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Current perspectives and challenges in the estimation of fruit juice consumption across the lifecycle in Europe

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Abstract

Fruit juice (FJ) is typically low in energy, contains natural sugars, important amounts of micronutrients and is not permitted to have added sugars/sweeteners. However, its role in a healthy diet is under scrutiny partly due to the wider adoption of the definition for free sugars in nutrition policy. This review aimed to identify data on FJ consumption from national food consumption surveys across Europe, to examine current intakes, percent consumers and its contribution to intakes of energy, total sugars, free sugars, vitamin C, folate and potassium. Data were extracted on the population mean intake of FJ and its contribution to nutrient intakes across the lifecycle and crude estimates of population mean intakes across countries were reported for the total population and for consumers only. This review highlighted significant gaps/challenges regarding the availability of country-specific national food consumption surveys across Europe and specifically data on FJ consumption (including complexities surrounding categorisations). Nonetheless, using a comparable/homogenous definition, the mean intake of FJ among consumers was approximately 1 × 150 ml glass/day for adults/older adults, with lower intakes among infants (86 g/d), children (108 g/d) and teenagers (112 g/d). FJ made important contributions to intakes of vitamin C while making little contribution to energy intakes but also contributed 2–14 % of free sugars intake (which may be considered modest compared to other sources). The complexity of collating and interpreting data on FJ intake as elucidated in this review raises questions surrounding the categorisation of FJ in research and presents significant challenges for policymakers with respect to dietary guidance for FJ.

Key words: **Fruit juice: Dietary role: Vitamin C: Free sugars: Beverages: National food consumption surveys**

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Introduction

Fruit juice is defined in European law as the fermentable but unfermented product obtained from fruit, which is sound and ripe, fresh or preserved by chilling, of one or more kinds mixed together, having the characteristic colour, flavour and taste typical of the juice of the fruit from which it comes[1]. Flavour, pulp and cells from the juice which are separated during processing may be restored to the same juice, but sugars or sweeteners may not be added nor can extra water be added, beyond the concentration (Brix) of the original juice[1]. In contrast to 100 % fruit juice (FJ), nectars and fruit drinks are permitted to contain added sugars and/or sweeteners as well as other ingredients, such as botanicals[1].

Current guidance on FJ consumption from food-based dietary guidelines (FBDG) is mixed, with some countries including it as part of the recommended intakes of fruit & vegetables (either as unlimited quantities or with guidance to limit to one portion or varying quantities (100–200 ml)). However, other countries include FJ as part of the recommended intakes of beverages within their FBDG (related to its contribution to total fluid intake) and others explicitly recommend avoiding it (grouping it with other sweet beverages)[2–4].

While few studies have collated data on the intake of FJ or its contribution to dietary intakes across countries, one recent global review of beverage intakes in over 187 countries found that adults consumed an average of 0·16 x 8oz servings (~36 g) of FJ daily[5], however, to the best of the authors' knowledge there are no such studies for children or teenagers. A large study of national food consumption surveys in the United States (US), United Kingdom (UK) and Brazil estimating FJ intakes in consumers only (across all age groups) reported intakes in these countries of 184 g/d, 130 g/d and 249 g/d, respectively[6]. With regard to the role of FJ in the overall diet, studies have shown that FJ consumption is associated with overall better diet quality and increased intakes of nutrients such as vitamin C, folate and potassium in children, teenagers and adults[7–12] however, some have also reported that FJ intake is associated with higher intakes of energy and total sugars[11,12]. Despite potential associations of FJ with energy and sugars intake, studies have shown that FJ consumption is not consistently associated with an increased risk for overweight/obesity or excess body weight among children, teenagers or adults with many concluding that, in the context of a healthy dietary pattern, consumption of FJ may provide beneficial nutrients and contribute to overall intakes of fruit and vegetables without having a negative impact on body weight[6,13–16].

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Despite the aforementioned evidence, the role of FJ in a healthy diet is under scrutiny due to its sugar and dietary fibre content per serving compared to the whole fruit counterpart, with the debate increasing in recent years alongside the wider adoption of the definition for free sugars in nutrition policy (replacing the previous definition of added sugars) since free sugars also include the natural sugars present in FJ, honey and syrups[17–19]. Within Europe, in the context of setting tolerable upper intake levels for sugar, the European Food Safety Authority (EFSA) have reported that FJ contributes 15–50 % of free sugar intakes for consumers only. However this is likely to represent an overestimate since EFSAs categorisation included nectars and FJ with added ingredients in addition to fruit juices and vegetable juices and should be interpreted with caution in the setting of guidance at population level[19]. In contrast, the UK Scientific Advisory Committee on Nutrition (SACN) provided a more conservative population-wide estimate in the UK of 8–14 % for the contribution of FJ to non-milk extrinsic sugars (NMES) intake (used for the setting of guidance on free sugars)[17]. These differences highlight the significant challenges in the interpretation of data used for policy making with respect to FJ consumption and dietary guidance.

In order to provide a reliable evidence-base for setting FBDG or nutrition policy with regards to specific foods, such as FJ, there is a need for the following: (1) precise and consistent characterisation (to examine a reasonably homogenous food category) and (2) data on current consumption patterns within a population group[20]. Therefore, the aim of this review was to identify available data on FJ consumption from national food consumption surveys across Europe and to examine current intakes and the proportion of consumers of FJ and to determine its contribution to intakes of energy, total sugars, free sugars, vitamin C, folate and potassium across the lifecycle.

Methods

Data were identified and extracted between December 2022 and August 2023. For this review, Europe was defined using a list of the 53 countries within the WHO European Union (EU) region. To identify the countries within this list which have conducted national food consumption surveys, the authors used relevant reviews[21–24] and searches of the grey and published literature for national food consumption surveys. Where necessary, the reports/studies were translated into English, to the best of the authors' ability using a web-based free-to-user translation service (Google Translate). Surveys were included in this review if they were nationally representative of their respective country (as stated in the study reports), collected dietary data at an individual level and had published summary data which was publicly available (i.e. no raw data were analysed). For surveys where food consumption data were available, the availability of FJ consumption data was identified by the overall food group reported (e.g. 'fruit & vegetables', 'beverages') and the most disaggregated reporting category (e.g. FJ, pure juices). To ensure only comparable data on FJ were included in this review, the survey reports were analysed to the best of the authors' ability to determine what was included in the FJ category. While this was not always clear, some surveys included components such as nectars, olives and vegetable juices in the FJ category and were excluded from this review on FJ (with the exception of 100 % vegetable juice, which would be considered similar to FJ with regards to nutritional composition). Therefore, only data which met the comparable/homogenous definition of 100 % pure fruit and vegetable juice were extracted further for this review.

