods, as recommended by the Association of Official Analytical Chemists (AOAC International. 2016). Total carbohydrates plus fibre were estimated by difference. After proximate analysis, energy values were calculated using the Atwater general factors (4 kcal/g for protein and carbohydrates; 9 kcal/g for fat). For the less common food items, which were not sampled for chemical analysis, nutritional composition (i.e. energy, protein, carbohydrates, total fat and, when available, saturated fatty-acids and sodium) was estimated using the Slovak Food Composition Database (Ministry of Agriculture and Rural Development of the Slovak Republic, 2019) or food composition labels. A street food purchase was defined as an acquisition consisting of at least one food. As such, for the purpose of describing the nutritional content, customers buying only beverages were excluded.

3. Results

A total of 68 street food vending sites were observed, of which 55 (80.9%) had customers observed. A total of 151 customers were identified, of which 60.9% were female. A total of 169 food items were purchased, with an average of 1.1 food items per customer and 3.7 food items per 10 min of observation. Approximately two-thirds of the observed customers (n=101, 66.9%) purchased at least one industrial food item. The most commonly purchased foods were buns/cakes/cookies (n=23 customers, 15.2%), confectionery (n=16, 10.6%), savoury snacks (n=14, 9.3%) and savoury pastries (n=13, 8.6%). The most frequently bought beverages were soft drinks/industrial juices (n=23 customers, 15.2%), water (n=21, 13.9%) and alcoholic beverages (n=18, 11.9%). Purchase of fruit was not observed (Fig. 2).

A total of 78 street food purchases (as defined above) were observed, whose nutritional composition, both per purchase and per 100 g, is displayed in Table 1. The purchases presented high energy density (median: 362 kcal/100 g), with the highest contribution to total energy value coming from carbohydrates (52.6%), followed by total fat (37.2%) and protein (7.7%). The highest contribution to total fat came from saturated fatty-acids, whose median content in a single purchase accounted for around one-quarter (25.1%) of its maximum daily intake recommendation, considering an average adult with a reference intake of 2000 kcal/day (World Health Organization. 2003). *Trans*-fat contributed to 2.7% of the total fat content, with the majority of the purchases (n=42, 60.9%) surpassing the limit of 2 g/100 g of total fat, recently legislated in some countries in the WHO European Region (World Health Organization. 2015b). These street food purchases also supplied a median of 585 mg of sodium (29.3% of the maximum daily intake recommendation for this nutrient (World Health Organization. 2003)) and 212 mg of potassium (only contributing to 6.0% of its minimum daily intake recommendation (World Health Organization. 2012)). Median molar sodium-to-potassium ratio was far above the

Fig. 1. Example of a customer purchasing at a street food vending site (**A**) and examples of two foods collected at street food vending sites for laboratorial analysis: homemade *pateuri*[a] (**B**) and industrial cookies (**C**).[a]*Pateuri* is a fried savoury pastry made with leavened dough filled with cheese, vegetables or meat.

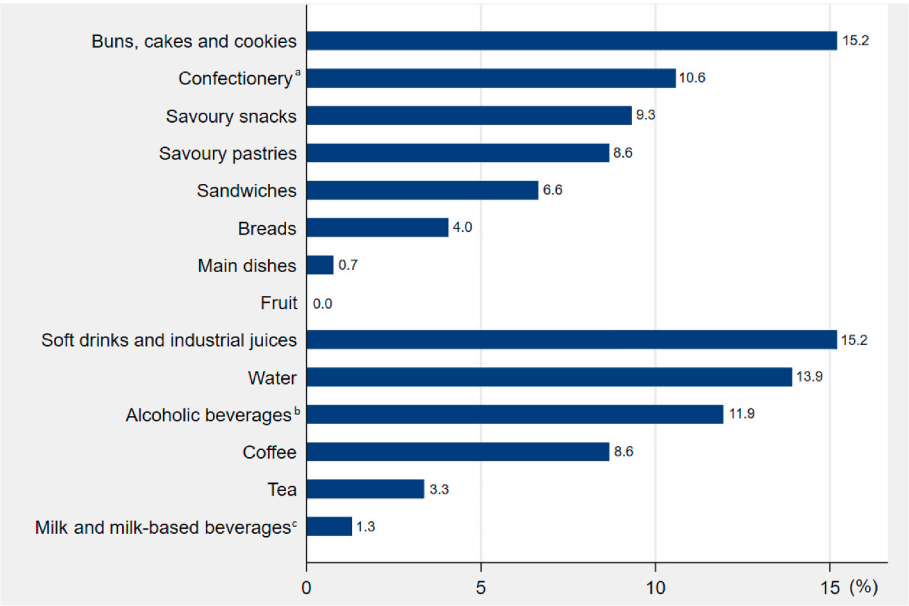

Fig. 2. Ready-to-eat foods and beverages purchased by customers of street food vending sites in Chișinău, Moldova (n=151).
[a]Includes ice-cream, candies and chocolate.
[b]Includes beer and *kvass* (a fermented beverage with low alcohol content made from rye bread).
[c]Includes milk and *kefir* (fermented milk drink prepared by inoculating cow, goat or sheep milk with kefir grains).

Table 1
Estimated nutritional composition of the purchases made by the street food customers observed in Chișinău, Moldova (n=78[a]).

	N	Per purchase	Per 100g
		Median (P25–P75)	Median (P25–P75)
Energy (kcal)	78	353 (243–666)	362 (268–688)
Macronutrients (g)			
Protein	78	8.2 (4.3–13.6)	9.8 (4.9–15.1)
CHO	78	53.1 (29.5–87.5)	50.4 (32.8–108.3)
Total fat	78	16.8 (7.5–31.4)	14.3 (9.4–28.2)
SFA	73[b]	5.6 (3.2–11.1)	6.0 (2.9–9.1)
MUFA	69[b]	4.8 (1.7–10.7)	4.2 (2.8–8.5)
PUFA	69[b]	3.8 (1.9–8.1)	3.9 (1.6–13.7)
n-6	69[b]	3.8 (1.9–8.0)	3.8 (1.6–13.5)
n-3	69[b]	0.1 (0.0–0.1)	0.1 (0.0–0.1)
TFA	69[b]	0.43 (0.12–1.00)	0.77 (0.09–1.88)
Micronutrients (mg)			
Na	73[b]	585 (227–1029)	616 (389–814)
K	69[b]	212 (114–263)	197 (144–337)
Na/K ratio	69[b]	5.5 (1.8–6.8)	

P25, percentile 25. P75, percentile 75. CHO, carbohydrates. SFA, saturated fatty acids. MUFA, monounsaturated fatty acids. PUFA, polyunsaturated fatty acids. TFA, *trans* fatty acids. Na, sodium. K, potassium.
[a] Number of customers who bought at least one food (customers buying only beverages were excluded).
[b] In these variables, the number of cases differ from the total due to missing values.

recommended value of one (World Health Organization. 2003).

4. Discussion and conclusions

Street food seemed to be frequently consumed in this urban area, as shown by a high number of foods and beverages acquired within a limited observation period. The frequent purchase of ultra-processed food products may reflect the westernization of food habits and a deviation from traditional gastronomy in these street food customers. A high availability of industrial food items such as confectionery, sweet pastries, savoury snacks and soft drinks was identified in this setting (Albuquerque et al., 2020), which may influence consumers' choices. Ready-to-eat fruit was not purchased by the customers observed, which may be in part explained by the fact that the availability of ready-to-eat fruit was very low (sold at only 2.5% of the observed vending sites) (World Health Organization. 2017, Albuquerque et al., 2020). This is in line with the low consumption of fruit that has been described for the Eastern European region (Willett et al., 2019). Nevertheless, it should be noted that vending sites selling exclusively unprepared fruits and vegetables were excluded from this study, since purchases made in these venues are usually directed towards household food consumption, which contradicts the definition of 'street food' as 'ready-to-eat'.

The street food purchases observed were found to be energy-dense and showed concerning levels of saturated fat, *trans*-fat and sodium, and low contents of potassium, which in the long term can have a negative impact on health. This nutritional profile may reflect the ingredients used during their preparation, as described for other settings (Gupta et al., 2016; Sousa et al., 2018). Frequent purchase of sugary foods and beverages, such as buns/cakes/cookies, confectionery and soft drinks/juices also suggests high levels of sugars intake by these customers. Our results are in line with findings from other LMIC, which showed that this nutritional profile is frequently found in many popular items made available by street food vendors (Steyn et al., 2014).

These results should be considered when designing public health strategies aiming to improve the urban food environment in this setting, while preserving and promoting gastronomic identity and cultural value. Multisectoral-based policies should be targeted to: (1) restrict the availability of ultra-processed food products rich in saturated fat, trans-fatty acids, sugar and salt, while improving the availability and affordability of nutrient-dense foods, such as ready-to-eat fruits and vegetable-based homemade dishes; (2) improve the nutritional value of the foods and beverages offered, especially its lipid profile and salt content, either through recipe improvement by the vendors and small manufacturers, or food product reformulation and labelling improvement at the food industry level; and (3) raise awareness and literacy of both vendors and consumers regarding street food's nutritional composition and its impact on health. Examples of some of these political efforts have been successfully implemented in other settings where street food sale is also frequent (Eurasian Economic Commission. 2011, Tester et al., 2012; Hawkes et al., 2013). Further guidance to governments and local authorities on the implementation of public health measures towards healthier food markets was recently published, containing examples of possible short, medium and long term interventions relevant for decision-makers (World Health Organization 2021). Regardless of the measures applied, continuous monitoring would be a vital step towards

the achievement and maintenance of a healthier street food environment (Gelormini et al., 2017).

A generalised lack of information regarding dietary intake has been recently identified for many countries within the WHO-Europe, including for Moldova, where no national nutrition surveys have been conducted yet (Rippin et al., 2018). As such, we consider that the FEEDCities research project has been contributing to reduce this nutrition-related research gap, by increasing knowledge regarding street food availability, purchasing habits and nutritional value. The development of a robust, stepwise and standardized methodology has resulted in comprehensive and comparable data among countries. However, due to local cultural specificities, generalisability of the results has been limited. Dissemination of these ground-breaking results should contribute for the evolution of health and food policy, ultimately leading to the improvement of these populations' health.

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Authorship

MG, AD, PM, JB, NL and PP designed the study. MG supervised the study implementation and data collection. SC and OP were responsible for the chemical analysis of the food samples collected. SS, NL and PP performed the analysis and interpretation of the results. SS drafted the manuscript. All authors critically revised and gave final approval of the manuscript submitted for publication.

Ethical standards

This study was conducted in accordance with the Declaration of Helsinki, and all procedures involving human subjects were approved by the Ethics Committee of the Institute of Public Health of the University of Porto (CE16058). Verbal informed consent was obtained from all vendors.

Implications for gastronomy

In Eastern European countries, street food is part of the cultural heritage and gastronomy, reflecting the availability of local food products, culinary practices and consumers' preferences. Furthermore, with the recent rise of gastronomic tourism, street foods are also becoming a great attraction to foreigners seeking to experience the unique and authentic flavours of the local cuisine.

Our study found a very frequent purchase of westernized food options, such as soft drinks and confectionery, which may suggest a separation from local gastronomy, in line with the nutrition transition process that is currently occurring in this setting. Our findings also showed that street food purchases are rich in energy, saturated and trans fats, as well as sodium, and poor in potassium. The improvement of the availability and affordability of nutrient-dense foods such as fruits, vegetables, legumes and nuts, as well as the promotion of the use of healthier ingredients and culinary practices while preserving gastronomic identity, would contribute to enhance the nutritional profile of Moldovan street foods. Promoting the consumption of homemade traditional dishes would also contribute to preserve traditional gastronomy. These strategies would contribute to increase food security in this setting, while counteracting the effects of nutrition transition.

The involvement of street food customers and vendors, as well as the food industry, is essential to guarantee this change in food availability and dietary habits, leading to a healthier street food environment, while not only maintaining but also promoting local food culture.

Declaration of competing interest

The authors declare that they have no conflict of interest. João Breda is a staff member of the World Health Organization Regional Office for Europe. The author is responsible for the views expressed in this publication, and they do not necessarily represent the decisions or stated policy of WHO.

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PAPER IV

Sousa S., Lança de Morais I., Albuquerque G., Gelormini M., Casal S., Pinho O., Motta C., Damasceno A., Moreira P., Breda J., Lunet N., Padrão P.

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Patterns of Street Food Purchase in Cities From Central Asia

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Street food makes a significant contribution to the diet of many dwellers in low- and middle-income countries and its trade is a well-developed activity in the central Asian region. However, data on its purchase and nutritional value is still scarce. This study aimed to describe street food purchasing patterns in central Asia, according to time and place of purchase. A multicentre cross-sectional study was conducted in 2016/2017 in the main urban areas of four central Asian countries: *Dushanbe* (Tajikistan), *Bishkek* (Kyrgyzstan), *Ashgabat* (Turkmenistan) and *Almaty* (Kazakhstan). Street food markets ($n = 34$) and vending sites ($n = 390$) were selected by random and systematic sampling procedures. Data on the purchased foods and beverages were collected by direct observation. Time and geographic location of the purchases was registered, and their nutritional composition was estimated. A total of 714 customers, who bought 852 foods, were observed. Customers' influx, buying rate and purchase of industrial food were higher in city centers compared to the outskirts (median: 4.0 vs. 2.0 customers/10 min, $p < 0.001$; 5.0 vs. 2.0 food items/10 min, $p < 0.001$; 36.2 vs. 28.7%, $p = 0.004$). Tea, coffee, bread and savory pastries were most frequently purchased in the early morning, bread, main dishes and savory pastries during lunchtime, and industrial products in the mid-morning and mid-afternoon periods. Energy and macronutrient density was highest at 11:00–12:00 and lowest at 09:00–10:00. Purchases were smaller but more energy-dense in city centers, and higher in saturated and *trans*-fat in the peripheries. This work provides an overview of the street food buying habits in these cities, which in turn reflect local food culture. These findings from the main urban areas of four low- and middle-income countries which are currently under nutrition transition can be useful when designing public health interventions customized to the specificities of these food environments and their customers.

Keywords: street food, ready-to-eat food, purchasing patterns, food choice, nutritional value, Central Asia, low- and middle-income countries, nutrition transition

INTRODUCTION

In the last few decades, most low- and middle-income countries (LMIC) have been experiencing rapid socioeconomic development, accompanied by a wide and abrupt increase in urban agglomerations and industrialization (1, 2). In central Asia, countries have undergone remarkable gross domestic product growth during the last decade, averaging around 5% per year (3), and urban population has grown from ∼25 million to more than 35.5 million people between 2000 and 2019, the latter representing almost half of the total central Asian population (4).

These major demographic and economic changes have led to marked lifestyle shifts, such as the growing participation of women in the workforce to the detriment of housework, and the increase in time spent working or commuting. This has hindered household food preparation and consumption, making away-from-home food sources, such as street-vended foods, to be seen by the urban dwellers as excellent alternatives for their everyday meals (5–8). Other factors such as the low cost, convenience and taste have strengthened street food's popularity, which is currently consumed everyday by millions of people worldwide (6). In cities from central Asia, street food trade is a well-developed activity, being often organized in typical markets called *bazaars*. Street food vending sites are common, reflecting the high cultural and dietary importance of street food in the region (9–12).

Frequent consumption of foods outside the home has been reported as a risk factor for overweight and obesity (13, 14), as well as higher energy and fat intake and lower micronutrient intake (15). In line with other LMIC (16), in urban areas from central Asia, street food has been reported as source of foods frequently rich in total fat, saturated and *trans* fatty acids, as well as sodium. Availability data showed that although local foods remain common, globalized ultra-processed food products such as industrial snacks and soft drinks are frequently available (9–12, 17–19). However, to the best of our knowledge, no systematic characterization of the purchasing patterns of street food in these settings is available. A recent scoping review also showed that, even though research on street food has been growing, its purchase and consumption are amongst the least studied topics (20). As such, the objective of this study was to describe the patterns of street food purchase in the main urban areas of four central Asian countries, Tajikistan, Kyrgyzstan, Turkmenistan and Kazakhstan, considering the food items bought and their nutritional composition, overall and according to time of the day and place of purchase. In this study, we go beyond the simple characterization of street food purchases and their nutritional value, by identifying where and when specific patterns of purchase emerge. With this approach, we hope to contribute to a more in-depth understanding of the street food buying practices in these cities (both in terms of meal context and city location), thus allowing the design of public health strategies customized not only to the reality of these food environments, but also to their customers' food habits.

MATERIALS AND METHODS

Overview

This study was implemented in the context of the FEEDCities project, which is based on a stepwise standardized characterization of the street food environment in cities from Central Asia and Eastern Europe. The general methodology of this research project is published elsewhere (21). For the purpose of this study, four cross-sectional evaluations of street food customers were conducted in the largest and most urbanized cities of Tajikistan, Kyrgyzstan, Turkmenistan and Kazakhstan (22), respectively *Dushanbe* (between April and May 2016), *Bishkek* (June and July 2016), *Ashgabat* (October 2016) and *Almaty* (August 2017).

Eligibility Criteria

Street food was defined by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), as "ready-to-eat foods and beverages prepared and/or sold by vendors or hawkers especially in the streets and other similar places" (23, 24). Eligible street food vending sites were those which sold street food in accordance to this definition, including both fixed and mobile units selling directly to the streets. As such, food establishments within four permanent walls or permanent storefront business not selling directly to the street, vending sites selling exclusively non-prepared fresh fruits, vegetables or other raw foods not ready-to-eat, such as fish or meat, or food stalls and carts that are part of permanent stores or licensed establishments, were excluded from the study.

Any customer approaching one selected street food vending site to buy ready-to-eat foods and/or beverages during a pre-specified time period was eligible for the study.

Sampling Procedure

In the four cities assessed, all public markets were identified ($n = 89$), in accordance to information provided by local authorities and collected during preliminary field visits, as described elsewhere (9–12, 17, 18). Ten markets were randomly selected in each city, except for *Ashgabat*, where four markets were selected by local authorities. To identify the study area in each city, buffers with a diameter of 500 m were drawn around the centroid of each selected market, that way covering the whole market and surrounding areas. Within each study area, all publicly accessible streets were canvassed by pairs of field researchers, who identified all street food vending sites eligible for the study.

Taking into account the density of vending sites encountered in each study area and the expected overall number of customers, a systematic selection of the vending sites was performed, in which one out of every ten (*Dushanbe*), one out of every four (*Bishkek* and *Almaty*) and all vending sites (*Ashgabat*) were selected for customer observation.

Each selected vending site was observed for a maximum period of 15 min to collect data on the street food items purchased. Each observation ended when four consecutive customers were observed, or whenever the maximum period

was reached. When no customers were observed within the pre-specified period, field researchers moved on to the next selected vending site. Observations were performed on consecutive days of the week, and covering all businesses' working hours, from 08:00 to 17:00.

Data Collection

Data was collected by direct observation of each selected street food vending site. Observations were performed by local field researchers, located at enough distance not to disturb the vendors' regular activity or the customers' usual behavior.

Data was collected by two observers who, for each customer observed, independently registered the foods and/or beverages purchased and respective quantities. Prior to data collection, all field researchers were trained (including both theoretical, practical and field training) aiming at the improvement and standardization of observations.

Inter-observer concordance was evaluated using Cohen's kappa (K) with 95% confidence interval (95% CI), being high to very high, regarding the foods and/or beverages purchased (97.6% agreement, $K = 0.98$, 95% CI 0.97–0.99) and their quantities (95.3% agreement, $K = 0.94$, 95% CI 0.92–0.97), as detailed elsewhere (25). Disagreements on the foods and/or beverages purchased or their quantities were eliminated using a set of standardized criteria: (1) if the two observers registered two different foods and/or beverages, the conflicting items were checked for their availability on the corresponding vending site (if only one of the conflicting items was available, this observation was assumed; if the conflicting items were both available or not available, both observations were disregarded); (2) if the two observers registered the same food and/or beverage, but with different degrees of specificity, the broadest observation was assumed; (3) if the two observers registered a different number of foods and/or beverages for the same customer, the observation with the higher number of food items was assumed, unless the conflicting item(s) was(were) not available in the corresponding vending site; and (4) if the two observers registered the same food and/or beverage, but different quantities, the average quantity between the two observations was assumed.

Based on the WHO nutrient profile model (26) and considering similarities of nature and/or composition, the purchased foods and beverages were grouped into six sub-categories each: (1) savory pastries and snacks; (2) main dishes; (3) sweet pastries and confectionery; (4) bread; (5) sandwiches; (6) fruit; (7) tea and coffee; (8) soft drinks and juices; (9) traditional beverages (non-alcoholic); (10) alcoholic beverages; (11) milk; and (12) water. Foods and beverages were also classified as *homemade* (foods and beverages that were prepared and/or cooked at home or in the street, even if using industrial ingredients) or *industrial* (foods and beverages that were produced by the food industry and sold as such, with no further preparation).

For each vending site observed, Global Positioning System (GPS) coordinates were recorded, as well as time of beginning and end of observation. The selected markets were classified as central or peripheral, according to their distance (below or above 3 km, respectively) to a city center reference point, assigned in each setting taking into account information provided by the respective WHO Country Offices and local collaborating institutions. The duration of the observation was calculated for each vending site, as well as the customers' influx (which was computed as the number of customers observed per 10 min of observation) and the food items buying rate (number of foods and/or beverages purchased per 10 min of observation). Purchases were then categorized taking into account time of the day, on an hourly basis (i.e. [09:00–10:00], [10:00–11:00], etc.) and city location (city center vs. periphery).

Nutritional Composition Estimation

The nutritional composition of all purchased street foods and beverages was estimated, either using data from chemical analysis or using information provided by food labels, standardized recipes and food composition tables.

During the first step of the research project, which assessed street food availability, the most frequently available street foods and beverages in each city were documented (9–12, 17, 18). Taking this information into account, chemical analyses of the most common street foods were performed, as previously described in detail (9–12, 17, 18), and included macronutrients (protein, total fat and carbohydrates by difference), fatty acids (saturated, monounsaturated, polyunsaturated and *trans*), sodium and potassium, as well as energy calculated using the Atwater general factors, following validated and standardized methodology (27). In *Ashgabat*, exceptionally, the samples collected were not analyzed for protein and carbohydrates contents, those being estimated using food composition tables, standardized recipes or food labels, as described below.

For the foods and beverages which were not sampled and subjected to chemical analysis, nutritional composition was estimated using: (1) food labels of the brands most commonly available in each setting, in the case of industrial foods or beverages (e.g. chocolate, soft drinks); (2) standardized recipes from each city, in the case of prepared and/or cooked homemade foods or beverages; (3) food composition tables, namely the Food Composition Table for Pakistan (28) and the Turkish National Food Composition Database (29), in the case of *in natura* foods or beverages (e.g. fruits, nuts) or recipe ingredients. Energy, protein, carbohydrates and total fat were estimated for all these foods and beverages, as well as sodium for industrial and *in natura* foods. Sodium contents of homemade foods and beverages were not estimated, due to the great variation in the quantities of salt added during their preparation or cooking.

Among all the foods and beverages purchased ($n = 852$), the nutritional composition of 582 (68.3%) was estimated using data from chemical analysis, and the remaining ($n = 270$, 31.7%) using food labels, standardized recipes and food composition tables. The nutritional value of the street food purchases of each customer was then computed by summing up the estimated energy, macro- and micronutrients of all foods and beverages purchased by the same customer on a single occasion.

Statistical Analysis

Absolute and relative frequencies were used to describe the foods and beverages purchased. Customers' influx, food items buying

rate and number of food items purchased per customer, as well as the nutritional composition of the purchases were described through median and percentiles 25 and 75. Pearson's Chi-squared test was used to compare the street food purchases throughout the day and by city location. Mann-Whitney's and Kruskal–Wallis tests were used to compare the customers' influx, food items buying rate and number of food items purchased per customer, as well as the nutritional composition of the purchases, either throughout the day or by city location, respectively. Differences were considered statistically significant when the critical level of significance (p) was less than 0.05. Statistical analysis was performed using *Stata*® version 15.0 (StataCorp., College Station, TX, USA).

RESULTS

A total of 390 street food vending sites were observed (71 in Tajikistan, 137 in Kyrgyzstan, 93 in Turkmenistan and 89 in Kazakhstan), corresponding to the completion of 4,769 min of observation. A total of 714 customers were observed, who bought 852 foods and beverages. In each vending site, a median of 2 customers were observed over a median period of 15 min.

The median customers' influx and food items buying rate varied across countries, being the lowest in Tajikistan (1.3 customers and 1.3 food items per 10 min of observation, respectively) and the highest in Turkmenistan (5.9 customers and 6.4 food items per 10 min of observation, respectively). The number of food items purchased by customer was similar in all countries, with a median of 1.0 (**Figure 1**). No customers were observed from 08:00 to 09:00 and from 16:00 to 17:00. Throughout the day, customers' influx and food items buying rate varied, being highest between 12:00 and 13:00 (median: 3.0 customers/10 min; 4.1 food items/10 min). The number of food items purchased by customer was constant (median of 1 in all hours of the day), although between 15:00 and 16:00, a higher proportion of customers (47.1%) purchased two or more foods and/or beverages (**Figure 2**). City centers showed higher customers' influx (4.0 vs. 2.0 customers/10 min, $p < 0.001$) and food items buying rate (5.0 vs 2.0 food items/10 min, $p < 0.001$) than the peripheries (**Figure 3**).

Purchase of foods was the highest between 12:00 and 13:00 (90.8%), whereas beverages were more frequently purchased in both the beginning (59.0%) and end of the day (52.9%). Between 15:00 and 16:00, it was observed a greater frequency of joint purchase of foods and beverages (35.3%). The purchase of foods was higher in the city center (86.8 vs. 74.2%, $p = 0.004$) while beverages were more frequently bought in the periphery (38.6 vs. 18.7%, $p < 0.001$; **Figure 4**). Purchase of homemade food items surpassed 80% from 9:00 to 10:00 and 15:00 to 16:00, while industrial products buying frequency was the highest between 10:00 and 11:00 (40.2%), and between 14:00 and 15:00 (38.8%). Customers purchasing industrial food items were significantly more frequent in the city center (36.2 vs. 28.7%, $p = 0.004$) (**Figure 5**). From all customers buying foods and beverages together ($n = 71$), more than half (59.2%) purchased both foods and beverages homemade (mostly savory pastries with coffee or tea) and one out of every three (35.2%) bought one or more homemade foods with one industrial beverage (mostly main dishes, sandwiches or savory pastries, plus soft drinks).

The distribution of groups of foods and beverages throughout the day and by city location is presented in **Table 1**. Among customers who bought foods, savory pastries and snacks were most frequently purchased from 09:00 to 11:00 and 15:00 to 16:00, main dishes between 11:00 and 13:00, sweets pastries and confectionery from 13:00 to 15:00, bread from 09:00 to 10:00 and 12:00 to 13:00, and sandwiches between 15:00 and 16:00. Among the purchases which included beverages, tea and coffee were most frequently purchased in the first time period, soft drinks and juices between 15:00 and 16:00, and water from 12:00 to 14:00. Bread and sweet pastries and confectionery were more commonly bought in the city center, while the purchases of savory pastries and snacks, as well as main dishes, were higher in the periphery.

The observed customers purchased a median amount of 120 g of foods and 200 g of beverages. **Table 2** presents the estimated nutritional composition of the purchases observed, including foods and beverages, throughout the day and by city location. Between 11:00 and 12:00, purchases were more energy-dense and richer in protein, carbohydrates and fat, the opposite being observed from 09:00 to 10:00. Saturated and *trans* fatty acids contents were both highest between 13:00 and 14:00. Purchases made in the city center were significantly more energy-dense and richer in all macronutrients, while in the periphery purchases showed higher saturated and *trans* fatty acids contents. The temporal and spatial distribution of the estimated nutritional composition of the street food purchases observed, without beverages, is presented in **Supplementary Table 1**.

DISCUSSION

Street food purchase in these four central Asian urban centers was frequent and reached its maximum around lunchtime. Purchases consisted of a diverse set of both local and westernized foods and beverages, and varied throughout the day and by city location. Tea, coffee, bread and savory pastries were frequently purchased in the early morning; bread, main dishes and savory pastries at lunch; and industrial snacks (both savory and sweet) and beverages (mainly soft drinks and juices) were mostly bought in the mid-morning and mid-afternoon periods. Purchase of industrial foods and beverages, sweet pastries and confectionery and bread was more frequent in the city center, while main dishes, savory pastries and snacks were mostly bought in the periphery. Energy and macronutrient density was highest around lunchtime and lowest in the early morning. Purchases were smaller but more energy-dense in city centers, and higher in SFA and TFA in the peripheries.

Customers' influx and food items buying rate was the highest between 12:00 and 13:00, which was also when the frequency of purchase of foods reached its peak. Nine out of 10 customers purchased foods during this time period, mostly bread, main dishes and savory pastries, suggesting that these food groups may

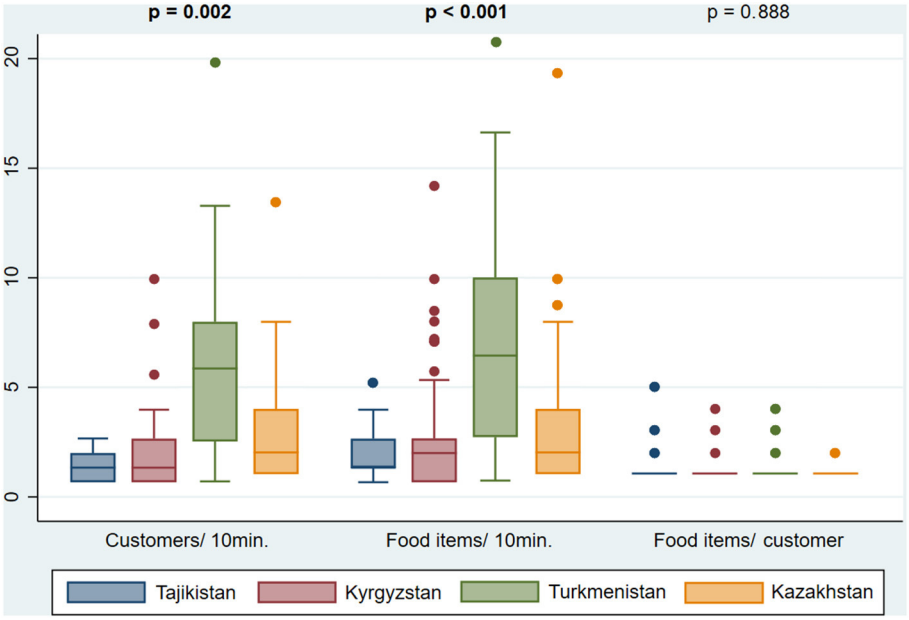

FIGURE 1 | Customers' influx (customers/10 min), food items buying rate (food items/10 min) and number of food items purchased per customer (food items/customer), in street food vending sites observed in *Dushanbe* (Tajikistan), *Bishkek* (Kyrgyzstan), *Ashgabat* (Turkmenistan) and *Almaty* (Kazakhstan). Values in bold represent statistically significant differences according to Kruskal–Wallis test with a significance level of 0.05.

