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ORIGINAL CONTRIBUTION

Sixteen-year trends in fruit consumption and related socioeconomic inequalities among adolescents in Western European countries

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Abstract

Purpose To investigate time trends in daily fruit consumption among Western European adolescents and in related socioeconomic inequalities.

Methods We used nationally representative data from 18 countries participating in five rounds (2002 to 2018) of the cross-sectional "Health Behaviour in School-aged Children" (HBSC) survey (n = 458,973). The questionnaire, standardised across countries and rounds, was self-administered at school by 11-, 13- and 15-year-old adolescents. Daily fruit consumption was assessed using a short food frequency questionnaire (sFFQ). Socioeconomic inequalities were measured using the Family Affluence Scale (FAS). Multilevel logistic regressions were applied to study linear time trends in daily fruit consumption, overall, by country and by FAS.

Results Between 2002 and 2018, daily fruit consumption increased in 10 countries (OR range, 1.04 to 1.13, $p < 0.05$) and decreased in 3 (OR range 0.96 to 0.98, $p < 0.05$). In all survey years combined, prevalence of daily fruit consumption was significantly higher among high FAS groups (42.6%) compared to medium (36.1%) and low FAS groups (31.7%; all countries: $p < 0.001$). Between 2002 and 2018, socioeconomic inequalities in fruit consumption increased in Austria, Germany, Italy, Netherlands, Scotland, Sweden, and Switzerland. Only in Norway FAS inequalities decreased while the prevalence increased.

Conclusion The prevalence of daily fruit consumption generally increased among adolescents between 2002 and 2018 in Western European countries, yet socioeconomic inequalities increased in some countries. Public health interventions should continue to promote fruit consumption with special attention to lower socioeconomic groups.

Keywords Time trends · Fruit · Adolescents · Health Behaviour in School-aged Children study · Socioeconomic inequalities · Multilevel models

Abbreviations

FAS	Family Affluence Scale
HBSC	Health Behaviour in School-aged Children
OR	Odds ratio
CI	Confidence interval
SEP	Socioeconomic position
sFFQ	Short Food Frequency Questionnaire
WHO	World Health Organisation

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Introduction

The benefit of adequate and habitual intake of fruit and vegetables in reducing the risk of overweight and obesity, as well as cardiovascular diseases, type 2 diabetes, colorectal cancer, and other chronic diseases, is well documented [1, 2]. In this regard, the World Health Organisation (WHO) recommends to eat at least five portions of fruit and vegetables per day [2]. While the positive effects of adequate fruit consumption on health are notable at any age, adolescence is a crucial period for establishing healthy eating habits that are likely to persist into adulthood [3]. It may thus provide long-term health benefits [4]. Yet adolescents are one of the population groups with the lowest fruit consumption, overall [5]. As adolescents become more autonomous in their food choices [6], and as the habits of fruit consumption may be different from those for vegetable consumption, it is valuable to study fruit specifically and apart from vegetables.

The international "Health Behaviour in School-Aged Children" (HBSC) survey has documented an increase in adolescents reporting daily fruit intake between 2002 and 2014 in Europe [7]. However, fruit consumption generally remains inadequate [1, 7]. The same international survey showed that the prevalence of daily fruit consumption decreased with age, and was generally higher among girls than boys in each age group (11-, 13- and 15-year-olds) [8]. Fruit consumption during adolescence is determined by several factors, including individual preferences, parental eating behaviours, availability of such foods (at home, at school), and time required to prepare [9]. Parental socioeconomic position (SEP) is also a determinant of fruit consumption [10]. A socioeconomic gradient in fruit consumption can be present during adolescence: higher fruit consumption among adolescents is associated with higher parental socioeconomic status [11]. Low-income households may have more difficulties to afford healthy foods [12].

In this regard, the European Union has launched various programs aimed at narrowing socioeconomic differences in food consumption among children and adolescents. For example, programs targeted schools to obtain subsidies to offer fruit, vegetables, and/or milk to pupils [13]. Also, many countries implemented policies and actions to reduce socioeconomic inequalities in access to healthy food, supported by the Food and Nutrition Action Plans of WHO Europe [14, 15]. Monitoring and evaluating such health promotion programs are essential to get a better understanding of their effectiveness, and their impact on socioeconomic inequalities in fruit consumption. Trend analysis is an important tool within this regard. In Europe, trend studies evaluating how socioeconomic differences in fruit consumption have changed over time in adolescents are scarce. Our research aimed (1) to update the analysis of trends in daily fruit consumption among adolescents between 2002 and 2018 in 18 Western European countries; and (2) to study trends in socioeconomic inequalities associated with fruit consumption in these countries. We hypothesized that, in most Western European countries, the prevalence of daily fruit consumption increased and associated socioeconomic inequalities might have decreased over time.

