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# Assessing diet in European populations using national dietary surveys

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The WHO encourages countries to conduct national dietary surveys (NDS) to inform preventative policies targeting malnutrition and noncommunicable diseases. Previous reviews have found inadequate nutrient intakes and survey provision across Europe. This research is the first to provide an updated review of NDS provision within the whole WHO European Region, across the lifecourse, with reference to disadvantaged groups, obesity and nutrients of concern. Over a third of WHO European countries, mainly Central and Eastern European countries (CEEC), had no identifiable NDS. Where countries reported nutrient intakes, poor WHO recommended nutrient intake attainment was Europe-wide across the lifecourse, particularly in CEEC. Lower educated individuals had poorer diet quality. However, heterogeneity in age group sampled, dietary assessment method, nutrient composition database and under-reporting hindered inter-country comparisons. Average population *trans* fatty acid intakes below WHO recommended limits may hide inequalities in disadvantaged groups; legislative bans may help alleviate this. There were few associations between NDS-derived consumed food portion size (FPS) and BMI. However, consumed FPS was greater than on-pack serving-size in the majority of foods studied. This review illustrates how NDS can generate information on diet, nutrient intakes and the food environment. However, to enable valid inter-country comparisons, countries should be encouraged to conduct and report harmonised NDS, particularly in the age groups sampled, dietary assessment methodology, nutrient range, underpinning food composition database and treatment of under-reporters. This will aid effective, coordinated policy development that can have a real impact on dietary improvement, on a population and subgroup level, throughout Europe.

**National dietary surveys: Nutrient intakes: *Trans* fatty acids: Portion sizes: WHO Europe: Nutritional epidemiology**

Noncommunicable diseases (NCD) represent a pressing global health burden. It is expected that by 2020 almost 75 % of all deaths worldwide and 60 % of all disability-adjusted life years will be attributed to chronic diseases. This is particularly the case in the WHO European region, where NCD are the largest cause of

**Abbreviations:** CEEC, Central and Eastern European countries; FPS, food portion size; GDP, gross domestic product; NCD, noncommunicable disease; NDS, national dietary surveys; RNI, recommended nutrient intake; TFA, *trans* fatty acid.
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disability and death[1]. Poor diet is a major behavioural risk factor for NCD[2], which, alongside related conditions such as overweight and obesity have significant and growing economic and social costs[1].

Obesity is one of the biggest health problems facing the European population. In forty-six countries (87 %) of the WHO European Region >50 % adults are overweight or obese, and obesity in the more economically disadvantaged Central and Eastern European countries (CEEC) has more than tripled since 1980[1]. Evidence links childhood overweight and obesity to chronic disease[3,4] and to an increased likelihood of these conditions in adulthood[5,6]. The WHO[1] therefore states that 'energy dense, micronutrient poor foods' high in energy, saturated fats, *trans* fats, sugar and salt should be limited for a healthy diet throughout the lifecourse.

Diet improvement across Europe is therefore needed. This is addressed by the WHO 'Best Buys' interventions[7], which include *trans* fatty acid (TFA) elimination and food portion size (FPS) reduction. National dietary surveys (NDS) assess food and nutrient intakes of whole diets at an individual level in a sample that is representative of the national population. The WHO explicitly encourages member states to strengthen and expand nationally representative diet and nutrition surveys[1]. They form a crucial part of the regular monitoring required to ensure interventions are successfully implemented and to facilitate healthy dietary patterns and nutrient intakes in European populations. NDS can also identify areas of concern and inequality and evaluate policy impact, thereby contributing to the promotion of best practice across the region[1].

This review aims to highlight where NDS provision is lacking, thereby demonstrating where efforts should be focused to fill knowledge gaps. It will assess adult and child nutrient intakes against WHO recommended nutrient intakes (RNI) to investigate areas of need. NDS will be used to investigate potential socioeconomic inequalities across Europe, both on a broader diet quality level and focusing on TFA as a nutrient of concern. NDS will then be used to determine consumed portion sizes in commonly consumed energy-dense snack foods in two case study countries, to address potential associations with BMI and consequently obesity. Consumed portion sizes will be compared to UK on-pack serving sizes to explore whether the policy is required to amend on-pack serving-sizes to limit excess energy intake and consequently obesity. This will be the first review of NDS provision within the whole WHO European Region, across the lifecourse, with reference to disadvantaged groups, obesity and nutrients of concern.

