

Meal patterns across 10 European countries – results from the European Prospective Investigation into Cancer and Nutrition (EPIC) calibration study

Huseinovic E¹, Winkvist A^{1,2}, Slimani N³, Park MK³, Freisling H³, Boeing H⁴, Buckland G⁵, Schwingshackl L⁴, Weiderpass E^{6,7,8,9}, Rostgaard-Hansen AL¹⁰, Tjønneland A¹⁰, Affret A^{11,12}, Boutron-Ruault MC^{11,12}, Fagherazzi G^{11,12}, Katzke V¹³, Kühn T¹³, Naska A^{14,15}, Orfanos P^{14,15}, Trichopoulou A^{14,15}, Pala V¹⁶, Palli D¹⁷, Ricceri F^{18,19}, Santucci de Magistris M²⁰, Tumino R²¹, Engeset D²², Enget T⁶, Skeie G⁶, Barricarte A^{23,24,25}, Bonet CB²⁶, Chirlaque MD^{25,27,28}, Amiano P^{25,29}, Quirós JR³⁰, Sánchez MJ^{25,31}, Dias JA³², Drake I³², Wennberg M², Boer JMA³³, Ocké MC³³, Verschuren WMM^{33,34}, Lassale C³⁵, Perez-Cornago A³⁶, Riboli E³⁵, Ward H³⁵ and Bertéus Forslund H¹

¹Department of Internal Medicine and Clinical Nutrition, The Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden

²Department of Public Health and Clinical Medicine, Nutritional Research, Umeå University, Umeå, Sweden

³Dietary Exposure Assessment Group, International Agency for Research on Cancer, 150 Cours Albert Thomas, 69372 Lyon Cedex 08, France

⁴Department of Epidemiology, German Institute of Human Nutrition, Nuthetal, Germany

⁵Unit of Nutrition and Cancer, Cancer Epidemiology Research Programme, Catalan Institute of Oncology (ICO-IDIBELL), Barcelona, Spain.

⁶Department of Community Medicine, Faculty of Health Sciences, University of Tromsø, The Arctic University of Norway, Tromsø, Norway.

⁷Department of Research, Cancer Registry of Norway - Institute of Population-Based Cancer Research, Oslo, Norway.

⁸Department of Medical Epidemiology and Biostatistics, Karolinska Institutet, Stockholm, Sweden

⁹Genetic Epidemiology Group, Folkhälsan Research Center, Helsinki, Finland

¹⁰Danish Cancer Society Research Center, Copenhagen, Denmark

¹¹Université Paris-Saclay, Université Paris-Sud, UVSQ, CESP, INSERM, Villejuif, France

¹²Gustave Roussy, F-94805, Villejuif, France

- ¹³German Cancer Research Center (DKFZ), Division of Cancer Epidemiology, Heidelberg, Germany
- ¹⁴Hellenic Health Foundation, Athens, Greece
- ¹⁵WHO Collaborating Center for Nutrition and Health, Unit of Nutritional Epidemiology and Nutrition in Public Health, Dept. of Hygiene, Epidemiology and Medical Statistics, University of Athens Medical School, Greece
- ¹⁶Epidemiology and Prevention Unit, Department of Preventive and Predictive Medicine, Fondazione IRCCS Istituto Nazionale dei Tumori, Milan, Italy
- ¹⁷Molecular and Nutritional Epidemiology Unit, Cancer Research and Prevention Institute – ISPO, Florence, Italy
- ¹⁸Unit of Epidemiology, Regional Health Service ASL TO3, Via Sabaudia 164, Grugliasco (TO), Italy
- ¹⁹Unit of Cancer Epidemiology, Department of Medical Sciences, University of Turin, Via Santena 7, Turin, Italy
- ²⁰Azienda Ospedaliera Universitaria (AOU) Federico II, Naples, Italy.
- ²¹Cancer Registry and Histopathology Unit, "Civic - M.P. Arezzo" Hospital, ASP Ragusa, Italy
- ²²Norwegian Food Safety Authority, Head Office, Oslo, Norway.
- ²³Navarra Public Health Institute, Pamplona, Spain
- ²⁴Navarra Institute for Health Research (IdiSNA) Pamplona, Spain
- ²⁵CIBER Epidemiology and Public Health CIBERESP, Madrid, Spain
- ²⁶Unit of Nutrition and Cancer, Cancer Epidemiology Research Programme, Catalan Institute of Oncology (ICO-IDIBELL), Barcelona, Spain
- ²⁷Department of Epidemiology, Regional Health Council, IMIB-Arrixaca, Murcia, Spain
- ²⁸Department of Health and Social Sciences, Universidad de Murcia, Murcia, Spain
- ²⁹Public Health Division of Gipuzkoa, BioDonostia Research Institute, San Sebastian, Spain
- ³⁰Public Health Directorate, Asturias, Spain.
- ³¹Escuela Andaluza de Salud Pública. Instituto de Investigación Biosanitaria IBS.GRANADA. Hospitales Universitarios de Granada/Universidad de Granada, Granada, Spain
- ³²Department of Clinical Sciences in Malmö, Lund University
- ³³Centre for Nutrition, Prevention and Health Services, National Institute for Public Health and the Environment (RIVM), Bilthoven, the Netherlands
- ³⁴Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, Utrecht, the Netherlands.