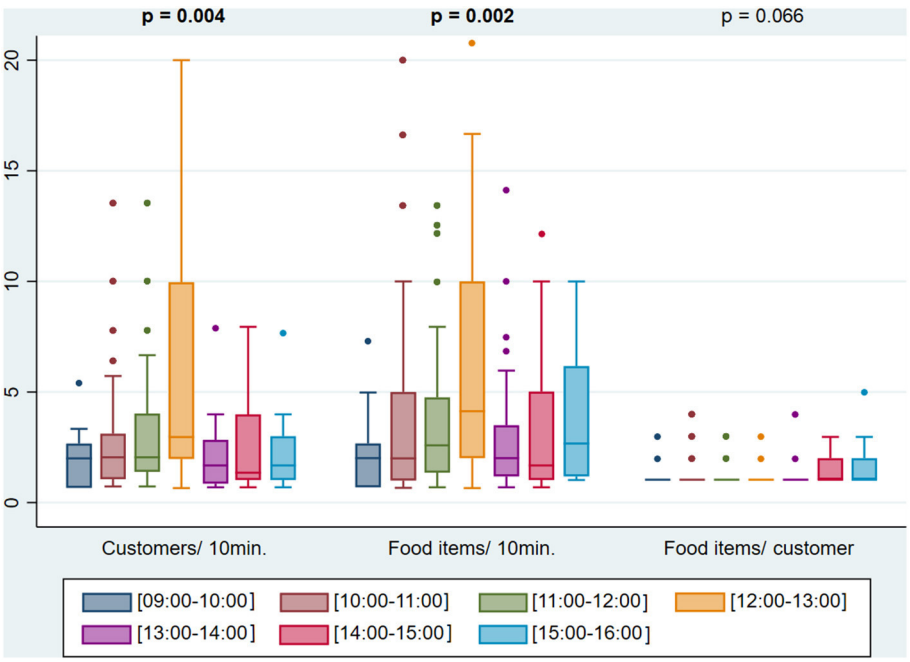

FIGURE 2 | Customers' influx (customers/10 min), food items buying rate (food items/10 min) and number of food items purchased per customer (food items/customer) throughout the day. Values in bold represent statistically significant differences according to Kruskal–Wallis test with a significance level of 0.05.

be frequently consumed by street food customers at lunch. This is in line with evidence showing that street food is often consumed as a substitute for home-cooked main meals (6, 30), and may be closely associated with changes in time allocation patterns occurring in Asian LMIC, toward an increasingly accelerated and much more work-oriented daily life (31, 32). One important aspect of the urban lifestyle is the increase in the number of time-limited consumers, which in turn increases the demand for

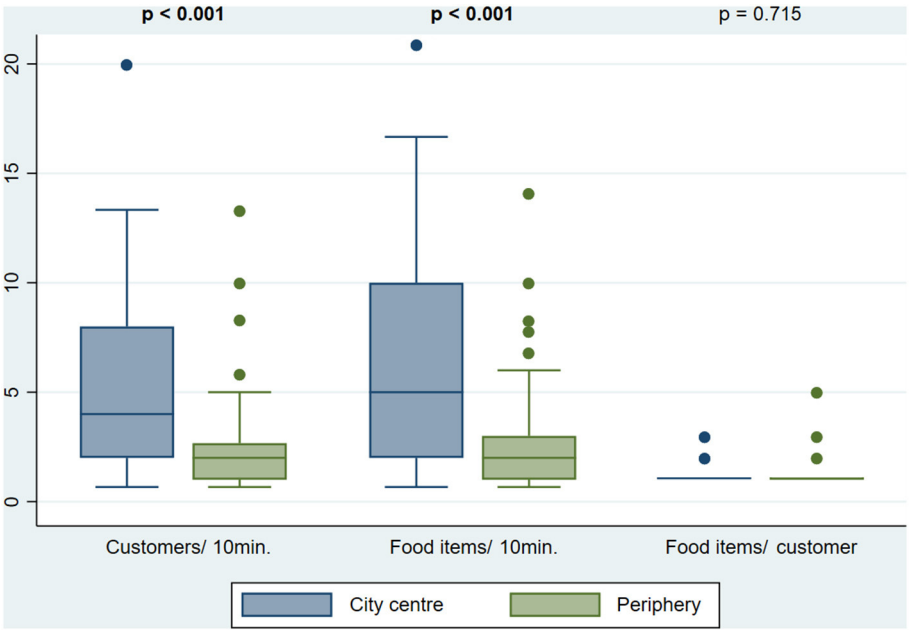

FIGURE 3 | Customers' influx (customers/10 min), food items buying rate (food items/10 min) and number of food items purchased per customer (food items/customer) by city location. Values in bold represent statistically significant differences according to Mann-Whitney's test with a significance level of 0.05.

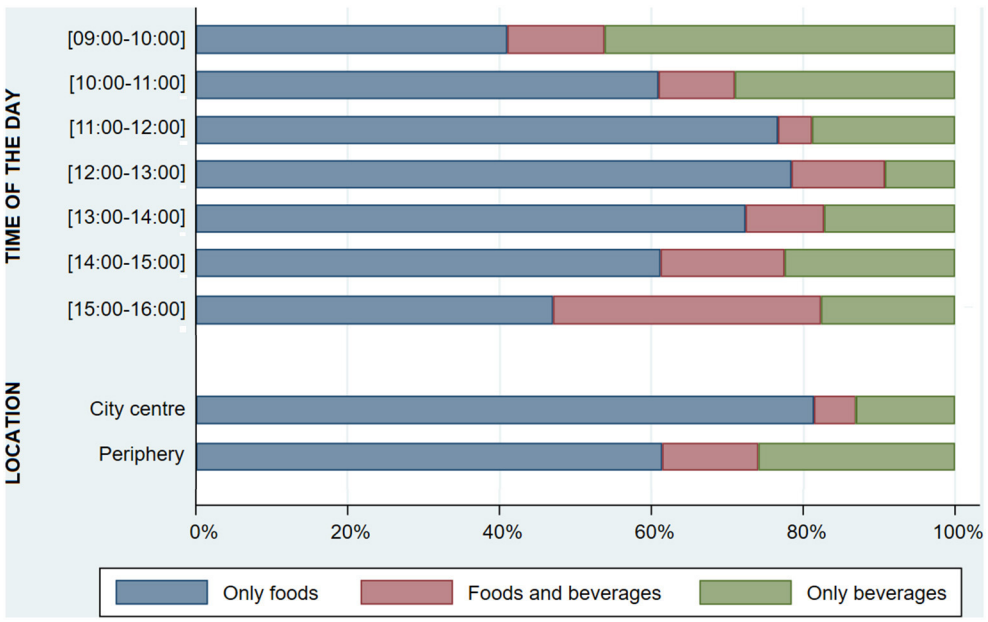

FIGURE 4 | Proportion of customers purchasing foods and/or beverages, throughout the day and by city location ($n = 714$).

convenience foods (31). Besides convenience, street food also offers affordable and fulfilling food options, gaining momentum in LMIC over more formal alternatives such as restaurants (6, 8, 16, 30). Customers' influx and food items buying rate was also higher in the city centers when compared to their outskirts, which was expected. These urban centers, similarly to other LMIC, have undergone abrupt growth and development, with an accelerated construction of infrastructures and increased concentration of companies, services and people. As a consequence, a large increase in the size of the labor force has occurred, especially in these city centers (2, 33). As reported in other LMIC, street food customers are usually urban workers but rural or peri-urban

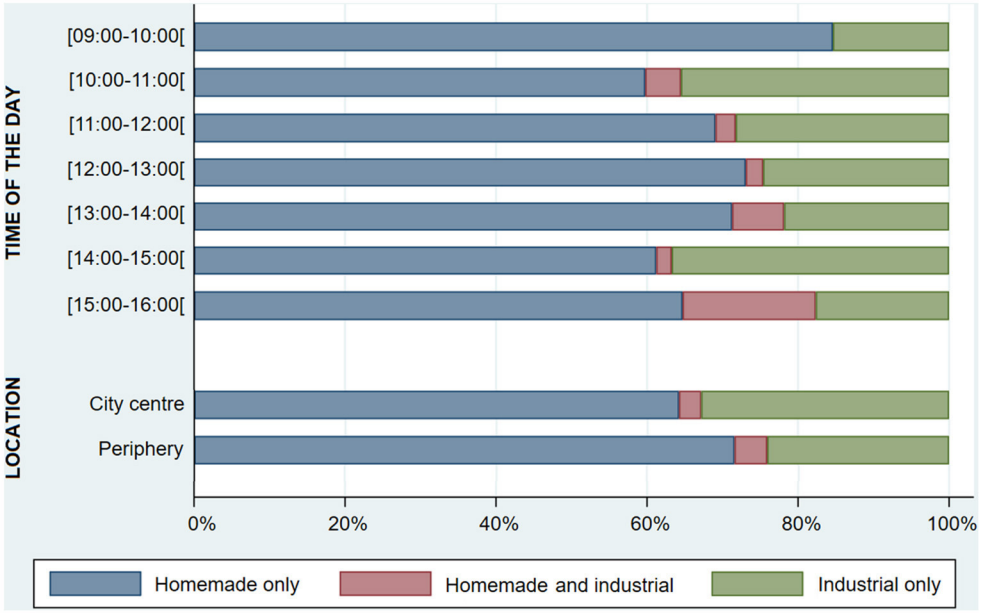

FIGURE 5 | Proportion of customers purchasing homemade and/or industrial food items, throughout the day and by city location ($n = 714$).

dwellers, who often need to make long commutes between house and the workplace on a daily basis (34, 35), and therefore have little availability to travel back home for their meals during the day. Accordingly, street food sites are often located near people gathering spaces, such as working places or main public transportation stations (6, 36), where it is expected that there will be a greater influx of people and higher demand for these ready-to-eat food options.

Frequency of purchase of industrial food products was highest in the periods between 10:00 and 11:00, and between 14:00 and 15:00. These acquisitions were mostly constituted of savory snacks, sweet pastries and confectionery, as well as soft drinks and juices. This suggests that these industrial foods and beverages may be commonly preferred by the street food customers as mid-morning or mid-afternoon snacks. Sweet pastries and confectionery were most frequently purchased between 13:00 and 15:00 which may as well correspond to an after lunch time period, suggesting that some of these foods may have also been consumed in the context of a dessert. However, we cannot exclude the possibility of sweet pastries being consumed as the main meal, since these foods are fulfilling and have a low cost per calorie (37), and in contexts of economic restriction, they may be seen by consumers as a good option to supply energy needs. Furthermore, food-based dietary guidelines and nutrition education programmes are still lacking in these countries, so there may be a lack of knowledge about which foods are suitable to consume at different meals throughout the day. Soft drinks and juices were less purchased between 12:00 and 14:00, and during this time period mainly tea and water were bought. This is consistent with the types of beverages that are traditionally consumed during lunchtime (38), and may indicate a lower preference of street food consumers for soft drinks during this meal.

Frequency of purchase of industrial foods was also higher in the city centers, and was mostly comprised of sweet pastries and confectionery (mainly candies, ice-cream and chocolates). This can either be explained by spatial variations on street food buying habits, or be a reflection of these foods' availability on central vs. peripheral vending sites. According to information from the first step of the FEEDcities project, there was a similar proportion of vending sites selling sweet pastries and confectionery in central and peripheral markets (unpublished data), which indicates that in city centers there seems to be a greater preference of street food consumers for these westernized foods. Industrial beverages, such as soft drinks and juices, were equally and frequently bought in both city subareas, suggesting that their consumption might be an already widely implemented habit. The acquisition of those ultra-processed sweetened beverages occurred at all hours of the day, almost always surpassing that of other common drinks, such as water, milk and non-alcoholic traditional beverages, the latter mostly comprised of fermented milk-based drinks (e.g. *kefir*, *ayran*, *chalap*). These results make us hypothesize that soft drinks and industrialized juices may be consumed as a substitute for others with a potentially healthier profile. Our results are in line with the increasing availability and consumption of ultra-processed foods and beverages that is happening in the region, arising from quick economic and technological development, as well as globalization, which have been transforming food systems in Asian LMIC (39, 40). The consumption of ultra-processed foods and beverages have been increasingly recognized as a risk factor for a set of adverse health effects, including overweight, obesity, cancer, type II diabetes, cardiovascular diseases and all-cause mortality (41, 42), being also associated to lower dietary quality by providing excessive amounts of fat, sugar, and/or sodium in an energy-dense and nutrient-poor food matrix (43). This is particularly concerning since excess weight, as well as

TABLE 1 | Distribution of the street food purchases throughout the day and by city location, by food and beverage groups.

	N[a]	Savory pastries and snacks	Main dishes	Sweet pastries and confectionery	Bread	Sandwiches	Fruit	*N*[b]	Tea and coffee	Soft drinks and juices	Non-alcoholic traditional beverages[c]	Water	Alcoholic beverages[d]	Milk
		n (%)							*n* (%)					
Time of the day														
[09:00–10:00]	21	11 (52.4)	2 (9.5)	1 (4.8)	6 (28.6)	2 (9.5)	0 (0.0)	23	16 (69.6)	4 (17.4)	3 (13.0)	0 (0.0)	0 (0.0)	0 (0.0)
[10:00–11:00]	120	54 (45.0)	23 (19.2)	25 (20.8)	13 (10.8)	10 (8.3)	2 (1.7)	66	25 (37.9)	24 (36.4)	5 (7.6)	11 (16.7)	2 (3.0)	1 (1.5)
[11:00–12:00]	181	48 (26.5)	52 (28.7)	47 (26.0)	20 (11.0)	18 (9.9)	3 (1.7)	52	9 (17.3)	20 (38.5)	14 (26.9)	3 (5.8)	6 (11.5)	0 (0.0)
[12:00–13:00]	118	23 (19.5)	35 (29.7)	20 (16.9)	39 (33.1)	4 (3.4)	0 (0.0)	28	14 (50.0)	4 (14.3)	4 (14.3)	6 (21.4)	0 (0.0)	0 (0.0)
[13:00–14:00]	72	15 (20.8)	12 (16.7)	22 (30.6)	15 (20.8)	18 (25.0)	2 (2.8)	24	8 (33.3)	3 (12.5)	5 (20.8)	5 (20.8)	3 (12.5)	0 (0.0)
[14:00–15:00]	38	8 (21.1)	9 (23.7)	13 (34.2)	9 (23.7)	1 (2.6)	1 (2.6)	19	9 (47.4)	7 (36.8)	2 (10.5)	0 (0.0)	0 (0.0)	2 (10.5)
[15:00–16:00]	14	7 (50.0)	3 (21.4)	0 (0.0)	0 (0.0)	4 (28.6)	0 (0.0)	9	0 (0.0)	8 (88.9)	0 (0.0)	0 (0.0)	1 (11.1)	0 (0.0)
***p*-Value**		**<0.001**	**0.007**	**0.010**	**<0.001**	**0.027**	0.720		**<0.001**	**<0.001**	0.080	**0.020**	0.076	**0.032**
City location														
City center	237	47 (19.8)	42 (17.7)	76 (32.1)	58 (24.5)	21 (8.9)	5 (2.1)	51	17 (33.3)	18 (35.3)	7 (13.7)	8 (15.7)	1 (2.0)	2 (3.9)
Periphery	327	119 (36.4)	94 (28.8)	52 (15.9)	44 (13.5)	26 (8.0)	3 (0.9)	170	64 (37.6)	52 (30.6)	26 (15.3)	17 (10.0)	11 (6.5)	1 (0.6)
***p*-Value**		**<0.001**	**0.025**	**0.001**	**0.025**	0.854	0.809		0.614	0.611	0.865	0.538	0.625	0.718

Values in bold represent statistically significant differences according to Pearson's Chi-squared test with a significance level of 0.05.

The proportions presented are relative to the number of customers purchasing foods (in the case of food groups) or beverages (in the case of beverage groups) in each time period or city location.

[a] *Number of customers purchasing foods (n = 564).*

[b] *Number of customers purchasing beverages (n = 221).*

[c] *Non-alcoholic traditional beverages included ayran (dairy-based fermented beverage made from sheep's milk), chalap (beverage made from fermented milk, salt and carbonated water;), dugob (fermented beverage made with sour milk or buttermilk), kefir (fermented milk drink prepared by inoculating cow, goat or sheep milk with kefir grains), maksym (fermented beverage made from grain, usually malt), tamshan (mix of maksym and chalap), kozhe (cold drink made by boiling rice, millet or pearl barley with a mixture of dairy products such as ayran or kefir) and yogurt.*

[d] *Alcoholic beverages included beer, vodka and some traditional beverages with a low alcohol content, such as kvass (a fermented beverage made from rye bread), bozo (a fermented beverage made from millet) and kymyz (a fermented product made from mare's milk).*

TABLE 2 | Estimated nutritional composition of the street food purchases observed (foods and beverages combined), throughout the day and by city location ($n = 714$).

	Amount purchased	Energy density	Protein	Carbohydrates	Total fat	SFA	MUFA	PUFA	TFA	Sodium	Potassium
	g	kcal/100 g	g/100 g	g/100 g	g/100 g	g/100 g of fat	g/100 g of fat	g/100 g of fat	g/100 g of fat	mg/ 100 g	mg/ 100 g
Time of the day											
[09:00–10:00]	200 (135–200)	88 (16–314)	2.5 (0.0–11.7)	15.6 (4.0–33.1)	1.0 (0.0–9.5)	34.1 (20.7–42.9)	27.1 (25.5–32.2)	35.2 (19.4–49.7)	1.98 (1.65–5.46)	500 (329–599)	109 (51–144)
[10:00–11:00]	200 (100–350)	228 (48–557)	6.3 (0.8–17.5)	26.0 (10.0–79.0)	6.2 (0.3–18.7)	36.0 (19.4–45.3)	28.8 (26.2–33.6)	29.4 (18.5–49.6)	1.94 (1.19–2.59)	597 (356–1,136)	309 (151–529)
[11:00–12:00]	200 (96–265)	310 (126–585)	9.1 (4.3–17.0)	45.1 (13.5–70.5)	10.0 (2.2–20.1)	35.5 (20.7–46.5)	29.3 (26.2–33.6)	34.5 (18.5–49.3)	1.67 (0.95–3.65)	490 (348–1,136)	279 (145–454)
[12:00–13:00]	120 (100–286)	286 (128–404)	8.5 (3.9–11.0)	40.6 (16.7–56.8)	4.5 (1.7–15.3)	22.3 (15.8–41.0)	26.6 (18.0–32.1)	49.4 (19.4–66.3)	1.08 (0.67–2.68)	467 (394–917)	170 (150–443)
[13:00–14:00]	150 (120–278)	233 (130–329)	9.0 (3.9–12.5)	33.3 (12.9–57.6)	2.5 (1.5–13.2)	38.6 (19.4–60.3)	27.3 (23.9–29.0)	24.9 (7.8–51.9)	3.33 (0.67–5.36)	472 (141–620)	166 (136–303)
[14:00–15:00]	156 (96–300)	274 (89–522)	5.6 (2.5–10.6)	42.1 (12.0–65.1)	7.7 (0.3–20.9)	31.1 (21.8–39.6)	28.3 (24.1–33.0)	32.0 (18.0–52.3)	2.50 (1.08–7.57)	497 (402–1,041)	244 (121–446)
[15:00–16:00]	265 (172.–494)	233 (117–286)	4.3 (2.7–8.5)	27.9 (17.3–40.9)	10.1 (4.0–13.4)	32.1 (23.1–37.5)	27.7 (24.7–31.8)	37.5 (28.6–51.1)	1.39 (1.08–2.14)	484 (197–1,264)	227 (122–461)
p-**Value**	0.458	**0.001**	**0.011**	**0.008**	**<0.001**	**0.008**	**<0.001**	**0.002**	**<0.001**	0.256	**<0.001**
City location											
City center	120 (96–265)	308 (206–552)	9.1 (4.0–17.1)	56.8 (20.6–80.2)	10.0 (1.7–20.1)	27.6 (19.4–41.6)	27.8 (24.0–32.0)	37.7 (18.5–52.9)	1.20 (0.81–2.15)	484 (435–1,042)	305 (150–507)
Periphery	200 (117–306)	216 (77–419)	6.6 (2.4–12.3)	26.0 (10.0–57.6)	4.6 (0.6–14.1)	33.9 (20.4–42.9)	27.9 (25.5–32.9)	34.5 (18.5–−51.1)	2.25 (1.29–5.46)	490 (294–980)	205 (125–402)
p-**Value**	**<0.001**	**<0.001**	**0.003**	**<0.001**	**<0.001**	**0.005**	0.055	0.094	**<0.001**	0.254	**<0.001**

SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; TFA, trans fatty acids.

All values are presented as median (P25–75). Values in bold represent statistically significant differences according to Kruskal–Wallis (throughout the day) and Mann-Whitney's tests (by city location) with a significance level of 0.05.

mortality and morbidity from non-communicable diseases, have been increasing during the last decades in central Asia. According to data from the Global Nutrition Report 2016, in this region overweight affected almost half of the adult population (49.8% of women and 49.2% of men) (44). In 2019, non-communicable diseases were responsible for approximately 84.7% of total deaths and 72.9% of total disability-adjusted life years in the region (45).

The highest purchase of homemade foods and beverages was observed between 09:00 and 10:00, indicating a preference by street food customers for home-like food options in the context of a breakfast. Nearly half of customers purchasing foods bought savory pastries during this time period, although they are usually consumed at any time of the day (38), which is consistent with our results. Bread, tea and coffee are also purchased at almost all hours of the day, but mainly between 09:00 and 10:00, and 12:00 and 13:00. These food items are traditionally consumed in the context of breakfast, or as part of lunch (38), our results indicate that this habit seems to remain amongst the street food consumers of these cities. Purchase of sandwiches was less common, occurring mostly in the afternoon (in the periods from 13:00 to 14:00 and from 15:00 to 16:00). Although their consumption in the region is not unusual (38), sandwiches can be potentially easier to prepare at home, and transported without losing quality, which may explain in part the lower purchase. On the other hand, the time periods in which there was a higher purchase of sandwiches suggest that this type of foods may be consumed by street food customers mainly at lunch as a main course [as reported elsewhere (17)] or as an afternoon snack. The sandwiches bought were most frequently filled with cheese, sausage or meat [e.g. *shawarma* (kebab), hamburger, hot-dog]. Similarly, savory pastries and main dishes were very often meat-based: the most frequently purchased savory pastries were *sambusa*, *piroshky* and *chebureki*, which are all traditional pastries, usually fried or baked and filled with meat; whereas the most commonly bought main dishes were *plov* (rice cooked in a seasoned broth with a mixture of spices, usually with meat and vegetables) and *shashlik* (skewered grilled cubes of meat, alone or with alternating pieces of meat, fat and vegetables). This reflects the importance of meat in this region's gastronomy, as it can be present in any meal and it is the primary source of protein in central Asian diets (38).

Fruit was the least frequently bought street food in all cities studied. This may be a direct reflection of the low ready-to-eat fruit availability that was found in the selected street food vending sites, which ranged from 1.0% in *Almaty* to 4.5% in *Dushanbe* (9–12, 17, 18). The Global Burden of Disease Study (46) and the EAT-Lancet Commission (47) provided targets for fruit consumption, at 200 and 250 g of fruit per day, respectively. In Central Asia, data from the FAOSTAT food balances show that fruit supply has been consistently rising throughout the years, and in 2018 it reached 72.61 kg/capita/year (48), which corresponds to approximately 199 g/capita/day. Since fruit supply do not correspond directly to actual consumption, due to factors such as edible portions and food waste losses, these values indicate that overall consumption of fruit may still be inadequate. However, the growth in fruit availability in the region

also suggests that it may be possible to reach these consumption targets in the near future. A study conducted in former Soviet Union countries (including Kyrgyzstan and Kazakhstan) found a positive correlation between the number of shops selling fruits and vegetables and their consumption (49). Improving access to fruits and vegetables by increasing their availability in the streets have also showed to have positive results in the consumption of these foods (49, 50). As such, there seems to be a window of opportunity to raise fruit consumption in these street food contexts through availability policies.

Regarding the nutritional composition of the purchases, the highest energy and macronutrient density was observed between 11:00 and 12:00, mostly due to a high level of purchase of main dishes and energy-dense sweets and savory pastries and snacks. On the contrary, purchases were poorer in energy and macronutrients from 09:00 to 10:00, which was also when the highest proportion of customers bought beverages, most of them with a very low nutritional value. Saturated fatty acids were the highest contributors to total fat in almost all hours of the day, reaching its highest content in purchases made between 13:00 and 14:00. *Trans*-fat was also high, and above the limit of 2 g/100 g of total fat (51, 52) between 13:00 and 15:00. These results can be explained by a high acquisition of sweets pastries and confectionery during these time periods. Some of these foods, particularly wafers, chocolate and ice-cream, were identified as rich sources of both saturated and *trans*-fat in these street food environments (9–12, 17, 18), which was particularly concerning due to their proximity to schools, as observed *in loco*. In the city centers, purchases were smaller but more energy-dense; however, in the periphery purchases had higher proportions of saturated and *trans*-fat, mostly due to the high percentage of customers buying savory pastries and snacks, as well as main dishes, some of them also providing high contents of those fatty acids (9–12, 17, 18).

Limitations of the present study should be discussed. We were unable to perceive purchasing variations throughout the week, or between week days and weekends. Although observation efforts comprised all days of the week (from Monday to Sunday), most street food markets were assessed during one or two consecutive days, due to logistical reasons. Future work could eliminate this limitation by assessing each market during a whole week. The fact that the observations were made during all days of the week was, nevertheless, an asset for this work, because it allowed us to ensure that variability over the 7 days of the week was covered when analyzing the patterns of purchase either throughout the day or by city location. Another limitation was that time of purchase may not directly mean time of consumption. However, all foods and beverages were ready-to-eat, purchased in small quantities and mostly unpackaged, suggesting that these purchases were made mostly for immediate consumption. Purchases including foods or beverages not ready-to-eat were not included in this study, thus eliminating purchases intended for household consumption.

To our knowledge, this is the first study describing street food purchasing patterns in cities from this region. The present results provide an overview of the street food buying habits in these cities, which may indirectly reflect consumption habits. Among the strengths of this study, the data collection through direct observation of customers by trained researchers instead of face to face interviews should be underlined, since it allowed us to minimize behavior alterations and social approval bias (53). We also highlight the high level of concordance between observers regarding the street food purchases. This reflects an underlying work of rigorous training, standardization of procedures and constant supervision, and resulted in a high reliability of these observational data. Finally, although generalizability of our results is very limited due to local gastronomic specificities, the FEEDCities standardized methodology (21) allows for data comparability among different cities, countries or regions.

CONCLUSIONS

In conclusion, street food purchases in *Dushanbe* (Tajikistan), *Bishkek* (Kyrgyzstan), *Ashgabat* (Turkmenistan) and *Almaty* (Kazakhstan) varied widely across time and space, showing higher rates in city centers and during lunch. Different types of foods and beverages were bought at different frequencies throughout the day and by city location, reflecting specific patterns of purchase. The present study is the first to report on spatial and temporal distributions of street food purchases, that way contributing to a better understanding of the street food buying habits in these settings, which should be considered when designing public health strategies and defining targets of action more specific to the reality of these food environments, their customers and their gastronomic identity. Further research on the prevalence, frequency and determinants of street food consumption by these populations, would also be an important step in future work.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors upon request, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of the Institute of Public Health of the University of Porto. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

MG, PM, JB, NL, and PP designed the study. GA, IL, and MG supervised the study implementation and data collection. OP and SC were responsible for the laboratorial analyses of the food samples collected in Tajikistan, Kyrgyzstan and Kazakhstan. CM coordinated the laboratorial analyses in Turkmenistan. SS, NL, and PP performed the analysis and interpretation of the results. SS drafted the first version of the manuscript. All authors critically revised the manuscript and gave their final approval of the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnut.2022.925771/full#supplementary-material

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Supplementary material

Supplementary Table 1. Estimated nutritional composition of the street food purchases observed (without beverages), throughout the day and by city location (n=564, number of customers purchasing foods).

	Amount purchased	Energy density	Protein	Carbohydrates	Total fat	SFA	MUFA	PUFA	TFA	Sodium	Potassium
	g	kcal/100 g	g/100 g	g/100 g	g/100 g	g/100 g of fat	g/100 g of fat	g/100 g of fat	g/100 g of fat	mg/ 100 g	mg/ 100 g
Time of the day											
[09:00-10:00[	120 (105-176)	319 (275-520)	11.7 (10.6-14.2)	53.7 (31.1-68.6)	13.6 (1.8-16.4)	26.7 (20.7-42.9)	27.0 (22.6-32.2)	44.9 (19.4-57.0)	2.21 (1.98-5.46)	560 (490-959)	144 (109-302)
[10:00-11:00[	117 (52-265)	420 (269-818)	14.6 (8.0-23.8)	58.6 (30.6-109.1)	14.9 (7.2-30.1)	33.6 (19.4-44.5)	30.4 (26.2-33.2)	28.3 (18.5-49.6)	1.90 (1.19-2.40)	892 (479-1787)	329 (184-538)
[11:00-12:00[	120 (94-265)	449 (274-663)	14.2 (7.0-18.7)	57.6 (31.1-81.2)	16.4 (6.2-26.3)	32.9 (20.5-46.5)	29.5 (26.2-33.6)	35.7 (18.5-49.3)	1.66 (0.90-2.79)	611 (435-1216)	301 (205-525)
[12:00-13:00[	120 (96-186)	286 (262-359)	14.0 (6.4-16.5)	56.8 (29.6-65.3)	7.0 (1.7-24.1)	22.3 (15.8-41.0)	26.6 (18.0-32.1)	49.4 (19.4-66.3)	1.08 (0.67-2.68)	467 (435-994)	205 (150-461)
[13:00-14:00[	126 (77-211)	287 (207-479)	11.0 (6.2-17.2)	50.5 (29.6-61.8)	5.9 (1.7-16.4)	39.2 (19.4-60.3)	27.3 (23.9-29.0)	26.1 (7.8-51.9)	3.10 (0.67-5.36)	490 (169-887)	167 (147-317)
[14:00-15:00[	120 (92-176)	328 (274-616)	10.5 (6.4-14.5)	57.2 (31.1-116.0)	16.2 (6.3-26.0)	28.9 (21.0-39.6)	28.2 (23.9-32.2)	33.0 (16.6-53.6)	1.87 (1.08-7.65)	505 (467-1052)	303 (139-461)
[15:00-16:00[	192 (100-265)	290 (258-585)	9.9 (8.5-14.9)	35.5 (28.8-72.2)	15.0 (11.5-24.1)	32.1 (23.1-37.5)	27.6 (24.7-31.8)	37.5 (28.6-51.1)	1.37 (1.08-2.14)	777 (541-1533)	353 (279-461)
p	0.487	**0.018**	**0.023**	0.122	**<0.001**	**0.019**	**<0.001**	**0.005**	**0.002**	**<0.001**	**<0.001**
City location											
City centre	117 (81-212)	424 (276-663)	11.0 (6.4-17.5)	57.6 (39.9-108.9)	14.0 (4.7-27.0)	27.6 (19.1-41.6)	27.8 (24.0-32.0)	37.7 (18.9-52.9)	1.20 (0.81-2.15)	541 (467-1136)	316 (151-536)
Periphery	124 (96-265)	319 (233-622)	11.1 (7.2-17.6)	45.1 (26.0-72.2)	11.7 (3.8-24.1)	31.2 (20.4-42.9)	28.1 (25.7-32.6)	37.3 (18.5-51.2)	2.07 (1.19-5.36)	560 (394-1136)	243 (147-461)
p	**0.003**	**0.027**	0.241	**<0.001**	0.262	0.220	0.052	**0.015**	**<0.001**	0.828	**0.007**

SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; TFA, *trans* fatty acids.
All values are presented as median (P25-75). Values in bold represent statistically significant differences according to Kruskal-Wallis (throughout the day) and Mann-Whitney's tests (by city location) with a significance level of 0.05.