Data for this review were extracted by population subgroups (i.e. infants; 0–3 years, children; 4–10 years, teenagers; 11–17 years, adults; 18–64 years and older adults; 65+ years) and categorised using the closest fit of age-groups reported from each survey. Where data were published by sex only or by smaller subgroups for age, the data were weighted using the provided *n* values to give one value per country for population subgroup reported and no attempt was made to compare between sexes or subgroups for age. Data were extracted from individual surveys on the population mean (SD) intake (g/d, ml/d) of FJ in the total population and for consumers only (note: the proportion of consumers (%) was included from individual surveys, only if intake data were available either for the total population or consumers only). Data were also extracted from individual surveys on the mean percent contribution of FJ to energy, total sugars, free sugars, vitamin C, folate and potassium intakes for the total population (i.e., non-consumers plus consumers). For consistency in reporting data from individual surveys, intake data were reported in grams (assuming 1 ml ≡ 1 g) and all data were rounded to the nearest whole number. Crude estimates of population mean intakes of FJ across countries per population subgroup were reported as a range, mean and median for the total population and for consumers only. For each country and population subgroup, the data used were (to the best of the authors' knowledge) the most recent that had been published prior to August 2023.

Results

Data availability

Of the 53 countries of the WHO EU Region, only 35 had conducted national food consumption surveys (Table 1)[25–87]. Of these, 13 countries did not publish their summary data in the online public domain[70–87] and a further 8 countries had food consumption data which was unsuitable for inclusion in this review (i.e., did not report FJ intakes separately, did not report population intakes (g/d, ml/d) or included other dietary components in the reporting of FJ intakes)[25–33,37,38,51]. In total, data from 14 countries across Europe were available for inclusion in this review[34–36,39–50,52–57,59–63,65–69]. It is important to note, however, that data were not available for all population subgroups within these 14 countries, few separately reported consumer intake data and not all countries reported the contribution of FJ to energy and nutrient intake data (or did not report this by subgroup).

100 % Fruit juice consumption

Infants, children & teenagers

For infants, FJ intake data were available for 8 countries; France, Iceland, Ireland, Italy, the Netherlands, Norway, Spain and the

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Table 1. Overview of national food consumption surveys across Europe which reported data on intakes of fruit juice or contribution of fruit juice to energy and nutrient intake, by population group reported

Country	Population	Survey	Year(s)	Age groups	Overall food group reported (intake data)	Most disaggregated reporting (intake data)	Overall food group reported (contribution data)	Most disaggregated reporting (contribution data)	Data on FJ available for inclusion in review
Andorra[26]	Teenagers	Evaluation of the Nutritional Status of the Andorran Population	2017–2018	12–24 y	Commercial Fruit Juices	Commercial fruit juice & nectars	*NR*	*NR*	Excluded as nectars included in estimates of intake
	Adults			25–64 y					
	Older adults			65–75 y					
Austria[27,28]	Children	Austrian Nutrition Report	2010–2012	7–12 y	Beverages	*NR*	*NR*	*NR*	Excluded as intakes not reported in suitable format
	Teenagers			13–14 y					
	Adults		2017	18–64 y	Beverages (Soft Drinks)	*NR*	*NR*	*NR*	
	Older adults		2010–2012	65–80 y	Beverages	*NR*	*NR*	*NR*	
Belgium[29,30]	Infants	Belgium National Food Consumption Survey 2014 (BNFCS 2014)	2014–2015	3–5 y	Fruits, nuts & olives	Fruit juice & olives*	*NR*	*NR*	Excluded due to olives being included in calculation of estimates of intake* (available by calculation)
	Children			6–9 y			*NR*	*NR*	
	Teenagers			10–17 y			*NR*	*NR*	
	Adults			18–64 y			*NR*	*NR*	
	Older adults	Belgian National Food Consumption Survey 2004 (BNFCS) 2004	2004	60–74 y 75+ y	Fruits, nuts & olives	*NR*	*NR*	*NR*	Excluded as intakes not reported in suitable format
Bulgaria[31,32]	Infants	National Survey of Nutrition Factors for Health Risk among the Population in Bulgaria	2014	1–2 y	Fruit juices (100 % natural, freshly squeezed)	*NR*	*NR*	*NR*	Excluded as intakes not reported in suitable format (% consumer data from FFQ only)
	Children			3–13 y					
	Teenagers			14–18 y					
	Adults			19–59 y					
	Older adults			60–74 y					
Czech Republic[25]	Children	Individual Food Consumption - The National Study SISP04	2003–2004	4–10 y	Fruit, vegetables, juice & potatoes	Juice (likely that respondents did not distinguish between pure fruit juices, nectars and other soft drinks with fruit content)	NR	*NR*	Excluded due to authors acknowledgement that it is very probable respondents did not distinguish between pure fruit juices, nectars and other soft drinks with fruit content
	Teenagers			11–14 y					
	Adults			16–64 y	*NR*	*NR*	*NR*	*NR*	Excluded as no published summary data available
Denmark[33]	Children	Danish National Survey of Diet and Physical activity (DANSDA)	2011–2013	4–9 y	Fruit & fruit products (incl. fruit juice	Juice (all kinds of fruit & vegetable juice, incl. applesauce)	Beverages	Juice (all kinds of fruit and vegetable juice, incl. applesauce)	Excluded as apple sauce included in estimates of intake
	Teenagers			10–17 y					
	Adults			18–75 y					
	Older adults			18–75 y					
Estonia[34]	Teenagers	National Dietary Survey among 11–74 years old individuals in Estonia	2013–2015	11–17 y	*NR*	*NR*	*NR*	*NR*	Excluded as no published summary data available
	Adults			18–74 y	Beverages	Juice	*NR*	*NR*	Intake data available in suitable format
	Older adults			75–79 y					
Finland[34,35]	Adults	The National FinDiet 2017 Survey	2017	18–74 y	Beverages	Fruit juices (100 %)	Drinks	Whole juices	Intake and contribution data available in suitable format
	Older adults			18–74 y					
France[36]	Infants	Individual National Food Consumption Survey (INCA 3)	2014–2015	0–3 y	Fruit & vegetable juices	Fruit & vegetable juices	*NR*	*NR*	Intake data available in suitable format
	Children			4–10 y					
	Teenagers			10–17 y					
	Adults			18–64 y					
	Older adults			65–79 y					
Germany[37,38]	Children	KIGGS 2 (EsKiMo II)	2015–2017	6–11 y	Total beverages	Juice (fruit & vegetable juice, fruit-based drinks, nectar, smoothies)	NR	NR	Excluded as nectars included in estimates of intake
	Teenagers			12–17 y					
	Adults	German National Nutrition Survey (Nationale Verzehrstudie) II (NVSII)	2005–2007	14–80 y	Non-alcoholic beverages	Fruit juice & nectars	NR	NR	
	Older adults			14–80 y					
Iceland[39–42]	Infants	What do Icelandic children eat? Diet survey of 3- and 5-year-old children	2007	3 y	Drinks	Pure juices	*NR*	*NR*	Intake data available in suitable format
	Children			5 y	Drinks	Pure juices	*NR*	*NR*	
		National survey on the diet of six-year-old children	2011–2012	6 y	Vegetables, fruits & pure juices	Pure juices	*NR*	*NR*	Intake data available in suitable format
		What do Icelandic children and teenagers eat? The Diet of Icelandic 9- and 15-year-old children and teenagers	2003–2004	9 y	Vegetables, fruits & juice/Drinks	Fruit & berry juice (clean juice)	*NR*	*NR*	Intake data available in suitable format
	Teenagers	What do Icelanders eat? A survey of the diet of Icelanders	2010–2011	15–19 y	Drinks	Pure juices	*NR*	*NR*	Intake data available in suitable format
	Adults			20–59 y	Drinks	Pure juices	*NR*	*NR*	
	Older adults			60–80 y	Drinks	Pure juices	*NR*	*NR*	
Ireland[43–47]	Infants	The National Pre-School Nutrition Survey (NPNS)	2010–2011	1–4 y	Fruit & fruit juices	Fruit juices (100 % juice)	Fruit & fruit juices	*NR*	Intake and some contribution (free sugars in adults) data available in suitable
	Children	The National Children's Food Survey II (NCFS II)	2017–2018	5–12 y	Fruit & fruit juices	Fruit juices (100 % juice)	Fruit & fruit juices	Fruit juices & smoothies	
	Teenagers	The National Teens' Food Survey II (NTFS II)	2019–2020	13–18 y	Fruit & fruit juices	Fruit juices (100 % juice)	Fruit & fruit juices	Fruit & fruit juices	