## National dietary surveys

Without clear, consistent and widespread provision of NDS, nutrient intakes cannot be determined, at-risk groups cannot be identified nor health inequalities assessed and prevented. Previous NDS reviews have different strengths and limitations. For example, Micha *et al.*[8] do not examine whole diets or differences between surveys; Novakovic *et al.*[9] and Mensink *et al.*[10] focus on micronutrients only; Merten *et al.*[11] limit their review to Western Europe, and all include some regional surveys in addition to nationally representative dietary surveys. Our research addresses the need for a complete, updated review of NDS across the lifecourse and the whole WHO European Region.

Methods of identifying and accessing NDS, and for extracting and presenting survey characteristics and estimated energy and nutrient intakes by age group and sex, have been reported[12–14]. A total of 111 NDS were found across thirty four (out of fifty three) countries; forty three NDS surveyed adults, twenty two surveyed children and forty six included both. Most used either 24 h recall or food diary methodologies[12]. Adult energy and nutrient intakes (excluding supplements) were extracted from twenty one surveys across twenty one countries and child nutrient intakes from twenty one surveys across eighteen countries from three regions: Northern, Western and Central & Eastern Europe. Over a third (*n* 19) of countries, mainly CEEC, had no identifiable nationally representative survey[12–14]. This fits with other literature; Novakovic *et al.*[9] examined selected micronutrient intakes in CEEC compared to other European countries and found that CEEC lacked intake data across all ages. This is concerning, as nutrition policies in these countries may therefore lack an appropriate evidence base.

See Supplementary material S1 for all nutrients extracted from NDS summary reports where possible. Of the twenty one surveys where intakes were extracted for adults and children, energy, macro and micronutrients were generally well reported and there were no apparent regional patterns in nutrient intake gaps. This provides a good basis for assessing population status and identifying vulnerable sex/age groups in these countries. The biggest reporting gaps in macronutrient provision were TFA, *n*-3 and *n*-6 fatty acids, iodine and sugar, the latter particularly in CEEC, which have been identified as nutrients of concern[1,15]. Only a third (*n* 7) of NDS from which nutrient intakes were extracted reported intakes by the socioeconomic group[13,14]. This has implications for developing policies for vulnerable population subgroups who may be at greater risk of nutrition-related issues.

Men were more likely than women to have elevated energy intakes. In two thirds of countries adult men of all ages exceeded UK energy reference intakes compared to just 10 % for women[13]. Whether this is due to real differences, or to under-reporting or other factors, is an area for further investigation. In children and adolescents, boys and older children generally had higher intakes[14].

Attainment of the WHO macronutrient RNI[16] was generally poor for both sexes across the lifecourse in all regions and marginally worse in CEEC. No adult and few children mean intakes met the carbohydrate or added sugar RNI and few countries met the fibre RNI at any age. This puts a large proportion of individuals at greater risk of the weight gain and associated risks linked to high sugar and low complex carbohydrate consumption. This is particularly concerning in children and adolescents, as over 60 % of children who are overweight

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before puberty are likely to remain so in adulthood[17]. The majority of countries also exceeded the total and saturated fat RNI (Fig. 1), which could lead to greater levels of NCD such as CHD[18].

Micronutrient RNI attainment was better than that of macronutrients, but concerning shortcomings remained for adults and children, particularly in CEEC. In children no country met the sodium RNI in any age/sex group, and only two countries (France and Portugal) met the vitamin D RNI, which raises concern about rickets, as well as other bone, muscle and immune functions[19]. Given the role of sunlight on vitamin D, future work could consider how geographical area and climate may be linked to RNI attainment. Total folate was lacking in adults, which is particularly concerning for women of reproductive age, due to the preventative effect of folate on neural tube defects in babies[20]. There were notable deficiencies in iron in older girls and women[14] (Fig. 2). This has implications for iron-deficiency anaemia and reduced intellectual, immune and other metabolic functions[21].

Low RNI attainment suggests that nutritional issues are prevalent across all European regions and age groups, although not necessarily to the same degree in each nutrient. The policy is therefore needed to support optimal macro and micronutrient intakes across the life-course and across Europe. For example, product reformulation to reduce the salt content of foods, food fortification and increased use of wholegrain in commercially available products.

However, heterogeneity between surveys made inter-country comparisons difficult. Age groups sampled, dietary assessment methodology employed and the range of nutrients covered were not consistent across countries[13]. In addition, the nutrient composition databases underpinning the surveys varied in their completeness, how often they are updated and how they reflect national fortification practices. Treatment of under-reporters also varied; most surveys either included under-reporters or did not specify[14]. This creates uncertainty as to whether differences in nutrient intakes are due to survey heterogeneity or a genuine intake disparity. The difficulties posed by the lack of comparability highlight the pressing need for harmonisation of methodologies and approaches. This would enable greater accuracy of inter-country comparisons on both a population level and in population groups based on sex and other characteristics. Future research could explore how these differences impact on reported intake levels across Member States.