³⁵Department of Epidemiology and Biostatistics, School of Public Health, Imperial College London, Norfolk Place, London W2 1PG, United Kingdom.

³⁶Cancer Epidemiology Unit, Nuffield Department of Population Health University of Oxford, United Kingdom

Corresponding author

Ena Huseinovic, Department of Internal Medicine and Clinical Nutrition, The Sahlgrenska Academy, University of Gothenburg, Box 459, SE-405 30, Gothenburg, Sweden. Phone: +4631-786 3283, Email: ena.huseinovic@gu.se

Short title

Meal patterns across the EPIC countries

Word count abstract: 250 (250)

Word count body: 3643 (5000)

Financial Support

This study was carried out with the financial support of the European Commission: Public Health and Consumer Protection Directorate 1993–2004; Research Directorate-General 2005, Ligue contre le Cancer (France); Soci te  3M (France); Mutuelle Ge ne rale de l'Education Nationale; Institut National de la Sante  et de la Recherche Me dicale (INSERM); Institute Gustave Roussy; German Cancer Aid; German Cancer Research Center; German Federal Ministry of Education and Research; Danish Cancer Society; Health Research Fund (FIS) of the Spanish Ministry of Health; Spanish Regional Governments of Andaluci a, Asturias, Basque Country, Murcia and Navarra and the Catalan Institute of Oncology; and ISCIII RETIC (RD06/0020), Spain; Cancer Research UK; Medical Research Council, UK; the Stroke Association, UK; British Heart Foundation; Department of Health, UK; Food Standards Agency, UK; the Wellcome Trust, UK; Greek Ministry of Health; Hellenic Health Foundation; Italian Association for Research on Cancer; Italian National Research Council, Regione Sicilia (Sicilian government); Associazione Italiana per la Ricerca sul Cancro-AIRC-Italy—ONLUS (Hyblean association for epidemiological research, NPO); Dutch Ministry of Health, Welfare and Sport; Dutch Prevention Funds; LK Research Funds; Dutch ZON (Zorg Onderzoek Nederland); World Cancer Research Fund (WCRF); Swedish Cancer Society; Swedish Research Council; Regional Government of Skane and the County Council of

Vasterbotten, Sweden. The funders had no role in the design, analysis or writing of this article.

Conflict of Interest

None.

Authorship

A.W. and H.B.F. initiated the study. E.H., A.W. and H.B.F. formulated the research questions, performed the analysis and wrote the manuscript taking into account comments from all co-authors. N.S., M.K. P., H.F., H.B., G.B., L.S. and E.W. contributed to the conception, analysis and interpretation of the data and drafting of the manuscript. All other co-authors were local EPIC collaborators involved in the collection of dietary data and other data. All authors read and approved the final version.

Abstract

Objective: To characterize meal patterns across ten European countries participating in the European Prospective Investigation into Cancer and Nutrition (EPIC) calibration study.

Design: Cross-sectional study utilizing dietary data collected through a standardised 24-h diet recall during 1995-2000. Eleven predefined intake occasions across a 24-h period were assessed during the interview. In this descriptive report, meal patterns were analysed in terms of daily number of intake occasions, the proportion reporting each intake occasion and the energy contributions from each intake occasion.

Setting: Twenty-seven centres across ten European countries.

Subjects: 36020 women (64%) and men (36%) aged 35-74 years.

Results: Pronounced differences in meal patterns emerged both across centres within the same country and across different countries with a trend for fewer intake occasions/day in Mediterranean countries as compared to central and northern Europe. Differences were also found for daily energy intake provided by lunch, with 38-43% for women and 41-45% for men within Mediterranean countries compared to 16-27% for women and 20-26% for men in central and northern European countries. Likewise, a south-north gradient was found for daily energy intake from snacks, with 13-20% (women) and 10-17% (men) in Mediterranean countries compared to 24-34% (women) and 23-35% (men) in central/northern Europe.

Conclusion: We found distinct differences in meal patterns with marked diversity for intake frequency and lunch and snack consumption between Mediterranean and central/northern European countries. Monitoring of meal patterns across various cultures and populations could provide critical context to the research efforts to characterize relationships between dietary intake and health.