PAPER V

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Article

Street Food and Takeaway Food Purchasing Patterns in Bosnia and Herzegovina

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Abstract: This study aimed to describe street food and takeaway food purchasing patterns in Sarajevo and Banja Luka, throughout the day and by city location. A cross-sectional evaluation of street food and takeaway food customers was conducted in 2017. All eligible vending sites (n = 348) in the vicinity of selected markets and bus stops were included. Data on the food items purchased, and time and geographic location of the purchases were collected. A total of 755 customers purchased 929 food items. Takeaway venues showed higher customer influx (5.0 vs. 2.0 customers observed per 10 min of observation, $p < 0.001$) and buying rates (6.7 vs. 2.0 items bought per 10 min of observation, $p < 0.001$; 1.5 vs. 1.0 items bought per customer, $p < 0.001$) than street food sites. These rates were higher in city peripheries for street food venues, and in city centres for takeaway establishments. The purchase of industrial food products prevailed throughout the day in street food venues, whereas most takeaway purchases comprised homemade foods, with or without industrial beverages. The proportion of customers buying foods and beverages together was higher in takeaway venues (15.3% vs. 6.0%, $p < 0.001$), especially during lunchtime and in city centres. In street food vending sites, sweet and savoury snacks seemed to be preferred in the afternoon, whereas in takeaway food establishments, savoury pastries and main dishes were mostly purchased at breakfast or lunch, and bread during the morning. Soft drinks and industrial juices were frequently purchased in both types of vending site and at all hours of the day, particularly in the afternoon. Our findings provide an overview of street food and takeaway food buying habits and consumer demands in these cities, reflecting local food culture and dietary behaviours. The identification of the meal contexts and city sub-regions in which specific purchasing practices emerge point to potential priority targets. These insights can be useful when designing interventions adapted to the specificities of these food environments and the food habits of customers.

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Keywords: street food; takeaway food; ready-to-eat food; purchasing patterns; food choice; Eastern Europe

1. Introduction

Following the collapse of communist regimes at the end of the 20th century, a set of socioeconomic transformations, including rapid industrialization, urbanization and economic development, occurred in Eastern European countries [1]. In Bosnia and Herzegovina, during the last 10 years the national gross domestic product increased by 19.8% [2] and the proportion of urban dwellers grew from 46% to 49% [3].

Rooted in these demographic and economic transitions, several changes in lifestyle and dietary habits were observed, especially in urban centres [1], including increasingly sedentary behaviours [4,5] as well as a growing demand for foods prepared away from home [6,7]. In this context, ready-to-eat street-vended foods and beverages have an important role in the urban food environments of the Eastern European region [8–10]. Specifically in cities in Bosnia and Herzegovina, in addition to traditional street food vendors, takeaway food establishments, such as "Buregdžinicas" (places selling savoury pies), "Ćevabdžinicas" (places selling barbecue) and "Pekaras" (bakeries), are also key providers of street-vended meals [9,10].

Eating out-of-home has been associated with lower dietary quality [11], also being reported as a risk factor for overweight and obesity [11,12]. Recent data on street food and takeaway food environments in cities in Bosnia and Herzegovina showed a high availability of homemade food items (60.2% in Sarajevo and 56.8% in Banja Luka), but also a relevant number of venues selling foods and beverages produced by the food industry (41.6% in Sarajevo and 57.4% in Banja Luka). A very high availability of soft drinks and fruit juice-based beverages was also a common feature in these settings [9,10]. These results suggest a shift to more westernized eating habits among street food and takeaway food customers. Nonetheless, to the best of our knowledge, their purchasing patterns have not yet been studied.

Food environments have been described as "the interface where people interact with the wider food system to acquire and consume foods". In this context, food acquisition has been identified as an important feature of food systems, interacting with food environments in a bi-directional way, as it both influences and is influenced by a complex network of external and personal drivers [13,14]. This vindicates the relevance of assessing food purchasing behaviours as significant targets for achieving healthier diets. However, although research on street food has grown in recent years, it focused mostly on its hygiene and safety, whereas its consumption or purchase were seldom explored [15]. Meanwhile, studies on takeaway food have been typically conducted in high-income countries, and frequently directed towards fast-food restaurants, while takeaway meals from small traditional outlets have been overlooked [16].

This study aimed to characterize street food and takeaway food purchasing patterns in the two main urban areas of Bosnia and Herzegovina (Sarajevo and Banja Luka), and to understand how these vary across time (throughout the day) and space (city centre vs. periphery).

2. Methods

2.1. Overview

This study was implemented as part of the FEEDCities (Food Environment Description in Cities) research project. The general methodology of this research project is published elsewhere [17]. For the purpose of this study, cross-sectional evaluations of street food and takeaway food customers were conducted between June and August 2017, in Sarajevo and Banja Luka, which are the two the largest and most urbanized cities in Bosnia and Herzegovina [18,19].

2.2. Eligibility Criteria

The Food and Agriculture Organization (FAO) and the World Health Organization (WHO) defined "street food" as "ready-to-eat foods and beverages prepared and/or sold by vendors or hawkers especially in the streets and other similar places" [20,21]. Similarly, a definition for "takeaway food vending site" was proposed by the United Kingdom authorities, as "an outlet whose primary business is the sale of ready-to-eat food and beverages for consumption off the premises" [22]. In general, street food vending units have a more informal setup (e.g., food stands, kiosks), whereas takeaway food vending sites are built within four permanent walls (Supplementary Figure S1). However, both types of business sell ready-to-eat food (homemade and/or industrial) which are bought to be consumed in similar contexts (i.e., in the streets, off the premises). As such, both these definitions were adopted in order to select the food vending sites eligible for this study.

Any customer approaching eligible street food or takeaway food vending sites during a pre-specified time period to buy ready-to-eat foods and/or beverages (hereafter referred to as "food items") was eligible for the study. All age groups were considered as eligible.

2.3. Sampling Procedure

A preliminary assessment of the distribution of street food and takeaway food vending sites in each city was accomplished through field visits conducted in Sarajevo and Banja Luka, and taking into account information provided by the WHO country office and by the respective local authorities. Whereas in Sarajevo the vending sites were clustered in and around public markets, in Banja Luka these were mainly distributed in and around the main city market (Gradska tržnica), in addition to several public transportation stops (bus stations). As such, sampling procedures were adapted, taking into account these specificities, following a decision tree for the selection of vending sites, presented in the FEEDCities protocol [17].

In Sarajevo, 10 main public markets were selected in collaboration with local authorities, considering criteria related to the size and importance of the markets. Around the centre of the selected markets, a 500 m diameter buffer was defined, with the exception of the larger main city market (Markale), where a 1500 m diameter was needed to accommodate all the vending sites within its perimeter. In Banja Luka, the main city market was selected along with 10 bus stops, pre-selected as they corresponded to the main station of the city bus routes. To define the study area, a 1500 m buffer was drawn around the centroid of the main city market; and for each bus stop, the buffer diameter was 100 m. Within the study areas of each city, all publicly accessible streets were canvassed by pairs of field researchers, who identified all vending sites eligible for the study. All vending sites identified in each city were selected.

2.4. Data Collection

Data was collected by direct observation of each selected vending site, during which any customer buying one or more eligible food items, according to the abovementioned definitions, was assessed. The observation of each vending site ended when four customers were observed, or when a maximum period of 10 min was reached. Observations were performed in periods covering all days of the week and businesses' working hours, from 8 a.m. to 6 p.m. A total of 348 vending sites were surveyed (224 in Sarajevo and 124 in Banja Luka), which corresponded to a total of 2941 min of observation.

Observations were performed by trained local field researchers, located at enough distance not to disturb the vendors' regular activity or the customers' usual behaviour. Training of field researchers occurred before data collection, and included theoretical, practical and field sessions, in order to standardize practices and maximize the quality of the collected data.

For each customer, two observers independently registered the food items purchased and respective quantities. Inter-observer concordance was evaluated using Cohen's kappa (K) with 95% confidence interval (95%CI), being high to very high, regarding both variables

(food item purchased: 98.2% agreement, K = 0.98, 95%CI 0.97–1.00; quantity purchased: 92.0% agreement, K = 0.89, 95%CI 0.86–0.92) [23]. Disagreements between observers were solved using a set of standardized criteria: (1) if the two observers registered different food items, the conflicting items were checked for their availability on the corresponding vending site (if only one of the conflicting items was available, that was the observation assumed, and both observations were disregarded if the conflicting items were both available or not available); (2) if the two observers registered the same food item, but with different degrees of specificity, the broadest observation was assumed; (3) if the two observers registered a different number of food items for the same customer, the observation with the larger number of food items available was assumed; and (4) if two observers registered the same food item, but different quantities, the average quantity of the two observations was assumed.

The purchased food items were grouped into sub-categories, based on the WHO nutrient profile model [24]: (1) main dishes; (2) bread; (3) savoury pastries; (4) savoury snacks; (5) sweet pastries and confectionery; (6) sandwiches; (7) coffee; (8) water; (9) soft drinks and industrial juices; (10) alcoholic beverages; and (11) yoghurt. Food items were also classified as homemade (foods and beverages that were prepared and/or cooked at home or in the street, even if using industrial ingredients) or industrial (foods and beverages that were produced by the food industry and sold as such, with no further preparation).

For each vending site observed, Global Positioning System (GPS) coordinates were recorded, as well as time of beginning and end of observation. Each selected buffer (market/bus stop) was classified as central or peripheral, according to their distance (below or above 2 km, respectively) to a city centre reference point, assigned in each city taking into account information provided by the respective local authorities and the WHO Country Office. The duration of the observation was also calculated for each vending site, as well as the customer influx (which was computed as the number of customers observed per 10 min of observation) and the food items buying rate (number of food items purchased per 10 min of observation). Purchases were then categorized taking into account time of the day, on an hourly basis (i.e., 8–9 a.m., 9–10 a.m., etc.) and city location (city centre vs. periphery).

2.5. Statistical Analysis

Absolute and relative frequencies were used to describe the food items purchased. Customer influx, food items buying rate and number of food items purchased per customer were described through median and percentiles 25 and 75. Pearson's Chi-squared test was used to compare the street food purchases throughout the day and by city location. Mann–Whitney and Kruskal–Wallis tests were used to compare the customer influx, food items buying rate and number of food items purchased per customer, throughout the day or by city location, respectively. Differences were considered statistically significant when the critical level of significance (p) was less than 0.05. Statistical analyses were performed using *Stata*® version 15.0 (StataCorp., College Station, TX, USA).

3. Results

A total of 755 customers purchased 929 food items. In each vending site, a median of three customers were observed over a median period of observation of 10 min. Takeaway food vending sites showed higher customer influx (5.0 vs. 2.0 customers/10 min, $p < 0.001$), food items buying rate (6.7 vs. 2.0 food items/10 min, $p < 0.001$) and number of food items purchased per customer (1.5 vs. 1.0, $p < 0.001$) when compared to street food vending sites (Figure 1). There were no significant differences between cities regarding these three variables.

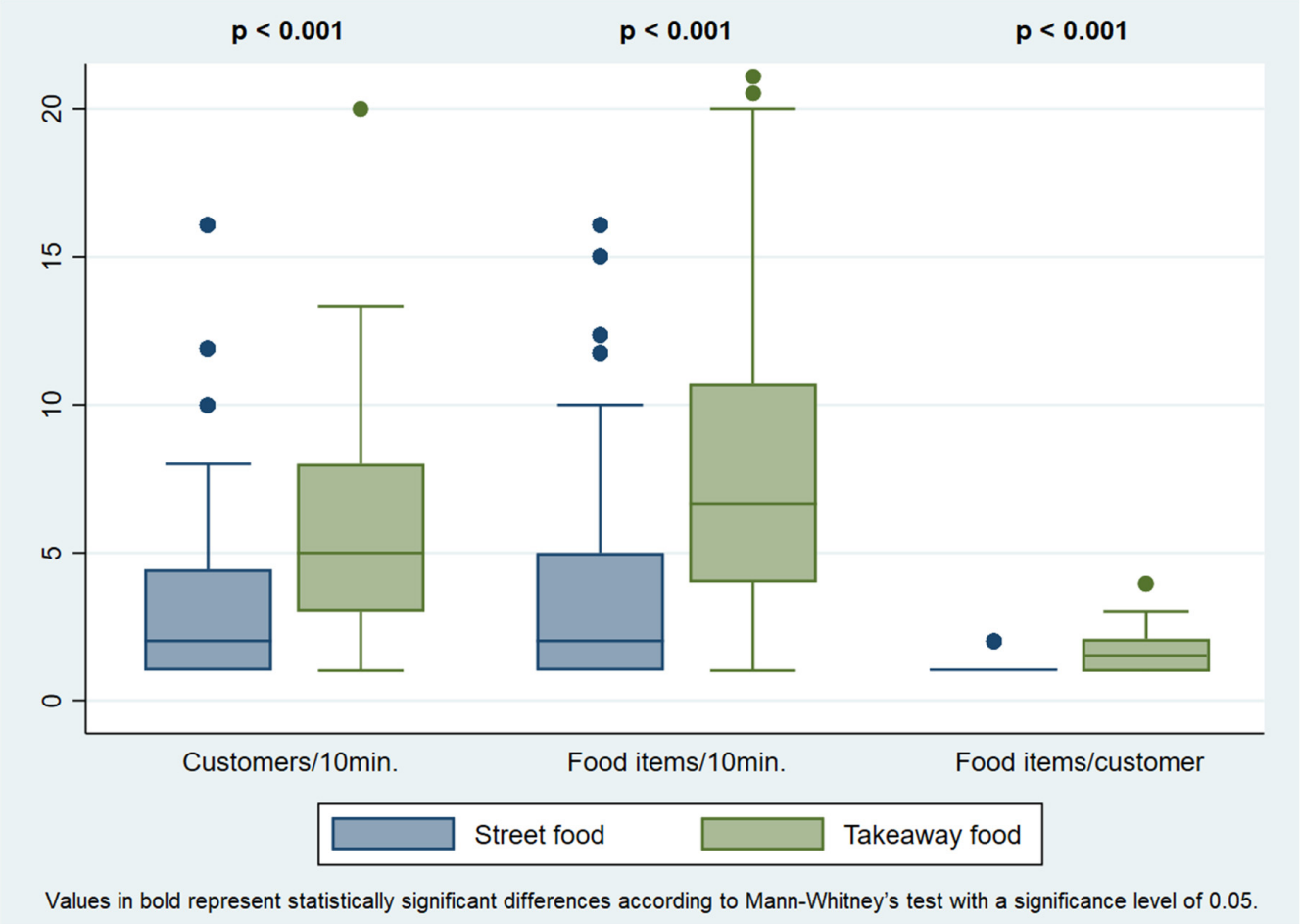
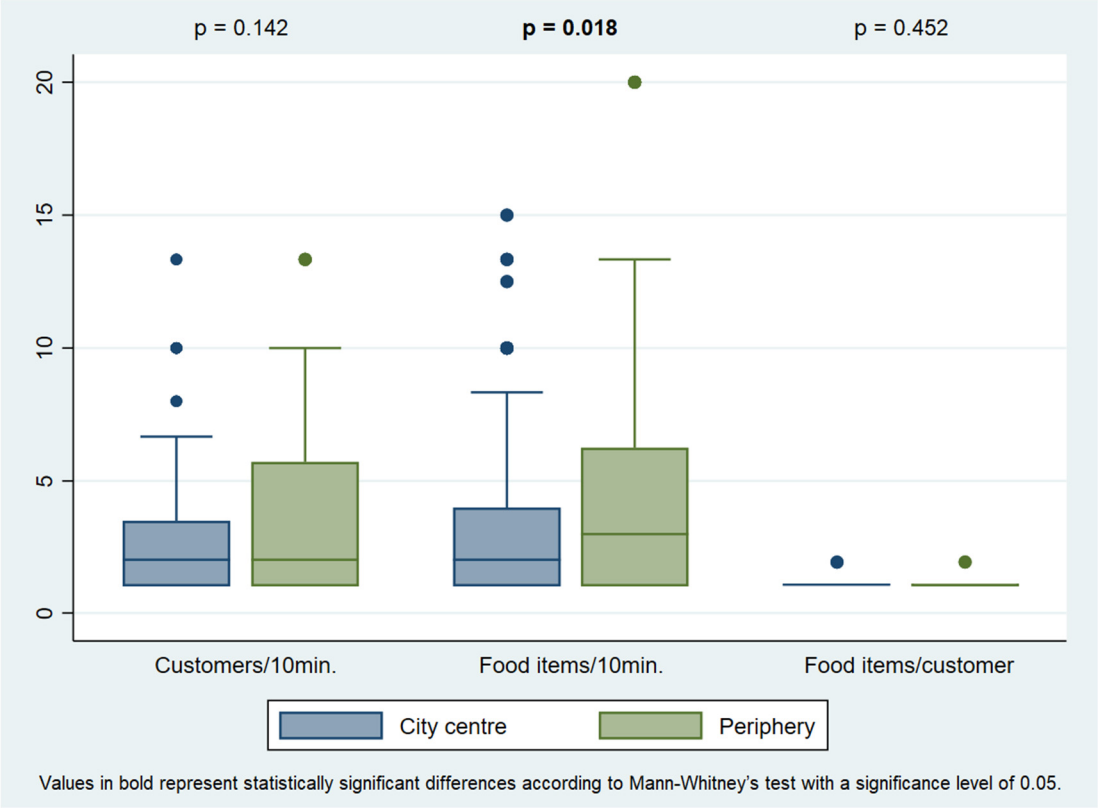
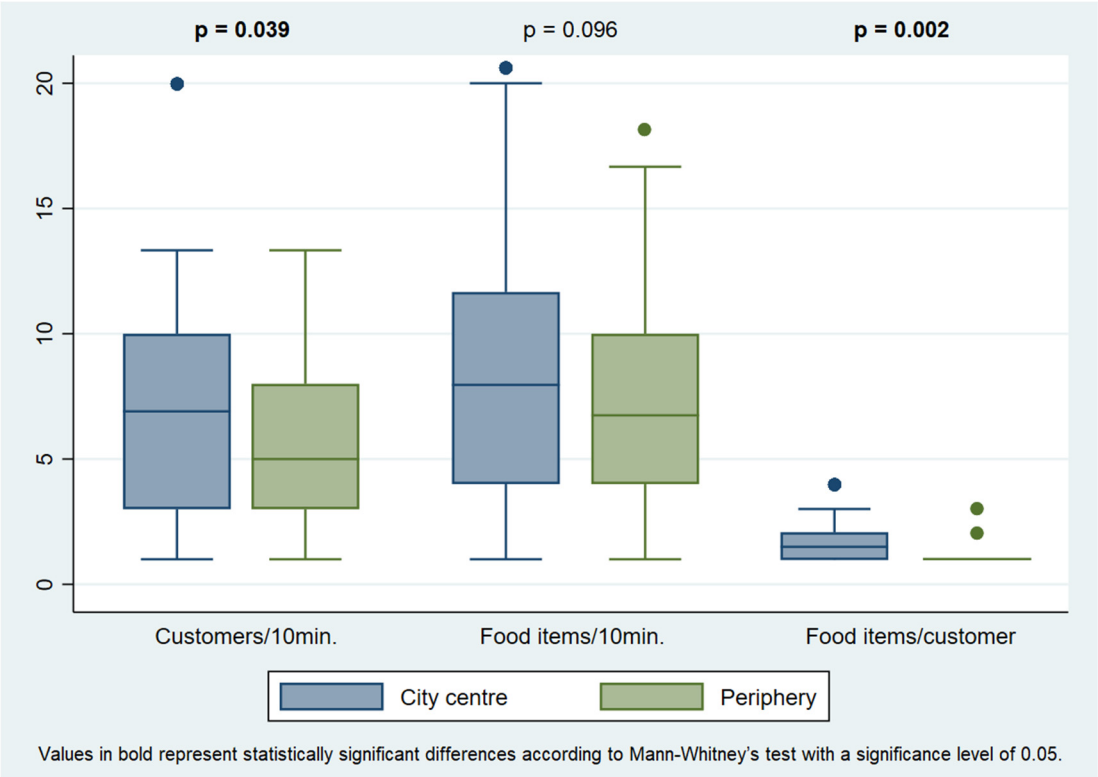


Figure 1. Customer influx, food items buying rate and number of food items purchased per customer, in the street food and takeaway food vending sites observed in Bosnia and Herzegovina.

Although no statistically significant differences were found, it was observed that customer influx and food items buying rate tended to be highest between 12 a.m. and 2 p.m. in street food vending sites, and from 10 a.m. to 1 p.m. in takeaway food vending sites (Supplementary Figure S2). Regarding city location, street food vending sites showed a higher food items buying rate in the periphery (3.0 vs. 2.0 food items/10 min, $p = 0.018$), whereas takeaway food vending sites presented higher customer influx (6.7 vs. 5.0 customers/10 min, $p = 0.039$) and number of food items purchased per customer (1.5 vs. 1.0, $p = 0.002$) in the city centre (Figure 2).



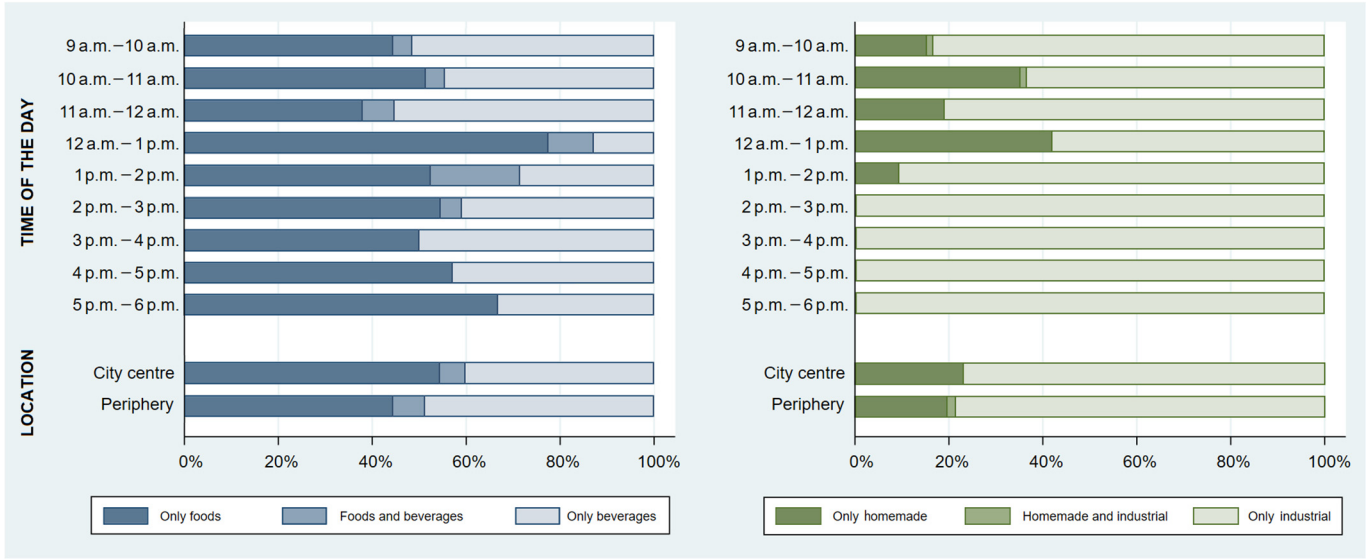
(**a**)



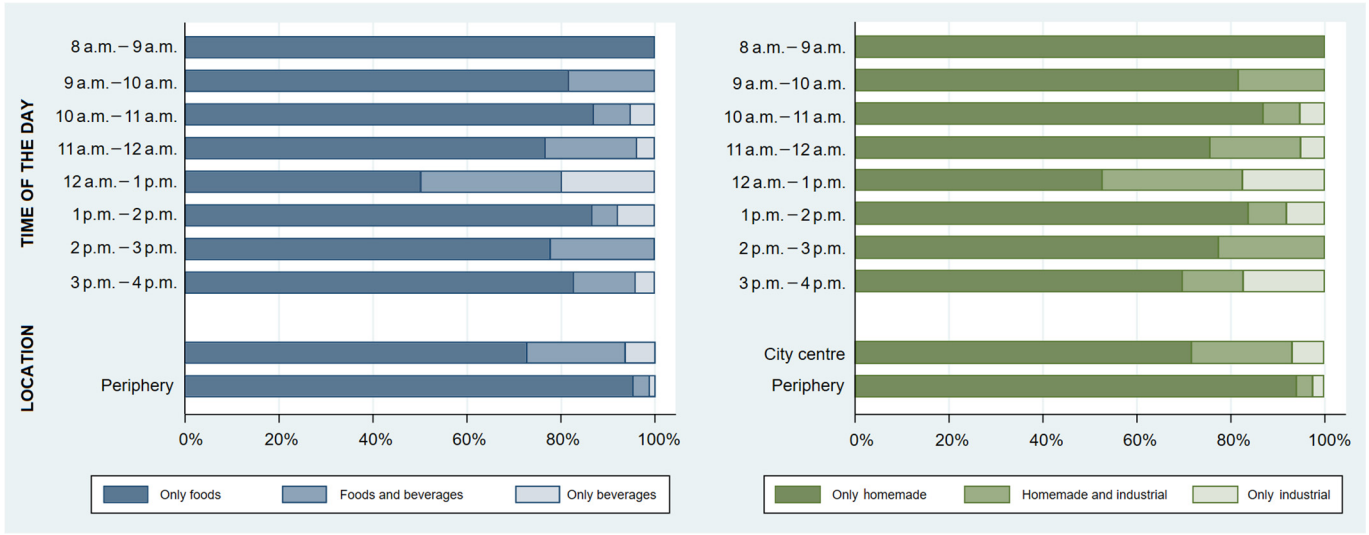
(**b**)

Figure 2. Customer influx, food items buying rate and number of food items purchased per customer, in (**a**) street food and (**b**) takeaway food vending sites, by city location.

In street food vending sites, the purchase of foods was highest from 12 a.m. to 1 p.m. (87.1%) and from 1 p.m. to 2 p.m. (71.4%), whereas the purchase of beverages was higher during the morning period, especially between 11 a.m. and 12 a.m. (62.1%). Between 12 a.m. and 2 p.m., a greater frequency of joint purchase of foods and beverages was also observed. Customers buying industrial food items prevailed throughout the whole day, especially during the afternoon period. The purchase of homemade food items only occurred during the first half of the day, and was highest between 12 a.m. and 1 p.m. (41.9%). Regarding city location, no statistically significant differences were found in the purchase of foods and/or beverages, as well as homemade and/or industrial food items (Figure 3a).



(**a**)



(**b**)

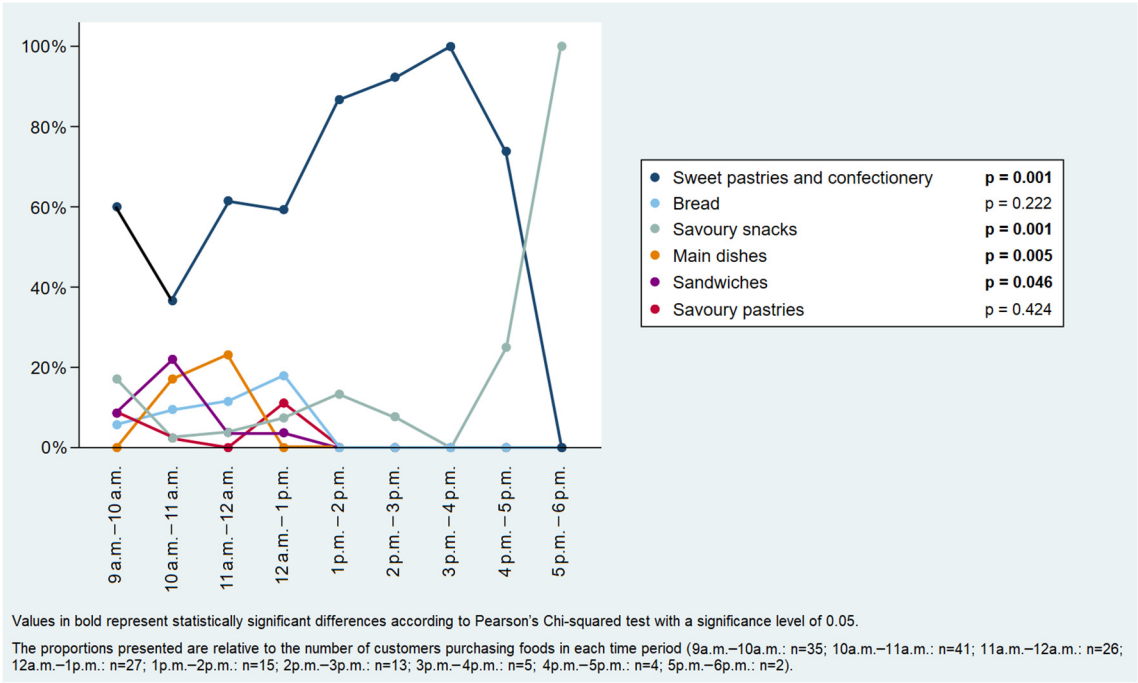
Figure 3. Proportion of customers purchasing foods and/or beverages and homemade and/or industrial food items, in the (**a**) street food and (**b**) takeaway food vending sites observed, throughout the day and by city location (street food: n = 298 purchases; takeaway: n = 457 purchases).

Considering takeaway venues, the purchase of foods was very frequent ($\geq$ 80%) throughout the whole day. Between 12 a.m. and 1 p.m., it was observed the highest frequency of the purchase of beverages (50.0%), as well as the joint purchase of foods and beverages (30.0%). The proportion of customers buying foods and beverages together

was significantly higher in the city centre (20.8% vs. 3.4%, $p < 0.001$). The purchase of homemade and/or industrial food items followed similar distributions, since almost all foods purchased (99.6%) were homemade and almost all beverages bought (98.8%) were industrial (Figure 3b).