Materials and methods

Study design, sampling, and database

HBSC is a cross-national survey repeated every 4 years since 1986 under the aegis of the WHO Regional Office for Europe. (For more information about the methods, see https://hbsc.org/publications/survey-protocols/). In brief, information on health, well-being, social environment, and health behaviours is collected by means of a standardised questionnaire in all participating countries and across time. In each participating country, a nationally representative sample of 11-, 13- and 15-year-old adolescents is drawn using sampling stratification by administrative area and/or school type. One or more classes for each targeted age group within schools are randomly selected [16]. In each participating country, the sample size recommended is a minimum of 1,500 per age group (precision of ± 3% for a 50% prevalence) [16]. The questionnaires were self-administered to the pupils in the classroom, and confidentiality was ensured. Standardised instructions were given by teachers or research assistants [16]. Time of data collection varied by country and by survey year [11, 17]. Participation rates varied between countries and were higher at pupil than at school levels. For instance, in 2018, median [Q25–Q75] school rate was 47.0% [22.1–66.1] and pupil rate was 82.4% [65.4–89.7] [11].

For our analysis, data from the last five survey rounds (2002, 2006, 2010, 2014, and 2018) were used. We included all the Western European countries (or regions) with data available for each survey year of interest, representing 18 countries/regions in total (Austria, Flemish-speaking Belgium, French-speaking Belgium, Denmark, England, Finland, France, Germany, Ireland, Italy, Netherlands, Norway, Portugal, Scotland, Spain, Sweden, Switzerland, and Wales).

Ethics

Authorizations (respectively exemptions) from the institutional ethics committees or the relevant boards at the country level were obtained before proceeding with data collection.

The surveyed schools, pupils and their caregiver(s) received detailed information about the study and the possibility to withdraw their participation. Participants voluntarily filled out the anonymous questionnaire at school. No direct identifiable information about study participants (e.g., names, addresses) was collected. Method to obtain pupils' consent varied across countries and survey rounds.

Fruit consumption

Adolescents' fruit consumption was assessed using the item on fruit consumption from a short Food Frequency Questionnaire (sFFQ) [18]. This sFFQ was validated in similar samples of adolescents aged 11 to 14 years in Belgium. Correlation with a 7-day food record was acceptable with a mean fruit consumption frequency of 4.36 days/week in the sFFQ vs. 2.38 in the record (overestimation in the sFFQ, Spearman correlation coefficient: 0.34, n = 101) [18]. Test–retest weighted kappa statistics were also acceptable (0.53 in 11-to-12-year-olds, n = 207; 0.57 in 13-to-14-year-olds, n = 560) [18].

Adolescents were asked to indicate how many times a week they usually eat fruit with response options ranging on a seven points responses scale from 'Never' to 'Every day, more than once a day'. For this study, we categorised adolescents' fruit consumption to daily ('Once a day, every day' and 'Every day, more than once a day') and non-daily ('Never', 'Less than once a week', 'Once a week', '2–4 days a week', '5–6 days a week').

Season of data collection

Data was collected all over the school year. Months of data collection were grouped in seasons: December, January, and February as 'winter' (27.6% of data collected overall throughout the studied period); March, April, and May as 'spring' (52.1%); June, July, and August as 'summer' (4.8%); and September, October, and November as 'fall' (15.5%).