Keywords

Meal patterns, intake occasion, intake frequency, meals, snacks, energy intake, standardisation, 24-hour dietary recall, EPIC

Introduction

The focus of human nutrition research during the last decades has been to define the relation between food choices, nutrient composition of the diet, and health; however, a growing body of evidence suggests that meal patterns may explain part of the variation in diet-related disease outcomes between individuals (1-3) and be a significant contributor to the obesity epidemic (4-6). Meal patterns can broadly be defined as patterned structures of food and drink intake and comprise daily frequency of meals and snacks, temporal distribution of energy intake and consistency of eating behaviours (7-9). There is evidence that frequency of meals and snacks and temporal distribution of energy intake are linked to cultural and environmental factors (10, 11), metabolic responses (12, 13) and circadian variations in appetite-regulating hormones and digestion (14, 15). Thus, there is an urgent need to examine the relative importance of meal patterns for metabolic risk factors and concurrent health in different populations in order to guide development of evidence-based dietary policies.

Today, few European authorities provide public health recommendations on meal patterns and although advice on regular meals exist in some countries, specific recommendations on frequency or temporal distribution of meals and snacks are rarely included (9). Further, in the latest revision of the Nordic Nutrition Recommendations from 2012 (16), the guideline on meal pattern from 2005 proposing 1-3 snacks/day (17) was withdrawn without comment. The absence of recommendations is likely to be due to a lack of consistency in the current literature examining the importance of meal patterns for health parameters which, in part, can be explained by several recurring methodological problems. These problems include a wide range of assessment methods used to examine meal patterns, heterogeneity in how meal patterns are analysed, lack of a standardized terminology and small study samples in specific populations (7, 18). Hence, these limitations have obstructed the research field and made interpretation and comparability between studies and countries challenging. Therefore, there is a need to map differences in meal patterns using consistent methodology and objective terminology in large and diverse population samples to advance the research field and promote development of dietary guidelines.

In the European Prospective Investigation into Cancer and Nutrition (EPIC) calibration study, standardized 24-h diet recalls were collected among approximately 37 000 participants from 27 centres in ten European countries (19). Dietary data were consistently collected through

computerised and harmonized interview software, allowing for a homogenous comparison of dietary patterns across the European countries (19, 20). Thus, in the light of the heterogeneous methodology traditionally used to assess and analyse meal patterns, the EPIC calibration study provides a unique opportunity to examine and describe differences in meal patterns across the European countries which will be a valuable resource and benchmark for Europe. Hence, the aim of this descriptive report is to characterize country and centre specific meal patterns in terms of daily intake frequency and temporal distribution of energy intake in the EPIC calibration study.

Methods

Study population

Data presented in this report were derived from the EPIC calibration study which was nested within the EPIC study and performed during 1995-2000. Details on the design, rationale and methodology of the EPIC study and the calibration study have been described in detail previously (19, 21). In short, EPIC is a multicentre prospective cohort study investigating the association between diet, lifestyle and cancer among approximately 520 000 participants across 23 administrative centres in ten European countries: Denmark, France, Germany, Greece, Italy, the Netherlands, Norway, Spain, Sweden and the United Kingdom (UK). Participants in the EPIC study were recruited from the general population (Bilthoven (the Netherlands), Greece, Germany, Sweden, Denmark, Norway, Cambridge (UK), Spain and Italy), breast cancer screening (Utrecht (the Netherlands), Florence (Italy)), members of a health insurance for school employees (France) and blood donors (some centres in Italy and Spain). In Oxford (UK), most of the participants (87%) were vegetarians or vegans and/or had a special interest in health and are therefore evaluated separately (the “Health-conscious” in contrast to the “General population” from Cambridge). For descriptive dietary analyses, the original 23 administrative centres have been reclassified into 27 centres according to their geographic region from which 19 centres recruited both female and male participants and 8 centres recruited women only (centres belonging to France, Norway, Utrecht (the Netherlands) and Naples (Italy)). The study began in 1992 and was approved by the ethical review boards of the International Agency for Research on Cancer (Lyon, France) and from all local recruiting institutes. Written informed consent was obtained from all participants.

Within the EPIC study, information on usual individual dietary intake was assessed using country-specific diet history or food frequency questionnaires (21). Thus, the EPIC calibration study was developed to correct for random and systematic errors in baseline dietary measurements and involved a single 24-h diet recall in a subsample of almost 37 000 participants to be used as the reference calibration method (19, 22, 23). The subsample represented approximately an 8% stratified random sample of the total EPIC cohort and was weighted according to the cumulative numbers of cancer cases expected by gender and 5-year age strata. The results in this paper are based on dietary data from the standardized 24-h diet recall.

