The influence of early feeding practices on fruit and vegetable intake among preschool children in 4 European birth cohorts1–3

Blandine de Lauzon-Guillain, Louise Jones, Andreia Oliveira, George Moschonis, Aisha Betoko, Carla Lopes, Pedro Moreira, Yannis Manios, Nikolaos G Papadopoulos, Pauline Emmett, and Marie Aline Charles

ABSTRACT
Background: Fruit and vegetable intake in children remains below recommendations in many countries. The long-term effects of early parental feeding practices on fruit and vegetable intake are not clearly established.

Objective: The purpose of the current study was to examine whether early feeding practices influence later fruit and vegetable intake in preschool children.

Design: The study used data from 4 European cohorts: the British Avon Longitudinal Study of Parents and Children (ALSPAC), the French Etude des Déterminants pré et postnatals de la santé et du développement de l'Enfant study, the Portuguese Generation XXI Birth Cohort, and the Greek EuroPrevall study. Fruit and vegetable intake was assessed in each cohort by food-frequency questionnaire. Associations between early feeding practices, such as breastfeeding and timing of complementary feeding, and fruit and/or vegetable intake in 2–4-y-old children were tested by using logistic regressions, separately in each cohort, after adjustment for infant's age and sex and maternal age, educational level, smoking during pregnancy, and maternal fruit and vegetable intake.

Results: Large differences in early feeding practices were highlighted across the 4 European cohorts with longer breastfeeding duration in the Generation XXI Birth Cohort and earlier introduction to complementary foods in ALSPAC. Longer breastfeeding duration was consistently related to higher fruit and vegetable intake in young children, whereas the associations with age of introduction to fruit and vegetable intake were weaker and less consistent across the cohorts. Mothers’ fruit and vegetable intake (available in 3 of the cohorts) did not substantially attenuate the relation with breastfeeding duration.

Conclusion: The concordant positive association between breastfeeding duration and fruit and vegetable intake in different cultural contexts favors an independent specific effect.


INTRODUCTION
Several surveys have reported that fruit and vegetable intake is below the recommended guidelines in adolescents (1) and younger children, especially vegetable intake (2–5). It is evident that a diet rich in fruit and vegetables in childhood has many beneficial effects on health outcomes throughout childhood and in adulthood (6); eg, children who eat more fruit and vegetables have lower blood pressure and a lower risk of stroke as adults (7, 8). Food preferences have been shown to take shape early in life and track through to adulthood (9, 10). Moreover, different nutritional education intervention studies show that it is difficult to modify food behaviors in adults (11–13) and in older children (14). Therefore, it appears important to understand which factors influence food-habit formation early in life to prevent the development of unhealthy eating habits and the manifestation of related metabolic disorders in later life.

Previous studies have reported that early feeding practices may be related to fruit and vegetable intake in later childhood. Longer breastfeeding duration (15, 16) and higher fruit and vegetable intake in infancy (17) were found to be related to higher vegetable intake in childhood. Moreover, in experimental studies a sensitive period in human flavor learning has been highlighted (18), which suggests that age of introduction to fruit and vegetables could be of great importance in later fruit and vegetable acceptance (16). There is evidence that child pickiness affects the intake of vegetables but not fruit (19), possibly because vegetables often have less palatable tastes than fruit. Furthermore, maternal intakes of fruit and vegetables have been shown to be strongly associated with intake in their children (19, 20).

The purpose of the current study was to examine, in 4 European birth cohorts with different cultural habits in terms of fruit and vegetable consumption, whether early feeding practices, eg, breastfeeding duration and timing of complementary feeding, influence fruit and vegetable intake in preschool children. When possible, the influence of maternal diet will also be tested.

1 From the Centre for Research in Epidemiology and Population Health, Villejuif, France (BdL-G, AB, and MAC); the University of Paris-Sud, UMR-S 1018, Villejuif, France (BdL-G, AB, and MAC); the School of Social and Community Medicine, University of Bristol, Bristol, United Kingdom (LJ and PE); the Department of Clinical Epidemiology, Predictive Medicine and Public Health (AO and CL), the Faculty of Food and Nutrition Sciences (PM), the Public Health Institute (AO, CL, and PM), University of Porto Medical School, Portugal; the Department of Nutrition and Dietetics, Harokopio University (GM and YM) and the Department of Allergy, 2nd Pediatric Clinic, University of Athens (NGP), Greece.
2 Supported by the European Community’s Seventh Framework Program (FP7/ 2007-2013) under the grant agreement n’FP7-245012-HabEat. The EuroPrevall study was funded by the EU through FP6- FOOD-CT-2005-514000.
3 Address correspondence to B de Lauzon-Guillain, INSERM U1018, Eq10, 16 avenue Paul Vaillant Courtois, F-94807 Villejuif Cedex, France. E-mail: blandine.delauzon@insERM.fr.
Received January 11, 2013. Accepted for publication June 5, 2013. doi: 10.3945/ajcn.112.057026.
SUBJECTS AND METHODS