Socioeconomic position

The Family Affluence Scale (FAS) is a validated tool for measuring the level of household material affluence among adolescents [19]. In the surveys from 2002 to 2010, the FAS was assessed by four scored questions: 1) 'Does your family own a car, van or truck?' (none = 0; 1 = 1; 2 = 2), 2) 'Do you have your own bedroom for yourself?' (no = 0; yes = 1), 3) 'How many computers does your family own (including laptops and tablets)?' (none = 0; 1 = 1; 2 = 2; more than 2 = 3), 4) 'During the past 12 months, how many times did you travel away on vacation with your family?' (never = 0; once = 1; twice = 2; 3 times or more = 3). Since 2014, to increase the discriminatory properties [20], the question about holidays was further specified to focus on holidays abroad. Furthermore, two additional items were included: 5) 'How many bathrooms (room with a bath/shower or both) are in your home?' (none = 0; 1 = 1; 2 = 2; more than 2 = 3), and 6) 'Does your family have a dishwasher at home?' (no = 0; yes = 1) [16]. To take the cross-national context and different assessment periods into account, we used a ridit transformation of the FAS that assesses the relative FAS of the adolescents. The ridit-scores, based on cumulative probabilities, thus ranked the subjects within each country, survey year, sex, and age group. It ranged from 0 (lowest affluence) to 1 (highest affluence) [21]. The ridit-scores were then divided into quintiles to obtain three groups: first 20% = low affluent; next 60% = medium affluent; last 20% = high affluent households [22]. The ridit scoring of the FAS scale to assess the relative SEP of adolescents was validated in previous studies [20, 23, 24]. Such a procedure permits to highlight the extreme groups relative to each country background and time period.

Statistical analysis

Descriptive analyses consisted of computing prevalence of daily fruit consumption and absolute differences in prevalence between 2002 and 2018. Linear time trends in daily fruit consumption between 2002 and 2018 were modelled using multilevel logistic regressions, disregarding potential short-term trends, which could be partly explained by slight variations in sample characteristics between survey years. Time was considered as a continuous variable (from 1 to 5, for 5 survey rounds). To investigate the trends in socioeconomic inequalities in daily fruit consumption between 2002 and 2018, we then added an interaction term between FAS categories and time in the models. Odds ratios (ORs) and their 95% confidence interval (95% CI) of the interaction terms between time and FAS categories (high affluence = reference category) were estimated. Socioeconomic inequalities increased between 2002 and 2018 if OR of interaction was lower than 1 and decreased if OR was higher than 1. Finally, predictive margins to plot trends in prevalence (95% CI) of daily fruit consumers by FAS category and survey year were computed. All models were adjusted for sex, age groups [4], and seasons of data collection, and for FAS categories (dummy variables), as these influence fruit consumption [25].

For the multilevel modelling on the whole sample, we used a three-level hierarchical structure with random intercept: adolescent nested in class (or school if the class information was missing), and nested in country. For the analyses by country, a two-level structure with a random intercept for the models was used (adolescent nested in class). Variance partition coefficients (or intraclass correlation coefficients) were computed for the empty models for each

country. They ranged from 0.01 to 0.05, indicating low correlation of fruit consumption among adolescents belonging to the same class (or school).

Participants with missing data on sex (n = 10), age (n = 3,924) and fruit consumption (n = 3,736) were excluded from the analyses (Supplementary File 1). Analyses were performed on the whole sample, per survey year, and per country using Stata® version 16 (Stata Corp., College Station, USA). Alpha level was set at $p < 0.05$.

Results

Sample characteristics

The sample included 458,973 participants for overall trend analyses and 435,055 (94.8%) participants for trend analyses by FAS (Supplementary Files 1 and 2). Percentages of missing data on FAS by country and by survey year are presented in Supplementary File 3. Across all surveys, an equal proportion of boys and girls were included, and all age groups (11-, 13-, and 15-year-olds) were equally distributed (Table 1).

In the whole sample (all survey years and countries combined), the overall proportion of daily fruit consumption was low (36.4%), but higher among girls (39.9% vs. 32.7% among boys, $p < 0.001$), younger adolescents (42.1% vs. 35.4% in 13-year-olds and 31.3% in 15-year-olds, $p < 0.001$), and the high FAS group (42.6% vs. 36.1 in medium and 31.7% in low FAS groups, respectively, $p < 0.001$) (Table 2).

Proportions of daily fruit consumers were the highest (41.1 to 48.4%) in French-speaking Belgium, Denmark, Portugal, and Switzerland, and the lowest (23.4 to 32.2%) in Flemish-speaking Belgium, Finland, Sweden, and Wales. As with the whole-sample analyses, country-level analyses showed that the proportions were higher among girls and adolescents from high FAS groups, and lower among older adolescents in all 18 countries (Table 2, $p < 0.001$).

Time trends in daily fruit consumption

In 2002, the countries with the highest prevalence (≥ 38.0%) were Austria, French-speaking Belgium, Germany, Italy, and Portugal. In 2018, Austria, French-speaking Belgium, and Portugal still were among the countries with the highest proportions (≥ 40.0%), along with England, Ireland, and Switzerland (Table 3).