Ongoing attempts to harmonise NDS to better facilitate intake comparisons demonstrate their importance. Although its primary motivation is exposure assessment rather than dietary improvement, gaining quality, harmonised food consumption data across Europe is one of the European Food Safety Authority's primary long-term objectives[22]. However, to produce reliable data, NDS must also be conducted regularly, so must be sustainable. Tuffrey[23] concluded that sustainability depended heavily on cost, and the scale of conducting NDS can have a heavy time and financial burden. New technologies could help mitigate this; web-based, self-administered dietary assessments such as myfood24 can reduce data entry expense and allow data collection for large numbers on multiple days over different time periods[24]. These technologies could encourage countries that lack NDS, particularly CEEC, to undertake them. This would increase the amount of dietary data available across Europe, directly contributing to the WHO objective of strengthening and expanding nationally representative diet and nutrition surveys[1].

## Nutrient intakes by socioeconomic group

This review has thus far dealt with NDS provision and nutrient intakes taken from the accompanying summary reports. However, despite evidence that higher national income is associated with better diet quality[25], few WHO Member States report intakes by the socioeconomic group[13,14], which is required to monitor potential health inequalities[1]. Analysis of raw data would enable stratified analyses of nutrient intakes by socioeconomic indicators, allowing inequalities to be assessed and potentially vulnerable subgroups to be identified. In an extension of work done on NDS and reported nutrient intakes[12–14], we investigated potential within and between-country socioeconomic inequalities through measures of individual-level education and country-level gross domestic product (GDP) in de novo data from 12 European countries[26].

For the 12 countries for which raw NDS datasets could be obtained, mean daily nutrient intakes for selected nutrients were weighted, age-standardised and plotted against GDP ($) per capita[27,28], to compare nutrient intake and assess any patterns by national income. These nutrient intakes were also assessed by education, used here and more widely in the literature[2,29,30] as a proxy for individual socioeconomic status.

Initial analyses show that individual-level socioeconomic inequalities were evident, as adults with less education generally had lower micronutrient and higher macronutrient intakes. This could potentially be explained by the association between higher socioeconomic status and better diet quality and nutrition knowledge[29,31]. This is further evidenced in the literature. Hiza *et al.*[32] found that American adults in the highest education and income groups had a higher diet quality score than lower groups. Darmon and Drewnowski[29] also found that food consumption patterns in higher socioeconomic groups demonstrated higher diet quality, particularly for micronutrients. This may be driven by diet costs, as lower educated individuals may have lower paid occupations[33], resulting in less income to spend on more expensive, higher quality diets. These groups may also have less nutrition knowledge and be less able to apply such knowledge with limited budgets[34].

Education was the best available indicator for individual socioeconomic status. However, having greater education or nutrition knowledge does not guarantee that individuals will choose healthier options. As when using nutrient intakes from NDS summary reports,

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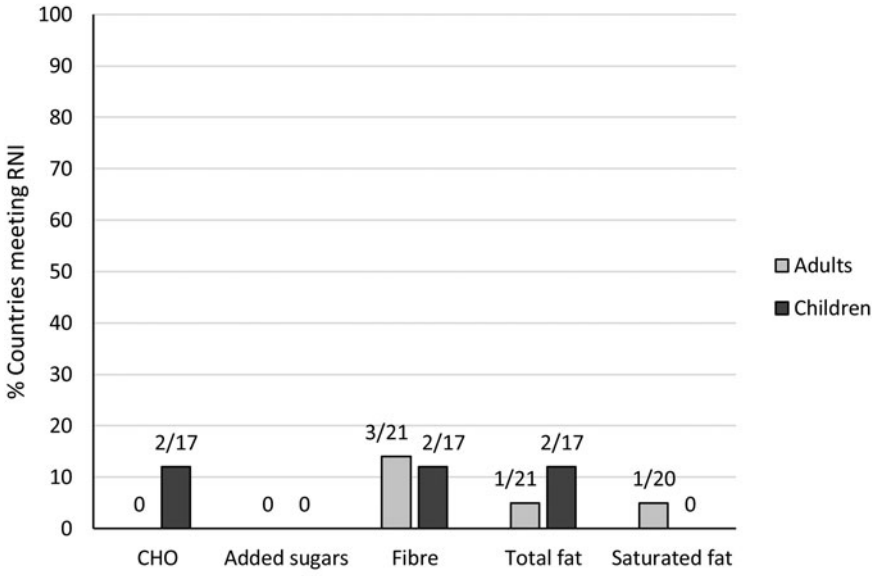


| Nutrient | WHO RNI |
|---|---|
| Carbohydrate | 55-75 %E |
| Added Sugars | 5-10 %E |
| Fibre | >=25g |
| Total fat | 15-30 %E |
| Saturated fat | <10 %E |

**Fig. 1.** Percentage of countries meeting WHO macronutrient recommended nutrient intakes (RNI), where reported, in at least one age/sex group[13,14].

differential under-reporting across WHO European Member States means that the data do not necessarily reflect true intakes, which has future policy implications. In addition, not all countries' databases will necessarily be equally comprehensive or up-to-date, meaning some mean nutrient intake values may be less accurate. Even assuming full accuracy, values are based on a composite sample of a limited selection of foods that may not include foods typically consumed by population subgroups. These groups may therefore have intakes higher than the population average, hiding potential health inequalities.