The analyses were based on 4 European cohorts: the British Avon Longitudinal Study of Parents and Children (ALSPAC)\(^4\), the French Etude des Déterminants pre et postnataux de la santé et du développement de l’Enfant (EDEN) study, the Portuguese Generation XXI Birth Cohort, and the Greek EuroPrevall study.

ALSPAC

ALSPAC is a longitudinal birth cohort study, which recruited pregnant women resident in a geographically defined area in southwest England with an expected delivery date between April 1991 and December 1992. A cohort of 14,541 pregnant women was established, which resulted in 13,988 children alive at 12 mo of age. More details can be found on the ALSPAC website (http://www.bristol.ac.uk/alspac/). Dietary information was collected via parent-completed food-frequency questionnaires (FFQs) at the ages of 6 and 15 mo and 2, 3, 4, 7, 9, and 13 y as part of larger questionnaires that were sent through the mail with a reply envelope. In the current study, we used dietary data collected at 4 to 8 y for comparison with the other cohorts and at 7, 9, and 13 y to assess the stability of results throughout childhood. The parent was asked to record how often the child consumed each of the foods “today.” Breastfeeding duration and age at introduction to various foods was obtained from the 6- and 15-mo questionnaires. Sociodemographic information and maternal diet (by FFQ) was collected by questionnaire during pregnancy. Data were available for all variables of interest on 7269 children (see Supplemental Table S1 under “Supplemental data” in the online issue). At 43 and 61 mo, children’s food intake was also assessed by using diet diaries. ANOVA showed that significantly higher fruit or vegetables intakes were measured in the diet diaries of those categorized in the FFQ as eating fruit or vegetables more than once a day compared with those categorized in the FFQ as eating fruit or vegetables once a day or less (43-mo data were available for all variables of interest on 7269 children (see Supplemental Table S1 under “Supplemental data” in the online issue). At 43 and 61 mo, children’s food intake was also assessed by using diet diaries. ANOVA showed that significantly higher fruit or vegetables intakes were measured in the diet diaries of those categorized in the FFQ as eating fruit or vegetables more than once a day compared with those categorized in the FFQ as eating fruit or vegetables once a day or less (43-mo data were available for all variables of interest on 7269 children (see Supplemental Table S1 under “Supplemental data” in the online issue)).

At 48 mo, the children’s food intake was also assessed by using diet diaries in a subsample (n = 437), and the Spearman’s correlation between fruit and vegetables intake assessed by FFQ or diet diaries was moderate to high (0.51 for fruit and 0.41 for vegetables).

French EDEN study

The EDEN mother-child cohort is a longitudinal study that recruited, between February 2003 and January 2006, 2002 pregnant women in 2 French university hospitals, in Nancy and Poitiers, before 24 wk of amenorrhea and on average at 15 wk. A questionnaire completed during pregnancy provided data on sociodemographic factors, maternal diet (FFQ) and, tobacco use. Birth data were collected from medical records. When the child was 4, 8, and 12 mo, mothers completed mailed questionnaires with details on the feeding method and age of introduction to several food groups. They also completed a 26-item child FFQ at 2 and 3 y. The questionnaire includes 7 categories of frequencies, ranging from never to more than once a day, and 5 items specifically related to fruit and vegetable consumption: vegetables or soups, raw vegetables, fresh fruit, fruit purees, and fruit juice. Complete data were available for 1302 children (see Supplemental Table S1 under “Supplemental data” in the online issue). The infant’s diet was also assessed by 3-d food records at ages 4 and 8 mo. A comparison of the response to the main questionnaires on breastfeeding with food records performed during the first year of life showed good agreement with only 2% of discordant answers.