Assessment of dietary intake

Information on dietary intake in the calibration study was collected using a standardized computer-assisted and interviewer-administered software program (EPIC-SOFT) specifically designed to standardize the 24-h diet recall across the EPIC centres. The structure and functions of the software program have been described in detail elsewhere (19, 20). In brief, the interview was structured into two steps; a first step where participants were asked to recall all foods and drinks consumed during the previous day, and a second step where they were asked to describe and quantify their intake. To standardize the memory aids used by the interviewer during the recall, eleven food consumption occasions (FCO) were predefined and asked for and information on all foods and drinks consumed were entered as one of the following FCOs according to the participant's answer: before breakfast, breakfast, during morning, before lunch, lunch, after lunch, during afternoon, before dinner, dinner, after dinner and during evening. For each FCO, questions on time (per full hour) and place of consumption were asked as additional probes; thus, each FCO could be selected several times because of intakes in different hours (except for breakfast, lunch and dinner). The diet interview was conducted according to a "wake-up to wake-up" approach with participants listing all foods and drinks consumed between waking up on the recall day to waking up on the interview day. However, the mean duration of the recalled day was always about 24 hours across the centres and countries (19). Interviews were conducted over various seasons and days of the week, however; interviews with regard to diet on Saturdays were conducted on Mondays in most countries for logistical reasons. All participants provided the diet recall through face-to-face interviews, except in Norway where a telephone interview was conducted (24). Energy and nutrient intakes were calculated using the EPIC nutrient database which was developed to harmonize nutrient databases across the EPIC countries (25, 26).

Definitions used to analyse meal patterns

In this report, all FCOs including food and/or drinks are defined as separate intake occasions except for FCOs consisting of water only (tap and mineral water), which were excluded. As a result, intake frequency describes the total number of intake occasions per day which can consist of food only, drinks only or food and drinks combined. In order not to limit intake frequency to a maximum of eleven intake occasions per day, we included information on time to separate single FCOs selected at several time points (e.g. FCO "during morning" consumed at both 9 and 11 am). No further criteria on time or energy intake were applied. Further, meals are defined as "breakfast", "lunch" and "dinner" while all other FCOs are defined as

“snacks”. Thus, the following aspects of meal patterns are presented in this report: daily intake frequency, the proportion reporting at least one intake occasion at each FCO and the absolute as well as relative energy contribution from meals and snacks.

Statistical analysis

Data are presented as mean (range), mean (standard error (SE)) and proportions stratified by gender, country and/or center as indicated. Intake frequencies displayed in Figure 1 are adjusted for age and weighted by season and day of the week using analysis of covariance to account for over- and under-sampling across all countries. Consequently, the adjusted means represent the mean number of intake occasions/day of a population with balanced distribution of recalls over season, day of the week and the mean age of 55.3 years for women and 56.8 years for men. In addition to the main analysis, we also conducted sensitivity analysis to exclude over- and under-reporters of energy intake. This was performed by calculating the ratio of reported energy intake over estimated basal metabolic rate taking age, sex, weight and height into account. The ratio of 1.55 was then used to calculate the confidence limits according to a 95% confidence interval (lower and upper limit of <0.88 and >2.72 , respectively). Ratios falling below or above the 95% confidence limits were used to define the presence of misreporting (27, 28). Although this method has poor sensitivity for identifying invalid reports of energy intake at the individual level from a single 24-h recall (29), it was considered sufficient to examine potential influence of extreme misreporting on the overall results. Data were analysed using SPSS version 21.0 (IBM, Somers, NY, USA).

Results

Study participants

A total of 36 020 participants (22 985 women and 13 035 men) with dietary data from the 24-h diet recall were included in this report after exclusion of participants aged under 35 or over 74 years due to low participation in these age groups (N=960) and individuals with incomplete information (N=14). Mean (range) age for women and men ranged from 49.0 (35.0-65.5) and 50.0 (35.2-65.2) years (Bilthoven, the Netherlands) to 61.4 (45.3-74.2) and 64.1 (50.5-74.3) years (Malmö, Sweden), respectively. Mean body mass index of women varied from 22.9 (14.4-37.6) (South of France, France) to 29.3 (17.9-48.8) kg/m² (Granada, Spain) and from 23.9 (18.2-31.8) (UK Health-conscious) to 29.3 (20.9-46.2) kg/m² (Granada, Spain) for men. Data on energy intake across the centres has previously been reported by Ocké et al (30).

Intake frequency across countries

After adjustment for age and weighting by season and day of recall, mean intake frequency for women ranged from 5.0 intake occasions/day in Greece and Italy to 7.0 intake occasions/day in the Netherlands. The corresponding numbers for men ranged from 4.9 in Italy to 6.8 in the UK General population (Figure 1 and Supplementary Table 1). There was a south-north gradient in intake frequency, with fewer intake occasions in the Mediterranean countries (Greece, Spain, Italy and France) as compared to central European (Germany, the Netherlands and UK) and Nordic (Denmark, Sweden and Norway) countries. Also, in several countries there was a tendency for slightly higher intake frequency in women than in men. For snack frequency only, see Supplementary Table 2.