Lower GDP countries had lower mean micronutrient intakes, and both lower and higher GDP countries had similarly high energy and macronutrient intakes. This could result in accelerating NCD levels in lower GDP countries, making policy interventions imperative. This is demonstrated in TFA intakes; although Kazakhstan met the WHO <1 %E recommendation, it had the highest mean % energy from TFA, and until 2018, had no TFA-reduction strategy[35].

Our analyses highlight the need for better harmonisation of and access to NDS data to further explore nutrient intakes in disadvantaged groups across Europe. This cannot be done using summary reports alone, as not all surveys report on socioeconomic status, or even education[13].

### *Trans* fatty acids

TFA provide a nutrient-specific example of the importance of assessing nutrient intakes by socioeconomic status. The WHO calls for a 'virtual elimination' of TFA, which has been described as one of the simplest public health measures to improve diet and reduce NCD risk[1]. Elevated TFA intake is estimated to cause over 500 000 deaths globally each year, and for every 2 % total energy gained from TFA there is a corresponding 2 % increase in CHD incidence[36]. However, lower socioeconomic groups are disproportionately affected by obesity and NCD[1]. Pearson-Stuttard *et al.*[37] estimated that a 1 % reduction in TFA of daily energy intake would result in five times fewer deaths and six times more life years in the most deprived quintile than the most affluent.

Although NDS may show mean TFA intakes that are compliant with WHO recommendations, these population averages could overshadow subgroup inequalities. For

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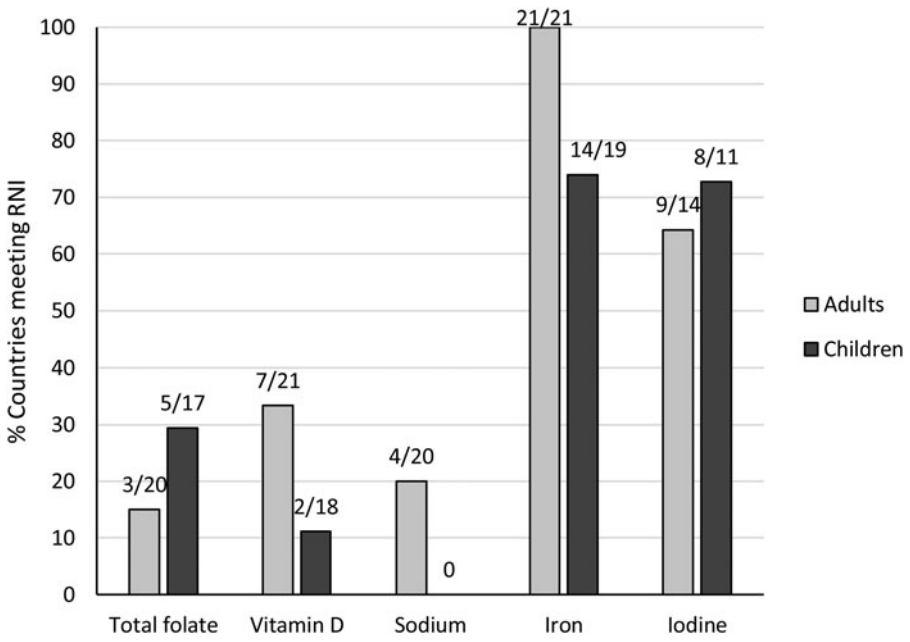


**Fig. 2.** Percentage of countries meeting WHO micronutrient recommended nutrient intake (RNI), where reported, in at least one age/sex group[13,14].

example, the 2007 UK Low Income Diet and Nutrition Survey showed the most deprived groups having higher intakes of processed foods, a known TFA source[38]. Stender *et al.*[39] conducted market basket investigations of TFA levels in baked goods across twenty European countries. They concluded that TFA were present in popular foods across Europe and that lower income and ethnic minority groups were at greater risk of high TFA exposure and therefore had elevated NCD risk.