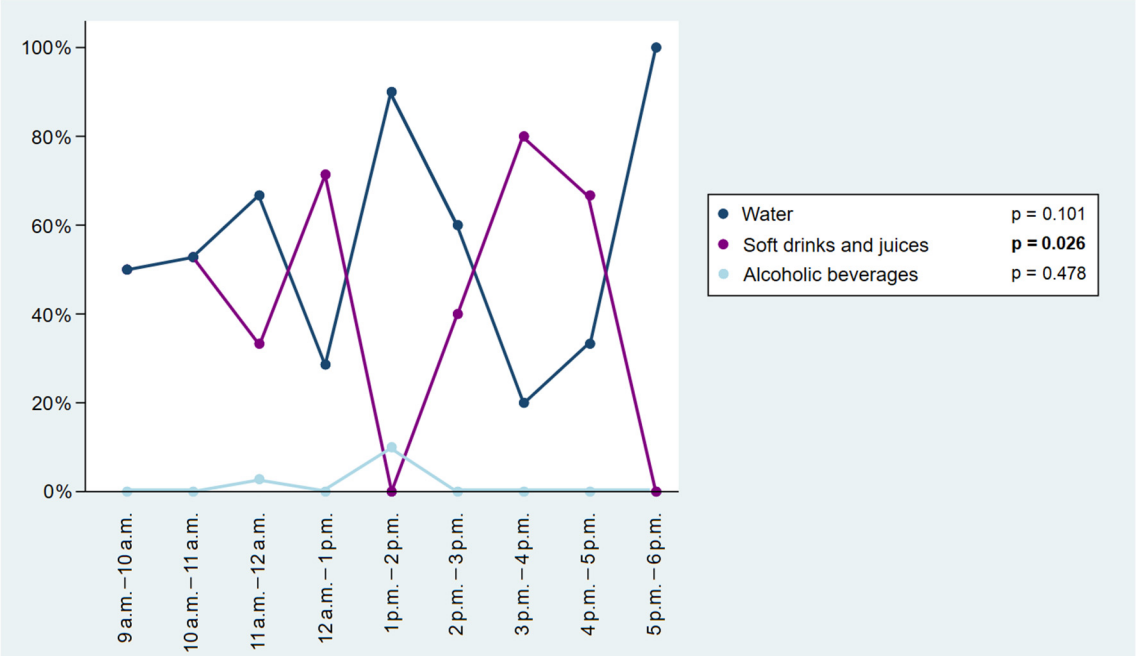
The joint purchase of foods and beverages was higher among takeaway food customers (15.3% vs. 6.0%, $p < 0.001$). In street food venues, 88.9% of joint purchases comprised both industrial foods and beverages (mostly sweet or savoury snacks plus soft drinks or juices), while in takeaway vending sites all these customers bought homemade foods with industrial beverages (mostly savoury pastries or main dishes with soft drinks, juices or yoghurt).

In street food venues, among customers who bought foods, sweets pastries and confectionery were more frequently purchased between 1 p.m. and 5 p.m., savoury snacks between 4 p.m. and 6 p.m., main dishes from 10 a.m. to 12 a.m. and sandwiches from 10 a.m. to 11 a.m. (Figure 4a); among purchases including beverages, soft drinks and juices were most commonly bought between 3 p.m. and 5 p.m. and from 12 a.m. to 1 p.m. (Figure 4b). Regarding takeaway food purchases, savoury pastries were most frequently bought from 9 a.m. to 10 a.m. and from 2 p.m. to 3 p.m., bread between 9 a.m. and 11 a.m., main dishes between 8 a.m. and 9 a.m. and from 12 a.m. to 1 p.m. (Figure 5a), soft drinks and juices between 2 p.m. and 3 p.m., and alcoholic beverages from 1 p.m. to 2 p.m. (Figure 5b).



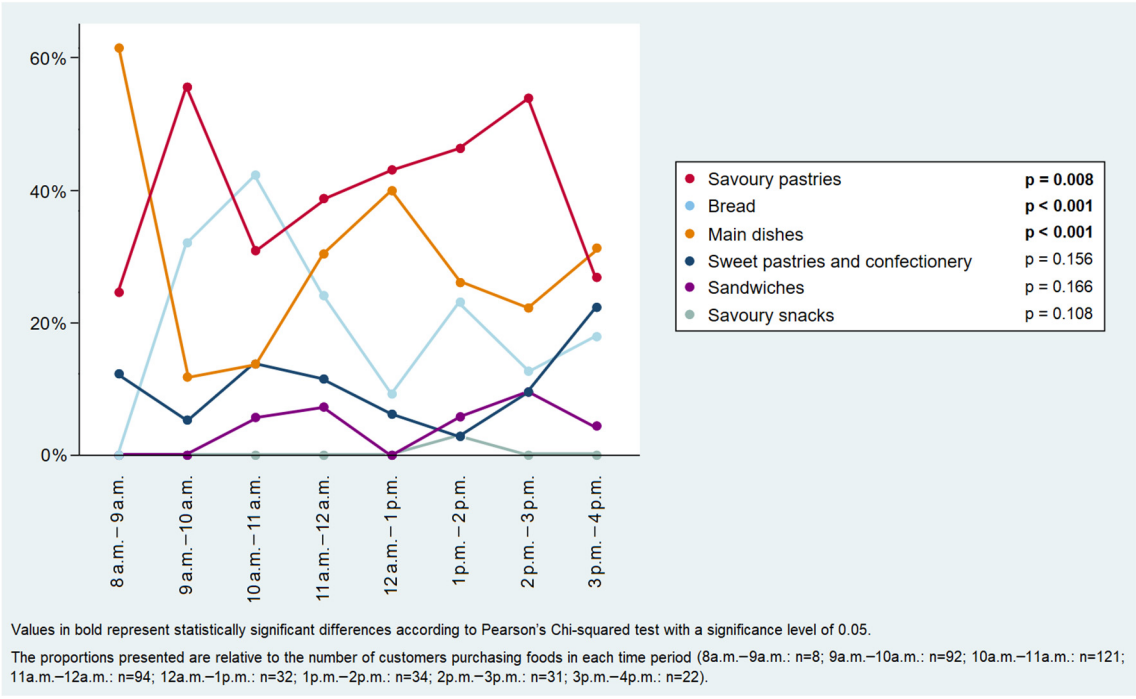
(**a**)

Figure 4. *Cont.*



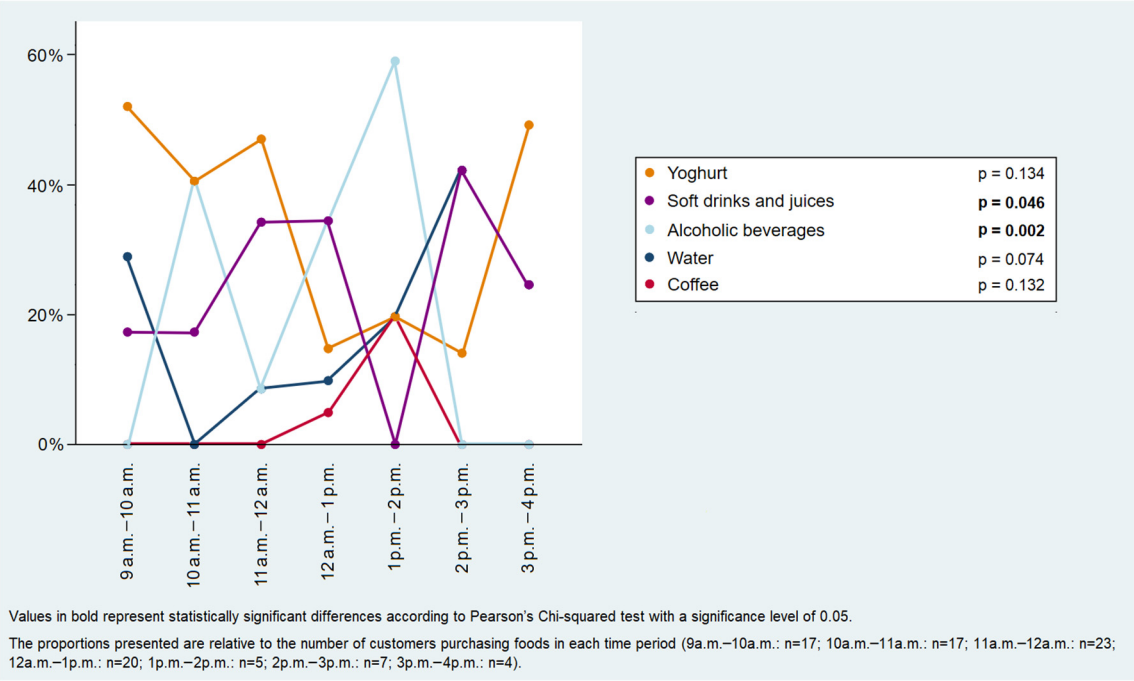
(**b**)

Figure 4. Distribution of the street food purchases throughout the day: (**a**) foods (n = 168) and (**b**) beverages. (n = 148).



(**a**)

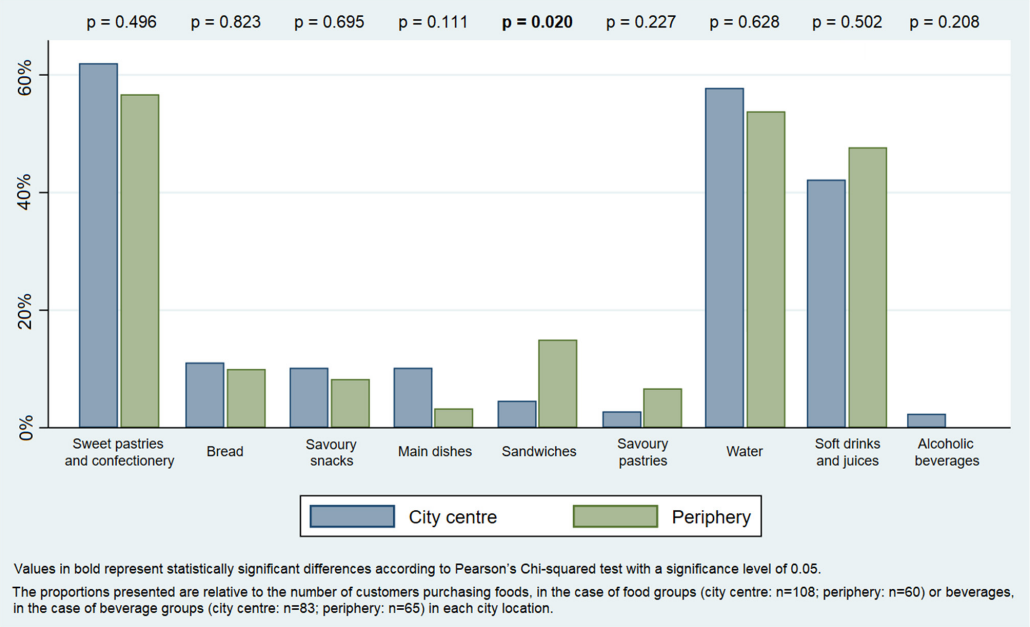
Figure 5. *Cont*.



(**b**)

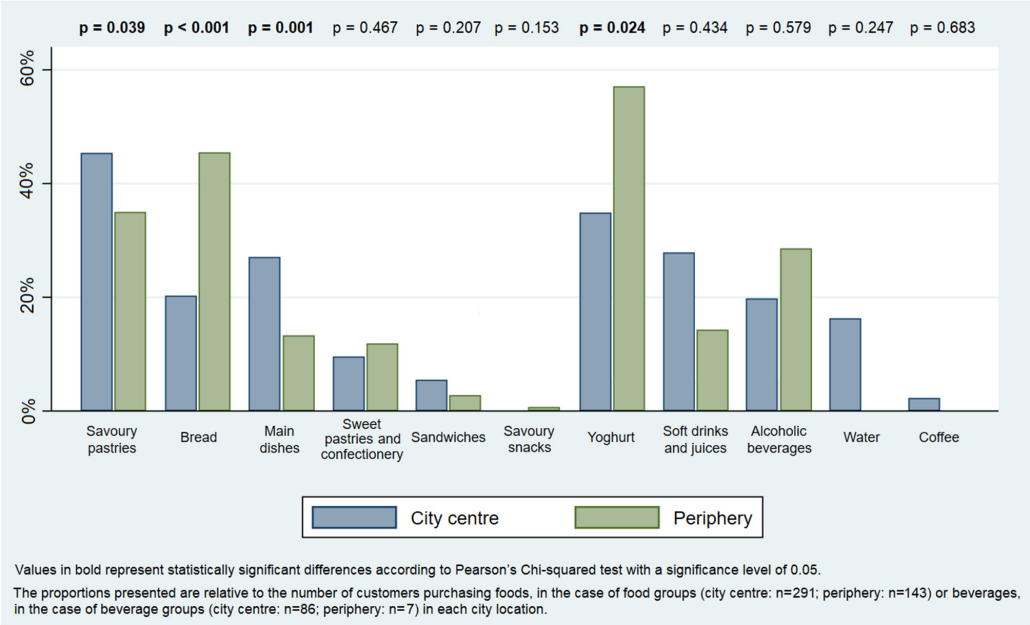
Figure 5. Distribution of the takeaway food purchases throughout the day: (**a**) foods (n = 434) and (**b**) beverages (n = 93).

Taking into account city location, among street food customers, the purchase of sandwiches was mostly observed in the peripheries (Figure 6a). In takeaway venues, the purchase of savoury pastries and main dishes was significantly more frequent in city centres, while bread was most commonly bought in the peripheries. Beverages were mostly bought in city centres, especially soft drinks and industrial juices, whereas the proportion of customers buying yoghurt was significantly higher in the peripheries (Figure 6b).



(**a**)

Figure 6. *Cont.*



(**b**)

Figure 6. Distribution of (**a**) street food purchases and (**b**) takeaway food purchases, by city location.

No statistically significant differences were found in the purchases made throughout the day and by city location, considering gender, age or weight status of the customers.

4. Discussion

Street food and takeaway food purchase in these two cities of Bosnia and Herzegovina was frequent, and included both homemade and industrially-produced food options. Customer influx and buying rates were higher in the city centres for takeaway food establishments, and in the periphery in the case of street food sites. The specific purchasing patterns found may reflect street food and takeaway food buying habits, which should be discussed in the context of the cultural and dietary specificities of these environments.

When compared to street food venues, takeaway food vending sites showed higher customer influx, food items buying rate and number of food items purchased per customer, indicating higher customers demand and a faster business activity. This is in line with the higher number of employees operating in takeaway establishments compared to street food vending sites (average number of employees: 6.1 vs. 3.2, unpublished data), which allowed for a faster service. Takeaway food activity was particularly faster in the city centres, whereas in street food vending sites, customer influx and purchasing rates tended to be higher in the periphery. This difference does not seem to be related to the geographical distribution of street food and takeaway vending sites, which was similar in both sub-regions [9,10], suggesting a higher demand for street food in the outskirts and for takeaway food in the centres of these cities. Considering the historical importance of street food in Eastern Europe [25], we hypothesize that, in cities from this region, buying in street food vending sites may still be a more culturally rooted habit, especially in the least modernized sub-areas, which could partly explain the higher demand for street food vending sites in peri-urban areas. On the other hand, takeaway food is a more recent phenomenon, which emerged with the growth and development of urban centres [16,26], where the concentration of people working in a variety of companies (e.g., industry, services) has been rapidly increasing. These consumers with limited time available for their meals may account for the greater demand for fast and home-like food options, which takeaway food vending sites can provide. The type of food items purchased also differed according to the type of vending site: in street food venues, customers purchased most frequently sweet pastries and confectionery, bread and savoury snacks, mostly industrially-produced, whereas in

takeaway food establishments purchases were more directed towards homemade savoury pastries, bread and main dishes. This can be in part related to the physical setups encountered in these two venues. It was observed that takeaway food vending sites were more formal establishments, with better access to clean water and equipment that allows for the preparation and cooking of foods. On the contrary, street food venues were mostly small street-located kiosks also selling non-food products, such as newspapers and magazines, and were therefore less able to sell homemade products [9,10]. As a consequence of those differences, and as our results suggest, customers seem to turn to each of these types of vending sites under different circumstances. Whereas street foods seem to be more frequently bought in the context of a small snack, takeaway food may be more commonly consumed in the context of a more fulfilling home-like meal.

In street food venues, the purchase of foods, as well as the joint purchase of foods and beverages, reached their maximum values around lunchtime. These results were similar to those found in cities from Central Asia [27]. In contrast, beverages, mainly water and soft drinks/juices, were mostly acquired during the morning period. The purchase of industrial food products prevailed throughout the whole day in both the city centres and their outskirts, unlike cities from Central Asia where the most consumed street foods were homemade [28]. These findings suggest that the consumption of westernized foods and beverages may be a very common habit amongst Bosnian street food customers, in line with the growing availability and purchase of ultra-processed foods that has been observed in the region. In Central and Eastern Europe, sales of ultra-processed foods and drinks have been continuously increasing during the last two decades, reaching in 2019 values of 64 kg/capita and 77 L/capita, respectively [29,30]. This growth has been occurring as a consequence of the industrialization of food systems, technological development and globalization, especially in highly-populated and urbanizing middle-income countries [30], such as Bosnia and Herzegovina. On the other hand, the increasing customer demand for these types of foods may also have played a role in the development of food industries in the country, highlighting the importance of purchasing behaviours as modulators of food offer. This is one example of the complex two-way nature of the interactions among consumers, food environments and the whole food system [13,14]. This widespread consumption of ultra-processed food products is particularly concerning since it has been associated with several adverse health outcomes, including overweight, obesity, increased cardio-metabolic risk, cancer, type II diabetes, cardiovascular diseases, irritable bowel syndrome, depression, frailty conditions and all-cause mortality [31,32]. Sweet pastries and confectionery were the most frequently purchased street foods, which is in line with their high popularity among Bosnians [33,34]. These foods are not commonly consumed as a dessert in this country, but rather as snacks during the day or, in the case of sweet pastries, at main meals such as breakfast [33,35]. This is in line with our study, in which 40% of the sweet pastries purchased in street food venues were bought during the first hour of the day. Confectionery was mainly purchased during the afternoon period, similarly to other industrially produced items, such as savoury snacks, soft drinks and juices, indicating that these foods and beverages may be usually consumed by street food customers as afternoon snacks. Similar results were found in central Asian cities, where these food options were mostly bought as snacks in the mid-morning and/or mid-afternoon periods [27].

The purchase of homemade foods by street food customers was only observed during the first half of the day. This might be explained by the fact that most homemade foods sold in the context of street food were either prepared by vendors in their own homes or bought from another establishment [9,10], presumably at the beginning of each day. Between 12 a.m. and 1 p.m., almost half of the customers purchased homemade foods, mostly savoury pastries, such as “sirnica” (phyllo dough baked pie, filled with cheese) and “burek” (baked pie, filled with meat, usually beef), as well as bread, suggesting that these foods may be frequently consumed by street food customers at lunch. Although both bread and savoury pastries may usually be consumed at any time of the day, these foods are very commonly present in the context of a breakfast or lunch [33], which is in line

with our results. Main dishes were mostly bought between 10 a.m. and 12 a.m., and 71.4% of these purchases corresponded to pizza, further suggesting the westernization of food habits among these customers.

In takeaway venues, the purchase of homemade cooked foods prevailed at all hours of the day, and in both city sub-regions, which is consistent with what was observed in central Asian street food environments [27], although contrasting with findings from similar settings in Mozambique and Moldova [36,37]. Drinks, mostly industrial, were rarely purchased alone, being mostly acquired together with foods. The joint purchase of foods and beverages was observed in approximately one in every six takeaway food customers, it being the highest between 12 a.m. and 1 p.m., and in city centres. Most of these meals were constituted by a savoury pastry, most frequently "burek" or "krompiruša" (meat or potato pie), or a main dish (mostly "ćevapi"), with a soft drink, a juice or a yoghurt, which is in line with what is usually consumed by locals outside the home at lunch. One of the most frequently consumed out-of-home foods is "ćevapi" (finger-sized barbecue-grilled ground meat, usually served with chopped onions in a split "lepinja", a Bosnian yeast flat bread), as well as traditional pies with a range of savoury fillings [33,34]. Traditionally, yoghurt is another very important part of the Bosnian meals, especially in urban areas [33]. In addition to the lunchtime period, main dishes and savoury pastries were also most frequently purchased in the early morning, suggesting that these foods may also be habitually consumed by takeaway food customers in the context of a breakfast. As observed *in loco*, the Bosnian breakfast seems to usually be very fulfilling, it being common to find foods such as savoury or sweet pastries, or even main dishes, in this meal [35]. Our results indicate that traditional foods remain common options for these urban dwellers, suggesting that local gastronomic identity continues to be preserved in these food environments. However, high levels of trans-fat and sodium were found in the homemade foods sold in these urban environments, particularly savoury pastries and barbecue dishes [9,10]. Furthermore, industrially produced beverages, such as soft drinks and juices, were also very frequently bought, especially in the city centres, which may be a reflection of the nutrition transition that is taking place in the region [1].

Sandwiches were among the least frequently bought foods in both street food and takeaway food venues, despite being one of the most frequently available foods in both cities [9,10]. The same was found in central Asian street food customers [27]. The preparation of these type of foods at home by urban dwellers may be easier and quicker when compared to other street-vended options, which may partly explain the lower demand. The purchase of ready-to-eat fruit was also not observed in our sample, which can be explained by the low availability found (in Sarajevo and Banja Luka, 1.3% and 0.0% of all eligible vending sites sold ready-to-eat fruit, respectively) [9,10]. Vegetables were also rarely present in the products sold. Similar results were found in Central Asian cities [28], and reinforce concerns about the low consumption of fruits and vegetables in former Soviet Union countries [38]. The implementation of strategies focusing on the increasing availability and accessibility of these nutrient-dense foods has the potential to improve their consumption, that way leading to a healthier food environment, as documented in other settings [38,39].

Strenghts and Limitations

Some strengths and limitations of the present study should be discussed. The observation efforts were distributed across all days of the week, which was an advantage for this work, since it allowed us to ensure that the variability over the week was covered when analysing purchase distributions throughout the day and by city location. One limitation was the fact that we assessed purchases, which may not correspond directly to consumption. However, foods or beverages which were not ready-to-eat were excluded from this study, in order to eliminate purchases intended for household consumption. Furthermore, all food items were acquired in single portions and mostly unpackaged or individually packaged, indicating that they should be mostly bought to consume immediately or shortly

after. As such, these results are expected to provide an overview of the street food and takeaway food buying habits in these cities, which should indirectly reflect consumption habits. By identifying where and when specific patterns occur, we go deeper into the understanding of these customers' practices and preferences, that way defining targets for action not only in terms of the meal context and city location, but also considering the type of vending site. Data collection was performed during summer months; as such, interpretation of these results should take into consideration the seasonality of these food environments. The implementation of a continuous monitoring system would contribute to overcome this limitation [40]. Direct observation of customers by trained researchers, instead of face-to-face interviews, was one of the strengths of the present work, because it allowed us to minimize interference with the vendors and their customers, which could lead to behavioural modifications and social approval bias [41]. Another strength that should be underlined was the high level of agreement between observers, which was a reflection of extensive training and constant supervision of the field researchers, leading to high quality observational data. Finally, the FEEDCities project is based on a standardized methodology [17], which allows for data comparability among different cities, countries or regions; however, due to local cultural specificities, the generalizability of our results is limited.

5. Conclusions

Purchases of street food and takeaway food in the two major urban areas of Bosnia and Herzegovina varied across time and space, reflecting specific patterns of purchase. Takeaway venues showed higher customer influx and buying rates in the city centres, whereas street food vending sites presented higher demand in the outskirts; and both types of establishments were busiest around lunchtime. Among street food customers, the purchase of industrial foods and beverages prevailed in both city centre and periphery, and throughout the day, whereas takeaway food customers purchased mostly homemade foods and industrial beverages. The patterns of street food and takeaway food purchase described in the present study contribute to better comprehend the buying habits of these customers. Further research focusing on the determinants of food choice by these consumers could give us additional insights on some of the patterns observed. This information can be useful in the development of public health policies more suitable to the cultural and dietary habits of the individuals who interact with these food environments. Such interventions (namely the improvement of food availability, educational strategies, nudging techniques, among others) could benefit from these insights as a reflection of customers' behaviours, preferences and demands.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/ijerph19159086/s1, Figure S1. Examples of (a) a street food vending site, and (b) a takeaway food vending site. Figure S2. Customer influx, food items buying rate and number of food items purchased per customer, in (a) street food and (b) takeaway food vending sites, throughout the day.

Author Contributions: M.G., A.D., P.M., J.B., N.L. and P.P. designed the study. G.A., I.L.d.M., M.G., A.F.-H. and D.S. supervised the study implementation and data collection. S.S., N.L. and P.P. performed the analysis and interpretation of the results. S.S. drafted the first version of the manuscript. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Ethics Committee of the Institute of Public Health of the University of Porto (CE16058), as well as by local authorities in each country.

Informed Consent Statement: Informed consent was obtained from all vendors involved in the study.

Data Availability Statement: The data presented in this study are available upon request to the corresponding author.

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Conflicts of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. J.B. is a staff member of the World Health Organization. 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 World Health Organization.

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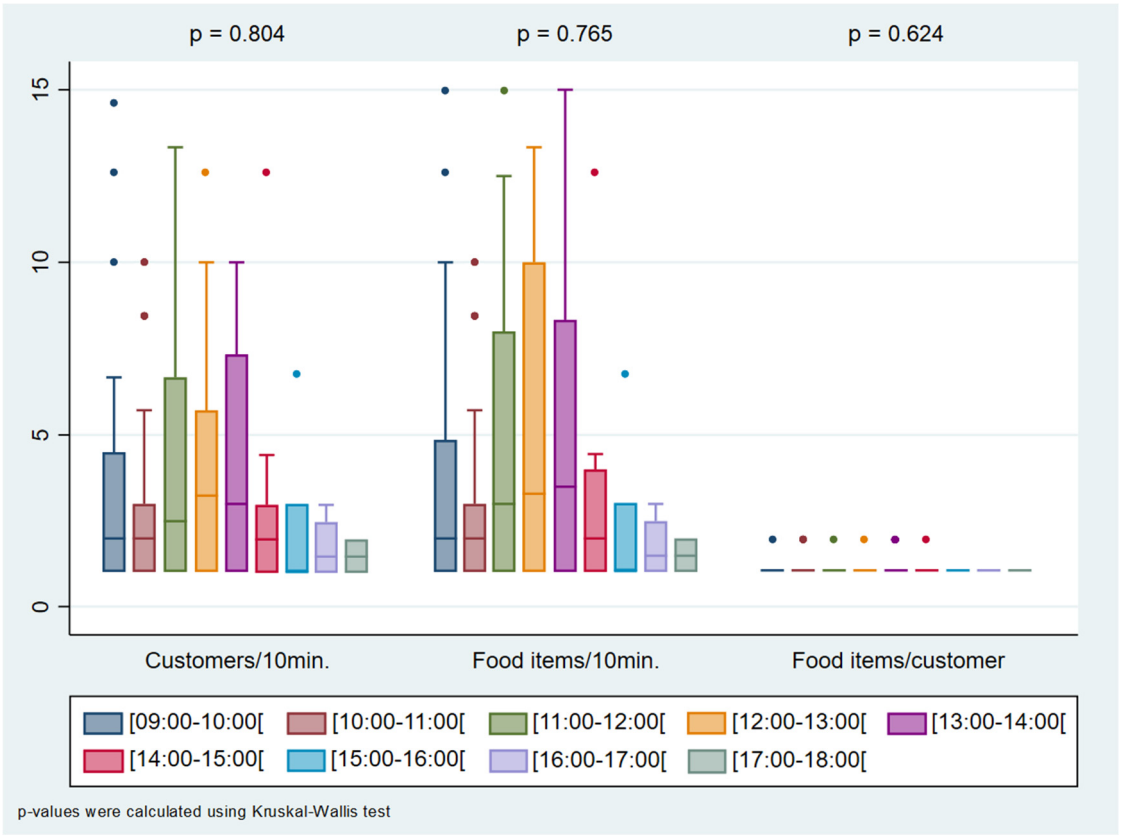
Supplementary Material

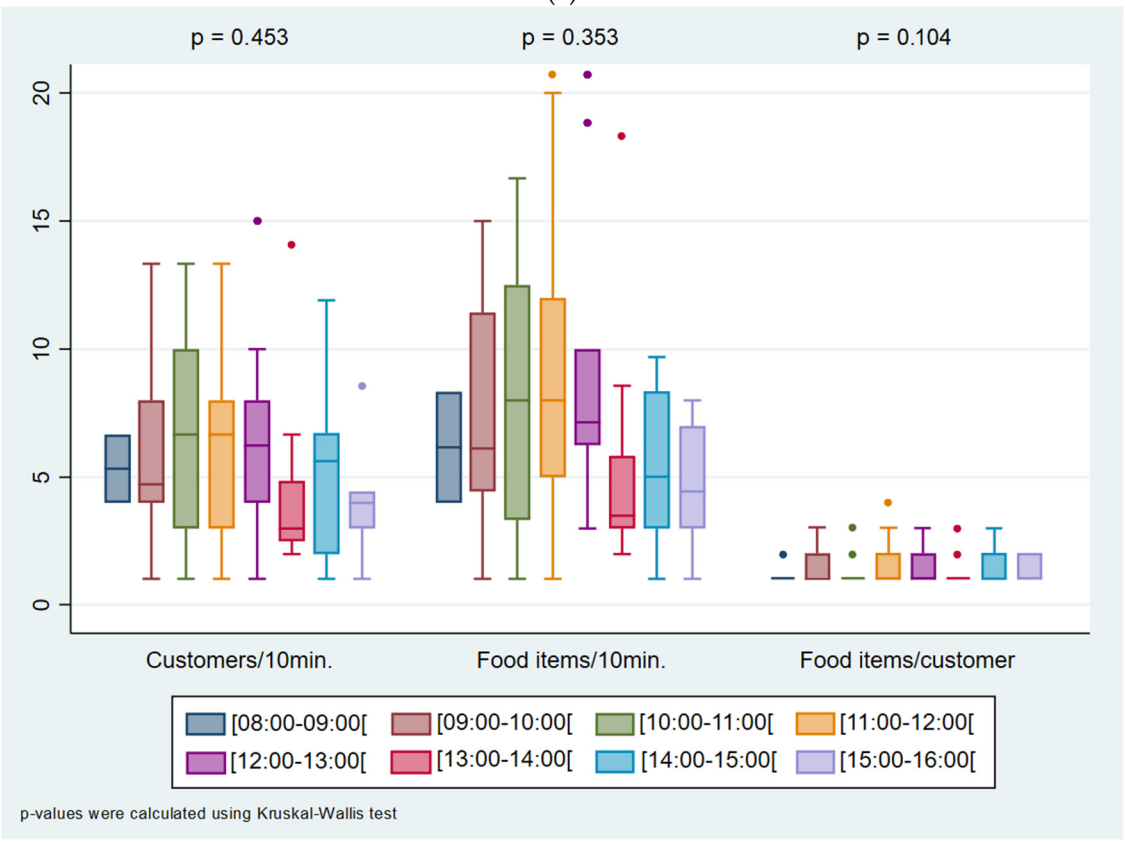
(**a**)

(**b**)

Figure S1. Examples of (**a**) a street food vending site, and (**b**) a takeaway food vending site.



(**a**)



(**b**)

Figure S2. Customer influx, food items buying rate and number of food items purchased per customer, in (**a**) street food and (**b**) takeaway food vending sites, throughout the day.

5. Discussion and Final Conclusions

The results emerging from this thesis suggest that the westernization of dietary habits currently taking place in Central Asia and Eastern Europe[16, 17, 19, 20] are reflected in the food choices made at street level. General findings point to common features amongst the cities assessed, supporting the need to monitor these exposures, as well as their health impact on these urban populations. Along with this, more specific patterns were found in each setting, further justifying the definition of interventions customized to the specificities of each food environment, with the ultimate goal of tackling the identified dietary risk factors for the development of NCDs.