Regarding linear trends (Table 3), a statistically significant increase was found in 10/18 countries: OR [95%CI] ranged from 1.04 [1.00–1.07] in the Netherlands to 1.13 [1.11–1.15] in French-speaking Belgium ($p < 0.05$). The largest increase (OR ≥ 1.10) occurred in Austria, Flemish-speaking Belgium, French-speaking Belgium, England, Ireland, Norway, Switzerland, and Wales. In Finland, France, Portugal, Scotland, and Spain, no significant change in prevalence of daily fruit consumption was observed. A significant decrease was observed in Germany, Italy, and Sweden (OR range, 0.96 to 0.98, $p < 0.05$).

Table 1 Characteristics of participants by survey year (HBSC, 2002 to 2018)

	Total	Survey year				
		2002	2006	2010	2014	2018
Participants/adolescents (n)	458,973	86,374	93,026	90,713	96,290	92,570
Sex (%)						
Boys	49.2	49.2	49.5	49.1	49.2	49.2
Girls	50.8	50.8	50.5	50.9	50.8	50.8
Age groups (%)						
11 years old	33.5	35.2	32.7	32.3	32.2	35.5
13 years old	34.5	34.2	34.2	34.2	34.7	35.1
15 years old	32.0	30.6	33.1	33.5	33.1	29.4
Family affluence Scale (%)						
Low	20.2	21.2	20.6	20.1	19.2	20.1
Medium	57.1	58.4	57.6	57.2	54.0	58.5
High	17.5	17.7	17.6	17.6	17.0	17.7
Missing	5.2	2.7	4.2	5.2	9.9[a]	3.7

[a]In 2013/2014, two more items were added to the 4 items of FAS, and the responses of participants were considered only if all 6 items were answered. Moreover, Spain made an oversampling (n = 10,930), and FAS questions were not asked to everyone

Table 2 Prevalence of daily fruit consumption (%) by sex, age group (n = 458,973) and by FAS (n = 435,055), overall and by country (HBSC, 2002 to 2018)

	Total	Sex[a]		Age group[a]			Family Affluence Scale[a]		
		Boys	Girls	11 years old	13 years old	15 years old	Low	Medium	High
All countries	36.4	32.7	39.9	42.1	35.4	31.3	31.7	36.1	42.6
Austria	39.8	34.3	45.1	48.8	41.3	29.4	36.8	39.2	44.4
Belgium (Flemish)	31.4	26.5	36.3	37.0	31.0	29.2	26.6	31.7	36.9
Belgium (French)	48.4	46.5	44.5	51.5	45.6	41.6	42.5	46.1	53.0
Denmark	41.1	35.4	46.4	45.3	39.3	38.0	37.6	40.6	46.4
England	36.9	33.9	39.8	39.9	36.5	33.7	28.4	36.9	46.0
Finland	23.4	18.0	28.5	26.6	22.4	21.0	19.7	23.2	28.6
France	34.9	33.2	36.6	39.4	34.2	30.6	30.5	34.4	41.3
Germany	38.0	32.3	43.6	44.4	37.6	32.4	33.7	37.5	44.4
Ireland	38.0	34.1	41.5	44.2	36.3	34.4	30.8	38.6	45.0
Italy	39.3	36.9	41.7	41.6	38.1	36.4	36.5	38.7	44.8
Netherlands	32.5	28.5	36.4	40.0	32.0	25.6	29.2	32.0	38.3
Norway	37.4	32.0	42.8	42.5	35.7	32.8	34.4	36.9	42.0
Portugal	44.7	41.9	47.2	51.6	43.8	38.0	39.9	43.9	51.8
Scotland	36.9	35.4	40.4	46.1	34.5	30.4	28.7	37.8	45.0
Spain	35.5	33.8	37.1	42.2	34.7	30.6	30.0	35.6	41.8
Sweden	28.3	25.9	30.8	36.3	25.0	23.6	26.7	27.7	32.5
Switzerland	43.1	38.1	48.1	49.4	42.8	37.6	39.9	42.6	48.6
Wales	32.2	29.7	34.8	37.8	30.8	27.2	25.7	32.0	40.6

[a] All p-values for differences between groups < 0.001

Trends in socioeconomic inequalities in daily fruit consumption over time

For the whole sample, socioeconomic inequalities in daily fruit consumption increased between 2002 and 2018 (Supplementary File 4). The difference in the proportion of daily fruit consumers between adolescents from high FAS group compared to their counterparts from medium and low FAS groups increased over time {adolescents with medium FAS [OR (95%CI) 0.97 (0.95–0.98), p < 0.001] and adolescents with low FAS [OR [95%CI]: 0.97 (0.95–0.99), p < 0.05], compared to adolescents with high FAS}.