Intake occasions across countries and centres

Tables 1 and 2 give the proportion of women and men reporting at least one intake occasion at the eleven different FCOs and the mean energy contribution from each FCO. As displayed in the tables, differences in meal patterns were found both across centres within the same country and across different countries with greatest heterogeneity for snack consumption. For example, the proportion of women having an intake occasion during the morning ranged from 31% in the north and west of Norway to 90% in Utrecht (the Netherlands). Further, the same discrepancy was seen during the afternoon with 30% of women in north and west of Norway and 93% of women in Utrecht (the Netherlands) reporting an intake occasion. The

corresponding numbers for men ranged from 38% in Granada (Spain) to approximately 80% in Bilthoven (the Netherlands) and UK General population for intake occasions during the morning, and from 37% in Murcia (Spain) to 89% in Aarhus (Denmark) for intake occasions during the afternoon. Likewise, a south-north gradient appeared for intake occasions during the evening with 2-33% of women in Mediterranean countries, 49-87% of women in central European countries and 73-77% of women in Nordic countries reporting an intake occasion. The same was revealed for men reporting an intake occasion during the evening with 2-30%, 59-85% and 78% in Mediterranean, central European and Nordic countries, respectively. As for main meals, the majority of participants across all countries reported consumption of breakfast (range 85-100%), lunch (range 76-100%) and dinner (range 90-99%); however, participants in central and northern European countries reported lunch to somewhat lesser degree than did Mediterranean countries.

Likewise, geographical differences in meal patterns were also found within countries. In Spain, 37-38% of women and men in Granada versus 60% of women and men in San Sebastian reported an intake occasion during morning. Moreover, 8-10% of Italian women and men in Ragusa reported an intake occasion during evening as compared to 32-36% in Turin. Finally, in Denmark, 66% of women in Copenhagen reported an intake occasion during evening as compared to 91% in Aarhus and this difference was also evident among Danish men (73% versus 90%, respectively).

Energy contribution of meals and snacks

Figures 2a and 2b as well as Supplementary Table 3 display the proportion of daily energy intake consumed as meals and snacks across countries. Breakfast contributed 11-19% and 9-20% of daily energy intake among women and men, respectively, across all countries. However, greater differences were revealed for lunch which provided 38-43% and 41-45% of daily energy intake for women and men within Mediterranean countries as compared to 16-27% and 20-26% for women and men in central European and Nordic countries. Less pronounced differences were observed for dinner which provided 24-37% and 29-40% of daily energy intake among women and men across all countries. Further, heterogeneity was also found for energy contribution of snacks with Mediterranean countries consuming 13-20% (women) and 10-17% (men) of daily energy intake as snacks while the corresponding numbers were 24-34% (women) and 23-35% (men) in central and northern countries. Figure 3 illustrates the overall differences in proportional distribution of daily energy intake across

meals and snacks between Mediterranean, central European and Nordic countries with women and men combined as no major differences were found between genders.

Sensitivity analysis

In general, mean energy intake from each intake occasion and the proportion reporting an intake occasion at each FCO increased slightly for both women and men after exclusion of misreporters, with some minor exceptions (Supplementary Tables 4 and 5). For intake frequency, sensitivity analyses differed by 0.0-0.2 and 0.0-0.1 intake occasions/day for women and men, respectively, except for UK Health-conscious (0.4 and 0.7 intake occasions/day for women and men, respectively).

Discussion

In this study, we aimed to characterize and compare meal patterns across ten European countries participating in the EPIC calibration study, taking advantage of the harmonized and detailed data collection across all the regions. We found pronounced geographical differences in meal structures across both countries and across centres within the same country. In general, a trend emerged that lunch provided a greater proportion of total energy intake in Mediterranean countries compared to central and northern European countries. In contrary, greater proportion of participants in central and northern countries reported intake occasions in between main meals and larger energy contribution of snacks, compared to participants in Mediterranean countries.

There is currently a discussion whether regular and socially shared meals are becoming increasingly rare and if grazing meal patterns, characterized by frequent snacking, are taking the place of traditional meals and dissolving collective norms guiding temporal eating (31, 32). In the present study, we examined meal patterns during 1995-2000 in an adult European population aged 35-74 years and found that most countries still shared uniformity in the three-meal-a-day pattern at that time, with a high proportion reporting consumption of breakfast, lunch and dinner across all countries, even though lunch was less frequently reported in Nordic and central European countries as compared to Mediterranean countries. This three-meal continuity has also been reported in more recent studies in Nordic (31), French (32-34) and Flemish (35) populations. However, for most central and northern countries, snacks contributed more to daily energy intake than did breakfast or lunch and in some countries snacks contributed nearly as much energy as did dinner. Still, for Mediterranean countries in general and for Italy and France in particular, snacks contributed significantly less energy than did lunch and dinner, indicating a preserved tradition in these regions for main meals to provide the majority of daily energy intake. Nevertheless, as these data were collected 15-20 years ago in a middle aged and elderly adult population, more recent shifts in meal patterns as well as meal patterns in younger populations need to be further explored.