In all the settings studied, a frequent purchase of ultra-processed industrial food products was observed, simultaneously with the acquisition of more traditional homemade foods and beverages. Among the homemade food options available, the most commonly purchased were, in general, savoury pastries, main dishes, breads and sweet pastries. On the other hand, the most popular industrially-produced foods consisted mostly of savoury snacks, confectionery and industrial bread. Fruit was rarely purchased. Soft drinks and juices, as well as tea, coffee and water, were amongst the most commonly bought beverages, although fermented traditional beverages (both alcoholic and non-alcoholic) were also popular choices in some cities, especially in *Bishkek* (Kyrgyzstan) and *Chișinău* (Moldova). These results reflect the diversity in food offer, very characteristic of previously studied street food environments[68, 70, 81, 82], as well as the coexistence of both local and westernized foods and beverages for sale, which was one of the most evident features of the urban foodscapes assessed in both regions[121-127].

Acquisition of industrial food products was particularly high in cities from Moldova, Bosnia and Herzegovina and Kazakhstan, where it almost reached, or in some cases surpassed half of the evaluated customers, contrasting with cities from Tajikistan and Kyrgyzstan, where these frequencies were closer to one-quarter. This reflects the higher availability of industrially-produced foods and beverages found in the former cities[123, 125-127], which may be related to their higher levels of economic, industrial and urban development[135, 136]. In fact, food availability has been well-described as one of the most important determinants for food consumption[43-48, 50]. As such, the widespread access to ultra-processed food products found in these street food environments is expected to have direct influence on their high purchase, which in turn can bring negative consequences to the health of these urban dwellers.

In terms of nutritional value, purchases were generally energy-dense, with a greater contribution from carbohydrates, followed by fat and protein, similarly to what was found in other street food settings[82, 95, 137-139]. Although cities from Bosnia and Herzegovina were an exception in terms of nutritional value estimation (since energy, carbohydrates and protein contents were not estimated), the relatively high fat content found in the foods analysed in these urban areas makes us hypothesize that these purchases should likewise have a high energy density. Furthermore, carbohydrates contribution was presumably high, due to the type of foods most frequently purchased (including savoury pastries, mostly pies and puff pastries, breads, confectionery, such as chocolate, ice-cream and other candies, as well as soft drinks and juices), suggesting that the purchases made in these Bosnian settings might follow a macronutrient profile tendentially similar to the other cities assessed. In all settings studied, our results showed a lipid profile characterized by the predominance of saturated fats over unsaturated ones, as well as high TFA contents. The highest amounts of SFA were found in cities from Turkmenistan and Bosnia and Herzegovina, where one purchase corresponded to approximately 40% of SFA maximum daily intake recommendation[140], whereas TFA values were especially high in *Almaty* (Kazakhstan) and *Chișinău* (Moldova), frequently surpassing the limit of 2 g/100 g of total fat, recently legislated in some countries in the WHO European Region[63]. Another common feature was the high amounts of sodium found, which together with the low potassium, resulted in values of sodium-to-potassium ratio way above the recommendation of one[60, 141]. This was particularly worrisome in cities from Tajikistan, Kyrgyzstan and Bosnia and Herzegovina, where purchases exceeded by more than five times the recommended ratio. The nutritional characteristics found were in general expected taking into account previous literature, both on the macronutrient profile and on the high contents of saturated fat, *trans*-fat and salt in street-vended foods[82, 95, 128-130, 137-139, 142]. Also, the unfavourable nutritional profile observed in the street food purchases seem to be in line with the epidemiological trajectories documented in these regions, specifically with regard to the growth of diet-related NCDs burden[29, 31-34], and confirm the need for policies aiming at their improvement.

Purchases containing at least one industrial food item tended to have a worse lipid profile, with higher amounts of SFA and TFA, and lower contents of unsaturated fats than those comprising exclusively homemade food items. On the other hand, the homemade food items

purchased tended to present higher sodium to potassium ratios when compared to industrial ones. These results highlight priorities of action, both in terms of the enhancement of the fat quality via reformulation of products by the food industry, and also targeting the reduction of salt and other sodium-rich ingredients used in homemade preparations, near the vendors and/or small manufacturers supplying these vending sites. The high variability of nutritional composition found in equivalent food products sold at different vending sites, which was found especially in homemade foods[123, 124, 128-130, 142], shows that the improvement of their nutritional profile could be feasible, through simple changes in the formulation of the recipes used. Increasing the offer of ready-to-eat fruits and vegetables (which was found to be very limited in all the street food environments assessed) would also be an essential step towards the improvement of potassium-rich foods available for consumption, as successfully implemented in other urban settings[143, 144]. Encouraging the inclusion of more vegetables in the culinary preparations to be sold in the streets, while maintaining their gastronomic identity, could also help to improve sodium to potassium balance of the street food meals consumed in these settings. In fact, many traditional recipes have vegetables and legumes as ingredients, and thus their consumption should be promoted. It was also very interesting to find that men and overweight/obese customers tended to present purchases with a less favourable nutritional profile, generally containing higher contents of energy, SFA, TFA and/or sodium, when compared to their female and under- or normal-weighted counterparts. Differences regarding sex were mostly observed in the contents per purchase, and thus may be in part explained by the quantities bought, which were found to be tendentially higher for men. Differences regarding weight status were expected, since subjects with less healthy food choices should be more likely to present excess weight[145, 146]. Based on these findings we may hypothesize that interventions targeting the improvement of food choices at street level would be particularly relevant to these specific groups of consumers.

Regarding the spatial and temporal distributions of the purchases, higher customer influx and buying rates around lunchtime and in the city centres over the outskirts, was another common feature amongst the cities studied. This was expected, considering the already described essential role of the street food in the replacement of home-cooked meals (especially lunch) for people who work in urban centres, without the possibility of having those at home[68, 70]. The types of foods and beverages bought at each time of the day were generally consistent with

the documented eating habits in these settings[147-149], indicating that the purchase patterns found seem to reflect the local food culture, while also providing specific insights on the buying habits in this context. In general, tea and coffee were mostly purchased in the early morning, while bread, savoury pastries and main dishes were most commonly bought in the morning or during lunchtime. Purchase of industrial foods and beverages was generally more frequent in the city centres, mostly in the mid-morning and mid-afternoon periods. This indicates that in urban centres customers may have a higher preference for these industrially-produced items, mostly in the context of a morning or afternoon snack. Unlike the cities from Central Asia, where traditional street food vending sites seem to dominate urban foodscapes[121-124], in Bosnia and Herzegovina, it was takeaway food vending sites that showed the highest rates of customer influx and food items purchase, especially in the city centres. This suggests that in these urban centres, a shift towards a greater preference for takeaway service, as a more formal and modern type of street food, might be occurring. This was observed specially around lunch, which should be related to the high availability, in this type of establishment, of some homemade food options, namely savoury pastries and main dishes[125, 126], which were commonly consumed during this meal. Exceptionally, in *Chișinău* (Moldova) it was not possible to assess temporal and spatial patterns of purchase, due to the lower number of vending sites and customers evaluated, together with the lower diversity in terms of geographical distribution of those vending sites, as only the main market, located at the city centre, was evaluated.

Another important aspect that may have been interfering with the observed customers' food choices is the cost, which has been widely described as one of the major factors influencing individual food intake[43-46, 48], and could be particularly determinant in low-income populations[150, 151]. Recently, a work in the context of the FEEDcities project explored the price of homemade street foods in Eastern Europe and Central Asia, as well as its relationship with their nutritional content[152]. Homemade street foods were found to be cheap (median: 1.00 USD/serving, 0.85 USD/100 g and 0.33 USD/100 kcal), in line with previous observations[68-70, 72, 81]. The highest prices per calorie were found in some vegetable- or meat-based traditional dishes and sandwiches, as well as in boiled corn. These nutrient-dense foods were more expensive when compared with, for example, savoury pastries, snacks, buns, cakes and cookies. This may in part explain the very frequent purchase of these energy-dense,

carbohydrates-rich foods, which were found to be low-cost food options (below 1.00 USD/serving). In line with this, carbohydrates content was negatively associated with food price, both per 100 g and per 100 kcal, further justifying the high carbohydrates contents of the purchases assessed. On the other hand, local traditional dishes were generally cheaper than westernized food options, which advocates the need to improve their nutritional quality, while preserving gastronomic identity, as well as promoting these foods as economic and fulfilling options. Homemade bread, which was the cheapest food group regardless of the metric, should also be promoted as a healthy and affordable street-vended food option, in order to increase its consumption over more popular and less healthy food choices, such as cakes or cookies.

The results obtained in the context of this work showed some concerning issues in terms of the nutritional profile of the purchases made by street food customers. Nevertheless, the consumer's perception on the healthiness of a certain food purchase may not always correspond to its actual nutritional composition. In fact, in some street food environments assessed (namely in Tajikistan and Kazakhstan), some food options that could normally be considered as healthy, such as soup or some traditional homemade dishes containing vegetables, were identified as rich sources of SFA, TFA and/or sodium[122, 123, 130]. This raises questions not only about the level of knowledge and awareness regarding the nutritional composition of street food by its consumers, but also about the knowledge and practices adopted by the vendors. In accordance with a report by the FAO, street foods may be a source of nutritionally balanced meals outside the home, provided that the consumers are well informed to be able to choose the proper combination of foods[153]. The FAO also defends that street foods may provide important nutrients for daily requirements, as long as appropriate ingredients and methods of preparation and cooking are observed[68]. These two conditions imply the existence of a sufficient level of nutrition literacy on the part of both consumers and vendors, which may be central in the improvement of their practices, and consequently in the provision and consumption of street foods with more favourable nutritional profiles. Also, the enhancement of nutrition literacy has the potential for increasing consumers' demand for healthier foods, which could motivate an upsurge in the production and availability of these options. However, the few existing studies conducted in LMIC on the educational level and nutrition knowledge of street food vendors or consumers have found very low scores[82, 91, 92].

Research on nutrition literacy in the context of street food in the regions of Central Asia and Eastern Europe is lacking, and would be an important step in the identification of future intervention needs towards healthier street food environments.

Despite the great progress that has been achieved in this area of knowledge, the potential for supporting the design and monitoring the impact of interventions and policies may be enhanced through a more in-depth characterization of these street food environments. In this regard, some research topics deserve further attention in the context of future works. The assessment of the prevalence and frequency of street food consumption in the general population, as well as the main factors influencing the consumers' food choices, as conducted in other food environments[72, 81, 83, 87, 143, 154], may be important to understand how to intervene in order to improve street food purchases and to foresee the potential impact of such strategies. To evaluate the ingredients and cooking techniques used by the vendors, such as the use of unhealthy fats[97] or sodium-rich ingredients[98], as well as the main determinants for choosing those practices, would also be an essential step for creating evidence that supports the improvement of the nutritional value of homemade foods.

The innovative nature of the data presented in this thesis should be highlighted. Some nutritional parameters evaluated in this research, namely fatty acids distribution and sodium-to-potassium ratio, which constitute key elements for the development of diet-related NCDs, so far have been seldom explored by previous studies on street food[69]. Furthermore, data collection using direct observation of customers was a pioneer method that allowed us to minimize interference with the subjects' usual behaviour. However, this type of assessment still lacks validation in these populations, whose implementation was not possible until now due to logistical constrains. Recently, a validation study of visual estimation of age and weight status (including height, weight and BMI) in adults has been performed in Portugal. According to this study, trained observers were able to estimate age categories and to identify overweight/obese participants with high sensitivity and specificity[155]. In our sample, a high level of agreement between observers was achieved, indicating high reproducibility of these observational data. In the specific case of weight status evaluation, although body measurement is the established gold standard, this method would probably be considered very invasive by most individuals due to religious and/or cultural norms, in addition to requiring a greater amount of human and material resources, making it less feasible in these

regions. Anthropometric self-reported data have also been frequently collected in large epidemiological studies. However, previous evidence has shown that subjects tend to underestimate their weight and overestimate their height, resulting in very low accuracy of the collected data[156, 157]. As such, future methodological research should consider the validation of the estimation of both anthropometric and demographic characteristics through direct observation by trained researchers in the assessed regions, as this would constitute a more practical and culture-friendly method to collect accurate observational data, particularly useful in settings with limited funds.

There are a number of research challenges in LMIC (and particularly in the regions studied) with relevant implications for the study of food environments and their interlinked actors. Although food environment research on LMIC is gaining prominence, a recent systematic scoping review identified that the paucity of evidence from high-quality studies is still an important limitation[158]. Other major challenges include the existence of informal food vendors which are more difficult to document, the high spatial and temporal variability of food availability in some settings, as well as constrains in terms of time and resources[51]. Scientific production from countires of the former Soviet Union, including health and medical research, seems to be underrepresented in the international literature, being mostly published in local periodicals, which are typically written in Russian or other local languages and not indexed in major scientific databases (e.g. *PubMed*®, *Scopus*®, *Web of Science*®). The number of international publications in the region were positively associated with Gross Domestic Product, indicating that these countries' economic status are important factors affecting publication productivity and quality[159]. Insufficient funding, lack of dedicated research centres and international peer-reviewed journals, and limited research training and practice have also been pointed out as major determinants[160, 161]. Specifically regarding the field of Nutrition, a generalized lack of data from recent dietary surveys was also identified in the region[66], as previously reported. The described handicaps vindicate a critical need for enhanced investment, improved study designs and standardized methodologies. The information generated in the context of this project should contribute to fulfill part of the existent health- and nutrition-related research gap, by providing data on out-of-home food consumption from a perspective of the nutritional quality of consumers' food choices in the street context. Because it is based on a systematic and standardized methodology, this investigation has the

potential to be expanded to other cities in the region, or even to other regions, by adapting the research procedures to the specificities of each food environment. Thus, it is expected that this project can set precedents for the advancement of new research efforts in other urban centres of LMIC, not only on the characterization of their food environments but also on other nutrition-related NCDs indicators.

Traditional food markets have great potential to provide safe, nutritious, affordable and culturally appropriate food, if suitable measures take place. Their central role in some populations' dietary intake[69] should be seen as an opportunity to promote health and prevent disease, by building healthier and more sustainable foodscapes particularly in less wealthy regions. The recent COVID-19 pandemic uncovered specific liabilities of traditional food markets, introducing new challenges to the promotion of safe and healthy food in these environments. Furthermore, the social and economic crisis caused by the pandemic may have also aggravated some food security issues experienced by already vulnerable groups[162-164]. Taking into account these insights, as well as the evidence gathered with the FEEDcities project, a guidance document for the establishment of safe and healthy traditional food markets in the WHO European region was developed (**Annex 2**), resulting from the work of a multidisciplinary team composed of experts in the areas of both nutrition and food safety. This guide proposes a stepwise framework for the implementation of safe and healthy traditional food market initiatives, comprising the identification of needs and priorities for action, the definition of interventions to be implemented, the development of an action plan, and the implementation, monitoring and evaluation of such initiatives. This document is targeted at all stakeholders involved, including policy-makers, market management authorities, local public health institutions and market workers, with the ultimate goal of providing access to foods that are in accordance with both food safety and nutrition guidelines. Consumer-centered actions are recommended throughout the report, highlighting their central role in the achievement of healthier food markets. Such actions include: empowering consumers to make healthier choices through health and nutrition education campaigns; nudging consumers to purchase foods with higher nutritional quality, by means of marketing techniques and healthy food messaging (e.g. "healthy food" seal marking food products that meet certain predefined criteria, such as the use of healthier ingredients or safe food handling practices); providing consumers with complete, unbiased and understandable information, for example by

improving nutrition data on both packaged and unpackaged foods (e.g. labels, flyers); ensuring adaptation to ever-changing consumer demands, to allow for maintenance of health- and nutrition-related market standards; promoting participation of the consumer as a valuable task force member for the implementation, monitoring and evaluation of all interventions; and stimulating frequent and transparent communication between the consumers and all market's stakeholders.

Street food assumes a high importance for LMIC in Central Asia and Eastern Europe, not only on a dietary level, but also on an economic, gastronomic and sociocultural level. The current conjecture of unprecedented challenges for local, regional and global food systems should open a window of action to shape urban food environments as promoters of healthy eating choices, ultimately leading to better health for all.

The main conclusions of this thesis are the following:

- The street food purchases made in cities from Central Asia and Eastern Europe were characterized by the coexistence of both local and globalized food options, suggesting westernization of dietary habits.
- Homemade savoury pastries, main dishes and sweet pastries, industrial savoury snacks and confectionery, as well as bread (both homemade and industrial), soft drinks, juices, tea, coffee and water were amongst the foods and beverages most commonly purchased, while fruit was rarely bought.
- The purchase of ultra-processed, industrially-produced foods and beverages (e.g. chips, confectionery, soft drinks) was frequent in all cities studied, being especially high in the most economically developed and urbanized settings.
- In general, purchases were energy-dense and rich in carbohydrate, total fat, SFA, TFA and sodium, and poor in potassium.
- The contents of SFA of the observed purchases were particularly high in the cities from Turkmenistan and Bosnia and Herzegovina, TFA values were highest in the cities from Kazakhstan and Moldova, and sodium-to-potassium ratios were higher in the cities from Tajikistan, Kyrgyzstan and Bosnia and Herzegovina, indicating specific priorities of action for each food environment.

- Purchases which included industrial food items showed higher contents of SFA and TFA, and lower amounts of MUFA and PUFA, while the homemade foods bought presented tendentially higher sodium to potassium ratios.
- Men and overweight or obese customers tended to present purchases with a worse nutritional profile than female and under- or normal-weighted buyers.
- In all the cities studied, the highest customer influx and food items buying rates were found around lunchtime and in the city centres.
- Savoury pastries, main dishes and bread were more frequently bought in the morning or during lunchtime, whereas tea and coffee were mostly purchased in the early morning.
- In general, purchase of industrial foods and beverages was higher in the city centres over the outskirts, and occurred mostly as mid-morning and mid-afternoon snacks.
- In cities from Bosnia and Herzegovina, takeaway food vending sites presented higher rates of customer influx and purchase when compared to street food establishments, indicating a higher consumer's demand for takeaway service over street food in the classic sense.

The findings arising from this thesis should be accounted for in the context of future research and policymaking, in order to improve the nutritional quality of the foods purchased at street level, not only by increasing availability, affordability and desirability of healthier street food options, but also by providing consumers with the tools necessary to make healthier food choices.

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7. ANNEXES

ANNEX 1

Lunet N., Gelormini M., Jewell J., Morais I., Albuquerque G., Sousa S., Damasceno A., Casal S., Pinho O., Moreira P., Breda J., Padrão P.

FEEDcities Project: A Comprehensive Characterization of the Street Food Environment in Cities. Project protocol

Copenhagen Ø, Denmark: World Health Organization Regional Office for Europe, 2019.

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FEEDcities project

A comprehensive characterization of the street food environment in cities

Project protocol
2019

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Project protocol
2019

Abstract

Introduction Ready-to-eat food sold in the street represents a global phenomenon, more common in urbanized areas, that constitutes an important dietary source in populations from low- and middle-income countries. However, research on the kind of street food offered and its composition is scarce. The main objective of this study is to characterize the urban street food environment, including vending places, the food offered, its nutritional composition, food purchasing patterns and advertising.

Methods and analysis This protocol provides a framework for a stepwise, standardized characterization of the street food environment; it consists of three steps that are of increasing complexity and demand increasingly great human and technical resources. Step 1 comprises identification of street food vending sites and characterization of the products available; this stage may be complemented with an evaluation of food advertising in the streets. Step 2 comprises description of street food purchasing patterns, by direct observation. Step 3 requires collection of food samples for bromatological analysis. Different levels of data collection may be defined for each step; hereafter, these are presented as core and expanded evaluations. For the most part, data analysis involves descriptive statistics and basic spatial analysis.

Ethics and dissemination This study was approved by the Ethics Committee of the Institute of Public Health of the University of Porto, Portugal. The research presents no risk to vendors or consumers, who will not be identified or identifiable through the information collected. Vendors will be kept informed and are free to refuse to collaborate. The findings of the study will be published on the World Health Organization (WHO) website as country reports, submitted for publication in international peer-reviewed journals, and presented at scientific meetings.

Keywords

STREET FOOD
READY-TO-EAT FOOD
COMMERCE
MARKETING
NUTRITIONAL COMPOSITION

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Contents

Authors and contributors vi

Abbreviations vii

1. Introduction 1

2. Methods and analysis 2

STEP 1 – Street food environment 2
STEP 2 – Characterization of street food purchasing patterns 10
STEP 3 – Street food collection and bromatological analysis 10
Data analysis and sample size 11

3. Ethics and dissemination 12

4. References 14

Annex 1. Study description 16

Annex 2. Model questionnaire 17

Annex 3. Project sticker 22

Tables

Table 1. Examples of eligible and ineligible vending sites selling products compatible with the FAO/WHO definition of street food 3

Figures

Fig. 1. Examples of eligible vending sites 3
Fig. 2. Examples of ineligible vending sites 5
Fig. 3. Decision rules for selection of vending sites 6
Fig. 4. Decision rules for defining procedures for evaluation of vending sites 8

Boxes

Box 1. Selection of street food vending sites in Dushanbe (Tajikistan) 7
Box 2. Selection of street food vending sites in Maputo (Mozambique) 7

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The study was conceived and designed by Marcello Gelormini, Albertino Damasceno, João Breda, Patrícia Padrão and Nuno Lunet. The first version of the manuscript was written by Nuno Lunet, Marcello Gelormini, Jo Jewell and Patrícia Padrão. All authors critically revised the manuscript for relevant intellectual content and approved the final version for submission.

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Competing interests

The authors declare that they have no competing interests.

Ethics approval

Ethics Committee of the Institute of Public Health of the University of Porto (Comissão de Ética do Instituto de Saúde Pública da Universidade do Porto, CE16058).

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Abbreviations

GPS	Global Positioning System
FAO	Food and Agriculture Organization
NCDs	noncommunicable diseases
TFAs	*trans*-fatty acids
WHO	World Health Organization

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1. Introduction

The Food and Agriculture Organization (FAO) and the World Health Organization (WHO) define street foods as "ready-to-eat foods and beverages prepared and/or sold by vendors or hawkers especially in the streets and other similar places" *(1, 2)*. At the global level, street food represents a cultural, social and economic phenomenon that is typical of urbanized areas, where the lifestyle is becoming more sedentary and the time dedicated to cooking at home is dramatically reduced *(3)*. Another important characteristic of street food is that it provides a very accessible and inexpensive dietary source for millions of consumers living in urban areas of low- and middle-income countries all over the world *(4)*.

Urbanization and globalization involve dietary changes such as decreases in the consumption of foods rich in fibre (e.g. pulses, fruits, vegetables, whole grains) and more frequent intake of processed foods. The latter are more likely to be energy-dense and high in trans fatty acids (TFAs), salt and free sugars, which are known to be associated with the occurrence of noncommunicable diseases (NCDs) *(5)*.

There are consistent results showing that industrially produced TFAs have serious adverse effects and contribute significantly to increased risk of cardiovascular diseases *(6)*. WHO advocates a complete elimination of TFAs from the global food supply *(7)*, and several public authorities have started to effectively ban or regulate their use *(8)*. Excessive sodium intake is associated with high blood pressure and an increased risk of cardiovascular diseases *(9)*. WHO recommends no more than 2 g of sodium per day – equivalent to 5 g of salt per day – for the adult population, in order to reduce the burden of NCDs *(10)*, though in most countries where recent data are available, dietary sodium intake is much higher *(11)*. Most of the dietary intake of sodium comes either from addition of salt during preparation and cooking of food or from processed foods. Sugar-sweetened beverages are an important source of free sugars *(12)*, and their consumption, which is promoted by aggressive marketing campaigns from multinational beverage companies, is believed to contribute to the obesity epidemic *(8, 13)*.

Exposure to food and beverage marketing can be considered another important aspect of the nutrition environment *(14, 15)*. It has the potential to shape consumers' preferences and dietary habits, and consequently to drive the supply of specific foods.

Worldwide, dietary changes are likely to be reflected in the urban street food environment. Characterization and monitoring of the street foods that are available and the purchasing patterns related to them, as well as food advertising in the streets, are particularly important in the context of efforts to prevent NCDs. However, research in low- and middle-income countries has focused mostly on issues linked to food safety, and there are very little up-to-date data on food availability, consumption and its nutritional composition that include prepared ready-to-eat foods *(16)*. Specifically, in countries in eastern Europe and central Asia, there is a generalized lack of knowledge about food and dietary habits, although, historically, street trade has always been a well-developed activity in this part of the world.

The primary objective of this study is to characterize the urban street food environment, including vending places, the food they offer, and food advertising in public places. Further aims of the study are to describe the nutritional value of the foods most commonly sold in the streets – in particular, their TFA and sodium content – as determined by bromatological analysis of locally obtained food samples; and to assess the patterns of street food purchasing, by direct observation.

A protocol for evaluating the urban street food environment was initially developed for a survey conducted in Mozambique *(17)*. This protocol was then improved and adjusted for use in other settings namely in central Asia, the Caucasus region and South-east European countries. It was expanded to include methods for characterization of customers of street food vending sites and bromatological analysis of industrially produced foods; and it was adapted to take account of different typologies of street food vending sites and patterns of distribution throughout cities.

2. Methods and analysis

This protocol provides a framework for a stepwise, standardized characterization of the street food environment; it consists of three steps that are of increasing complexity and demand increasingly great human and technical resources. Step 1 comprises identification of street food vending sites and characterization of the products available; this stage may be complemented with an evaluation of street food advertising. Step 2 comprises description of street food purchasing patterns, by direct observation. Step 3 requires collection of food samples for bromatological analysis. Different levels of data collection may be defined for each step; hereafter, these are presented as core and expanded evaluations. The steps to be considered in each survey and the levels of detail to be observed in data collection depend on availability of resources.

Data collection started in 2016, in eastern Europe and central Asia. The first surveys, conducted between May and November 2016, were carried out in Tajikistan (Dushanbe), Kyrgyzstan (Bishkek), the Republic of Moldova (Chisinau) and Turkmenistan (Ashgabat). In 2017, studies were conducted in Bosnia and Herzegovina (Sarajevo and Banja Luka) and Kazakhstan (Almaty, Aktau and Kyzylorda). These surveys demonstrated the feasibility of this kind of comprehensive evaluation; the training of interviewers; and the use of standardized procedures for data collection, including use of apps for electronic data collection, which contributed to a low level of missing data.

STEP 1 – Street food environment

Core evaluation: street food vending sites and food offer

Eligibility criteria

We adopted the definition of street food proposed by the FAO and WHO: "ready-to-eat foods and beverages prepared and/or sold by vendors or hawkers especially in the streets and other similar places" *(18)*. This definition includes products that have been prepared in advance (e.g. sandwiches, salads) or cooked (e.g. boiled eggs, traditional dishes), as well as raw foods (e.g. fruits, nuts) that are sold for immediate consumption, even though these products may sometimes be bought to be consumed later (e.g. at home or at work).

Regarding physical setup, eligible vending sites are those that sell ready-to-eat food, including beverages and/or snacks, from any venue other than a permanent storefront business or an establishment with four permanent walls, operating in a predefined perimeter, that does not sell directly on the street. The definition includes "street hawkers", or mobile vendors, as well as sellers with semi-static or stationary vending units.

Even when the physical setup and the foods offered meet the criteria defined above, vending sites are not eligible if they are oriented to selling products that are essentially for household consumption. It may sometimes be difficult to determine the eligibility of a given vending site, and there is some potential for misclassification, but these criteria should allow a clear distinction between foods that are sold in a context where they are expected to be consumed shortly after purchase (e.g. fruit sold by a mobile vending site) and those that are sold mostly to be consumed at home (e.g. fruit sold in a farmers' market where no prepared or cooked foods are also available). Table 1 gives examples and illustrations of eligible and ineligible vending sites, which are illustrated in Fig. 1 and 2, respectively.

Table 1. Examples of eligible and ineligible vending sites selling products compatible with the FAO/WHO definition of street food

Eligible [Fig. 1, A–J]	**Ineligible** [Fig. 2, A–F]
• Kiosk [1A] • On the ground [1B] • Push cart [1C] • Refrigerator/freezer/cooler [1D] • On-street window from a permanent storefront business or establishment with four permanent walls [1E] • Soft ice-cream vending machine [1F] • Stall [1G] • Stand [1H] • Car boot [1I] • Van, truck, trailer [1J]	• Food stall or cart that is part of a permanent store or licensed establishment [2A] • Vending site exclusively selling fruit and vegetables (unless it sells ready-to-eat fruit and vegetable salads) [2B, C] • Vending site selling raw or processed meat, fish or dairy products (unless it sells other types of ready-to-eat products, such as confectionery, beverages, bread and sandwiches) [2D–F]

Fig. 1. Examples of eligible vending sites

[1A] Kiosk

[1B] On the ground

[1C] Push cart

[1D] Refrigerator/freezer/cooler

[1E] On-street window from a permanent storefront business with four permanent walls

[1F] Soft ice-cream vending machine

Fig. 1. Examples of eligible vending sites *(cont.)*

[1G] Stall

[1H] Stand

[1I] Car boot

[1J] Van, truck, trailer

Fig. 2. Examples of ineligible vending sites

[2A] Food stall or cart that is part of a permanent store or licensed establishment

[2B] Informal vending site exclusively selling fruit and vegetables, without selling other types of ready-to-eat products

[2C] Vending site exclusively selling fruit and vegetables, without selling other types of ready-to-eat products (market hall)

[2D] Informal vending site selling raw meat and fruit, without selling other types of ready-to-eat products

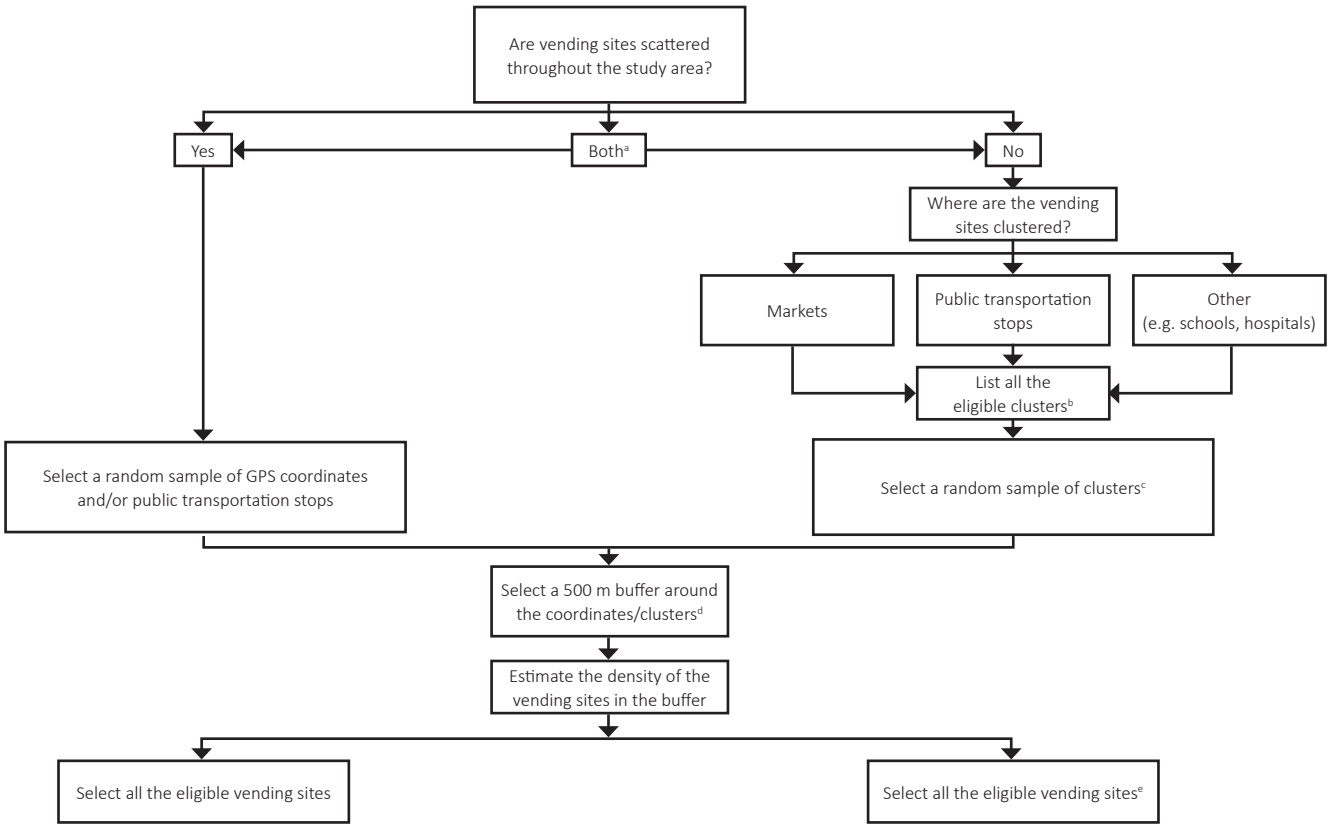
[2E] Vending site selling raw or processed meat, without selling other types of ready-to-eat products

[2F] Vending site selling raw or processed meat, without selling other types of ready-to-eat products

Selection of vending sites

Street food vendors may operate in different locations within a city, either concentrated in places where there is a great flow of people (for instance, around main bus terminals, in enclosed spaces such as bazaars and public markets, in various kinds of commercial area, and in places of entertainment) or scattered across broader areas. Sampling procedures therefore need to be adjusted to the specificities of the particular street food offer in the study area; in this respect, both the distribution of vendors across the city and their estimated overall numbers are relevant (a proposed selection scheme is given in Fig. 3.