Regarding the trends in the proportion of daily fruit consumers by FAS, for each country separately (Fig. 1), there was a change in socioeconomic inequalities in eight countries. Between 2002 and 2018, socioeconomic inequalities in daily fruit consumption increased between adolescents with low FAS and these with high FAS in Austria, Italy, Netherlands, Scotland, and Switzerland (OR range, 0.90 to 0.95, p < 0.05, Supplementary File 4). Socioeconomic inequalities also significantly increased between the medium FAS adolescents and the high FAS group in Germany, Italy, and Sweden (OR range, 0.92 to 0.94, p < 0.05, Supplementary File 4). Only in Norway the difference in the prevalence of daily fruit consumption between the medium and the high FAS groups narrowed over time (i.e. less inequalities) from 2002 to 2018 [OR (95%CI) 1.07 (1.01–1.13), p < 0.05]. Thus, the reduction in daily fruit consumption occurring since 2006 in Norway was more marked among the adolescents from high and medium FAS groups. In the other countries (10/18), inequalities in daily fruit consumption remained stable (Supplementary File 5).

Discussion

Between 2002 and 2018, an increase in daily fruit consumption among adolescents was found in 10 out of the 18 studied Western European countries (Austria, Belgium [Flemish- and French-speaking], Denmark, England, Ireland, Netherlands, Norway, Switzerland, and Wales) but the proportions of daily fruit consumers remained low. A decrease was observed in 3 countries (Germany, Italy, and Sweden). Socioeconomic inequalities in daily fruit consumption increased in 7 countries (Austria, Germany, Italy, Netherlands, Scotland, Sweden, and Switzerland), decreased in 1 (Norway), and remained stable in the other 10.

Increasing daily fruit consumption over time

The results support existing HBSC survey data showing that fruit consumption follows increasing trends in Western European countries [4, 26]. Similar trends were also observed with other data, such as in the Netherlands

Table 3 Trends in prevalence of daily fruit consumption (%) between 2002 and 2018, overall (n = 458,973) and by country (n defined in Supplementary File 2)

	Survey year[a]					Difference in prevalence: 2018—2002	OR[b]	CI 95%
	2002	2006	2010	2014	2018			
All countries	32.6	36.3	37.4	37.0	37.9	+ 5.3	1.01	1.00–1.02[d]
Austria	38.2	34.6	39.9	45.7	42.5	+ 4.3	1.11	1.05–1.16[c]
Belgium (Flemish)	36.5	35.2	29.7	38.9	39.2	+ 2.7	1.11	1.08–1.13[c]
Belgium (French)	38.4	44.8	48.8	49.1	51.3	+ 12.9	1.13	1.11–1.15[c]
Denmark	32.6	42.0	49.6	43.7	38.1	+ 5.5	1.04	1.01–1.06[d]
England	27.2	43.6	38.5	38.4	40.9	+ 13.7	1.08	1.06–1.11[c]
Finland	21.5	23.4	25.0	24.0	22.0	+ 0.5	1.02	1.00–1.05
France	34.3	31.4	39.6	35.8	34.4	+ 0.1	1.01	0.99–1.02
Germany	42.8	35.6	37.0	37.1	38.2	− 4.6	0.96	0.93–0.99[d]
Ireland	33.0	36.5	35.5	40.9	43.5	+ 10.5	1.11	1.08–1.13[c]
Italy	38.0	43.4	41.7	37.4	36.1	− 1.9	0.96	0.94–0.98[c]
Netherlands	28.3	32.6	32.6	35.0	34.0	+ 5.7	1.04	1.00–1.07[d]
Norway	29.0	41.8	42.4	39.4	35.1	+ 6.1	1.12	1.08–1.17[c]
Portugal	48.7	43.8	43.5	41.4	46.8	− 1.9	1.00	0.97–1.03
Scotland	34.2	38.7	36.3	38.5	36.3	+ 2.1	1.00	0.97–1.04
Spain	36.9	33.2	37.7	35.0	37.3	+ 0.4	1.02	1.00–1.04
Sweden	27.4	32.3	28.5	27.4	26.5	− 0.9	0.98	0.96–1.00[d]
Switzerland	35.6	41.5	42.5	47.2	45.7	+ 10.1	1.10	1.08–1.13[c]
Wales	23.0	34.6	32.5	31.9	33.7	+ 10.7	1.10	1.07–1.12[c]