Table 1. (*Continued*)

Country	Population	Survey	Year(s)	Age groups	Overall food group reported (intake data)	Most disaggregated reporting (intake data)	Overall food group reported (contribution data)	Most disaggregated reporting (contribution data)	Data on FJ available for inclusion in review
	Adults	The National Adult Nutrition Survey (NANS)	2008–2010	18–64 y	Fruit juices	Fruit Juices	Fruit & fruit juices	Fruit juice (free sugars only)	
	Older adults	The National Adult Nutrition Survey (NANS)	2008–2010	≥65 y	Fruit juices	Fruit Juices	Fruit & fruit juices	Fruit juice (free sugars only)	
Italy[48,49]	Infants Children Teenagers Adults Older adults	The Italian National Food Consumption Survey (INRAN-SCAI)	2005–2006	0·1–2·9 y 3–9·9 y 10–17·9 y 18–64·9 y ≥65 y	Water and other non-alcoholic beverages	Fruit & vegetable juices	Water and other non-alcoholic beverages	Fruit & vegetable juices	Intake and contribution data available in suitable format
Lithuania[50]	Adults Older adults	Study of actual nutrition and nutrition habits of Lithuanian adult population	2013–2014	19–64 y 65–75 y	Fresh fruit & vegetable juices, beverages & bottled water	Fruit & vegetable juices	*NR*	*NR*	Intake data available in suitable format
Malta[51]	Adults	Malta Standards Authority Food Consumption Survey	2010	16–65 y	Fruit juice (reported in cups/day by meal only)	*NR*	*NR*	*NR*	Excluded as intakes not reported in suitable format
Netherlands[52–54]	Infants Children Teenagers Adults Older adults	Dutch National Food Consumption Survey 2019–2021/Dutch National Food Consumption Survey 2012–16*	2019–2021/2012–2016*	1–3y 4–11 y 12–17 y 18–64 y 65–79 y	Non-alcoholic beverages	Fruit & vegetable juices	Non-alcoholic beverages*	Fruit & vegetable juices*	Intake and contribution data available in suitable format
Norway[55–59]	Infants	Spedkost 3 Nationwide survey of the diet among infants in Norway	2018–2019	6 m, 12 m	Juice	Juice	Juice (for limited nutrients)	Juice (for limited nutrients)	Intake data available in suitable format
		Småbarnskost 3 Nationwide dietary survey among 2-year-olds in Norway	2019	2 y	Other drinks	Juice	*NR*	*NR*	Intake data available in suitable format
	Children Teenagers	Ungkost 3 Nationwide dietary survey among pupils in 4th and 8th grade in Norway	2015–2016	4 y, 9 y 13 y	Juice, smoothie	Juice, smoothie	Juice, smoothie	Juice, smoothie	Excluded as smoothies included in estimates of intake
	Adults Older adults	Norkost 3 Nationwide dietary survey among men and women in Norway aged 18–70	2010–2011	18–59 y 60–70 y	Juice, most Juice, most	Juice, most Juice, most	Juice, most Juice, most	Juice, most Juice, most	Intake and contribution data available in suitable format
Portugal[60,61]	Children Teenagers Adults Older adults	National Food, Nutrition and Physical Activity Survey of the Portugese General Population (IAN-AF)	2015–2016	3–9 y 10–17 y 18–64 y 65–84 y	Non-alcoholic beverages	Natural & 100 % fruit juice (incl veg juices)	Non-alcoholic beverages	Natural & 100 % fruit juice (incl veg juices)	Intake and contribution data available in suitable format
Spain[62–64]	Infants Children Teenagers	ENALIA Spanish National Dietary Survey on children and adolescents/ Anthropometry, Intake and Energy Balance (ANIBES)*	2013–2014/2013*	1–3 y 4–9 y 10–18 y	Drinks	Fruit & vegetable juices	Non-alcoholic beverages*	Juices & nectars*	Intake data available in suitable format (Contribution data excluded due to nectars included in estimates)
	Adults Older adults	ENALIA 2 National Food Survey on adults, the elderly and pregnant women/ Anthropometry, Intake and Energy Balance (ANIBES)*	2014–2015/2013*	18–64 y 65–74 y	Drinks	Fruit & vegetable juices	Non-alcoholic beverages*	Juices & nectars*	
Sweden[65,66]	Children Teenagers	Riksmaten Ungdom	2016–17 2016–17	5th & 8th Grade Yr2 Highschool	Beverages	Fruit & vegetable juice	Fruit juice	Fruit juice	Intake and contribution data available in suitable format
	Adults Older adults	Riksmaten -Vuxna - Food and Nutritional Intake among adults in Sweden	2010–11 2010–11	18–64 y 65–80 y	Beverages	Fruit & vegetable juice	Fruit juice	Fruit juice	
Switzerland[67]	Adults/Older adults	National Nutrition Survey Switzerland MenuCH	2014–2015	18–75 y	Non-alcoholic drinks	Fruit juice	Beverages	Fruit & vegetable juices	Intake and contribution data available in suitable format
United Kingdom[68,69]	Infants Children Teenagers Adults Older adults	National Diet and Nutrition Survey (NDNS) Years 9–11/ National Diet and Nutrition Survey (NDNS) Years 1–4*	2016/17–2018/19/ 2008/09–2011/12*	1·5–3 y 4–10 y 11–18 y 19–64 y 65+ y	100 % fruit juice & the fruit juice component of smoothies	100 % fruit juice & the fruit juice component of smoothies	100 % fruit juice & the fruit juice component of smoothies (*Vitamin C)	100 % fruit juice & the fruit juice component of smoothies (*Vitamin C)	Intake and contribution data available in suitable format