Although we found the three-meal pattern to be widespread across Europe, we demonstrated different distribution of energy intake across the main meals. For example, a south-north gradient was found for lunch with Mediterranean countries consuming greater proportion of their daily energy intake at lunch as compared to central and northern countries. This gradient

was also reported in the SENECA study where meal patterns among 2600 elderly participants from 12 European countries were assessed in 1988-1989 (36, 37). In that study, lunch contributed 45-48% of daily energy intake in Italy and France as compared to 21-33% in northern and central Europe. The authors also found that total energy intake among women was higher in centres where energy contribution of lunch was low (36). As studies have reported evening meals to be less satiating than morning meals and glucose tolerance and insulin secretion to decrease over the day (9, 14, 38), consuming a high proportion of total energy intake at lunch has been suggested to compose an additional positive component of the Mediterranean diet when looking beyond the solely nutritive aspects (39). Further, as previous research has found snacking and high intake frequency to be positively associated with energy intake and overweight and obesity (4, 6), absence of snacking might be yet another favourable component of the Mediterranean diet. However, aspects such as meal times and timing of snacks need to be further explored in order to fully characterize differences in temporal disposal of energy intake across Europe. In sum, future research should consider if the beneficial effects of the Mediterranean diet are possibly also mediated by a meal pattern with greater energy contribution from lunch and less from snacking by widening the scope of dietary surveys to include assessment of meal structures and temporal distribution of energy intake.

We reported high intake frequency in northern and central Europe, with participants in the UK and the Netherlands consuming an average of 6-7 intake occasions/day. Prominent snacking among Dutch subjects was also reported in the SENECA study where 31-32% of daily energy intake was derived by snacks and in the latest Dutch national food consumption survey from 2007-2010 (30% of daily energy intake from snacks) (40), similar to the 34-35% in the EPIC cohort. Further, the SENECA study also found low energy contribution of snacks among Mediterranean countries with 6-8% in France and Italy (36, 37) as compared to 10-13% in the EPIC cohort. The consequences of different intake frequencies are a hot topic within the research field, dividing scientists into opposing opinions. On one hand, snacks have been reported to be less nutritive, more energy dense and more motivated by social and/or cultural drivers than by biological energy needs as compared to meals (4, 41). Hence, this would suggest that transition to grazing meal patterns might have negative health consequences given the risk for overconsumption of energy intake. On the other hand, snacks have the potential to increase the opportunity for healthy, nutrient-dense foods such as fruit and fiber-rich grains (42-44). In addition, gender differences have been suggested such that

women are more likely to make healthier food choices while men more often choose sweets, savouries and sugar-sweetened drinks (42). Also, as energy compensation for drinks has been demonstrated to be weak in comparison to solid foods (45, 46), the effect of drinks consumed as snacks warrant further exploration. Thus, there is a need to characterize not only frequency but also quality of snacks, especially in countries and populations where people derive high percentages of energy through snacks, as snacks have the potential to improve overall dietary intake and impact health.

The strengths of this report include a large and diverse population sample across several European countries concurrent with standardized and homogeneous methodology which enabled an objective assessment and comparison of meal patterns across a broad geographical span. However, there are some limitations to this report. Firstly, populations included in the EPIC study are not nationally representative samples of the European general population (19) and younger adults may have different meal patterns than those reported here. Nevertheless, data may still reveal significant geographical differences in meal pattern due to the broad range of participating countries and harmonized methodology used. Second, one 24-h diet recall does not provide data at the individual level; however, due to the large sample size, trends in proportions consuming various intake occasions across the day should still appear. Third, underreporting of energy intake is a limitation within all self-reported dietary assessments and a previous EPIC report found that underreporting was more prevalent among women and participants with overweight and obesity (47). Thus, as underreporting has been reported to affect both energy intake and intake occasions (8, 48), intake frequencies and proportions are likely to be underestimated as demonstrated by the slight increase when misreporters were excluded in the sensitivity analysis. Fourth, as the predefined FCOs only enabled three main meals to be reported, foods considered to be consumed as a main meal beyond the three predefined meals have been classified as snacks in this report. Thus, this could influence the interpretation of meal and snack patterns in countries where traditionally four meals are considered “main meals” as for example in Norway (breakfast, lunch, dinner and evening meal). Also, as no predefined time- or energy content criteria for FCOs were provided to participants, food and drinks were entered as different FCOs according to participant description. Finally, considering these data are now 15-20 years old, differences in meal patterns reported here need to be confirmed in more recent data; still, this study provides a valuable resource and benchmark for studying trends in Europe.

Conclusion

We examined meal patterns in a large scale study across ten European countries. We found distinct differences in meal patterns with marked diversity for intake frequency and lunch and snack consumption between Mediterranean and central/northern European countries.

Monitoring of meal patterns, currently and over time, across various cultures and populations could provide critical context to the research efforts to characterize relationships between dietary intake and health.

1 **Table 1**

2 The proportion of women reporting at least one intake occasion at the specific food consumption occasions (FCO) and the average energy

3 contribution from each FCO in the EPIC calibration study.