[a]Crude prevalence (without adjustment)

[b]Time trends estimated by multilevel logistic models adjusted for sex, age group, and season of data collection (odds ratio for time as a continuous variable). OR > 1 means that the prevalence of daily fruit consumption increased between 2002 and 2018. OR < 1 means that the prevalence of daily fruit consumption decreased between 2002 and 2018

[c]P-value for trend < 0.001

[d]P-value for trend < 0.05

(9-to-18-year-old adolescents carried out in 2012 and 2016) [27], in Norway (regional sample, between the longitudinal studies Young-HUNT1 (1995 to 1997) and Young-HUNT3 (2006 to 2008)) [28] and in the United States (trends in diet quality across nine cycles of NHANES surveys (1999–2000 to 2015–2016)) [29]. Our work coupled with the existing studies confirm an overall tendency among adolescents that is transnational. In comparison, such tendencies are not the same in adults. For instance, in UK, there was little change in fruit intake between the first and the 9th National Diet and Nutrition Surveys [30].

The implementation of national nutrition public health initiatives may explain the rising trends in fruit consumption in adolescents. Since the 2000 s, many countries have launched "5 a day" campaigns [13] (or "6 a day" in Denmark [31]), which could have increased awareness of the importance of regular fruit consumption [31]. Along with educational programs, nutrition policies have been set up in Europe to increase the availability and accessibility of fruit (and vegetables) in order to not base behaviour changes on individual responsibility only. For example, some countries have established guidelines for school canteens (e.g., Denmark, England, Norway, Sweden, Italy) [32]. This may have contributed to the observed increase in daily fruit consumption in our study among school-aged children. Since 2009, subsidies from the European Commission have been available for schools to provide healthy food products (including fresh fruit) to pupils for free [33]. Acting on fruit availability might also have contributed to a higher consumption [34]. Based on our descriptive findings, attributable effects of such actions can only be assumed, but reported changes are encouraging.

Nevertheless, in three countries (Germany, Italy, and Sweden), we observed a significant decrease in the prevalence of daily fruit consumption in adolescents between 2002 and 2018. In Sweden and Italy, the prevalence increased until 2006 and then decreased until 2018. A 2021 systematic review and meta-analysis over the impact of the 2008 economic crisis on dietary intake [35] reported a decrease in fruit intake in 14/18 studies and a decrease in the prevalence of daily consumers in all studies examining fruit consumption. This may reflect a behaviour change for cheaper foods than fruit and vegetables, which are perceived as expensive, especially when reported to kcal/100 g [36]. Decreased or