Fig. 3. Decision rules for selection of vending sites



[a] In this case, follow both left-hand and right-hand arms.
b Samples of one or more types of cluster may be considered; exclusion criteria may be defined according to the characteristics of each cluster (e.g. restriction to major public transportation hubs).
[c] A stratified sample may be appropriate to ensure equitable representation of specific places (e.g. districts, markets of different sizes).
[d] The proposed buffer dimension is based on our previous experience, but it may have to be adjusted to the density of vending sites or the size of clusters (for example, when vendors concentrate in places that occupy a larger area, such as markets, buffers with a larger area may be more appropriate).
[e] Define the number of vending sites to be invited to participate (e.g. all, every two, every five) according to the density of vending sites and the intended sample size.

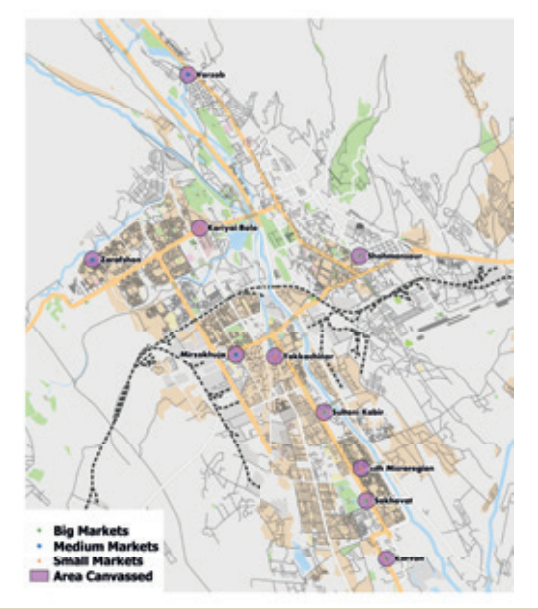
Examples of different strategies for sampling street food vending sites are given below, based on surveys conducted in Tajikistan (Box 1) and Mozambique (Box 2).

These sampling frames are expected to allow for selection of vending sites that represent the diversity of the street food offer within the selected city (Dushanbe) or neighbourhood (Maputo), which may vary according to the population density and socioeconomic characteristics of the study area concerned.

Box 1. Selection of street food vending sites in Dushanbe (Tajikistan)

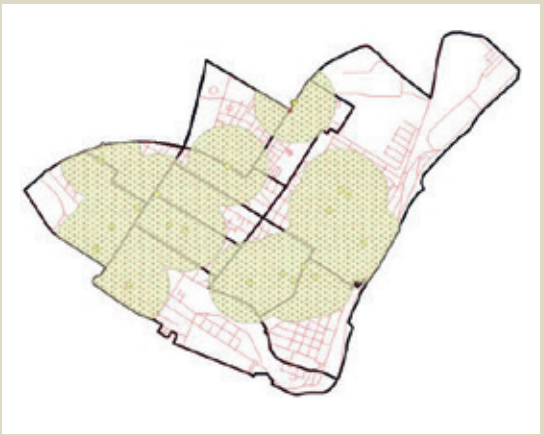
The survey started with a site visit for preliminary assessment of the pattern of distribution and density of street food vending sites across the city. We encountered very few vendors operating directly on the streets, except for trucks selling dairy products from nearby farms and sellers of a traditional homemade soda. The usual "street hawker" – a mobile vendor commonly found in other parts of the world – was missing from Dushanbe. The great majority of street food vending sites were semi-static or fixed, and concentrated in enclosed spaces such as bazaars or public markets, which are general trading places where many different kinds of goods, other than just foodstuff, are sold. Vending units selling directly onto the street through an open window (whether or not seating options were provided inside) were also common.

Our final assessment was that vending sites were predominantly concentrated in markets and their surroundings. Our sampling procedure therefore started with identification of all public markets present in Dushanbe; this phase was supported by information provided by local authorities and gathered during the preliminary field visit. We randomly selected a fixed proportion (approximately 25%) of the markets from each district. For each of the markets selected, we defined a 500-meter diameter buffer around its centre point, to represent the study area, as shown on the map. Taking into account the intended sample size and the estimated number of vending sites in the areas to be studied, we opted to invite all eligible vendors to participate.



Box 2. Selection of street food vending sites in Maputo (Mozambique)

The survey was limited to the wealthiest and most urbanized of the seven municipal districts, which was considered to represent the area with the highest concentration and variety of street food vendors. In this setting, there were both fixed and mobile vending sites scattered throughout the area. We therefore opted to select a random sample of public transport stops. After identifying all the stops in the selected district, as shown on the map, we randomly selected approximately 20% of them. A 500-meter buffer was drawn around each of these to define the study area, which was canvassed by field researchers to identify all eligible vendors.



Data collection

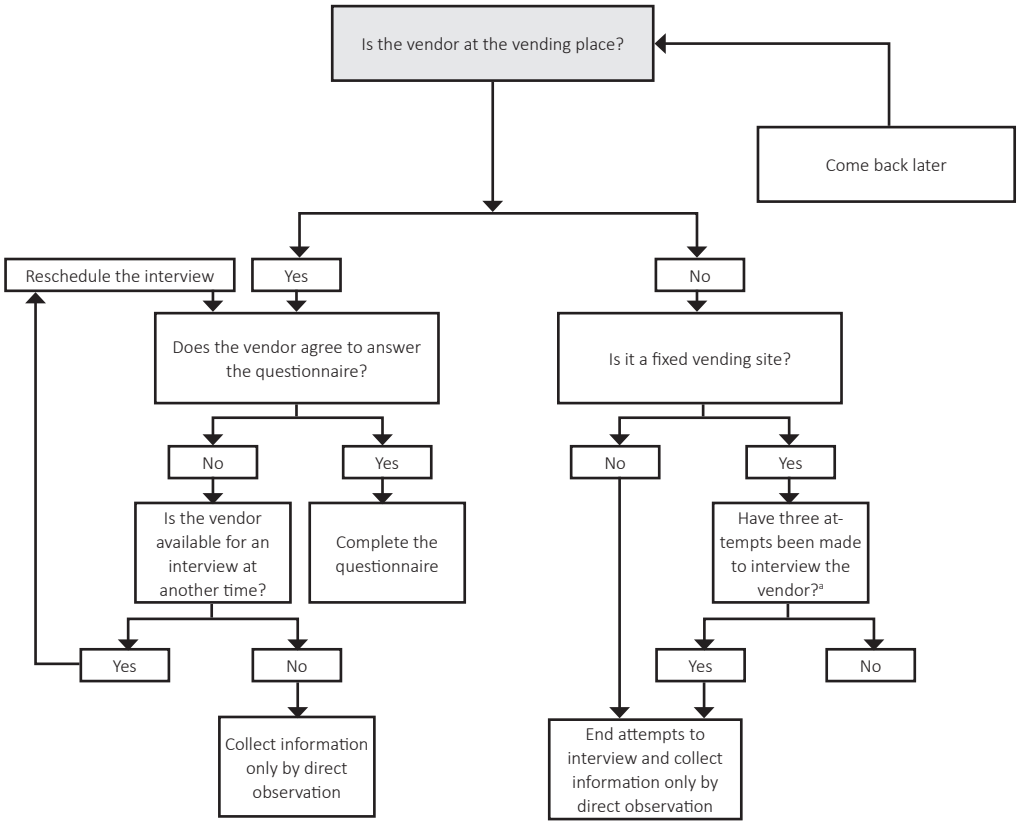
The period selected for evaluation of the vending sites should include both weekdays and weekends. Each study area may be evaluated in a single day or on consecutive days, depending on the number of eligible vending sites, and data collection should take place during the whole day, to ensure that usual mealtimes are covered. Evaluations on specific holiday periods when activity or the food offer may be different to normal should be avoided.

Field researchers should operate in pairs, walking through every publicly accessible street in the study area, in search of street food vending sites. When evaluating public markets, researchers should access the venue through the main entrance, and only after the market itself has been completely canvassed should they move on to areas surrounding the market that are included in the study area. In the case of larger markets that are not completely contained within the 500-meter buffer, the study area may be redefined so that it is circumscribed by the streets that limit its perimeter; in these streets, only vending sites that are on the side of the street closest to the market should be evaluated.

For vending places considered eligible for inclusion in the study, field researchers should register their typology along with the corresponding Global Positioning System (GPS) coordinates. Researchers should then approach each vendor and present the study objectives and procedures; leaflets including a description of the study should be made available (an example of a study description is provided in Annex 1).

Face-to-face interviews with vendors who agree to participate are used to collect data on the following: mobility of vending site; physical setup (e.g. stand, push cart, cooler); operating periods (working days and hours); number of employees; ownership; access to clean water and electricity; and offer of ready-to-eat foods (type of food products available, portion size, method of preparation, type of packaging, price, etc.). If vendors are unwilling to collaborate, researchers should still record their geographical location and any other relevant information on their activity that can be gathered by observing their vending site and the products available. Details of procedures and forms/questionnaires for data collection are provided in Fig. 4 and Annex 2, respectively.

Fig. 4. Decision rules for defining procedures for evaluation of vending sites



[a] Attempts should preferably be made at different times of day, or on different days, to maximize the possibility of collecting data by interview.

In order that field researchers may avoid interviewing the same vendor twice, once each interview has been completed, a sticker with the research project logo should be attached (with the vendor's permission) to the vending site (an example is provided in Annex 3).

Expanded evaluation: food advertising and brand marketing in public spaces

Eligibility criteria

Permanent outdoor product advertising or brand marketing media located in public spaces should be targeted; examples include billboards, banners, posters, painted walls and electronic screens, regardless of size. Non-permanent media, such as mobile advertising (e.g. on vans or push carts), sponsored equipment (e.g. umbrellas/parasols, coolers, tables, chairs, ashtrays) or printed promotional material (e.g. flyers, menus) are not eligible.

Selection of advertisements

All eligible advertisements located in any of the streets canvassed by field researchers in the course of identifying street food vending sites should be selected. Additionally, when vending sites are clustered in confined spaces such as markets, the main routes of urban public transport (e.g. buses, trams) should be selected and both sides of the streets evaluated for the presence of advertising.

Data collection

All eligible outdoor advertisements visible in the study area that refer to foods or drinks, as well as non-alimentary products, should be photographed or filmed, to allow for subsequent analysis.

STEP 2 – Characterization of street food purchasing patterns

Eligibility criteria

Sales of the street food vending sites identified in Step 1 should be assessed by direct observation of their regular activity; this assessment will be complementary to characterization of the street food they offer. All vending sites and their customers buying ready-to-eat products are eligible.

Selection of customers of street food vending sites

Data should be collected by direct observation of people buying street food at the selected vending sites. The observation period should start at the first multiple of five minutes after evaluation of the food offer and end either when four customers have been observed or after 10 minutes (this predefined period may be longer if the expected number of customers is small), whichever comes first.

Customers should be observed either in all vending sites or in a subsample that has been systematically selected (e.g. every second site, every fifth site), depending on the expected overall number of vending sites and customers. For example, if the survey is designed to evaluate 300 vending sites and an average of four customers is expected in each observation period, in order to evaluate a total of 300 customers it will be necessary to select 75 out of the 300 vending sites; this corresponds to a systematic selection of every fourth vending site.

Data collection

Data collection should be done by two independent observers, standing as close as possible to the vending site but at a sufficient distance that they do not disturb the vendor's regular activity. Vendors should be informed that field researchers are going to observe their customers for a few minutes, but no specific consent needs to be requested.

Field researchers should record the start and end time of the observation, and for each customer buying street food, they should describe the type and quantity of food items purchased; the customer's sex and estimated age, height, weight and body mass index status should also be recorded (using broad categories).

STEP 3 – Street food collection and bromatological analysis

Selection of food samples

After characterization of vending sites with respect to their food offer has been completed, the 20 most frequently available homemade foods and the 10 most frequently available industrial foods should be selected for bromatological analysis.

Samples should be collected over consecutive days, including both weekdays and weekends. On each collection day, only one sample of homemade food and one sample of industrial food should be obtained from a single vending site.

For each type of food, a sample should be bought from four different vending sites; these should be selected by a random route procedure, starting with random selection of GPS coordinates within each study area. If no vendor is working at the selected coordinates (i.e. if the vending site is closed or the vendor is mobile), these coordinates should be used as the starting point for a systematic selection procedure in which field researchers start moving north and change direction clockwise (first east, then south, then west, then north again) whenever the limits of the study area or a physical barrier (such as a wall or a canal) are met, until they reach vending sites where the selected foods are available.

Collection and processing of samples

No consent is required to acquire the food samples as they are bought by investigators as part of a regular transaction.

The food samples should correspond to the usual serving/portion, or one unit, if the item is prepacked. For any type of food sold in small portions (e.g. small snacks, biscuits), each sample may include more than one portion of the same food.

Each sample should be photographed and weighed, and then divided into four homogeneous subsamples and packed individually in rigid plastic containers; solid and semi-solid foods should first be subjected to mechanical grinding. After packaging, each container should be weighed again and stored in a freezer (at −18 °C) until bromatological analysis is conducted.

Bromatological analysis

On each working day, samples should be moved from −18 °C to 4 °C in the evening, left to defrost slowly overnight, and then homogenized. Two aliquots of each food sample should be collected immediately after homogenization and analysed separately. When the variation coefficient between duplicates is greater than 5%, analysis should be repeated.

Proximate analysis and TFA evaluation should be performed in accordance with the most recent standard AOAC International methods *(20)* – namely, in the case of (a) moisture, by oven drying at 103 °C until constant weight; (b) protein, by the Kjeldahl method; (c) fat, by the Soxhlet method; (d) ash, by calcination; (e) fatty acids, by gas chromatography for the fatty acid ethyl esters, according to a validated method *(19)*; and (f) sodium and potassium, by inductively coupled plasma optical emission spectrometry (ICP-OES) *(21)* or flame photometry *(22)*. Total carbohydrates plus fibre should be estimated by difference *(20)*. The caloric value of samples should be estimated after proximate analysis of the food components has been carried out.

Data analysis and sample size

The street food environment should be characterized, overall and according to the socioeconomic and physical characteristics of the neighbourhood, using descriptive statistics and spatial analysis.

Vending sites should be described with respect to their mobility, physical setup, operating periods, number of employees, ownership, and access to clean water and electricity.

Food products sold should be identified and classified into three groups: fruit, beverages, and food other than fruit. Ready-to-eat food products, which fall into the category of food other than fruit, should be classified as homemade or industrial. For the purposes of this study, homemade foods are defined as foods cooked and/or prepared at home or on the street, regardless of the origin of their ingredients; and industrial foods as food products produced by the food industry and sold as they are, without further preparation and/or cooking. Homemade foods should also be grouped as “cooked”, “prepared but uncooked” and “uncooked and unprepared”. Beverages should be classified according to similarities of composition into the following groups: soft drinks, water, fruit juices, milk, yogurt, alcoholic beverages, energy drinks, coffee/tea, traditional beverages, and other beverages.

Foods purchased should be described according to their typology, as described above, and according to the characteristics of their purchasers (sex, estimated age and body mass index).

With respect to advertising, data analysis should comprise description of an advertisement’s location, including its relation to specific places such as schools, and of its physical characteristics, including size, format and content.

With respect to food’s proximate composition, the average of two determinations of each sample should be considered for data analysis, and results should be presented as the mean and range of each component by food item or food group, expressed on a fresh mass basis, both per 100 g and per average serving size. The mean and range of individual portions should also be presented.

Sample size

The studies should aim for a minimum sample size of 300 vending sites and 300 customers in each city. Assuming a design effect up to 1.5, sample sizes of approximately 300 vending places and 300 customers will yield 95% confidence intervals up to 15% wide for observed proportions ranging between approximately 30% and 70%, and 95% confidence intervals for means with a width of approximately 30% of the observed standard deviation.

No minimum sample size was defined for characterization of advertising, since its assessment in the same areas where street food vendors are identified is expected to result in a relatively small number of advertisements. For this reason, this aspect should be seen as a secondary objective – one that is complementary to assessment of street food vending sites and their food offer – which allows a more comprehensive evaluation of the street food environment with virtually no increase in resources above those already allocated to data collection.

No statistical analysis requiring a specific sample size was defined in advance for food samples, as this is essentially an exploratory analysis whose main purpose is to provide descriptive data to complement those already available on food composition. However, food sampling was defined in such a way as to take account of the expected diversity and variability of homemade and industrial foods. The larger number of samples of homemade foods is justified because their composition is often completely unknown.

3. Ethics and dissemination

Informed consent

The information collected as part of the present study relates only to the products sold by street food vendors, the characteristics of their vending sites, and the street food consumption of urban residents in the selected areas. A waiver to the requirements for informed consent is considered necessary, given the particular conditions of the present study:

(a) although food vendors will be asked to collaborate in data collection, this type of information can be obtained just by observing the vending site, and vendors will not be identified or identifiable through the information collected;

(b) the only human data collected will be obtained by direct observation of customers (sex and estimated age, height, weight and body mass index), and subjects will not be identified or identifiable on the basis of the information recorded;

(c) the research involves no risk to vendors or their customers;

(d) the waiver will not adversely affect the rights and welfare of vendors or their customers;

(e) the research could not practically be carried out without the waiver;

(f) vendors will be informed about the research objectives and asked to collaborate in data collection, but are free to refuse their collaboration at any time.

Potential discomfort and impact on vendors' businesses

The risks associated with participation in this study are minimal; they do not constitute a threat to confidentiality, and all efforts will be made to minimize potential disruption of vendors' businesses and any discomfort they might feel while participating in the research. Observation of customers will be carried out for short periods only and at a distance considered appropriate to avoid disturbing vendors' regular activity.

Vendors may experience discomfort and nervousness about participating caused by concerns over investigations performed by regulatory authorities (23). Such anxiety will be minimized by providing simple and clear information on the study objectives and, whenever possible, by involving residents of the neighbourhoods being evaluated in the process of data collection, as well as younger university students who are expected to be perceived as less of a threat.

To reduce the risk of interfering with vendors' businesses, interviews may be conducted at convenient moments – for instance, at relatively quiet times of the day – as long as this does not conflict with the research objectives. The questionnaire used for field data collection is estimated to take about 10 minutes to complete; most of the information will be gathered by simply observing the vending site, without the need to constantly interact with the vendor.

Confidentiality

Subjects' names will not be used to identify their vending sites on any study records. Instead, a unique study number will be assigned to each vending site; only this number will be used on study documents that relate to the vending site.

Potential benefits to vendors from participation

There are no direct benefits to vendors. They will not receive any compensation for collaborating in data collection.

Potential benefits to society

Knowledge and insights emanating from this study will potentially advance research efforts into nutrition in urban contexts, and may ultimately lead to better prevention of diet-related diseases (such as obesity, cardiovascular diseases and malnutrition) and more suitable interventions (such as improved food regulations and dietary guidelines).

Data deposition

No data will be destroyed. Data collected during the study will be retained for record-keeping purposes and for future research use – namely, tracking changes that may occur to the parameters evaluated in the present study.

All physical records related to the study will be kept in closed cabinets inside the WHO country office of the country concerned. Electronic data curation will be the responsibility of the Institute of Public Health of the University of Porto, Portugal.

Dissemination of results

The project description and its results will be made available on the WHO website. In addition, they will be submitted for publication in international peer-reviewed journals and presented at scientific meetings.

For each country involved, reports of the main study findings will be prepared for presentation to local authorities.

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Annex 1. Study description

What is FEEDcities?

FEEDcities stands for “Food environment description in cities in eastern Europe and central Asia”. It is a research project with the principal aim of characterizing the street food environment in some main cities of eastern Europe and central Asia; it includes both the available street food and food advertisements. The research project is funded by the World Health Organization (WHO) through its Regional Office for Europe. The research will be carried out by the WHO local office in **[Country name]** and by the University of Porto.

What are the main objectives?

- To describe the characteristics of the food offered at selected street vending places; to map their location; and to describe the customers present and the street foods purchased.
- To assess the nutritional composition of the ready-to-eat foods sold on the street.
- To map the spatial distribution of food advertisements and to describe the typology and content of food advertisements.

Who is eligible for this study?

Any street food vendor selling ready-to-eat foods, including beverages and snacks, and food establishments/permanent storefront businesses with four permanent walls selling ready-to-eat foods through a window onto the pavement, operating within the perimeter of selected public markets.

What type of data will be collected?

No human data (name, age, telephone number) will be collectßed. Food vendors cannot be identified in any way. The only information to be collected and recorded relate to the vending site (operating hours, location, food offer).

For further information, please get in touch with **[Team Member name]** (WHO **[Country name]**) at **[institutional telephone number]** or at **[institutional email]**.

Annex 2. Model questionnaire

SECTION 1 - Vending Activity			
NO.	**QUESTIONS AND FILTERS**	**CODING CATEGORIES**	**SKIP**
101	**What is the sex of the vendor?**	MALE 1	
		FEMALE 2	
		NOT AVAILABLE 99	
102	**What type of food products are being sold?**	FOOD (Industrial/Home-cooked)..... 1	
		FRUIT 2	
		DRINKS 3	
		NON-FOOD PRODUCTS 4	
103	**Is the vendor available for the interview?**	YES 1	→ 105
		NO 2	
104	**Specify why the vendor is not available for the interview**		
	_____		→ 109
105	Hello, I am (*Insert name*) from the World Health Organization. Our team is working on a project related to what foods people have available to them on the streets. This activity is part of a research project whose main goal is to improve the dietary and health conditions of the urban population, particularly its poorest sections. We are independent from any regulatory entity, both at municipal and governmental level. We do not collect any personal information that can make you identifiable. I am just making a few notes, and I'll be out of your way in a short time. Is that okay?		
	YES ☐	NO ☐ →	END
106	**Are you the owner of this food vending activity?**	YES 1	108
		NO 2	
107	**What is your relationship with the owner?**	EMPLOYEE 1	
		RELATIVE 2	
		FRIEND 3	
		OTHER 8	
		Specify _____	
108	**Have you already taken part, in the previous weeks, in any questionnaire/research from the World Health Organization about street food?**	YES 1	→ END
		NO 2	
109	**Are you able to answer questions regarding the vending activity? (i.e. food preparation, business schedule)**	YES 1	→ 111
		NO 2	
110	**IF NOBODY IS AVAILABLE OR CAPABLE OF ANSWERING, SCHEDULE A SECOND VISIT**		
	Second visit due on: (date)_____	(time)_____	→ END

SECTION 1 - Vending Activity			
NO.	**QUESTIONS AND FILTERS**	**CODING CATEGORIES**	**SKIP**
111	**During which day is your cart/truck/stand usually here?**	MONDAY 1	
		TUESDAY 2	
		WEDNESDAY 3	
		THURSDAY 4	
		FRIDAY 5	
		MONDAY to FRIDAY 6	
		MONDAY to SATURDAY 7	
		THE WHOLE WEEK 96	
112	**During which hours is your cart/truck/stand usually here?**	hours min	
		FROM ☐☐ ☐☐	
		TO ☐☐ ☐☐	
113	**During which period of the year is your cart/truck/stall usually here?**	SUMMER 1	
		WINTER 2	
		THE WHOLE YEAR 96	
		OPERATING FOR LESS THAN A YEAR..... 99	
114	**Is your cart/truck/stand here no matter what the weather?**	YES 1	
		NO 2	
		DON'T KNOW 99	
115	**When did you start your vending activity?** GIVE AN APPROXIMATE DATE	MONTH ☐☐	
		DON'T KNOW MONTH 99	
		YEAR ☐☐	
		DON'T KNOW YEAR 99	
116	**Do you live in the same neighborhood in which you operate?**	YES 1	→ 118
		NO 2	
117	**Specify distance from workplace** CHOOSE ONE OF THE MEANS MENTIONED"	minutes	
		WALKING ☐☐	
		PUBLIC TRANSPORT ☐☐	
		PRIVATE CAR ☐☐	
		BICYCLE ☐☐	
		DON'T KNOW 99	
118	**Are you a mobile vendor?**	YES 1	
		NO 2	→ 121
119	Do you follow a fixed itinerary to sell?	YES 1	→ 124
		NO 2	
120	**Explain the reasons why**		

_____

SECTION 1 - Vending Activity					
NO.	**QUESTIONS AND FILTERS**	**CODING CATEGORIES**			**SKIP**
121	**When did you first start bringing your cart/truck/stand to this location?** GIVE AN APPROXIMATE DATE	MONTH		☐	
		DON'T KNOW MONTH 99			
		YEAR		☐	
		DON'T KNOW YEAR 99			
122	**Do you take your cart/truck/stand anywhere else?**	YES 1			
		NO 2			→ 124
		DON'T KNOW 99			
123	**Explain the reasons why** _____				
124	**Are there other people employed/involved in this food vending activity who assist you, for example, preparing and/or selling the food products?**		YES	NO	
		RELATIVE	1	0	
		FRIEND	2	0	
		EMPLOYEE	3	0	
		OTHER	8	0	
		Specify _____			
		NONE	9	0	→ 127
125	**SPECIFY THE NUMBER**	RELATIVE		☐	
		FRIEND		☐	
		EMPLOYEE		☐	
		OTHER		☐	
126	**SUM ANSWERS FROM QUESTION 125 AND ENTER TOTAL**	TOTAL PEOPLE		☐	
127	**CHECK 126:** Just to make sure that I have this right: there is a TOTAL of _____ people working in this food vending activity. Is that correct? YES ☐ NO ☐ → PROBE AND CORRECT Q124-126				
128	**Do you have access to electricity?**	YES 1			
		NO 2			
129	**Do you have access to drinking water?**	YES 1			
	NO 2	NO 2			→ 132

SECTION 1 - Vending Activity			
NO.	**QUESTIONS AND FILTERS**	**CODING CATEGORIES**	**SKIP**
130	**What is the main source of drinking water?**	PIPED WATER	
		PIPED INTO VENDING SITE 1	
		PIPED TO MARKET 2	
		PUBLIC TAP/STANDPIPE 3	
		TUBE WELL OR BOREHOLE 4	
		DUG WELL 5	
		WATER FROM SPRING 6	
		RAINWATER 7	
		TANKER TRUCK 8	
		CART WITH SMALL TANK 9	
		SURFACE WATER ..... 10 *(RIVER/DAM/LAKE/POND/STREAM)*	
		BOTTLED WATER 11	
		OTHER 98	
		Specify _____	
131	**Do you do anything to the water to make it safer to drink/use for cooking?**	BOIL 1	
		ADD BLEACH/CHLORINE 2	
		STRAIN THROUGH A CLOTH 3	
		USE WATER FILTER ..... 4 *(CERAMIC/SAND, ETC)*	
		SOLAR DISINFECTION 5	
		LET IT STAND AND SETTLE 6	
		OTHER 98	
		Specify _____	
		DON'T KNOW 99	
132	**Do you have access to a toilet facility when at work?**	YES 1	
		NO 2	→ 135
133	**Including yourself, how many people use this toilet facility?**	TOTAL NUMBER 0 *If less than 10*	
		MORE THAN 10 95	
		DON'T KNOW 99	
134	**Where is the toilet facility located?**	INSIDE THE MARKET 1	
		ELSEWHERE 2	

SECTION 1 - Vending Activity			
NO.	**QUESTIONS AND FILTERS**	**CODING CATEGORIES**	**SKIP**
135	**What type of fuel do you use to cook?**	ELECTRICITY 1	
		LPG 2	
		NATURAL GAS 3	
		BIOGAS 4	
		KEROSENE 5	
		COAL, LIGNITE 6	
		CHARCOAL 7	
		WOOD 8	
		STRAW/SHRUB/GRASS 9	
		OTHER 98	
		Specify _____	
136	**In which place do you usually wash your hands?**	AT THE VENDING SITE 1	
		TOILET/BATHROOM 2	
		OTHER 98	
		Specify _____	
		NONE 99	

Annex 3. Project sticker

Fig. A3.1. FEEDcities project sticker

Fig. A3.2. A vending site displaying the FEEDcities project sticker

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ANNEX 2

Albuquerque G., Sousa S., Hoejskov P., Moreira P., Lunet N., Padrão P.

Safe and healthy food in traditional food markets in the WHO European Region

Copenhagen Ø, Denmark: World Health Organization Regional Office for Europe, 2020.

SAFE AND HEALTHY FOOD IN TRADITIONAL FOOD MARKETS

IN THE WHO EUROPEAN REGION

World Health Organization
REGIONAL OFFICE FOR Europe

ABSTRACT

This technical report contains guidance on the promotion of safe and healthy food in traditional markets within the WHO European Region, targeting all stakeholders from policy-makers to market workers. This document outlines the main guiding principles of a safe and healthy traditional food market and proposes a stepwise approach to the implementation of safe and healthy traditional food market initiatives.