Portuguese Generation XXI Birth Cohort

Generation XXI is a population-based birth cohort established in a defined geographic area in the north of Portugal (Porto) by recruiting pregnant women in 5 maternity units between April 2005 and August 2006 (21). A total of 8647 children and 8495 mothers were enrolled at baseline. Of the invited mothers, 91.4% accepted to participate. Data on demographic and social conditions, lifestyles, medical history, and prenatal care were collected by trained interviewers during the first 24–72 h after delivery. At 15 mo of age, information was collected on breastfeeding and complementary feeding (available for a subsample of 1040). At 4 y, parental report of their child’s dietary intake was assessed by FFQ covering the last 6 mo. The questionnaire included 9 categories of frequencies, ranging from never to ≥4 times/d, and 4 items specifically relating to fruit and vegetable consumption: vegetable soup, cooked vegetables, raw vegetables, and fruit. Complete data were available for 556 children (see Supplemental Table S1 under “Supplemental data” in the online issue). At 48 mo, the children’s food intake was also assessed by using diet diaries in a subsample (n = 437), and the Spearman’s correlation between fruit and vegetables intake assessed by FFQ or diet diaries was moderate to high (0.51 for fruit and 0.41 for vegetables).

Greek EuroPrevall Study

The Greek EuroPrevall cohort study was a longitudinal study conducted with 1084 newborns between October 2005 and October 2007 in 2 different clinics in Athens. The Greek EuroPrevall cohort data presented in the current study were collected as part of the EuroPrevall project (22) that was funded by the European Union. Standardized questionnaires were used to collect baseline data from each mother regarding her pregnancy, child’s birth, dietary intake (focusing mainly on foods related to allergies), and quality of life. Sociodemographic data, such as parental educational level, parental age, occupational status, and family income were collected at birth. Follow-ups, using similar questionnaires, were conducted when children were 12-, 24-, and 30-mo old by telephone. During these interviews, data on breastfeeding and complementary feeding practices were collected. Child’s food intake was collected at 24 mo by using a 80-item FFQ covering the past 3 mo. The questionnaire included 11 categories of frequencies, ranging from never to more than time a day and 24 items specifically relating to fruit and vegetable consumption. Complete data were available for 800 children (see Supplemental Table S1 under “Supplemental data” in the online issue).

Fruit and vegetable intakes were assessed from FFQs in each cohort. For these analyses, fruit intake was exclusive of jams/

\(^{4}\)ALSPAC, Avon Longitudinal Study of Parents and Children; EDEN, Etude des Déterminants pre et postnataux de la santé et du développement de l’Enfant; FFQ, food-frequency questionnaire.
jellies and fruit juice, whereas vegetable intake was exclusive of legumes and potatoes. Common cutoffs for fruit and vegetable intake frequency were used across the 4 cohorts (>1 serving/d compared with ≤1 serving/d for fruit and for vegetables considered separately), except for vegetable frequency in Generation XXI where the number of children in the ≤1 serving/d category was very low (5.4%), mainly because of the high daily consumption of vegetable soup in Portugal. Therefore, the cutoff used for vegetable frequency was >3 serving/d compared with ≤3 serving/d in Generation XXI.

Breastfeeding was considered both exclusive and mixed (designated as any breastfeeding), and its duration was assessed as a categorical variable: never, <1 mo, 1–3 mo, 3–6 mo, and ≥6 mo.

Associations between early feeding practices and later fruit and vegetable intake were tested by using logistic regressions (OR, 95% CI) and were adjusted for several potential confounders. These confounders included the sex of the child, sociodemographic variables (maternal age, education level, social class, and family income), perinatal factors (birth weight, gestational age, parity, maternal smoking, and maternal diet during pregnancy), parental BMI, and other aspects of feeding practices (age of introduction of food other than fruit and vegetables). Only variables that were associated with both the outcome and the timing of complementary feeding consistently in ≥2 cohorts were included in the final model: child’s age, child’s sex, maternal age, educational level, smoking during pregnancy, and, as a second step in ALSPAC and Generation XXI, maternal fruit and vegetables intake at 47–48 mo, or in EDEN, maternal fruit and vegetables intake during pregnancy. Because early feeding practices are likely to be highly related, breastfeeding duration and age of introduction of fruit and vegetables were introduced simultaneously in the regression models.

Subjects with missing values on fruit and vegetable intake or parental feeding practices or maternal age, education level, and maternal smoking during pregnancy were excluded from the analyses. In cohorts with twins, one of them was selected at random to be included in the analyses. The different steps of the sample selection are presented elsewhere (see Supplementary Table S1 under “Supplemental data” in the online issue). Differences at baseline between subjects included in these analyses and subjects excluded are described for each cohort elsewhere (see Supplemental Table S2 under “Supplemental data” in the online issue). Included mother were more educated, older, and less often overweight than excluded mothers.