m: months, y: years.

* Denotes where data were sourced from two different surveys.

Countries with no national food consumption survey found for inclusion: Albania, Armenia, Azerbaijan, Belarus, Bosnia & Herzegovina, Georgia, Kazakhastan, Kyrgzstan, Luxembourg, Monaco, Montenegro, Republic of Moldova, San Marino, Serbia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan.

Countries which have conducted national food consumption surveys but did not publish their summary data in the online public domain: Croatia[70,71], Cyprus[72,73], Greece[74], Hungary[75,76], Israel[77,78], Latvia[79], Poland[80], Romania[81], Russian Federation[82], Slovakia[83], Slovenia[84,85], The former Yugoslav Republic of Macedonia[86], Turkey[87].

Table 2. 100 % Fruit juice intake (g/d) in infants in the WHO European Region, as reported in national food consumption surveys, in the total population and consumers only

			Total population			Consumers			
				g/d				g/d	
Country	Age groups	Fruit juice classification (intakes)	*n*	Mean	SD	% Cons	*n*	Mean	SD
France[36]	0–3 y	Fruit & vegetable juices	214	26	*NR*	37	*NR*	*NR*	*NR*
Iceland[39]	3 y	Pure juices	225	67	85	*NR*	*NR*	*NR*	*NR*
Ireland[43]	1–4 y	Fruit juices (100 % juice)	500*	51	NA	51	258	98	NA
Italy[48]	0·1–2·9 y	Fruit & vegetable juices	52	66	103	46	24	144	109
Netherlands[52]	1–3 y	Fruit & vegetable juices	703*	27	NA	*NR*	*NR*	*NR*	*NR*
Norway[55–57]	6 m, 12 m, 2 y	Juice	5552*	9	NA	1	31	15	21
Spain[62]	1–3 y	Fruit & vegetable juices	*NR*	60	NA	*NR*	*NR*	*NR*	*NR*
United Kingdom[68]	1·5–3 y	100 % fruit juice & the fruit juice component of smoothies	*NR*	35	77	*NR*	*NR*	*NR*	*NR*

* Calculated from data reported on sex/age subgroups weighted using the provided n values to give one value per country per subgroup reported.
m: months, y: years, NR: Not reported, NA: Not available (due to calculated data from sex/age subgroups).

Table 3. 100 % Fruit juice intake (g/d) in children in the WHO European Region, as reported in national food consumption surveys in the total population and consumers only

			Total population			Consumers			
Country	Age groups	Fruit juice classification (intakes)	*n*	g/d	SD	% Cons	*n*	g/d	SD
France[36]	3–9 y	Fruit & vegetable juices	821	91	*NR*	67	*NR*	*NR*	*NR*
Iceland[39–41]	5 y, 6 y, 9 y	Pure juices	568*	75	NA	*NR*	*NR*	*NR*	*NR*
Ireland[44]	5–12 y	Fruit juice (100 % fruit)	500	38	75	40	200	94	55
Italy[48]	3–9·9 y	Fruit & vegetable juices	193	80	96	66	127	122	95
Netherlands[52]	4–11 y	Fruit & vegetable juices	548*	28	NA	*NR*	*NR*	*NR*	*NR*
Portugal[60]	3–9 y	Natural & 100 % fruit juice (incl. veg juices)	521	21	*NR*	*NR*	*NR*	*NR*	*NR*
Spain[62]	4–9 y	Fruit & vegetable juices	*NR*	97	NA	*NR*	*NR*	*NR*	*NR*
Sweden[66]	5th, 8th Grade	Fruit & vegetable juice	2099*	83	NA	26	*NR*	*NR*	*NR*
United Kingdom[68]	4–10 y	100 % fruit juice & the fruit juice component of smoothies	*NR*	53	85	*NR*	*NR*	*NR*	*NR*

* Calculated from data reported on sex/age subgroups weighted using the provided n values to give one value per country per subgroup reported.
y: years, NR: Not reported, NA: Not available (due to calculated data from sex/age subgroups).