Country and centre	N	Before breakfast			Breakfast			During morning			Before lunch			Lunch			After lunch			During afternoon			Before dinner			Dinner			After dinner			During evening		
		%	kJ	SE	%	kJ	SE	%	kJ	SE	%	kJ	SE	%	kJ	SE	%	kJ	SE	%	kJ	SE	%	kJ	SE	%	kJ	SE	%	kJ	SE			
Greece	1368	12.9	565	45	92.8	853	19	53.9	626	24	12.8	700	56	98.6	2840	40	21.4	523	39	75.2	617	22	14.0	630	46	93.5	1647	34	21.3	664	47	1.6	612	120
Spain	1443	15.2	220	21	98.4	1104	20	48.0	598	23	19.3	577	36	99.6	3216	40	23.7	330	26	66.3	746	27	10.9	676	52	97.6	2175	35	24.5	483	26	8.1	392	38
Granada	300	25.7	232	46	98.0	1150	40	36.7	575	59	25.7	415	44	100	2828	81	25.7	265	36	70.3	688	41	14.7	782	104	95.3	1857	59	23.3	433	45	11.0	386	60
Murcia	304	17.8	165	26	99.0	1004	49	49.0	508	69	28.0	688	81	100	3378	100	49.0	340	45	49.3	895	99	11.5	640	94	96.7	2343	84	30.6	546	66	4.6	488	99
Navarra	271	2.2	211	52	98.5	1001	35	55.4	611	45	17.3	524	89	98.9	3418	85	9.2	587	139	74.5	741	45	11.4	627	99	97.4	2020	73	22.1	478	40	9.6	302	46
San Sebastian	244	16.0	270	53	97.5	1166	49	60.2	522	37	10.2	573	110	99.2	3505	99	22.1	222	33	73.8	609	50	7.4	453	82	99.2	2365	86	26.6	364	30	13.9	476	102
Asturias	324	13.6	221	34	98.8	1195	48	42.3	477	38	13.6	703	89	99.7	3040	74	11.4	409	78	65.7	850	73	9.0	748	165	99.7	2286	79	21.0	563	72	3.1	226	48
Italy	2510	21.3	193	14	93.6	900	13	50.7	411	14	9.9	504	39	99.0	3014	31	16.8	236	22	61.4	535	16	8.8	398	61	98.4	2826	30	12.2	522	35	24.9	472	22
Ragusa	137	29.2	93	17	94.2	742	53	44.5	388	69	10.9	717	219	98.5	3332	184	21.9	140	50	61.3	474	69	10.9	489	147	100	2864	143	9.5	813	395	9.5	485	228
Florence	783	23.4	182	23	94.4	916	25	51.7	487	26	7.9	521	75	98.7	2978	51	8.7	210	45	57.9	509	28	6.0	694	125	98.9	2898	58	6.9	474	64	23.8	509	48
Turin	392	26.0	374	52	89.3	803	34	50.0	355	30	9.7	314	43	99.2	2999	77	18.1	173	36	66.3	453	38	10.7	516	81	99.0	2881	76	15.1	385	63	31.9	439	42
Varese	795	10.7	158	22	97.1	995	23	47.8	345	19	11.8	511	69	99.4	2936	51	15.2	343	40	62.3	587	26	9.8	687	100	99.1	2723	47	15.8	548	47	31.7	434	30
Naples	403	31.0	116	14	89.3	814	32	57.3	446	42	9.7	564	102	98.8	3149	93	32.5	205	48	62.0	576	47	9.9	991	209	95.3	2825	83	13.6	588	100	11.9	612	91
France	4735	11.1	195	10	99.5	1424	12	36.7	300	10	10.8	692	28	99.3	3116	22	56.0	156	6	62.7	626	14	19.0	881	33	98.8	2669	21	14.3	285	19	32.7	411	14