KEYWORDS

Noncommunicable diseases
Food markets
Food safety
Sustainable and healthy diets

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CONTENTS

Acknowledgements iv

List of contributors v

Executive summary vi

1. Background 1

2. Objectives of the guidance document and target audience 4

3. Guiding principles for promoting safe and healthy food in traditional markets 5

3.1 Food systems approach 5

3.2 Risk-based approach 6

3.3 Safe, healthy and sustainable food for all 7

3.4 One Health approach 8

3.5 Stepwise approach 8

4. Components of a safe and healthy traditional food market 9

4.1 Basic infrastructure 10

4.2 Appropriate legal basis 10

4.3 Risk-based inspection and enforcement services 11

4.4 Basic food hygiene and training of market vendors 11

4.5 Safe and healthy food 13

4.6 Health promotion and communication 13

4.7 Procedures for emergency response 16

5. Stepwise approach to implementation of healthy traditional food market initiatives 17

5.1 Assess the current setup of the market and the extent to which it provides safe and healthy food 17

5.2 Identify key nutrition and food safety issues and understand their origin 18

5.3 Decide on the intended future shape and characteristics of the market 19

5.4 Identify possible interventions to overcome the issues identified 20

5.5 Devise action plan, priorities, timeframe and budget 20

5.6 Implement, monitor and evaluate healthy traditional food market initiatives 21

6. Issues of particular importance to markets in the context of COVID-19 22

References 24

Annex 1. Safe and healthy food in traditional food markets in the WHO European Region 26

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EXECUTIVE SUMMARY

Traditional food markets are important sources of food for millions of people in the WHO European Region. They can play a central role in ensuring access to safe, nutritious and culturally appropriate food, promoting health and preventing disease. However, limited availability and access to safe and healthy foods in many markets often hinder the adoption of nutritionally adequate diets. Traditional food markets have also been associated with foodborne and zoonotic outbreaks, including most recently COVID-19. With this multi-layered challenge in mind, this document aims to provide guidance on the development of markets offering safe and healthy food, taking into account the diversity of settings across the WHO European Region.

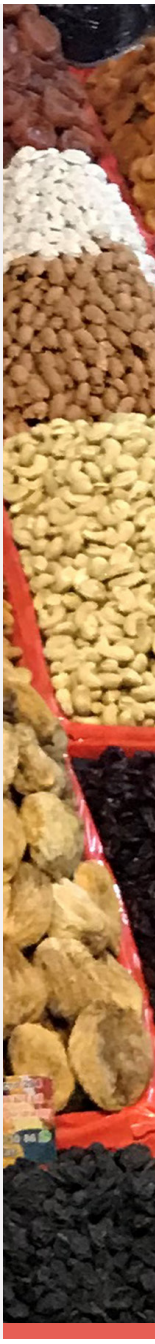
A safe and healthy traditional food market should provide a given population with food that is safe and nutritionally adequate. To achieve this, several aspects have to be taken into consideration: physical layout and facilities; hygiene practices; availability and accessibility of nutritious and sustainable foods; culture; preparation/cooking practices of ready-to-eat food; and awareness and knowledge on the part of consumers and vendors, among others. To this end, the implementation of a combination of diverse interventions, encompassing research, regulation and education and operating at different stages of the food chain, has the potential to yield the best results.

Success in establishing and maintaining a safe and healthy traditional food market is highly dependent on the current state of the market in terms of location, facilities and equipment; nutrition and food safety awareness among workers and customers in the market; and the ability of governments and market authorities to make the best use of existing resources. Taking account of the great variety of markets across the WHO European Region, the purpose of this guidance document is to outline the basis of a stepwise approach to implementing a safe and healthy traditional food market initiative, which must be adjusted to the particular characteristics of each context. This process comprises identifying needs and priorities for action, defining interventions to be implemented, developing an action plan, and implementing, monitoring and evaluating the plan.

The current conjuncture of unprecedented challenges for local and global food security and safety must be seen as an opportunity to take multisectoral action to build healthier and more sustainable food environments which provide safe and nutritious food for all. This will ultimately lead to better health for all.

Key messages

- The WHO European Region faces a series of challenges affecting the management of food safety and nutrition risks in traditional food markets. The COVID-19 pandemic has introduced new challenges, particularly at the local level, requiring an additional focus on food security, food safety and personal behaviour.
- Traditional food markets play a central role in communities across the WHO European Region. To promote safe and healthy food in traditional markets, it is necessary to adopt a stepwise approach which is rooted in the guiding principles of food systems, One Health and risk-based approaches, as well as in several other factors that shape safe and healthy diets.
- The main components of a healthy traditional food market include the basic infrastructure, an appropriate legal basis, risk-based inspection and enforcement services, basic food hygiene and training of market vendors, safe and healthy food, health promotion and communication, and effective emergency response procedures.
- To improve the availability, accessibility, utilization and stability of safe and healthy food, it is necessary to identify key nutrition and food safety issues and their origin; to decide on the intended future characteristics of the market; to identify possible interventions; and to prepare action plans, priorities and budget, which should be adapted to local characteristics. Further monitoring and evaluation are essential to promote a sustainable approach.
- In order to prevent the spread of COVID-19 and other infectious diseases in traditional food markets, both workers and the general public need to be aware of the recommended personal hygiene and respiratory practices – physical distancing, frequent cleaning and disinfection of work surfaces, and avoiding contact with live animals and potentially contaminated surfaces.



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1. Background

Access to nutritionally adequate and safe food was recognized as a right of each individual by the World Declaration on Nutrition, jointly made by the Food and Agriculture Organization of the United Nations and WHO in 1992.[1] Although there have been considerable improvements, one third of the world's population, including in the WHO European Region, is currently experiencing malnutrition. While most high-income countries essentially face a high prevalence of overweight/obesity and diet-related noncommunicable diseases and mortality due to them, many low- and middle-income countries face a double burden of malnutrition, including additionally some forms of undernutrition. The most vulnerable groups are particularly affected.[2]

Foodborne diseases are a significant public health concern in the WHO European Region. In 2010, an estimated 23 million people fell ill, and approximately 4700 people died, from consuming contaminated food.[3,4] Unsafe food is not only a threat to human health but also plays a fundamental role in the socioeconomic development of countries, affecting people's ability to purchase safe and healthy food.

The United Nations Sustainable Development Goal No. 2 is an international commitment to reduce inequality within and among countries and to eradicate hunger and malnutrition.[5] A set of international recommendations for safe and healthy diets followed,[6,7] and currently much of the emphasis is on prioritizing local food environments to better acknowledge and address food safety and nutrition inequities.[8]

Over recent decades, food systems have become more industrialized, with considerable advances in production, distribution and processing technologies, and they face unprecedented challenges as a consequence of urban expansion, although at different rates in high-income countries and low- and middle-income countries. Currently, approximately 74% of the European population lives in urban areas; the percentage is lower, but growing, in the countries of eastern Europe (70%) and central Asia (48%).[9] In many countries, traditional food markets* play a central role in communities, as major food suppliers and as sociocultural spaces. In some regions, such markets form the basis for food security and people's livelihood, while in others they play a smaller role and mostly offer exclusive niche products. Furthermore, traditional food markets may comprise different organizational dynamics: while some are permanent with fixed designated locations (for example, bazaars), others are temporary and can be set up on an ad-hoc basis (for example, informal markets and some farmers' markets).

Food prices are an important determinant of food acquisition, ultimately influencing food consumption.[10] Thus, ensuring that nutrient-dense and safe foods are available, accessible and also affordable in traditional food markets has the potential to positively influence people's dietary preferences and choices, and thus to help improve their nutritional status and health. Furthermore, foods must be culturally

DRIED FRUITS AND NUTS ON DISPLAY IN A TRADITIONAL FOOD MARKET IN KAZAKHSTAN

* The term "traditional food market" is used throughout this document to include wet markets, bazaars, informal markets and farmers' markets, where foods of animal and non-animal origin and dried goods are sold and live animals are sometimes housed and slaughtered on site.

appropriate and produced with low environmental impact.[11] In traditional food markets, the food offer is likely to vary but usually encompasses a wide range of products, including fruits, vegetables, grains, tubers, meat, poultry, fish, eggs, dairy products and beverages. Many of these markets also make available a range of ready-to-eat foods, either industrially processed or manufactured by smallholders.[12] For example, the WHO FEEDcities project assessed markets in eastern Europe and central Asia, with the aim of characterizing urban food environments in this area of the WHO European Region. It found a wide availability of energy-dense foods high in sodium, sugar, and saturated and *trans* fats, possibly contributing to the growing burden of noncommunicable diseases.[13–19]

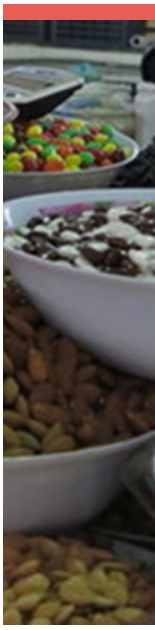
In some parts of central Asia, live animals are also traded for food, which makes markets more vulnerable to the spread of emerging foodborne and zoonotic diseases. Most recently, a large number of the early COVID-19 pandemic cases were associated with a traditional food market in China, where live animals were caged, slaughtered and sold to the public. Besides the direct risk of spreading disease, the COVID-19 pandemic has also worsened an ongoing food security and nutrition crisis, exposing the risks, vulnerabilities and inequities in global food systems. Policy measures taken to slow the spread of the virus (such as lockdowns and physical distancing) have had a major impact on food safety, food security, diet quality and sustainability, and have increased demand for e-commerce services.[20] Closures and restrictions on informal and open-air markets have also contributed to increased vulnerabilities in short supply chains.[21] In the face of this threat, more equitable, resilient and sustainable food* systems are needed,[2,22] along with health promotion strategies to raise awareness of food safety and nutrition among consumers, producers and vendors.

In 2006, WHO developed *a Guide to healthy food markets*.[12] The guide provides basic orientation and a reference point for developing safe and healthy traditional

* Sustainable foods are foods that are produced in a manner that takes full account of the needs of present and future generations, as well as profitability, environmental health, and social and economic equity.

food market pilot projects. It advocates for healthy traditional food markets as valuable settings that can effectively improve food safety, nutritional status and environmental health. The guide contributed to good progress in developing healthy traditional food markets around the world, including in the WHO European Region. A decade and a half later, the globalization of the food chain, increasing international trade, urbanization, new technologies, climate change, increased consumer awareness and concern about health have changed the conditions under which food is produced and consumed, and how food safety and nutrition risks are managed in the Region. The COVID-19 pandemic has added an additional layer of complexity to the way food safety and zoonotic disease risks are managed. For these reasons, existing guidance on healthy traditional food markets needs to be updated in order to prevent and control potential future zoonotic and foodborne disease outbreaks, to prevent the spread of infectious diseases such as COVID-19 in traditional markets, and to improve the nutritional composition of food and tailor it to current food safety and nutrition challenges in the WHO European Region.

This guidance aims to bring together the basic principles of safe and healthy food in traditional food markets, emphasizing the need for an interconnected perspective on the urban-rural food systems in the WHO European Region.[23] It emphasizes the role that traditional food markets can play in contributing to environments that promote health and food safety, advocating for safe, healthy, sustainable, accessible and affordable food for the population, with a particular focus on the most vulnerable groups (among consumers, vendors and other market workers). Based on a One Health approach to promoting safe and healthy food in traditional food markets, it recognizes the interconnectivity of sectors and stakeholders along the food supply chain. The guidance also outlines a stepwise implementation of these principles in markets across the Region, while taking into account the unique characteristics of each urban-rural environment.



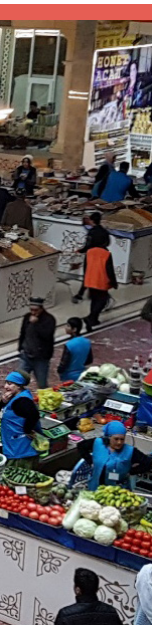
PULSES BEING SOLD IN A TRADITIONAL FOOD MARKET IN TAJIKISTAN

2. Objectives of the guidance document and target audience

The purpose of this document is to give guidance on the development of traditional markets that offer safe and healthy food, taking into account the diversity of settings across the WHO European Region. The specific objectives of the document are:

- to offer advice on taking a One Health and stepwise approach to the management of food safety and nutritional risks associated with traditional food markets;
- to promote the preparation, handling, sale and consumption of safe and healthy foods and beverages in traditional food markets;
- to guide governments and market authorities in implementing measures that help traditional food markets become environments that promote health and food safety;
- to support governments and local authorities in strengthening public health interventions to reduce the risk of transmission of COVID-19 and other infectious diseases in traditional food markets.

The target audience comprises all stakeholders involved in traditional food markets, including local policy-makers and market management authorities, health and food safety experts and academics, local community leaders, market vendors and workers. The document will also be useful to national authorities as a food policy instrument that aims to assess, monitor and overcome critical nutrition and food safety issues. This will help reduce inequalities and inequities in food environments and contribute to a transformation of food systems that builds resilience and sustainability at several levels.



3. Guiding principles for promoting safe and healthy food in traditional markets

The intention of the guiding principles set out below is to simplify and standardize the implementation across the WHO European Region of the initiative to promote safe and healthy food in traditional markets, while preserving the unique characteristics of each market. Although each of these principles is described in a separate section, it should be recognized that they are in fact intertwined and should be used together to promote healthy and safe food in traditional markets. In each market, the main risks, and the opportunities to reduce risk, should be assessed at every step of the food chain, relying on the collaboration of all stakeholders.

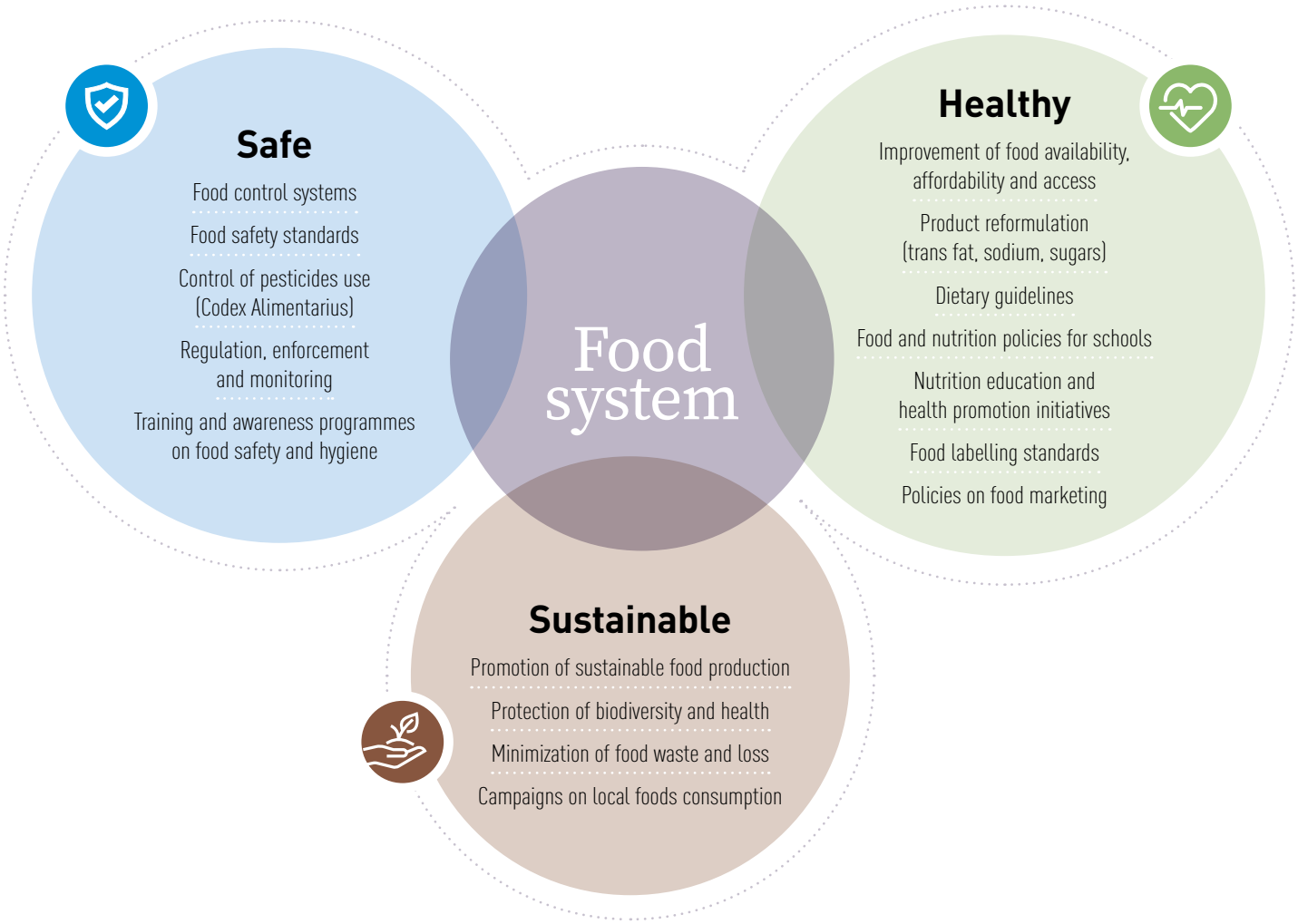
3.1 Food systems approach

Food systems encompass the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products. These goods are derived from agriculture, forestry or fisheries, and parts of the broader economic, societal and natural environments in which they are embedded. A food system must also be considered in the context of rapid population growth, urbanization, changing consumption patterns and globalization, as well as climate change and the depletion of natural resources.

A TRADITIONAL FOOD MARKET IN TAJIKISTAN

Fig. 1.
A simplified and schematic view of a food system, from farm to table

A food systems approach to healthy diets in traditional food markets focuses on using entry points within the food system to influence the consumption of healthy diets by populations with the aim of attaining optimal nutritional status. For food safety, a food systems approach recognizes that food contamination can take place anywhere along the food chain continuum and that food safety risks must be managed at every step of the food chain from farm to table (Fig. 1).



3.2 Risk-based approach

Applying a risk-based approach to promote healthy and safe food in traditional food markets implies the existence of an underlying science or evidence base where risk factors for unhealthy diets and food contamination are identified. A risk-based approach encompasses the use of tools to assess risks and create systems that optimize the ability of governments or market authorities to prevent and control foodborne and zoonotic diseases and improve public health.

Improving nutrition and food safety in traditional food markets requires the best possible use of resources. This means focusing government efforts on the greatest risks and opportunities to reduce risk, wherever they may arise. This includes the adoption of a combination of interventions and approaches that will yield the greatest health improvements.

3.3 Safe, healthy and sustainable food for all

A safe and sustainable healthy diet should promote physical, mental and social health and well-being, while being available, affordable for all and respecting local culture at all times. A safe and healthy diet advocates frequent intake of unprocessed or minimally processed foods, with restriction of highly processed foods and beverages; abundance and variety of fruits and vegetables, as well as wholegrains, legumes and nuts; inclusion of eggs, dairy, poultry and fish in moderate amounts, as well as small quantities of red meat; and safe, clean water as the beverage of choice. Foods should provide adequate energy (energy intake balanced with energy expenditure) and nutrients across the lifecycle, with less than 30% of total energy intake from total fat, less than 10% from saturated fats, less than 1% from *trans* fats (as low as possible), less than 10% from free sugars (less than 5% if possible), and no more than 5 g of salt intake per day. Risks arising from biological or chemical contaminants (pathogens, chemicals, toxins, veterinary drugs, plastics and derivatives) should be reduced and managed, food loss and waste should be minimized, and sociocultural aspects, accessibility and desirability should be respected.[11]

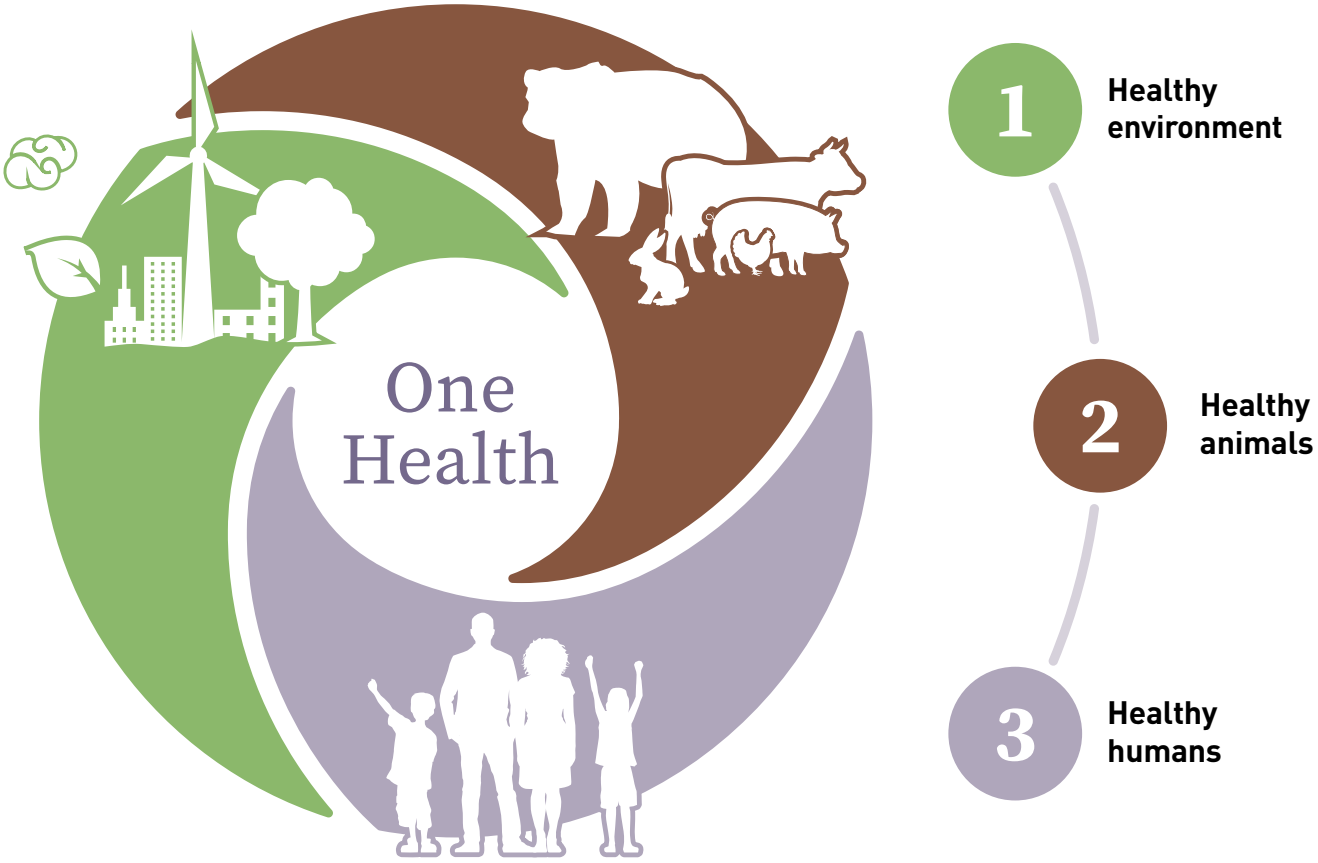
Some discrepancies with these principles have been identified when current dietary patterns in different regions of the world, including Europe and central Asia, are compared. Policies should take into account these discrepancies, which include overconsumption of some food groups, especially red meat and starchy vegetables, together with insufficient consumption of vegetables, fruit, legumes, wholegrains, nuts and fish.[6] The greater demand for nutrient-rich foods in international and domestic traditional food markets is an opportunity to generate economic growth and profitable employment.[24] Encouraging the availability of organic foods is one example of how this could be done.[25]

A safe and sustainable healthy diet should be rooted in sustainable practices of food production, handling, sale and consumption, through optimization of natural resources and protection of ecosystems. This requires dietary diversification and frequent consumption of local and traditional products (vegetables, fruits, small stock) while respecting seasonality.[8] It should also take into account the local ethnic cultural heritage and social identity – protecting food workers, using food as a means to connect and achieve fruitful relationships across the generations, and recovering ancient and renewed foods and flavours, and dietary and culinary traditions.[26] Diversity is one of the main characteristics of food culture in the WHO European Region, at national and local level. While some societal changes are leading to a shift towards a more globalized and industrialized food system, many social movements, such as the Slow Food movement and initiatives based on local food, are also emerging.[27,28,29] Meanwhile, food tourism is becoming an upward trend globally and across countries in the WHO European Region. This trend could be seen as an opportunity to expand the function, visibility and economic profitability of traditional food markets. Tourists seek to explore and taste traditional foods and beverages steeped in local culture and traditions. This is leading to greater popularity of activities that are primarily based in traditional food markets, such as participating in food festivals, visiting local markets and tasting ready-to-eat (street) food.[30] A safe and healthy market should incorporate the specificities of the local food culture, embracing its diversity and evolving dynamics.

3.4 One Health approach

One Health is an approach to designing and implementing programmes, policies, legislation and research in which multiple sectors communicate and work together to achieve better public health outcomes. One Health recognizes that no person, organization or sector alone can address issues at the animal–human–environment interface (Fig. 2). For public health interventions to successfully tackle food safety and zoonotic disease issues, they require communication, collaboration and coordination among food safety and human, animal and environmental health partners.

Fig. 2.
The interface between animals, humans and environment in the One Health approach



3.5 Stepwise approach

Advancing and facilitating the availability, accessibility, stability and utilization of safe and healthy food in traditional food markets must take place in a stepwise manner. The WHO European Region is very diverse in terms of economic development, culture, traditions and values, and this is reflected in food production, supply and consumption. The process of advancing traditional food markets to become conducive to safe and healthy food must be tailored to specific country needs and priorities. The correct timing for the introduction of interventions must consider political momentum, resource availability, private sector engagement and public support.

4. Components of a safe and healthy traditional food market

The various components that need to be in place if a traditional food market is to be safe and healthy are summarized in Table 1 and then described in detail in the subsequent sections.

Table 1.
Summary of the essential components of a safe and healthy traditional food market

Section	Components	Capacities
4.1	Basic infrastructure	• Adequate safe water • Toilets and handwashing facilities • Waste management • Rest areas • Changing rooms • Adequate light and ventilation • Maintenance and cleaning programmes • Facilities to separate live animals and slaughtering from areas where ready-to-eat food is sold to the public
4.2	Appropriate legal basis	• Comprehensive contemporary food laws and regulations covering food safety and nutrition issues
4.3	Risk-based inspection and enforcement services	• Risk-based food inspection plan • Adequate human and financial resources • Registries of food businesses • Models for risk categorization of food products and businesses • Inspection record systems • Risk-based inspection guidelines and checklists
4.4	Basic food hygiene and training of market vendors	• Adherence to good food hygiene practices • Training strategies • Practical hands-on training • Health promotion activities
4.5	Safe and healthy food	• Improvement of availability and access to safe and healthy food • Promotion of local production and short supply chains • Guidelines for safe and healthy food preparation
4.6	Health promotion and communication	• Health communication strategies • Nutrition and food safety promotion • Correctly labelled food, in accordance with Codex standards and guidelines
4.7	Procedures for emergency response	• Clear description of roles and responsibilities for emergency response • Traceability and recall procedures • Procedures for communication between government agencies, market authorities, market vendors and consumers

4.1 Basic infrastructure

The physical layout, facilities and organization of traditional food markets provide the basis for promoting safe and healthy food, improving occupational health, and reducing the risk of transmission of foodborne and zoonotic diseases. Basic infrastructure includes an adequate water supply (safety, quantity and pressure) for cleaning and food preparation, appropriately designed drainage, and a sufficient number of appropriately placed toilets with designated hand-washing facilities. Basic infrastructure also encompasses facilities for appropriate solid and liquid waste management, amenities such as rest areas, changing rooms and designated eating areas, and adequate light and ventilation. Maintenance and cleaning programmes, fire control, and use of proper building materials are other important components of basic market infrastructure.

It is important that markets are organized and structured in such a way that, if live animals are kept and slaughtered in the market, they are kept away from areas to which the public has access. Typical high-risk areas for transmission of pathogens in traditional food markets are locations where live animals are kept or caged and slaughtered. The slaughtering process, during which people may be exposed to body fluids, faeces and other animal waste, is of particularly high risk for transmission of zoonotic diseases and poor occupational health.

Measures to reduce the risk of transmission of zoonotic diseases include phasing out live animal marketing and slaughter in proximity to the public and physically separating such activities from other parts of the market. Slaughter and dressing should be carried out in separate facilities under the control of the official veterinary service for ante- and post-mortem inspections and with good hygiene and sanitation standards for workers and animals.

4.2 Appropriate legal basis

Evidence-based food policy and legal frameworks underpinned by effective food control management and consistent compliance and enforcement are pivotal in promoting safe and healthy food in traditional food markets. Food laws and regulations are essential to create an enabling and predictable environment for food production, preparation and sale. The legal basis for safe and healthy food in traditional food markets must determine the legal obligations for managing food safety and nutrition risks, define the roles and responsibilities of the stakeholders involved, adopt risk-based approaches, and allow for legal updates and amendments as circumstances change and new food and nutrition issues emerge.

Food legislation must be based on international standards and recommendations such as *Codex Alimentarius*, apply to all steps of the food chain, and be based on the best available scientific evidence and risk assessments. Such legislation should include strict biosecurity measures to prevent the introduction or spread of infectious and zoonotic diseases. Veterinary public health authorities should provide appropriate monitoring and control of any live animals and animal slaughtering in the market.

Food regulations must be developed through a comprehensive and consultative process, involving all concerned stakeholders, and should be managed and communicated appropriately. It is important that market vendors and consumers

are aware of the legal requirements pertaining to safe and healthy food in traditional food markets and have the necessary capacity and means to implement them.

The legal basis for safe and healthy food in traditional food markets should also include regulations that address issues related to nutrition and diet-related noncommunicable diseases. These may include regulations to control advertising and marketing of foods/beverages high in fat, sugar and/or salt to children, restrictions or thresholds for sodium in ready-to-eat food, elimination of the use of industrially produced *trans* fats, and measures for food labelling, including health and nutrition claims.

Developing and updating food laws, regulations and standards is typically the responsibility of national or subnational governments. However, there are also opportunities for local authorities and market managers to develop and implement standards that apply to specific markets or parts of markets.

4.3 Risk-based inspection and enforcement services

Risk-based food inspection protects consumers by ensuring that food in the market is handled, stored, manufactured, transported, prepared and sold in accordance with applicable legal requirements for food safety and nutrition.

Food business operators have the primary responsibility to ensure food safety and comply with the regulations applicable to the market. The role of the government and market authorities is to enact food laws and regulations and to verify compliance through enforcement actions. Food inspection is central to the enforcement process and a vital component of a national food safety system.

Risk-based food inspection aims to prevent food safety incidents and instances of non-compliance by identifying risk factors and assessing the effectiveness of the control measures in place. Effective risk-based food inspection follows a clear risk-based food inspection plan, is well coordinated across food inspection agencies, and has adequate human and financial resources. Other aspects of risk-based food inspection include registries of food businesses, models for risk categorization of food products and businesses, inspection record systems, risk-based inspection guidelines and checklists, and mechanisms for review and learning for continuous improvements.

It is important that food and veterinary inspectors are qualified and well trained for the job and free from any conflict of interests. They must undertake their duties competently and independently in order to perform food controls in a consistent manner. Specific training programmes should be developed for food and veterinary inspectors who are responsible for enforcing regulations in traditional food markets. Annual training plans should be developed, and training records for each inspector should be maintained and kept up to date.