UK (Table 2)[36,39,43,48,52,55–57,62,68]. The population mean intake of FJ (across countries) ranged from 9 to 67 g/d (mean: 43 g/d, median: 43 g/d). For infants, data on FJ intakes among consumers were available for 3 countries: Ireland (51 % consumers), Italy (46 %), and Norway (1 %) (France reported 37 % consumers but did not separately report intakes in this group). For infants, the population mean intake of FJ among consumers (across countries) ranged from 15 to 144 g/d (mean: 86 g/d, median: 98 g/d).

For children, FJ intake data were available for 9 countries: France, Iceland, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the UK (Table 3)[36,39–41,44,52,60,62,66,68]. The population mean intake of FJ (across countries) ranged from 21 to 97 g/d (mean: 63 g/d, median: 75 g/d). For children, data on FJ intakes among consumers were available for 2 countries: Ireland (40 % consumers) and Italy (66 %) (France and Sweden also reported 67 and 26 % consumers, respectively but did not separately report intakes in these groups). For children, the population mean intake of FJ among consumers (across countries) ranged from 94 to 122 g/d (mean: 108 g/d, median: 108 g/d).

For teenagers, FJ intake data were available for 9 countries: France, Iceland, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the UK (Table 4)[36,42,45,48,52,60,62,66,68]. The population mean intake of FJ (across countries) ranged from 28 to 107 g/d (mean: 69 g/d, median: 71 g/d). For teenagers, data on FJ intakes among consumers were available for 2 countries: Ireland (30 % consumers) and Italy (71 %) (France and Sweden also reported 63 and 22 % consumers, respectively but did not separately report intakes in these groups). For teenagers, the population mean intake of FJ among consumers (across countries) ranged from 107 to 117 g/d (mean: 112 g/d, median: 112 g/d).

Adults & older adults

For adults, FJ intake data were available for 14 countries: Estonia, Finland, France, Iceland, Ireland, Italy, Lithuania, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the UK (Table 5)[34,36,42,46,48,50,52,59,60,63,65,67,68]. The population mean intake of FJ (across countries) ranged from 24 to 115 g/d (mean: 53 g/d, median: 48 g/d). For adults, data on FJ intakes among consumers were available for 5 countries: Finland (29 % consumers), Ireland (39 %), Italy (55 %), Sweden (91 %) and Switzerland (47 %) (France also reported 29 % consumers but did not separately report intakes in this group). For adults, the population mean intake of FJ among consumers (across countries) ranged from 53 to 212 g/d (mean: 137 g/d, median: 128 g/d).

For older adults, FJ intake data were available for 13 countries: Finland, France, Iceland, Ireland, Italy, Lithuania, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the UK (Table 6)[34,36,42,46,48,50,52,59,60,63,65,67,68]. The population mean intake of FJ (across countries) ranged from

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Table 4. 100 % Fruit juice intake (g/d) in teenagers in the WHO European Region, as reported in national food consumption surveys in the total population and consumers only

			Total population			Consumers			
Country	Age groups	Fruit juice classification (intakes)	***n***	g/d	SD	% Cons	***n***	g/d	SD
France[36]	11–17 y	Fruit & vegetable juices	949	104	*NR*	63	*NR*	*NR*	*NR*
Iceland[42]	15–19 y	Pure juices	124	103	*NR*	*NR*	*NR*	*NR*	*NR*
Ireland[45]	13–18 y	Fruit juice (100 % fruit)	428	32	74	30	128	107	103
Italy[48]	10–17·9 y	Fruit & vegetable juices	247*	83	NA	71	175	117	NA
Netherlands[52]	12–17 y	Fruit & vegetable juices	572*	28	NA	*NR*	*NR*	*NR*	*NR*
Portugal[60]	10–17 y	Natural & 100 % fruit juice (incl. veg juices)	632	32	*NR*	*NR*	*NR*	*NR*	*NR*
Spain[62]	10–18 y	Fruit & vegetable juices	*NR*	107	NA	*NR*	*NR*	*NR*	*NR*
Sweden[66]	Y2 High School	Fruit & vegetable juice	1000*	71	NA	22	*NR*	*NR*	*NR*
United Kingdom[68]	11–18 y	100 % fruit juice & the fruit juice component of smoothies	*NR*	63	104	*NR*	*NR*	*NR*	*NR*

* Calculated from data reported on sex/age subgroups weighted using the provided n values to give one value per country per subgroup reported.
y: years, NR: Not reported, NA: Not available (due to calculated data from sex/age subgroups).

Table 5. 100 % Fruit juice intake (g/d) in adults in the WHO European Region, as reported in national food consumption surveys in the total population and consumers only

			Total population			Consumers			
Country	Age groups	Fruit juice classification (intakes)	***n***	g/d	SD	% Cons	***n***	g/d	SD
Estonia[34]	18–74 y	Juice	2713*	42	NA	*NR*	*NR*	*NR*	*NR*
Finland[34]	18–74 y	Fruit juices (100 %)	1655*	47	NA	29	*NR*	163	NA
France[36]	18–64 y	Fruit & vegetable juices	2121	65	*NR*	29	*NR*	*NR*	*NR*
Iceland[42]	20–59 y	Pure juices	1115*	50	NA	*NR*	*NR*	*NR*	*NR*
Ireland[46]	18–64 y	Fruit juices	1274	50	90	39	499	128	103
Italy[48]	18–64·9 y	Fruit & vegetable juices	2313*	30	NA	55	1269	53	NA
Lithuania[50]	19–64 y	Fruit & vegetable juices	2213*	37	NA	*NR*	*NR*	*NR*	*NR*
Netherlands[52]	18–64 y	Fruit & vegetable juices	1137*	36	NA	*NR*	*NR*	*NR*	*NR*
Norway[59]	18–59 y	Juice, most	1406*	115	NA	*NR*	*NR*	*NR*	*NR*
Portugal[60]	18–64 y	Natural & 100 % fruit juice (incl. veg juices)	3102	24	*NR*	*NR*	*NR*	*NR*	*NR*
Spain[63]	18–64 y	Fruit & vegetable juices	623*	49	NA	*NR*	*NR*	*NR*	*NR*
Sweden[65]	18–64 y	Fruit & vegetable juice	1430*	60	NA	91	1627	128	112
Switzerland[67]	18–75 y	Fruit juice	2057	102	170	47	974	212	190
United Kingdom[68]	19–64 y	100 % fruit juice & the fruit juice component of smoothies	*NR*	34	92	*NR*	*NR*	*NR*	*NR*

* Calculated from data reported on sex/age subgroups weighted using the provided n values to give one value per country per subgroup reported.
y: years, NR: Not reported, NA: Not available (due to calculated data from sex/age subgroups).