All countries whose NDS reported TFA intakes showed average population intakes below the <1 % WHO limit (Fig. 3). This has been achieved in the Netherlands and UK via successful national voluntary reduction programmes[40]. The top 10 % UK TFA consumers had a more ruminant based TFA profile, whereas Dutch high consumers obtained TFA from artificial as well as ruminant sources (see Supplementary material S2). However, TFA intakes in both countries may be underestimated due to under-reporting and limitations regarding food composition databases, which may not have fully updated or complete TFA information. In addition, food composition database TFA values are based on averages of a limited range of popular foods from large retailers, but lower income groups or ethnic minorities may consume more non-reformulated, low budget foods potentially higher in TFA. Therefore, inequalities in TFA consumption cannot be ruled out.

TFA provide a good illustration of the use of NDS in assessing nutrition policy impact across the WHO European Member States. Where reported, TFA intakes can be cross-checked against national TFA-reduction strategies, or lack thereof. This information provides a starting point for exploring how well reduction strategies work and whether further action is needed to improve population health. The main TFA-reduction strategies adopted across Europe are legislative bans and voluntary reduction. Mandatory labelling of TFA is not permitted within the European Union, but is an option for non-European Union countries. Their effectiveness should be measured not only by national TFA intake levels, but by how well they target all TFA-containing products regardless of price-point, and the impact on all socioeconomic groups. This may also differ across different countries. Although TFA content has decreased substantially in Western Europe, the same trend has not necessarily been seen in CEEC. Voluntary reduction policies appear successful in the Netherlands and UK[40], but the Netherlands may be an atypical example, as the country has a successful history of tackling social problems via collaboration, which other countries may not share[41]. Zupanic *et al.*[42] findings support this; voluntary reformulation and public education on the risks related to TFA consumption impacted upon, but did not eradicate, TFA-containing partially hydrogenated oil levels in the Slovenian food supply.

Voluntary agreements do not include all products in the food supply; those outside the agreements may remain high in TFA, resulting in a price differential and widening health inequalities. Legislative measures are the WHO-preferred TFA-reduction strategy[35], alongside a suite of accompanying sector-specific measures. In 2004 Denmark became the first country globally to introduce a legislative TFA ban, which all but eradicated TFA from the food supply and led to a reduction in deaths from CVD by 14·2 deaths per 100 000 per year in the 3 years after the policy was implemented[43]. Legislative TFA reduction also appears favourable from a cost-benefit perspective[44]. Other European countries have since implemented legislative bans, demonstrating the feasibility of removing TFA from the food supply for the whole population, with no apparent negative consequences for consumers.

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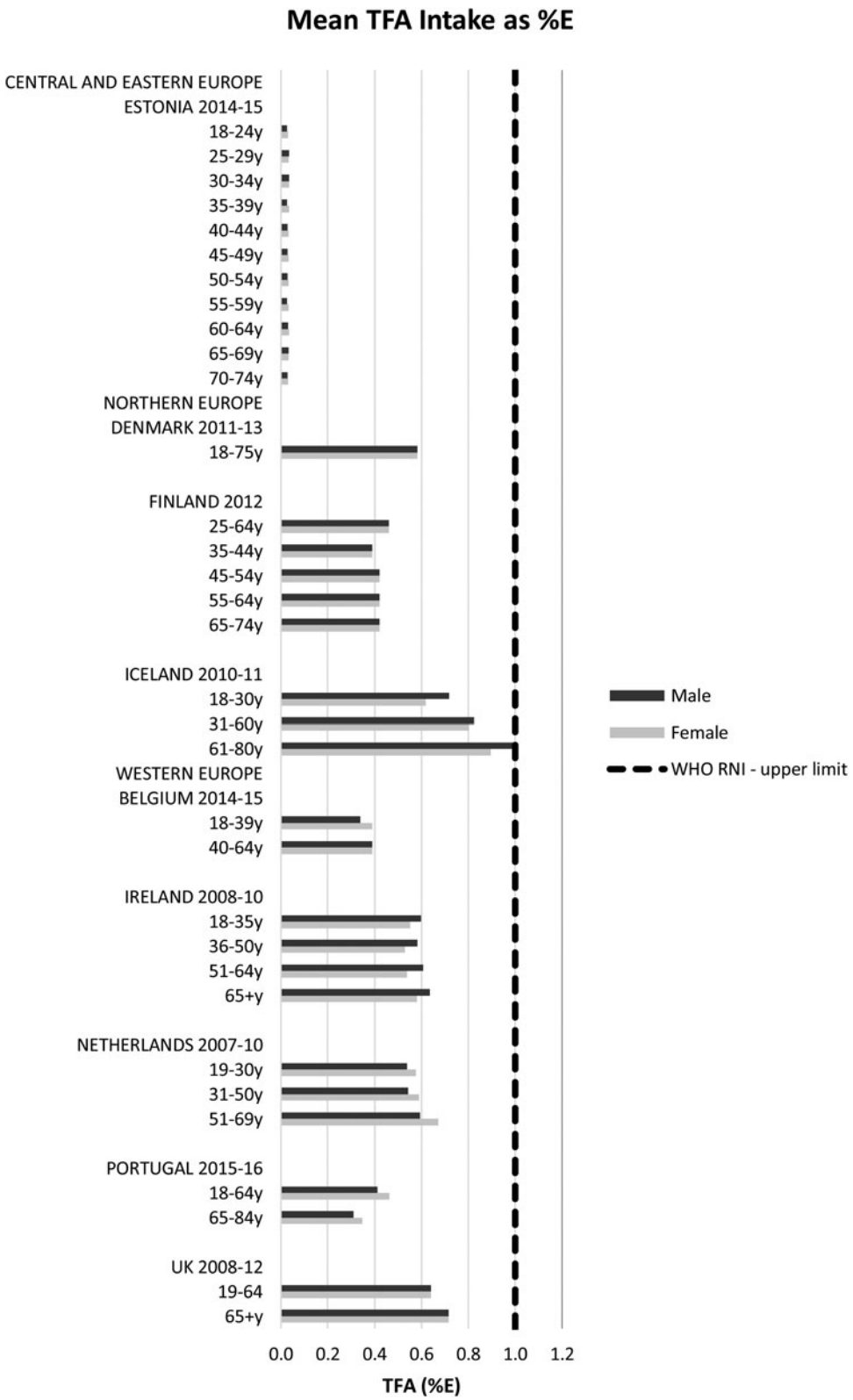