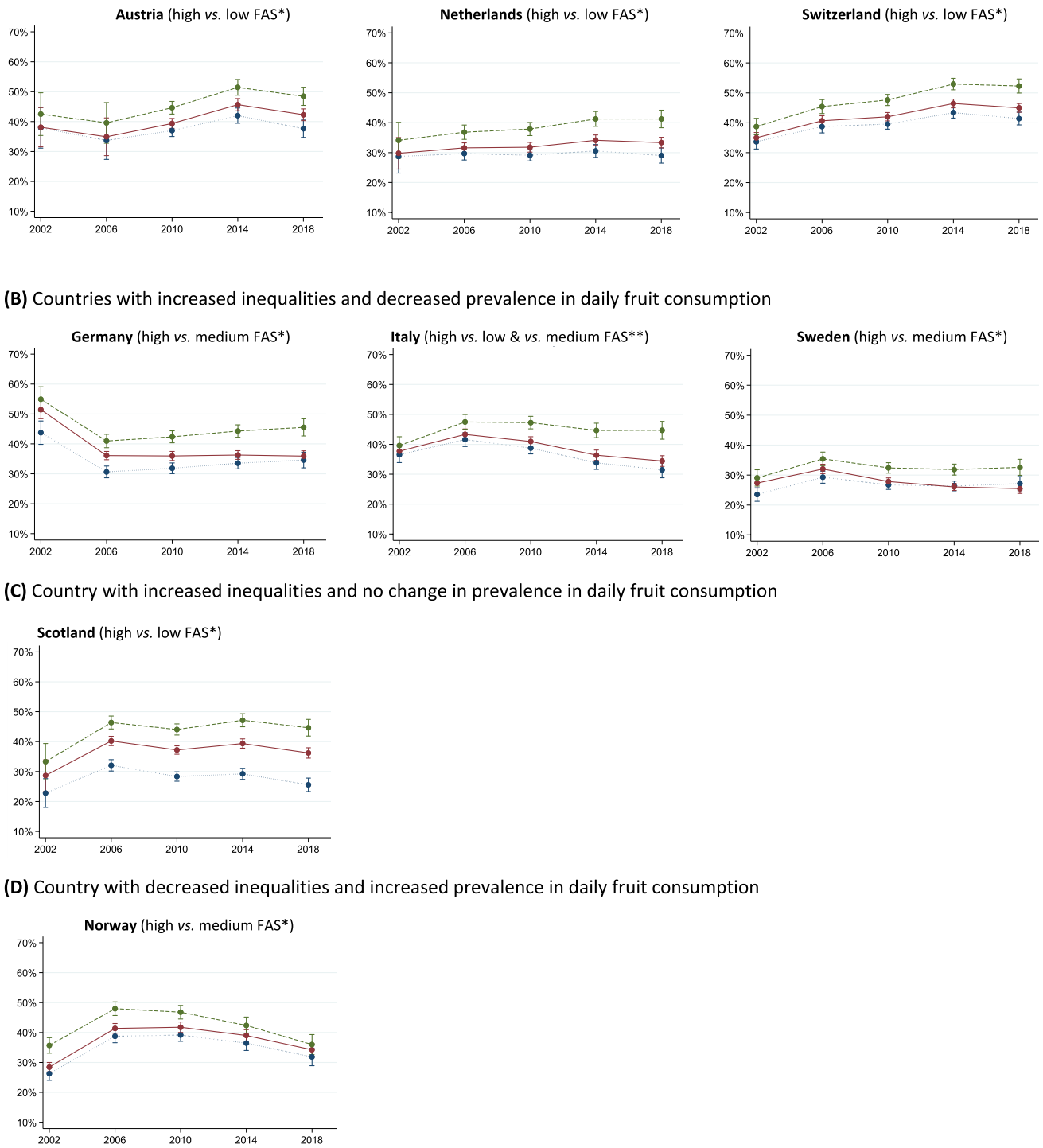

Fig. 1 Trends in prevalence and their 95% CI of daily fruit consumers by country and by FAS category (*p < 0.05; **p < 0.001 for interaction terms FAS*time). On the top (**A**, **B**, **C**) are countries with increasing inequalities in daily fruit consumption and at the bottom (**D**) is the country with decreasing inequalities. The multilevel logistic models (dependent variable: daily fruit consumption; independent variable: FAS categories) were adjusted for sex, age group, survey year, and season of questionnaire administration). Number of participants by country are presented in Supplementary File 2. Legend: low FAS; medium FAS; high FAS. FAS, Family Affluence Scale

increased prevalence of daily fruit consumption may thus have been influenced by various factors and differently across the countries. This observation still deserves further research to be fully understood.

Trends in socioeconomic inequalities in daily fruit consumption

Our study showed that although the prevalence of daily fruit consumers increased in all FAS groups in many countries, differences across groups remained high, particularly in Scotland. Socioeconomic inequalities in fruit consumption increased in Austria, Germany, Italy, Netherlands, Scotland, Sweden, and Switzerland. Remarkably, during the same period, inequalities in daily vegetable consumption increased only in two of these countries: Austria and Scotland (HBSC data, not shown). In our study (2002–2018), socioeconomic inequalities in daily fruit consumption between adolescents from the most affluent families and the medium affluent families decreased only in Norway.

Further efforts to reduce socioeconomic inequalities in fruit consumption are needed. One possible intervention to reduce social inequalities in diet quality, including fruit, is to act on school meals. A U.S. survey conducted in 2014 [37] showed that adolescents from low-income families consumed more fruit and vegetables when they ate their hot meals at school.