Table 6. 100 % Fruit juice intake (g/d) in older adults (≥65y) in the WHO European Region, as reported in national food consumption surveys in the total population and consumers only

			Total population			Consumers			
Country	Age groups	Fruit juice classification (intakes)	***n***	g/d	SD	% Cons	***n***	g/d	SD
Finland[34]	18–74 y	Fruit juices (100 %)	1655*	47	NA	29	*NR*	163	NA
France[36]	65–79 y	Fruit & vegetable juices	511	95	*NR*	44	*NR*	*NR*	*NR*
Iceland[42]	60–80 y	Juice	228*	39	NA	*NR*	*NR*	*NR*	*NR*
Ireland[46]	≥65 y	Fruit juices	226	46	72	43	97	108	74
Italy[48]	≥65 y	Fruit & vegetable juices	518*	22	NA	47	242	48	NA
Lithuania[50]	65–75 y	Fruit & vegetable juices	300	24	*NR*	*NR*	*NR*	*NR*	*NR*
Netherlands[52]	65–79 y	Fruit & vegetable juices	607*	29	NA	*NR*	*NR*	*NR*	*NR*
Norway[59]	60–70 y	Juice, most	381*	77	NA	*NR*	*NR*	*NR*	*NR*
Portugal[60]	65–84 y	Natural & 100 % fruit juice (incl. veg juices)	750	13	*NR*	*NR*	*NR*	*NR*	*NR*
Spain[63]	65–74 y	Fruit & vegetable juices	310	37	NA	*NR*	*NR*	*NR*	*NR*
Sweden[65]	65–80 y	Fruit & vegetable juice	367	47	85	91	1627	128	112
Switzerland[67]	18–75 y	Fruit juice	2057	102	170	47	974	212	190
United Kingdom[68]	65+ y	100 % fruit juice & the fruit juice component of smoothies	*NR*	35	73	*NR*	*NR*	*NR*	*NR*

* Calculated from data reported on sex/age subgroups weighted using the provided n values to give one value per country per subgroup reported.
y: years, NR: Not reported, NA: Not available (due to calculated data from sex/age subgroups).

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Table 7. Contribution (%) of 100 % fruit juice to intakes of energy and nutrients across the lifecycle in the WHO European Region, as reported in national food consumption surveys in the total population

Country	Age groups	*n*	Fruit juice classification (contribution)	% contribution to intake					
				Energy	Total Sugars	Free Sugars	Vitamin C	Folate	Potassium
Infants									
Italy[49]	0–2·9 y	52	Fruit & vegetable juices	3	11	*NR*	20	*NR*	3
Netherlands[53]	1–3 y	672	Fruit & vegetable juices	1	4	*NR*	4	1	2
United Kingdom[68,69]	1·5–3 y	*NR*	100 % fruit juice & the fruit juice component of smoothies	1	*NR*	11	15	3	3
Children									
Italy[49]	3·9–9 y	193	Fruit & vegetable juices	2	10	*NR*	26	*NR*	3
Netherlands[53]	4–8 y	520	Fruit & vegetable juices	1	4	*NR*	6	2	3
Sweden[66]	5th, 8th Grade & Yr 2	3099	Fruit & vegetable juice	2	*NR*	NR	15	5	3
United Kingdom[68,69]	4–10 y	*NR*	100 % fruit juice & the fruit juice component of smoothies	2	*NR*	10	19	4	4
Teenagers									
Italy[49]	10–17·9 y	247	Fruit & vegetable juices	2	9	*NR*	20	*NR*	3
Netherlands[53,54]	9–18 y	1043*	Fruit & vegetable juices	1	4	12 (7–18 y)	8	3	3
Sweden[66]	5th, 8th Grade & Yr 2	3099	Fruit & vegetable juice	2	*NR*	NR	15	5	3
United Kingdom[68,69]	11–18 y	*NR*	100 % fruit juice & the fruit juice component of smoothies	2	*NR*	11	18	6	4
Adults									
Finland[35]	1874	1655	Whole juices	1	4	*NR*	16	4	2
Ireland[47]	18–90 y	1500	Fruit juice	*NR*	*NR*	8	*NR*	*NR*	*NR*
Italy[49]	18–64·9 y	2313	Fruit & vegetable juices	1	3	*NR*	8	*NR*	1
Netherlands[53,54]	19–70 y	1561*	Fruit & vegetable juices	1	5	14 (19–69 y)	11	3	3
Norway[59]	18–70 y	1787	Juice, most	2	*NR*	*NR*	19	7	4
Sweden[65]	18–80 y	1797	Fruit & vegetable juices	1	*NR*	*NR*	13	3	3
Switzerland[67]	18–75 y	2057	Fruit & vegetable juices	*NR*	8	13	*NR*	*NR*	*NR*
United Kingdom[68,69]	19–64 y	*NR*	100 % fruit juice & the fruit juice component of smoothies	1	*NR*	6	12	3	2
Older Adults									
Finland[35]	1874	1655	Whole juices	1	4	*NR*	16	4	2
Ireland[47]	18–90 y	1500	Fruit juice	*NR*	*NR*	8	*NR*	*NR*	*NR*
Italy[49]	≥65 y	518	Fruit & vegetable juices	0	2	*NR*	6	*NR*	1
Netherlands[53]	71–79 y	517*	Fruit & vegetable juices	1	4	*NR*	11	3	2
Norway[59]	18–70 y	1787	Juice, most	2	*NR*	*NR*	19	7	4
Sweden[65]	18–80 y	1797	Fruit & vegetable juices	1	*NR*	*NR*	13	3	3
Switzerland[67]	18–75 y	2057	Fruit & vegetable juices	*NR*	8	13	*NR*	*NR*	*NR*
United Kingdom[68,69]	65–75 y	*NR*	100 % fruit juice & the fruit juice component of smoothies	1	*NR*	7	10	3	2
Total population only									
Portugal[60,61]	3 m–84 y	5811	Natural & 100 % fruit juice (incl. veg juices)	0	1	3 (5–9 y) 4 (10–17 y) 3 (18–64 y) 2 (≥65 y)	4	2	1