**Fig. 3.** Mean adult *trans* fatty acid (TFA) intake (as a % of energy) (excluding supplements)[13]. RNI, recommended nutrient intake.

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## Portion sizes

Whilst NDS-derived nutrient intakes provide a high-level view of a country's nutritional situation, information on the amounts and types of foods consumed is also useful. The accuracy of food and nutrient intake measurements in NDS is limited by portion size estimates, which could lead to incorrect associations between diet and NCD[45].

Experimental literature suggests a 'portion size effect', where consumption increases when individuals are exposed to larger portions[46–48]. However, this association is not necessarily linear. Zlatevska *et al.*[49] found that overall energy intake increased by 35 % when the offered serving size was doubled, and this was not uniform across all population groups. Positive associations between BMI and portion size have also been found in children. Albar *et al.*[50] found that BMI increased in UK adolescents with every extra 10 g biscuits and cakes consumed. Lioret *et al.*[51] found similar positive associations in croissants and sweetened pastries in French children.

There are policy implications of portion size changes. Marteau *et al.*[52] found that removing large portions from the food environment could reduce energy intake by 12–16 % in UK adults, which could help tackle obesity. However, they claim current policy does not adequately reflect this, and recommend reducing default portion sizes and making larger portions less readily available[52].

Packaging and product format affects portion size estimation accuracy[45], but few studies consider consumed portion sizes in the context of manufacturer-set on-pack serving sizes. Hieke *et al.*[46] studied six European countries and identified a 'pack size effect', where larger packs resulted in larger portion size estimates. Therefore, smaller pack sizes could therefore help reduce consumption and obesity. However, further research is needed. The Bucher *et al.*[53] systematic review on associations between on-pack serving size and consumed portion size only found five studies, with inconclusive outcomes.

Herman *et al.*[54] challenge the view that larger portion sizes are a primary factor in the obesity epidemic. They state that much of the evidence for larger portion sizes increasing energy intake is tested in a single day and cite frequency of consumption as an equally contributory factor. However, Kelly *et al.*[55] investigated whether different portion sizes of pre-packed foods influenced food consumption and energy intake over 4 days. They found that food consumption and energy intake was significantly higher in the larger portion condition, with little evidence of compensation. Others are similarly divided over the relative impact of portion size and consumption frequency on energy intake. Hartmann *et al.*[56] found no association between snacking frequency and BMI in Swiss adults, whilst both O'Connor *et al.*[57] and Murakami & Livingstone[58] concluded that consumption frequency was associated with measures of adiposity in some cases.

Due to this lack of consensus, we examined associations between consumption frequency and BMI in addition to portion size to gain a fuller picture and to better inform policy development. Using the 2005–2007 French Étude Individuelle Nationale des Consommations Alimentaires 2[59] and UK National Diet and Nutrition Survey years 1–4 and 5–6 (2008–2012 and 2012–2014)[60,61], we analysed consumed FPS for selected energy-dense food groups in relation to BMI in adults aged 19–64 years. Commonly consumed energy, fat and sugar-dense food groups were identified in the UK National Diet and Nutrition Survey and split on the food item level into product-based subgroups[62].