South coast	620	12.7	168	17	99.8	1280	31	37.6	313	31	8.9	740	98	99.4	3196	60	46.8	135	11	62.4	599	38	18.7	947	113	98.5	2590	57	10.0	239	48	35.5	375	33		
South	1425	8.3	194	15	99.6	1413	21	35.4	331	20	9.5	633	57	99.5	3201	40	48.4	152	10	60.8	626	23	16.2	796	53	99.0	2595	37	12.4	335	44	29.7	397	28		
North-West	631	4.3	271	37	99.8	1513	30	31.4	191	21	10.6	637	70	99.7	3096	51	63.2	151	12	64.7	578	41	18.9	925	75	99.0	2565	50	17.0	247	41	33.3	412	35		
North-East	2059	14.7	195	16	99.3	1448	18	39.1	304	15	12.3	729	39	99.1	3039	33	61.9	165	9	63.5	650	21	21.0	897	51	98.7	2775	32	16.1	280	26	33.8	432	21		
Germany	2147	14.7	238	18	97.2	1481	19	60.1	657	18	12.7	403	31	89.5	2061	26	18.3	531	36	80.0	984	20	17.5	715	43	95.2	2164	28	29.3	781	33	48.5	704	20		
Heidelberg	1087	17.0	222	24	96.8	1474	27	58.6	518	22	17.7	371	36	89.1	2125	40	25.5	534	43	76.6	892	27	20.8	716	58	94.9	2234	42	35.6	708	40	51.3	700	30		
Potsdam	1060	12.4	259	29	97.6	1489	27	61.6	810	27	7.6	479	60	89.9	1997	34	10.9	523	65	83.5	1078	29	14.2	714	65	95.6	2092	38	22.9	898	56	45.6	709	25		
The Netherlands	2946	14.9	198	12	91.0	1149	14	86.7	465	10	4.2	548	56	88.5	1906	18	3.4	362	42	92.2	610	12	19.1	683	28	97.6	2635	25	15.1	1031	57	87.0	838	15		
Bilthoven	1076	14.8	190	20	86.2	1258	25	80.7	522	20	1.9	606	186	82.9	1912	32	2.0	366	89	90.9	736	25	14.7	633	50	97.5	2693	42	13.6	1113	122	86.6	1127	33		
Utrecht	1870	15.0	203	15	93.7	1091	16	90.2	439	12	5.5	537	57	91.7	1903	21	4.2	361	48	93.0	548	14	21.7	702	34	97.6	2602	32	16.0	991	61	87.2	728	15		
United Kingdom	767																																			
General population	571	52.2	121	12	95.3	1138	27	76.2	365	22	6.7	516	120	93.9	2048	53	11.2	379	101	80.2	453	27	20.8	625	65	93.9	2632	62	15.8	376	64	80.9	603	28		
Health-conscious	196	43.9	165	32	96.4	1300	52	78.1	530	82	2.0	182	88	95.9	2057	82	5.6	121	27	81.6	607	47	11.2	806	176	94.9	2678	99	9.2	215	67	75.0	891	92		
Denmark	1994	8.0	252	21	97.4	1344	18	62.0	500	17	9.0	506	65	88.0	1910	28	11.6	740	67	80.3	838	21	24.6	669	30	95.6	2801	34	24.3	780	36	72.5	957	24		
Copenhagen	1484	6.3	290	30	97.5	1337	21	61.9	477	19	7.3	532	102	86.6	1910	33	13.8	735	73	77.8	792	24	24.4	715	37	94.9	2812	40	30.7	796	37	66.2	925	29		
Aarhus	510	12.9	199	28	97.3	1364	35	62.2	563	35	13.9	466	52	92.0	1908	51	5.1	779	160	87.6	937	40	25.1	539	46	97.8	2772	68	5.5	531	129	91.0	1016	40		
Sweden	3278	11.8	354	21	98.4	1317	12	54.7	611	14	1.2	468	75	83.7	2021	22	4.4	597	57	74.8	755	14	4.6	679	55	92.3	2557	25	15.6	881	35	76.6	855	14		
Malmö	1711	6.0	310	41	98.9	1324	17	52.7	626	19	0.8	583	149	82.2	2092	31	3.1	599	85	70.5	780	20	4.1	665	74	89.9	2492	36	6.8	958	80	78.0	888	20		
Umeå	1567	18.3	370	24	97.9	1309	18	56.9	595	20	1.6	404	82	85.3	1947	30	5.8	595	76	79.5	731	19	5.2	692	80	94.9	2626	35	25.1	858	39	75.0	816	19		
Norway	1797	18.5	226	19	96.4	1525	20	31.9	378	25	19.6	520	39	76.4	1665	26	18.5	684	41	32.9	872	39	10.4	723	57	89.8	2643	33	38.5	1152	48	77.0	1385	28		

South and East	1004	19.1 241 26	96.7 1541 27	32.4 371 33	20.0 449 48	79.6 1723 36	20.1 641 50	35.1 853 51	11.6 781 77	89.2 2665 45	35.8 1198 73	75.6 1347 39
North and West	793	17.8 206 27	96.0 1505 29	31.3 388 38	19.0 614 64	72.4 1584 36	16.4 751 68	30.1 902 60	8.8 628 82	90.4 2615 50	41.9 1102 60	78.7 1428 41

4 Values are country- and centre specific proportion, mean and standard error.

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South and East	0											
North and West	0											

24 Values are country- and centre specific proportion, mean and standard error. ¹Eight centres recruited women only (centres belonging to France, Norway, the

25 Netherlands (Utrecht) and Italy (Naples)).

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33 **Figure 1**

34 Mean number of intake occasions/day by country and sex, adjusted for age and weighted by
35 season and day of dietary recall. Error bars represent standard error.

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37 **Figures 2a and 2b**

38 Proportion of daily energy intake consumed as breakfast, lunch, dinner and snacks by country
39 and sex for (a) women and (b) men.

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41 **Figure 3**

42 The proportion of daily energy intake consumed as breakfast, lunch, dinner and snacks in
43 Mediterranean, central European and Nordic countries for women and men combined.

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