* Calculated from data reported on sex/age subgroups weighted using the provided n values to give one value per country per subgroup reported.
m: months, y: years, NR: Not reported

13 to 102 g/d (mean: 47 g/d, median: 39 g/d). For older adults, data on FJ intakes among consumers were available for 5 countries: Finland (29 % consumers), Ireland (43 %), Italy (47 %), Sweden (91 %) and Switzerland (47 %) (France also reported 44 % consumers but did not separately report intakes in this group). For older adults, the population mean intake of FJ among consumers (across countries) ranged from 48 to 212 g/d (mean: 132 g/d, median: 128 g/d).

Patterns of fruit juice consumption

Based on the available data, these results show that estimates of population mean intake of FJ was lowest among infants (43 g/d) and highest in children (63 g/d) and teenagers (69 g/d). Intakes among adults (53 g/d) were lower than in children and teenagers with older adults (47 g/d) having similar intakes to infants. Looking at consumers only, infants had the lowest intakes (86 g/d) while adults and older adults had the highest intakes (137 g/d and 132 g/d, respectively) while intakes among children and teenagers were generally similar (108 g/d and 112 g/d, respectively).

Contribution of fruit juice to energy & nutrient intakes

Data on the contribution of FJ to intakes of energy, total sugars, free sugars, vitamin C, folate and potassium were available from 9 countries: Finland, Ireland, Italy, the Netherlands, Norway, Portugal, Sweden, Switzerland and the UK (Table 7)[35,47,49,53,54,59–61,65–69]. Most countries provided contribution data by age group

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(infants, children, teenagers, adults, older adults) while Portugal provided information for the total population (3–84 years)[60] (with the exception of information on the contribution to intakes of free sugars[61]) and Ireland provided information on the contribution to intakes of free sugars for adults 18–90 years only[47]. Across the lifecycle, FJ contributed very small proportions of energy intake (0–3 %). FJ contributed 4–11 % of total sugars intake in infants, children and teenagers, but contributed smaller proportions in adults and older adults (2–8 %). FJ contributed 3–12 % of free sugars intake in infants, children and teenagers with similar contributions in adults and older adults (2–14 %). With respect to contributions to vitamin C, FJ made important contributions across the lifecycle (4–26 % of intake). Across the lifecycle, FJ contributed relatively small proportions of folate (up to 7 %) and potassium (up to 4 %).

Discussion

This review has collated FJ consumption data across the lifecycle from nationally representative food consumption surveys in Europe and has examined the contribution of FJ to intakes of energy and key nutrients including total sugars, free sugars, vitamin C, folate and potassium. The review has identified significant gaps regarding the availability of country-specific data relating to FJ consumption for population groups across Europe. It has also highlighted the challenges in interpreting/collating data across countries due to variances in the classification, disaggregation and reporting of both intake and nutritional contributions. Based on crude estimates from the available data (within inclusion criteria), population mean intakes of FJ for the total population were highest in children and teenagers and lowest in infants and older adults. Among consumers only, adults and older adults consumed approximately 1 × 150 ml glass/day (range: 132–137 g/d) which is consistent with some FBDG, with intakes being lower in infants (86 g/d), children (108 g/d) and teenagers (112 g/d)[2,88]. Across the lifecycle, FJ made negligible contributions to total energy intake (<3 %), small contributions to intakes of folate and potassium (up to 7 %) but contributed up to one-quarter of intakes of vitamin C (4–26 %). In addition, FJ contributed to up to 11 % of total sugars intake and 2–14 % of free sugars intake across the lifecycle.

Gaps and challenges

The importance of having recent, high-quality, country-specific, nationally representative food consumption data to inform nutrition policy has been well acknowledged in the literature[22,89–92], therefore the first aim of this review was to identify available data on FJ consumption from national food consumption surveys across Europe. This review showed that there are significant gaps in the availability of country-specific data relating to FJ consumption for population groups across Europe. Out of 53 countries within the WHO European region, only 14 had comparable data on FJ consumption for any population subgroup with an underrepresentation of data from Central and Eastern European countries. This highlights significant challenges in setting guidance or policy at European level for FJ or associated nutrient/health outcomes. The lack of available data from national food consumption surveys has been previously highlighted for other food groups and nutrient intakes[22,23,90]. Even within the 14 countries, data were not available for all population subgroups (or were not reported by population subgroup) and not all had suitable data e.g., for percent consumers or contributions to energy and nutrient intakes. These points are important to note as policy is set for all population subgroups (i.e. across the lifecycle) and therefore there is a need to have representation of all population subgroups within individual countries and not just across countries within a region.

In the context of this review, beyond gaps in the data, there were also significant challenges within categorisation of data on FJ. Food groups are often reported in such a way that allows meaningful comparisons with country specific FBDG and broadly include groups such as cereals, dairy, meat, fruit, vegetables, fats and discretionary foods. This review found that the categorisation of FJ reported across countries and even across different surveys within the same country were heterogenous with FJ often categorised as part of 'fruit & fruit juices' but sometimes categorised as part of 'non-alcoholic beverages' and for some countries, it is categorised in both places. Furthermore, between countries, there was a large variation in what was included in the FJ category between countries e.g., the inclusion of nectars, olives, applesauce and smoothies. This raises questions about whether some reported FJ categories are actually measuring FJ consumption and its nutritional role or if they are reporting an overestimate due to the inclusion of other components in the categorisation. Furthermore, it has been highlighted in some studies and policy documents that within individual food consumption surveys and other research studies, participants may not have the knowledge or information to differentiate between FJ with no added sugars and nectars and fruit drinks with added sugars, and/or the questions posed may be insufficiently specific to differentiate between sweetened and unsweetened juices[19,25].

These findings suggest that estimates of FJ intake and nutritional contributions from some countries may be overestimated using current characterisations which may have implications for the development of population-based nutrition policies and re-iterates the need for precise and consistent characterisation of FJ data across Europe.