There were very few significant associations between FPS and BMI in the energy-dense food subgroups and only the French Cakes main food group had a significant association, where adults with higher BMI reported consuming larger FPS. However, the extent to which this is a valid finding or one resulting from methodological limitations and misreporting cannot be fully determined. Consumption frequency had a small negative association with BMI in Cakes and Chocolate, and in Chocolate after excluding under-reporters[62]. Whilst unexpected, this highlights the difficulties presented by under-reporting and other limitations with the cross-sectional data, including differences in dietary assessment methodology and consumption frequency definitions[58].

The consumed FPS information generated from these analyses adds to the body of knowledge that may help inform investigations into portion size policies and on-pack serving sizes. Despite on-pack serving-size reduction forming part of the UK's ongoing energy-reduction drive[63,64], portion size guidelines have not been updated in the UK in over two decades[65].

Evidence suggests that UK on-pack serving-sizes, which are set by manufacturers, have increased in some energy dense food categories[65–67]. However, even if on-pack serving-sizes decreased, it is not clear how this would impact purchase and consumption. Individuals may consume multiple smaller portions, thus maintaining or potentially increasing energy and nutrient intake. A recent review[53] found that the effects of on-pack serving size labelling on consumed portion size remained unclear, but that there was a clear need for consistent terminology, consumer education and further research. We explored these issues by reporting the average manufacturer-set on-pack serving-size of frequently consumed energy, fat and sugar-dense snack food types in the UK and comparing these with consumed portion sizes derived from the UK National Diet and Nutrition Survey[68].

In all four main food groups studied, over 90 % of products had pack-size information, but in the Chocolate group only 35 % products had available on-pack serving-size, rising to 79 % for the Crisps category[68]. The lack of on-pack serving-size guidance is therefore a widespread issue, particularly in certain energy-dense foods. Without on-pack serving-size information consumers may substitute pack-size as a unit of consumption, resulting in over-consumption and excess energy intake[68].

The consumed portion size was higher than on-pack serving-size in all four main food groups and the majority of subgroups studied (see Supplementary material S3 and Fig. 4 for a single category example)[68]. The greatest

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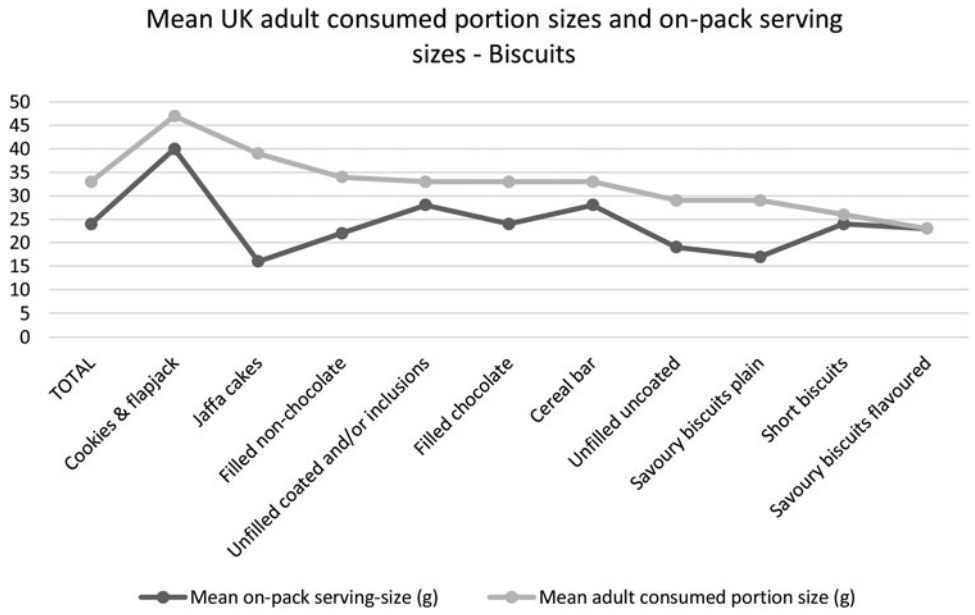


**Fig. 4.** Mean adult consumed portion sizes and on-pack serving sizes – Biscuits[68].

difference was in 'Popcorn' at 151 %, which equates to an extra 240 kcal, 11 g sugar, 10·2 g fat, 2·5 g saturated fat and 0·48 g more salt consumed than if consumers adhered to the recommended on-pack serving-size (see Supplementary material S3). This suggests that consumers are eating more than the on-pack serving-size, possibly consuming multiple single-serve packs in one eating occasion. There is also evidence that increasing on-pack serving-sizes may normalise larger portion sizes, leading to overconsumption in home-prepared meals[4]. This demonstrates the need for policies to set product pack and serving-sizes that help individuals consume smaller portions across their diets.