In the Greek EuroPrevall study, maternal age and maternal smoking during pregnancy were available only for a subsample of 221 children. Thus, it was decided to provide results of the analysis without these confounders in the Greek cohort and then to report a sensitivity analysis on this sub-sample with all confounders. To test for linear trend, the median value for each category was used as a continuous variable. All analyses were performed by using SAS software, version 9.2 (SAS Institute Inc) in EDEN; STATA/SE (StataCorp) version 10.0 in Generation XXI; SPSS 19.0 in ALSPAC and EuroPrevall.

### TABLE 1

Characteristics of mothers and children in 4 European cohorts: ALSPAC, EDEN, EuroPrevall, and Generation XXI

<table>
<thead>
<tr>
<th></th>
<th>ALSPAC, 2 y (n = 7269)</th>
<th>EDEN, 2 y (n = 1302)</th>
<th>Greek-EuroPrevall, 2 y (n = 800)</th>
<th>Generation XXI, 4 y (n = 556)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal age [n (%)]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;25 y</td>
<td>1144 (16)</td>
<td>190 (15)</td>
<td>NA</td>
<td>63 (11)</td>
</tr>
<tr>
<td>25–35 y</td>
<td>5547 (76)</td>
<td>967 (74)</td>
<td>NA</td>
<td>413 (74)</td>
</tr>
<tr>
<td>&gt;35 y</td>
<td>578 (8)</td>
<td>145 (11)</td>
<td>80 (14)</td>
<td></td>
</tr>
<tr>
<td>Firstborn [n (%)]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>215 (3)</td>
<td>297 (23)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>3207 (44)</td>
<td>337 (26)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>3847 (53)</td>
<td>668 (51)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal BMI [n (%)]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>518 (7)</td>
<td>19 (1)</td>
<td>NA</td>
<td>87 (16)</td>
</tr>
<tr>
<td>&lt;18.5 kg/m²</td>
<td>292 (4)</td>
<td>102 (8)</td>
<td>13 (2)</td>
<td></td>
</tr>
<tr>
<td>18.5–24.9 kg/m²</td>
<td>5137 (71)</td>
<td>860 (66)</td>
<td>286 (51)</td>
<td></td>
</tr>
<tr>
<td>25–29.9 kg/m²</td>
<td>977 (13)</td>
<td>221 (17)</td>
<td>122 (22)</td>
<td></td>
</tr>
<tr>
<td>≥30 kg/m²</td>
<td>345 (5)</td>
<td>100 (8)</td>
<td>48 (9)</td>
<td></td>
</tr>
<tr>
<td>Maternal smoking during pregnancy [n (%)]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonsmoker</td>
<td>5739 (79)</td>
<td>1022 (78)</td>
<td>NA</td>
<td>448 (81)</td>
</tr>
<tr>
<td>Ever-smoker</td>
<td>1530 (21)</td>
<td>280 (22)</td>
<td>108 (19)</td>
<td></td>
</tr>
<tr>
<td>Sex [n (%)]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>3710 (51)</td>
<td>672 (52)</td>
<td>416 (52)</td>
<td>279 (50)</td>
</tr>
<tr>
<td>Girls</td>
<td>3559 (49)</td>
<td>630 (48)</td>
<td>384 (48)</td>
<td>277 (50)</td>
</tr>
<tr>
<td>Gestational age [n (%)]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;37 wk</td>
<td>353 (5)</td>
<td>69 (5)</td>
<td>53 (7)</td>
<td>89 (16)</td>
</tr>
<tr>
<td>≥37 wk</td>
<td>6916 (95)</td>
<td>1233 (95)</td>
<td>747 (93)</td>
<td>450 (81)</td>
</tr>
<tr>
<td>Fruit intake (servings/d)</td>
<td>1.2 ± 0.7</td>
<td>1.3 ± 0.8</td>
<td>1.1 ± 0.5</td>
<td>1.7 ± 0.8</td>
</tr>
<tr>
<td>Vegetable intake (servings/d)</td>
<td>1.2 ± 0.6</td>
<td>1.1 ± 0.7</td>
<td>0.7 ± 0.4</td>
<td>3.3 ± 1.3</td>
</tr>
</tbody>
</table>

1 ALSPAC, Avon Longitudinal Study of Parents and Children; EDEN, Etude des Determinants pre et postnataux de la sante et du developpement de l’Enfant; NA, not available.
2 Subsample with complete data at both 15 mo and 4 y, after exclusions.
3 Mean ± SD (all such values).
RESULTS

Early nutrition across the 4 European cohorts

Characteristics of the study samples were described in Table 1. Fruit and vegetable intake in early childhood varied across the 4 cohorts, with an average intake of <1 vegetable/d in the Greek EuroPrevall study and >3 vegetables/d in the Generation XXI cohort.