Estimation of FJ intakes across the lifecycle

The second aim of this review was to use the comparable/homogenous definition of FJ to examine current intakes and the proportion of consumers of FJ and to determine its contribution to intakes of energy, total sugars, free sugars, vitamin C, folate and potassium across the lifecycle in Europe.

Population mean intakes of FJ across the lifecycle for the total population across Europe ranged from 44–71 g/d with intakes generally increasing from infants to teenagers and decreasing in adults and older adults. While few studies have collated and compared data on intakes of FJ, a recent global review of beverage intake in over 187 countries found that adults (20+ years) consumed an average of 0·16 x 8oz servings (~36 g) of FJ daily with intakes across European regions (Central, East, West) ranging from 20–61 g/d which is similar to our findings for

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adults and older adults (47–53 g/d)[5]. To the best of the authors' knowledge, there are no reviews which have provided quantified estimates of FJ intake in children and teenagers between different countries. However, a review of fluid intakes from beverages across age groups (including adults) found that daily fruit & vegetable juice consumption varied globally with consumption decreasing with age[93]. Both of these reviews defined FJ as 'beverages containing 100 % fruit or vegetable juice with no added sweeteners' which is similar to the definition used in the present review.

While FBDG vary across countries, where FJ is included as part of the fruit & vegetable group, it is generally recommended that consumption is limited to <150 ml/d (which can count towards 1 fruit/vegetable portion only per day)[2,3,94]. This review found that, among consumers, intakes of FJ across the lifecycle were approximately 1 × 150 ml glass/day (range: 132–137 g/d) for adults and older adults, with lower intakes among infants (86 g/d), children (108 g/d) and teenagers (112 g/d). While other FBDG explicitly recommend avoiding FJ (grouping it with sugar-sweetened beverages)[2–4], some studies support the evidence for FJ as an important contributor to overall intakes of fruit & vegetables in all population groups[7,88] This is of particular importance as intakes of fruit and vegetables are consistently below recommendations globally[95] with the WHO attributing approximately 16 million disability-adjusted life years and 1·7 million deaths worldwide to these low intakes[96]. While this review found that intakes of FJ across the lifecycle in Europe are broadly in line with quantitative guidelines from FBDG which allow for the consumption of FJ, higher intakes have been reported for consumers across all age groups from national food consumption surveys in the US and Brazil (184–249 g/d)[6].

Nutritional contributions from FJ

FJ is typically low in energy, contains natural fruit sugars, important amounts of key micronutrients including vitamin C, folate and potassium[97] and by law is not permitted to have added sugars or sweeteners[1]. However, the role of FJ in a healthy diet is under scrutiny due to its sugar and dietary fibre content compared to the whole fruit counterpart. Considering this ongoing debate surrounding the role of FJ within FBDG and wider nutrition policies[17–19] it is important to consider available data on its contribution to energy and nutrient intakes at population level to better understand its overall dietary role.

This review found that across the lifecycle in Europe, FJ made negligible contributions to total energy intake (<3 %), small contributions to intakes of folate and potassium (up to 7 %) but contributed up to one-quarter of vitamin C intakes (4–26 %) (which promotes the absorption of iron). These data indicate the important role of FJ in the context of vitamin C intakes in population groups with little contribution to energy intakes. They also add to the evidence base for a nutritional role of 100 % FJ, given that other studies report an association between FJ and overall better diet quality including increased intakes of vitamin C, folate and potassium across the lifecycle[7–11]. However, this review also found that FJ contributed 2–11 % of total sugars and 2–14 % of free sugars intake across the lifecycle which is of public health interest as intakes of free sugars globally (including Europe) are higher than recommendations[23,98]. While these findings show a modest contribution of FJ to free sugars, a recent review has shown that sweet products and beverages (excluding FJ) are the major sources of added sugars across Europe (contributing 48–92 % of intakes)[98]. This highlights the importance of targeting sugar reduction strategies for discretionary/'top-shelf' foods which are not recommended in FBDG and, unlike FJ, where reformulation is legally possible.

Of note, the findings from this review that FJ contributed to 2–14 % of free sugars intake across the lifecycle differ considerably from the estimation made by EFSA (15–50 % contribution) in the setting of tolerable upper intake levels for sugar[19]. However, it is important to acknowledge that the values provided by EFSA were firstly for consumers only and secondly included other items such as nectars and FJ with added ingredients in the categorisation[19]. The findings of the current review are more in line with those reported by the UK SACN which provided more conservative estimates of the contribution of FJ to NMES (8–14 %) at population level[17]. This highlights significant challenges in the interpretation of data used for policy making with respect to FJ consumption and dietary guidance. To add to these challenges, FJ has recently been included as a topic of discussion in the context of ultra processed foods (UPF)[99], hence it is important to note that the definition of FJ utilised in this review (100 % pure FJ) would be classified as NOVA group 1 'minimally processed' (in comparison to FJ drinks which contain added ingredients)[100].

Conclusion

In conclusion, this review has identified significant gaps regarding the availability of country-specific national food consumption surveys across all population groups and specifically data relating to FJ consumption across Europe. However, using a comparable/homogenous definition of FJ, this review has reported population mean intakes of FJ across Europe were highest in children and teenagers and lowest in infants and older adults. Among consumers, adults and older adults consumed approximately 1 × 150 ml glass/day, which is similar to the amounts recommended in some FBDG, with lower intakes among infants (86 g/d), children (108 g/d) and teenagers (112 g/d). FJ made important contributions to intakes of vitamin C across the lifecycle while making little contribution to energy intakes but also contributed 2–14 % of free sugars intake (which may be considered modest considering reported contributions from low nutrient dense discretionary foods in other studies). Considering the findings of this review and previous studies of the relationship between FJ and health, these data would suggest there is a nutritional role for FJ at current consumption levels across Europe. However, the complexity of collating and interpreting data on FJ intake as elucidated in this review (and noted in other studies) raises questions surrounding the categorisation of FJ in research related to associations with health and may have implications for the development of population-based nutrition policies with respect to FJ consumption and dietary guidance.

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Authorship

JW and LK collated the data, interpreted the data, drafted the manuscript and read and approved the final version of the manuscript.

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