On-pack serving sizes that better reflect consumed portion sizes may enable people to more accurately judge their energy intake and therefore avoid over-consumption. However, Dallas *et al.*[69] found that consumers wrongly believed that on-pack serving sizes referred to the amount to be consumed for a healthy diet rather than a typically consumed portion size. This suggests that although outdated UK government guidance may no longer reflect currently consumed portion sizes, careful consideration is needed before embarking on policy development to update this. Increasing on-pack serving sizes to reflect consumed portion sizes may lead consumers to believe that elevated portion sizes are healthy.

In addition, variation in the definitions of the portion size and the methods used to measure it contributes to consumer confusion and over-consumption[45]. For example, industry-based portion size systems often differ from those used by government and non-governmental organisations in healthy eating recommendations. There is a real need to establish standardised guidance and prevent consumer confusion over what an appropriate portion size is. Despite heterogeneity between the NDS used to derive consumed portion sizes, research suggests that portion size standardisation could begin even before such harmonisation. Gibney *et al.*[70] examined the methodologically different Irish National Adult Nutrition Survey and European Union Food4Me study and found that portion sizes had a high agreement, suggesting that despite differences in European NDS, a standardised European approach to portion size setting may be a viable policy option.

However, even if harmonised, NDS provide cross-sectional data, which cannot demonstrate causal relationships between the portion size and BMI[71]. Cross-sectional data also provides a snapshot in time, whereas commercially available products change regularly, leaving on-pack serving-size data outdated. Under-reporting, estimated at over 30 % in the National Diet and Nutrition Survey 2008–2012[72,73], also presents a limitation in using NDS to assess consumed portion size. Evidence suggests that under-reporting is higher for energy-dense foods[74–76], so the impact on our analyses may be greater than if other food groups had been selected. Therefore, updated guidance may be more robust if based on plausible reporters only, as in our analyses. Future work could consider other energy-dense food and drinks that are related to the BMI, such as fast food, breakfast cereals, ice cream, sugar-sweetened beverages or alcohol. In addition, the difference in consumed portion size, adherence to on-pack serving sizes, and under-reporting by sex could be explored to determine whether specific policies targeting men and women separately would be beneficial.

## Conclusion

The current food environment across Europe requires monitoring and investigation in order to identify areas for improvement and develop a policy to tackle pressing

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concerns surrounding poor nutrition and related NCD. In this review, NDS data provide the platform from which selected WHO priority aspects of population health including nutrient intakes, TFA and portion sizes, are investigated. Our research found that over a third of the WHO European Member States, mainly CEEC, had no identifiable NDS[12]. In those countries with NDS that reported nutrient intakes, WHO RNI attainment was poor across the lifecourse and across Europe, particularly in CEEC[13,14]. However, heterogeneity hindered inter-country comparisons. Analysis of raw survey data allowed nutrient intakes to be assessed by the socioeconomic group, where those with lower education had poorer diet quality[26]. Although NDS may show average population TFA intakes below WHO recommended limits, this may hide inequalities in certain disadvantaged groups[40]. Legislative bans may help alleviate this. There were few associations between NDS-derived consumed FPS and BMI[62]. However, consumed FPS was greater than on-pack serving-size in the majority of foods studied. This highlights the need for clearer policy guidance to help consumers choose smaller portions[68].

This research forms the first review of NDS provision across the whole WHO European Region, multiple lifecourse stages, and with reference to obesity-related NCD, nutrients of concern and disadvantaged groups. The information generated can be used to inform and evaluate policy, but this is limited by issues of heterogeneity and also lack of NDS provision, particularly in CEEC. Efforts are clearly needed to harmonise NDS implementation, particularly in the age groups sampled, dietary assessment methodology employed, nutrient range covered, the underpinning food composition database and treatment of under-reporters. Only then can effective, coordinated policy be developed that can have a real impact on dietary improvement, on a population and subgroup level, throughout Europe.

## Supplementary material

The supplementary material for this article can be found at https://doi.org/10.1017/S0029665119001174.

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## Conflict of Interest

None.

## Authorship

H. L. R. was responsible for the review concept and design, undertook primary statistical analysis, interpreted the data and wrote the manuscript. J. H. and J. E. C. assisted in designing the review and interpreting the data. J. J. and J. J. B. provided insight on WHO policy matters and access to key contacts. All authors reviewed and approved the final manuscript.

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