4.4 Basic food hygiene and training of market vendors

Proper handling of food along the entire food supply chain can help to reduce food safety and quality risks. Many risks to food safety and quality and transmission of infectious diseases in traditional food markets cannot be addressed solely by

regulations and enforcement. Behaviour change among stakeholders along the entire food chain and adherence to good food hygiene practices are required.

Training strategies and materials that are developed for training purposes should be appropriate to existing levels of knowledge and awareness and grasp available opportunities to bring about behaviour change. Formal training sessions for market vendors should be tailored to their specific needs and be designed to minimally disrupt busy working schedules.

The WHO Five Keys to Safer Food provide the basic principles of food safety and good food hygiene and explain the basic principles that all individuals should know if they are to prevent foodborne and zoonotic diseases.[31] The Five Keys are:

(1) keep clean

(2) separate raw and cooked food

(3) cook thoroughly

(4) keep food at safe temperatures

(5) use safe water and raw materials.

Personal hygiene and good food handling practices can be coupled with healthy lifestyle interventions such as the promotion of healthy diets and physical activity.

4.5 Safe and healthy food

Traditional food markets serve as an important venue for promoting healthy and sustainable diets. The foods available in these settings should be local and produced in a way that respects principles of seasonality, territorial variety, short supply chains and fair trade.

Policies towards safe and healthy food in markets should target a range of issues, including food production and handling procedures, availability, accessibility and labelling. The offer of safer and healthier foods should be improved in order to nudge consumers to purchase foods with higher nutritional quality in preference to other types of food.[32] To this end, the offer of fruits, vegetables, wholegrains, legumes, nuts and fish should be promoted, whereas the availability of red and processed meat should be limited, as should ultra-processed foods and beverages rich in sugar, salt and/or *trans* fats, such as industrial baked and fried snacks, confectionery, soft drinks and industrial juices. Within ready-to-eat food establishments, such as street food stalls, cafeterias and vending machines, guidelines for safe and healthy food preparation should be adopted to create healthier eating environments. The implementation of discounting strategies for safe and healthy products that might not, at first sight, appeal to consumers (because of their imperfections, short expiry date, etc.) would also promote local, healthy and affordable foods while reducing food loss.[33,34]

4.6 Health promotion and communication

Health promotion through communication is the use of communication strategies to inform people and influence their decisions and actions in order to improve health.[35] As such, health promotion and communication strategies must be integrated into the foundations of all health policies towards safe and healthy food in markets.[36]

Food promotion – the marketing or advertising of food – directly influences consumers' food preferences, nutrition knowledge, diets and health. However, the transformative potential of communication to change people's health and consumption behaviours can happen in either a positive or a negative way. Advertising of ultra-processed foods, which is widely present in society, calls for stronger government regulatory efforts to restrict excessive promotion of unhealthy foods, especially to children and adolescents, and to ensure healthier food environments. This can be achieved by regulating private sector marketing and advertising of foods and drinks (either in the marketplace or through media) while implementing public measures to provide consumers with complete and unbiased information.[2] Food promotion and marketing techniques could also be

A MEAT VENDOR IN A TRADITIONAL FOOD MARKET IN KAZAKHSTAN

used at the point-of-sale level to spread healthy food messaging in traditional food markets (for instance, by means of posters carrying important health and nutrition messages, or signs marking specific shelves with fresh/healthier/local/organic food options) or to encourage purchase of healthier food options (for instance, by introducing tasting activities for unprocessed foods such as fresh fruit and vegetable juices, nuts or wholegrain snacks, etc.).

The effectiveness of health communication strategies is highly dependent on people's ability to understand the message. As such, all health promotion strategies should be developed in a way that takes account of the current health literacy of the local population and their ability to change behaviour. Also, improving consumers' food and nutrition knowledge and awareness is vital if health promotion interventions are to be successful. Food and nutrition education programmes can be implemented at the market level through theoretical and practical group sessions, with themes adapted to the specific needs of the community. Examples include (among others) dietary needs and recommendations; popular misinformation; how to prepare safe and nutritious meals; how to plan and shop for healthy meals; nutritional composition of foods; the association between good nutrition and health; and how to read labels correctly.[37]

Based on the success of the Five Keys to Safer Food, WHO developed the 3 Fives concept, providing simple messages to people on how to improve their health through safer food, healthy diets and physical activity.[38] The 3 Fives provide three sets of five simple messages on how to prepare food safely, what to eat to be healthy, and how to keep moving to stay in good shape (Fig. 3).

In many countries of the WHO European Region, social media has become a pivotal tool for informal communication and rapid exchange of information. Social media and mobile phones provide invaluable opportunities for communicating with the public and promoting healthy lifestyles and should be used proactively to promote safe and healthy food in traditional food markets.

Labelling of prepackaged foods is a useful tool to inform consumers about the composition and origin of a food product and to guide them to make healthy choices. A food label includes information on the ingredients and/or nutritional composition of the food product. The WHO European Region has issued a recommendation that nutrition labelling standards for food products produced and sold in the Region should be harmonized and that such labelling should be made more interpretative and consumer-friendly. Major food industry stakeholders have adhered to such considerations in recent years, while also reformulating food products to reduce the content of sugars, sodium and *trans* fats.[38] In many traditional food markets across the WHO European Region, industrially produced foods are less common than raw and homemade foods* sold by small manufacturers (such as bakeries). Small-scale producers may not have the capacity to comply with applicable food labelling standards and guidelines. Several homemade foods sold in traditional food markets in central Asia and eastern Europe have been identified as high in sodium, saturated fatty acids and *trans* fatty acids.[13–19] In order to make this information accessible to consumers, it is recommended that the labelling of homemade food products available in traditional food markets is brought into compliance with the *Codex Alimentarius* general standards for prepackaged foods.[39]

* Homemade foods are defined as self-prepared food products, either at home or on the street/at the market, even if processed or ultra-processed ingredients (such as oils, sugar and sauces) are used.

The 3 Fives

Five keys to safer food.

- Keep your hands and all surfaces clean
- Separate raw and cooked foods
- Cook thoroughly
- Keep food at safe temperatures
- Use safe water and raw materials

Five keys to a healthy diet.

- Breastfeed for the first six months of life
- Eat a variety of foods
- Eat plenty of vegetables and fruit
- Eat moderate amounts of fats and oils
- Eat less salt and sugars

Five keys to appropriate physical activity.

- Start regular physical activity and reduce sedentary activities
- Be physically active every day in as many ways as you can
- Do at least 150 minutes per week of moderate-intensity physical activity
- If you can, do some regular vigorous-intensity physical activity
- School-aged young people: do at least 60 minutes per day of moderate to vigorous-intensity physical activity

Fig. 3.
WHO's 3 Fives concept to promote safer food, healthier diet and appropriate physical activity

These include the name of the food; ingredients list (including additives and allergens); date marking; name and address of the manufacturer; net content of the food; lot identification; country of origin; and instructions for use and storage of the food. Such labelling would not necessarily be required on the packaging of products sold in bulk, as the information regarding the product may be displayed in another way at the vending site.

The use of digital media in the promotion of healthy and sustainable diets could be another promising and innovative approach, using technology to contribute to health and well-being.[40] An example would be the development of an online platform (such as a website or mobile app) functioning as a health education tool; this could be used to search for health and nutrition topics (such as heart disease or *trans* fatty acids), to seek food vendors meeting certain criteria for a healthy food offer (this could be linked to the "Healthy food" seal; see Box 1), or to learn more about wellness activities within the community. For this tool to work as a real health promoter, such a platform would have to be based on a continuously updated database, with information from certified sources.

Box 1

"Healthy food" seal: an example of health promotion

A possible strategy to promote safe and healthy food products in traditional food markets would be the creation of a "Healthy food" seal to be displayed by market vendors whose food products meet certain predefined standards (use of locally produced and/or healthier ingredients, safe food-handling practices, etc.). Such a strategy would be multifaceted, rewarding food vendors/retailers for complying with safe and healthy food standards while empowering consumers to make healthier food choices. The seal would have the additional benefit of being used in nutrition education/marketing campaigns, and its use could ultimately be extended to a number of stakeholders along the food supply chain.

4.7 Procedures for emergency response

Traditional food markets are vulnerable to emergencies and disasters that could have an impact on the safety and quality of the food they sell or serve to consumers. However, in times of crisis, traditional food markets also serve to enhance food security by providing safe and healthy food to local communities.

Emergencies may include natural disasters, extreme weather events such as flooding and drought, fires, and disease outbreaks. It is important that traditional food markets have plans in place to deal with emergency situations, and emergency response plans must be designed to reflect country-specific considerations and characteristics of the market. These may include the types of food or animals that are sold, the physical location of the market, the customer base, the facilities available and the legal basis for market operations.

An emergency response plan must include a clear description of roles and responsibilities across the various government agencies responsible for the market, as well as the responsibilities of market vendors and workers. It must also include requirements for market vendors to keep records of their suppliers and measures to quickly remove contaminated or potentially contaminated foods from the market if required. Procedures for communication between government agencies, market authorities, market vendors and consumers must be in place, and regulations to close traditional food markets (or specific parts of them), temporarily or permanently, must be adopted and implemented when necessary (for instance, in situations when the market is the origin of the incident or emergency).

5. Stepwise approach to implementation of healthy traditional food market initiatives

Traditional food markets in the WHO European Region are diverse in terms of their organization, layout and food supply, and countries have different means to address food safety and nutrition issues. Efforts to improve food safety and nutrition in traditional food markets must, therefore, be tailored to specific market needs and priorities. Recognizing this diversity, this guidance promotes a stepwise process to assess the current situation, identify food safety and nutrition issues, decide on priorities for improvements, identify necessary interventions, develop an action plan, implement interventions and monitor performance (Fig. 4).

The successful and sustainable implementation of an initiative to promote safe and healthy foods in traditional markets is dependent on the partnership and shared vision of several agents, including local administration and health authorities (and market managers, in the case of private administration), suppliers (such as farmers and transportation/logistics entrepreneurs), vendors, other market workers and consumers. The process should start by defining a multisectoral task force, including at least one representative from each of these groups and preferably a local health authority. The task force should be responsible for detailing needs, prioritizing activities, developing a workplan, mobilizing resources, and facilitating enforcement, monitoring and evaluation.

5.1 Assess the current setup of the market and the extent to which it provides safe and healthy food

To improve food safety and nutrition in traditional food markets, it is necessary to conduct a preliminary assessment of the market and the extent to which it provides safe and healthy food. The initial assessment of the market setup should focus on the infrastructure and operational environment. The information summarized in Table 1 (page 9) should be registered by direct observation and an auxiliary checklist (ideally electronic).

The assessment may be made by means of a survey, consisting of a structured questionnaire or focus group discussions (in person or web-based, defined by the task force), conducted among members of the market community, to identify their concerns and possible solutions from their viewpoints. Local authorities should provide information on the size of markets and, for each market, the number of vending sites and the estimated number of visits daily. This process could be facilitated by the multisectoral task force.

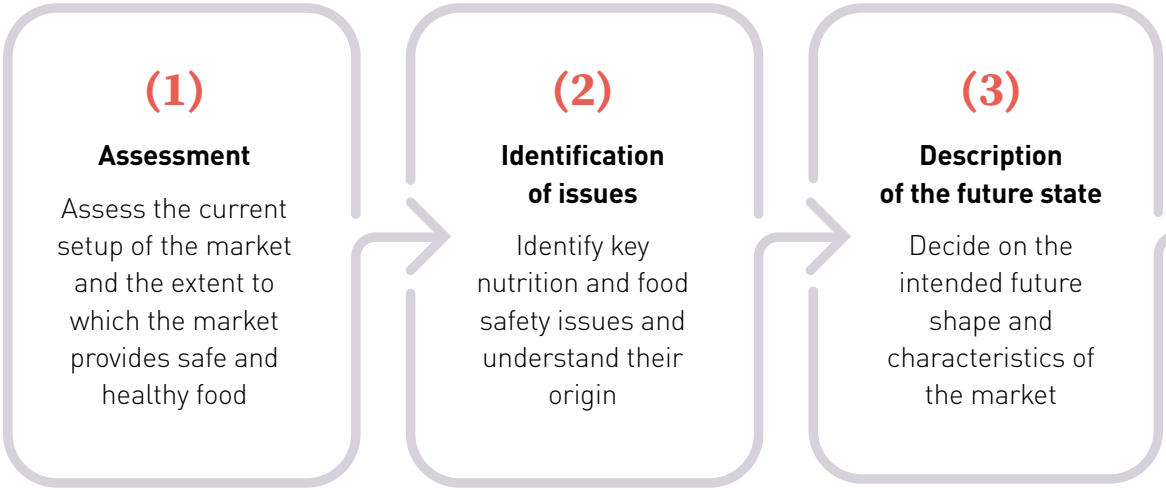


Fig. 4. Stepwise approach to improving food safety and nutrition in traditional food markets

Mapping the existing vending sites and their basic food availability and food safety characteristics is also essential. This could be performed by applying a checklist-based structured questionnaire (ideally electronic).

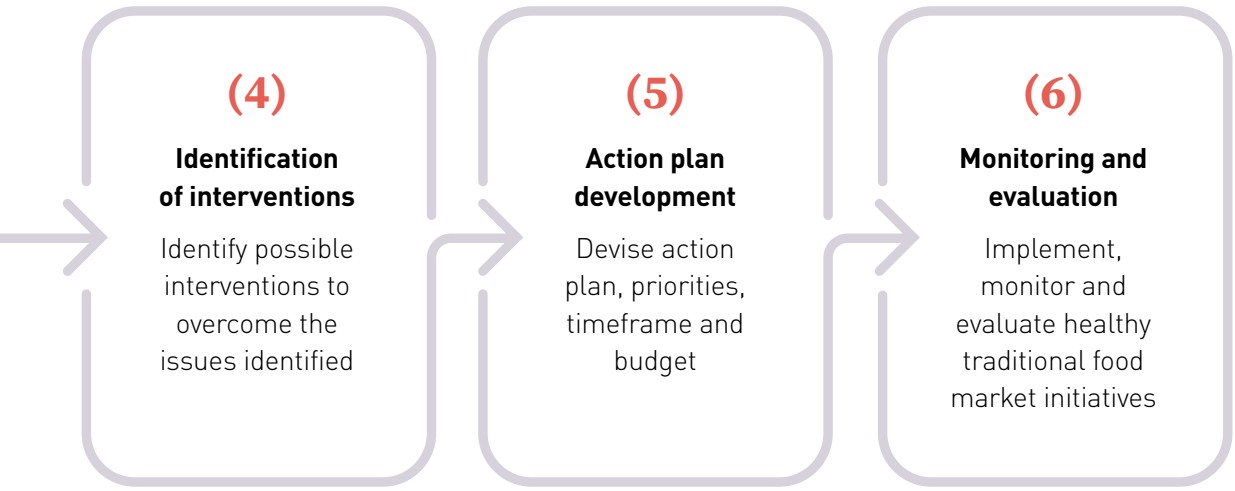
The questionnaire should include a registry of:

1. Vending site and business characteristics
   - 1.1 Typology (mobile versus permanent vending site)
   - 1.2 Type of physical setup (e.g. formal, such as stands, stalls or trucks; informal, such as pushcarts; displaying foods on the floor or freezers; selling soft ice cream or beverages)
   - 1.3 Dimensions
   - 1.4 Number of vendors and other employees
   - 1.5 Operating hours
2. Types of product available (specifying raw, ready-to-eat, homemade and/or industrial)
3. Availability of health promotion materials
4. Availability of basic food safety conditions

The implementation of additional techniques, such as direct observation of food vending and/or purchasing actions, may provide more in-depth information on specific topics.

5.2 Identify key nutrition and food safety issues and understand their origin

The task force should be responsible for evaluating the findings of the assessment, which should then be presented and discussed among all the members of the task force. Then, by adopting a risk-based approach, key food safety and nutrition issues should be identified and prioritized for action.



Regarding nutrition, the main issues to consider should include:

1. Availability and access to different food products, such as fruits and vegetables and other staple foods, ready-to-eat foods (homemade and industrial) and beverages
2. Nutritional composition of the most commonly available foods (*trans* fats, salt, sugar, etc.)
3. Usual practices of food preparation and ingredients used
4. Food and nutrition labelling
5. Food literacy/health promotion
6. Sustainability

From the food safety viewpoint, the main issues to consider should include:

1. Personal hygiene and food-handling practices
2. Temperature control
3. Cleanliness
4. Vending site layout
5. High-risk areas for transmission of communicable diseases
6. Access to clean water and waste management

Additional topics may be considered, according to their local or cultural importance. Some possible nutrition and food safety issues likely to emerge in this step, and their origin, are shown in Annex 1.

5.3 Decide on the intended future shape and characteristics of the market

Based on the initial assessment of the setup of the market, as well as on the identification of the main nutrition and food safety issues and needs, it may be possible to draw initial conclusions about the intended future characteristics of the markets (focus on a timeframe of 1–5 years). A set of recommended/desired market characteristics to improve or implement in the future should

be listed. Brainstorming or other creative thinking techniques, as well as more systematic approaches such as SWOT* analysis, conducted among task force members, might be feasible in this step.

Potential topics to emerge in this step may be related to physical infrastructure, market operating conditions, food environment and health promotion practices, among others. These are described in more detail in the next step (5.4).

5.4 Identify possible interventions to overcome the issues identified

Based on the initial conclusions reached in the previous steps, the task force should determine the interventions to be implemented on both nutrition and food safety fronts, taking into account the most urgent or concerning issues encountered, as well as the objectives to be achieved in future stages. For each intervention, a set of specific measures should be planned, always bearing in mind the specific conditions (needs versus resources) of the market.

Possible interventions may include improvement of the physical environment; monitoring services; accessibility to health services for market workers; safety and nutritional quality of the foods and beverages available; food pricing and labelling regulations; population awareness of topics related to nutrition and food safety; and expansion of market services to cover e-commerce solutions. Examples of possible interventions are shown in Annex 1.

5.5 Devise action plan, priorities, timeframe and budget

The development of a clear, pragmatic and realistic action plan is essential for the success of any initiative to promote safe and healthy food in traditional markets. To this end, a number of features should be considered when designing a work plan: tasks (including description, priority level, specific objectives and person(s) responsible); timeframe; definition of measurable monitoring and evaluation indicators; and resources needed. The action plan should also clearly distinguish between governmental and community-based interventions.

Feasibility must be guaranteed in all aspects of the action plan, both in terms of the amount of work that is planned and the time and resources that are needed. The tasks schedule must be carefully thought out and include a distinction between short-, medium- and long-term actions and a clear definition of the time deadlines proposed for each. When defining the budget, the expenditure predicted for carrying out the various tasks must be balanced against possible sources of financing. Funding of interventions could include grants, loans, financing from nongovernmental organizations, and in-kind contributions, among others.

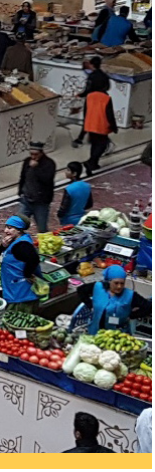
* Strengths, Weaknesses, Opportunities and Threats.

5.6 Implement, monitor and evaluate healthy traditional food market initiatives

Implementation of the planned interventions is a central step that should comply with the work plan and the defined timeline. In this stage, principles such as coordination, cooperation, transparency and frequent communication among all stakeholders are particularly important.

After implementation, it is necessary to monitor and evaluate the progress made. For this, specific milestones should be set for the short, medium and long term. The previously defined indicators for monitoring and evaluation will allow the task force to understand whether the defined objectives are being successfully achieved. The monitoring methodology varies across the different components of the traditional food market to be evaluated. Assessment could be made through direct observation, checklists, interviews based on structured or semi-structured questionnaires, and chemical and/or microbiological analyses of foods, among others. It is the responsibility of the task force to decide, for each objective to be met, on the most cost-effective method(s).

The time and frequency of external monitoring actions (for instance, audits) must be defined depending on each specific objective and what is possible in each setting. Nevertheless, continuous self-monitoring should be carried out by each traditional food market community. Sustainable implementation of initiatives to promote safe and healthy foods in traditional markets should ensure adaptation to ever-changing market needs and consumer expectations. As such, it is essential to empower and encourage each traditional food market community to build an adequate and effective monitoring system.



6. Issues of particular importance to markets in the context of COVID-19

The COVID-19 pandemic has been driven by human-to-human transmission. The virus can spread directly from person to person when someone infected with COVID-19 coughs or sneezes, producing droplets that reach the nose, mouth or eyes of another person. Alternatively, the respiratory droplets can land on objects and surfaces surrounding the infected person. Someone may become infected by touching a contaminated surface or object, or the hand of an infected person, and then touching their mouth, nose or eyes.[41]

There is no evidence that food is implicated in the transmission of COVID-19. Similarly, there is no evidence that the virus responsible for the current COVID-19 pandemic is carried by domestic food-producing animals, such as poultry, pigs, sheep and cattle. However, it is likely that the virus which causes COVID-19 has its origin in wild animals, as it belongs to a group of coronaviruses that are usually found in bat populations.[42]

In some countries in the WHO European Region, traditional food markets offer live animals for sale. These markets pose a particular risk of pathogen transmission from animals to humans, as well as between animals. Typical high-risk areas for transmission of pathogens in traditional food markets are places where live animals are kept or caged and slaughtered. The slaughtering process is also high-risk, as people may be exposed to body fluids, faeces and animal waste.

While the sale and slaughtering of captured live wild animals should be prohibited, the sale of farmed captive wild animals and domestic live animals may be acceptable if animal health and welfare regulations, strict biosecurity measures, and food and meat hygiene standards are strictly followed during production, processing and marketing. Risk reduction requires that animals are sourced from approved, registered and controlled farms and that they are slaughtered in approved facilities which are separated from areas of the market to which the public has access and are subject to risk-based meat inspection.

Traditional food markets are often congested as they gather many people in often small spaces. Physical distancing is very important to help prevent and slow the spread of communicable diseases such as COVID-19. The risk of transmission can be reduced by minimizing contact between people and keeping a physical distance of at least 1 m.

Physical distancing in crowded market settings can be challenging. Possible ways to encourage physical distancing and reduce physical interaction between people include: designing one-way systems so that customers can move between stalls while remaining at least 1 m apart; regulating the number of customers who enter the market to avoid overcrowding; placing alert notices and posters providing practical advice on how to reduce the risks of disease transmission; painting floor markings consistent with physical distancing advice on entry to

the traditional food market; providing hand sanitizers, spray disinfectants, and disposable paper towels at the market entry points; encouraging customers visiting the market to wear face masks to reduce the risk of disease transmission; and introducing plexiglass barriers to physically separate market traders from the public and encouraging the use of contactless payments.

Market workers and the general public visiting traditional food markets need to understand how to prevent the spread of COVID-19. The following actions can help reduce the risk of transmission of COVID-19 and other infectious diseases: good personal hygiene practices, including good hand hygiene and frequent use of alcohol-based hand sanitizers; good respiratory hygiene (covering mouth and nose when coughing or sneezing; disposing of tissues and washing hands); avoiding touching eyes, nose or mouth with hands; frequent cleaning and disinfection of work surfaces; avoiding close contact with anyone showing symptoms of respiratory illness; and avoiding contact with live animals and surfaces potentially contaminated with animal waste.[42]

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ANNEX 1

Examples of possible nutrition and food safety issues in a traditional food market

Issue/risk/challenge	Context	Possible interventions
Nutrition		
High availability of homemade ready-to-eat foods rich in sodium and unhealthy fat content (e.g. saturated and *trans* fatty acids).	• Unhealthy fats and oils, as well as sodium-rich ingredients (e.g. sauces, stocks), traditionally used as ingredients in some local recipes. • Low price of ingredients with high potential to increase palatability. • Methods of preparation (e.g. frying or deep frying, reuse of oils over the accepted limit). • Customer expectation and preference.	**Short term** • Identification of the ingredients most commonly used by food manufacturers. • Nutrition education interventions with vendors and small manufacturers, aiming to: replace the use of ingredients rich in unhealthy fats and sodium by healthier options; promote healthier cooking techniques; increase nutrition literacy and awareness of the harmful effects of excessive consumption of unhealthy fats and sodium. • Incentives to increase vendors' adherence to safe and healthy food standards (e.g. food labelling, economic incentive by providing healthier ingredients at lower cost). • Nutrition education campaigns for consumers at the market or local level, aiming to: increase responsible purchases of healthy foods and beverages; increase nutrition literacy and awareness of the harmful effects of excessive consumption of unhealthy fats and sodium; promote recipes for healthy versions of traditional foods and dishes to cook at home with fresh ingredients available in the market; empower consumers to read and better understand food labels. **Medium and long term** Adapt market regulations: • Reallocate healthy food vending sites to more visible areas of the market.
High availability of highly processed ready-to-eat foods, usually energy-dense, rich in sugar, salt and unhealthy fat.	• Low price. • High customer acceptance/ preference.	**Short term** • Incentives to vendors to display healthier options, such as homemade alternatives prepared with healthier ingredients, as well as ready-to-eat snacking options including fruits, vegetables, nuts, wholegrains and other core foods, using locally produced ingredients (e.g. "Healthy food" seal proposed in Box 1, page 16). • Nutrition education campaigns for consumers to encourage responsible purchases of healthy foods and beverages, improvement of consumers' nutrition literacy and awareness of the harmful effects on health of excessive consumption of highly processed food products. **Medium and long term** Adapt market regulations: • Limit the permitted amount of ultra-processed food products available at each vending site. • Reformulation of food products by the food industry to improve their nutritional profile (e.g. lower energy density, lower content of total fat, saturated and *trans* fatty acids, sugar and sodium).

Issue/risk/challenge	Context	Possible interventions
Weak sale of fresh food products such as fruits and vegetables, leading to food waste.	• Customers' fear of visiting the market and being contaminated with infectious diseases. • High price. • Low consumer awareness about the health benefits of consuming fresh products such as fruits and vegetables.	**Short term** • Public disclosure of the measures taken by local authorities to ensure the safety of vendors, customers and food products, through multiple channels (media, social networks, etc.). • Availability of less appealing fruits and vegetables at lower prices. • Nutrition education campaigns encouraging consumption of fresh products such as fruits and vegetables; improvement of nutrition literacy among consumers. **Short, medium or long term** • Expansion of the market to cover e-commerce solutions (e.g. creation of the market website; integration of a wide range of producers, vendors and interested stakeholders in an online platform allowing online/telephone orders, home deliveries, and mobile vending outside the market premises).
Frequent purchases of sugar-sweetened beverages (SSBs).	• High availability of SSBs. • Customer preference.	**Short term** • Incentives to vendors to display healthier options, such as water and fresh fruit-juice based drinks, using locally produced ingredients (e.g. provision of low-cost mature or "unappealing/ugly" fruits, which regular consumers would not buy). • Nutrition education campaigns for consumers to encourage responsible purchases of healthy foods and beverages; improvement of consumers' nutrition literacy and awareness of the harmful effects on health of excessive consumption of sugary foods and SSBs. **Medium and long term** Adapt market regulations: • Limit the permitted amount of certain types of beverages, such SSBs and alcoholic beverages, available at each vending site. • Reallocate healthy food vending sites to more visible areas of the market.
Food safety		
Risk of cross-contamination between live animals, ready-to-eat food and humans.	• Inappropriate physical infrastructure.	**Short term** • Reallocate vendors according to the types of food products sold. • Separate areas for selling and slaughtering live animals from areas open to the general public. • Implement veterinary supervision of the slaughtering of live animals. • Implement good hygiene and sanitation standards for workers. **Medium and long term** • Provide training for food handlers and market workers. • Provide adequate waste management systems. • Phase out the sale and slaughter of live animals. • Upgrade sanitary facilities (toilets, handwashing), pest control, waste management, drains and sewage.

Issue/risk/challenge	Context	Possible interventions
Risk of transmission with infectious diseases such as COVID-19.	• High concentration of people in small spaces. • Poor understanding of respiratory etiquette and good hygiene practices.	**Short term** • Redesign the circulation of people inside the market (e.g. keeping to the right and following a predefined circuit; specific doors designated for entry and exit). • Implement restrictions on the maximum number of people in the market at the same time, combined with strict monitoring. • Implement measures to spread people out and avoid congregation. • Place warning notices at entry points requesting customers not to enter the market if they have symptoms of COVID-19 or other infectious diseases. • Implement queue control by painting floor markings consistent with physical distancing advice on entry to the traditional food market. • Provide hand sanitizers, spray disinfectants and disposable paper towels at market entry points. • Use floor markings inside the market to facilitate compliance with physical distancing. • Encourage customers visiting the market to wear face masks to reduce the risk of transmission of diseases between infected people. • Introduce plexiglass barriers to physically separate market traders from the public. • Encourage the use of contactless payments. • Encourage market workers to report symptoms of COVID-19 and other infectious diseases to local health authorities and not to enter the market if they feel unwell.
Contamination of fresh produce and ready-to-eat food.	• Poor cleaning and hygiene standards.	**Short term** • Advise the public to wash fruits and vegetables. • Encourage the public and market workers to always strictly observe good personal hygiene practices around open food areas. • Keep food at a safe temperature (i.e. above 60 °C or below 5 °C). • Use safe water and raw materials. • Separate raw and cooked food.
Limited knowledge and awareness of food safety and risks of food contamination.	• Market workers with limited or no training in food safety.	**Short term** • Implement simple food safety training sessions for market workers and stall holders in line with the WHO Five Keys to Safer Food, which minimally disrupt busy working schedules. • Tailor simple and easily understood information messages for dissemination via a number of different platforms, including social media and mobile phones, to encourage behavioural changes. **Medium and long term** • Develop education strategies and materials for food handlers and consumers consistent with existing levels of awareness. • Develop and implement communication and training programmes aimed at reducing the risk of disease transmission in a low-cost and sustainable manner and adapted to local context.
Weak and inconsistent legal framework for food safety in traditional food markets.	• Outdated and/or inconsistent food laws, regulations and standards across sectors.	**Short term** • Prepare and implement preliminary measures for food handling, preparation and sale in traditional food markets. **Medium and long term** • Review the legal framework for food safety pertaining to traditional food markets and identify gaps and inconsistencies. • Develop, adopt and implement legal measures for nutrition and food safety risk management in traditional food markets in line with *Codex Alimentarius* and applicable national regulations and standards.

Issue/risk/challenge	Context	Possible interventions
Weak enforcement of food safety regulatory requirements.	• Limited knowledge and skills of food inspectors and market authorities in conducting risk-based food inspection activities.	**Short term** • Allocate adequate resources to implement risk-based food inspection activities in the market. • Establish a registry of food businesses in the market and categorize them according to food safety and non-compliance risk. • Establish an inspection record system and use it as a basis for conducting risk-based food inspection activities. • Develop guidelines and checklists for use by food inspectors in traditional food markets. **Medium and long term** • Develop and implement clear procedures for risk-based food inspection activities in traditional food markets. • Develop and implement training programmes for food and veterinary inspectors. • Develop training plans and maintain training records for all food inspectors.
Poor management of food safety incidents and emergencies.	• No food safety emergency plans and procedures in place.	**Short term** • Develop and test procedures for recalling and withdrawing contaminated and potentially contaminated food from traditional food markets. **Medium and long term** • Develop and test tailored food safety emergency response plans as part of broader emergency and disaster preparedness and response plans. • Develop and test procedures for communication between market vendors, market authorities and health authorities in cases of food safety incidents and emergencies.

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