The WHO Regional Office has formulated recommendations for public health policies and actions in the Member States in the Food and Nutrition Action Plans [15, 38]. One of the objectives was to create healthy food and drink environments, for instance by acting on school nutrition policies, or by introducing targeted subsidies to act on the affordability and accessibility of fruit and other healthy foods [15]. Many countries have then implemented nutrition programmes, such as *Free School Fruit Scheme* (one daily portion of free fruit or vegetables in schools with subsidies from EU) or *Fruit Subscription Programmes* with parent's participation (Northern Europe). Such initiatives could lead to an increase in fruit intake among the least affluent adolescents. For instance, these programmes in Norway helped to reduce socioeconomic differences [39]. These findings suggest that school meals may help compensate for the poorer quality of meals consumed at home, thereby reducing socioeconomic inequalities in diet as long as pupils who need it most attend school canteens [40]. Future research should investigate why some countries fail to narrow socioeconomic inequalities in fruit consumption among adolescents, by studying for instance associations with family structure, fruit availability, parent's feeding styles, and related outcomes, e.g. overweight and obesity. Examining other macro-level characteristics could also be interesting to further explore the differences in the social gradient across countries and time. Additionally, as this study was based on data collected before the COVID-19 pandemic, it would be relevant to look over the effect of COVID-19 on socioeconomic inequalities in fruit consumption.

Strengths and limitations

Firstly, a major strength of our study is the long period of analysis spanning a 16-year period, and the use of highly standardised and comparable data stemming from large nationally representative samples of 11-, 13- and 15-year-old adolescents from 18 countries. This ensured a reliable estimation of trends in daily fruit consumption and of trends in related socioeconomic inequalities. Secondly, the standardized sampling plan enabled to reach representative samples at a national level. Of note, descriptive analyses in all countries together may not be interpreted as representative of the population of European adolescents because they were not proportionate to the relative distribution of populations in Europe. However, trends, which were our main objective, still were relevant to address because the disproportion was constant over time. Thirdly, using a simple family affluence scale as a valid proxy for estimating family material affluence among adolescents [41] allowed us to limit missing data on SEP, unlike other socioeconomic indicators (e.g., parental education or perceived family wealth, not measured in HBSC every round in all countries). However, FAS only reflects one aspect of SEP, i.e. household material affluence and SEP differences in fruit consumption might have been under-estimated in comparison with those observed using parental education or occupation for instance, as partially observed in the 2002 HBSC survey [42]. In addition, using FAS to estimate relative SEP may not well distinguish adolescents in all countries [43]. Fourthly, our analyses were adjusted for the season when questionnaires were administrated, since fruit consumption may vary across seasons [25]. Fifthly, one limitation of our study is the use of a sFFQ to self-assess the frequency of fruit consumption without collecting data on portions or amounts consumed, which limits the assessment of the adherence with WHO recommendations [2]. When carrying out the same analyses using "more than once a day" frequency as a threshold, our conclusions were similar for all analyses based on the total sample (data not shown). In addition, the sFFQ did not include details on the type of fruit consumed nor their nutritional quality in relation with cooking process for instance. However, the HBSC sFFQ has an acceptable reliability [18] and is valid for the current research purposes. Sixthly, with self-reporting dietary intake data, social desirability bias cannot be excluded, as healthy foods such as fruit can be overreported [44]. Also, cognitive factors can influence the reliability and accuracy of responses in children and adolescents [44], including poor memory regarding past dietary habits.

However, this issue probably remained constant over time (i.e., limited impact on trend analyses).

Conclusions

The prevalence of daily fruit consumption among 11- to 15-year-old adolescents increased between 2002 and 2018 in most countries (significant increase in 10/18) but remained low. Moreover, socioeconomic inequalities in fruit consumption were present, and even increased in 7/18 countries. A decrease in socioeconomic inequalities over time was observed in Norway only. Public health policies should continue to focus on increasing fruit consumption and more efforts are needed to narrow the gap between adolescents from less affluent families and more affluent ones in the consumption of healthy foods, such as fruit and vegetables.

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Author contribution CN, AC, and KC conceived and designed the manuscript as well as defined the methodology. CN analyzed the data, and drafted the manuscript under the supervision of AC and KC. All co-authors reviewed the manuscript, provided critical recommendations, and approved the final manuscript.

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Data availability Stata do-files are available on request.

Declarations

Conflicts of interest CN, MR, MD, CK, ASF, PN, KC, and AC declare no conflict of interest.

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