There were differences in early feeding practices across the 4 cohorts. Longer breastfeeding duration was found in Generation XXI than in ALSPAC, EDEN, and Greek EuroPrevall (Figure 1). The timing of complementary feeding (foods other than milk) varied also across the cohorts (Figure 2): complementary foods were introduced mainly between 3 and 4 mo of age in ALSPAC, at ~4 mo in Generation XXI, and at ~5 mo in Greek EuroPrevall. In EDEN, there was no peak age for introduction to complementary foods.

Association between breastfeeding duration and later fruit and vegetable intakes

Breastfeeding duration was positively associated with later fruit intake in EDEN and ALSPAC but not consistently in Generation XXI and EuroPrevall (Figure 3). Associations between any breastfeeding duration and vegetable intake were more consistent across the cohorts (Figure 4); a shorter breastfeeding duration was related to lower vegetable intake at age 2–4 y. Compared with infants breastfed for 3 to 6 mo, those who were never breastfed had an OR for the intake of >1 serving/d of vegetables of 0.7 (95% CI: 0.6, 0.8) and 0.5 (95% CI: 0.3, 0.7) in ALSPAC 2 y and EDEN 3 y, respectively. A persistent positive trend was found in ALSPAC and EDEN at older ages. The association was not significant in EuroPrevall and Generation XXI, although in the same direction. Additional adjustment for maternal fruit or vegetable intake in childhood was tested in ALSPAC and Generation XXI. The positive associations remained significant in ALSPAC, although slightly attenuated. In never-breastfed infants compared with infants breastfed 3–6 mo, the ORs were 0.8 (95% CI: 0.7, 0.9), 0.93 (95% CI: 0.79, 1.08), and 0.8 (95% CI: 0.7, 1.0) for high vegetable intake at 2, 3, and 4 y, respectively, and 0.7 (95% CI: 0.6, 0.8), 0.8 (95% CI: 0.7, 1.0), and 0.8 (95% CI: 0.7, 1.0) for high fruit intake at 2, 3, and 4 y, respectively. In Generation XXI, the association remained similar. In never-breastfed infants compared with infants breastfed 3–6 mo, the ORs were 0.7 (95% CI: 0.3, 1.5) for high vegetable intake but 2.2 (95% CI: 1.1, 4.5) for high fruit intake. In EDEN, additional adjustment for maternal fruit or vegetable intake during pregnancy was tested, and the associations remained similar. In never-breastfed infants compared with infants breastfed 3–6 mo, the ORs were 0.5 (95% CI: 0.3, 0.7) and 0.5 (95% CI: 0.4, 0.8) for high vegetable intake at 2 and 3 y, respectively; for high fruit intake in never-breastfed infants compared with infants breastfed 3–6 mo, the ORs were 0.6 (95% CI: 0.4, 0.8) and 0.9 (95% CI: 0.6, 1.2) at 2 and 3 y, respectively. A sensitivity analysis was run in EuroPrevall in the subsample of 221 children with data on all confounding variables, and the results were similar to those presented in the figures (data not shown). In ALSPAC, the positive association

![Figure 1](image-url). Any breastfeeding duration in 4 European cohorts: ALSPAC, EDEN, EuroPrevall, and Generation XXI. ALSPAC, Avon Longitudinal Study of Parents and Children; EDEN, Etude des Déterminants pré et postnataux de la santé et du développement de l’Enfant.
between breastfeeding duration and later fruit and vegetable intake remained stable throughout childhood (at least until 13 y). Finally, after additional adjustment for intake of other food groups classified as dairy products, protein foods, starchy foods, and other foods, associations between breastfeeding and fruit or vegetable intake remained similar (data not shown).

Associations between timing of complementary feeding and later fruit and vegetable intakes

Later introduction to fruit (Figure 5) appeared to be related to lower fruit intake in the ALSPAC cohort at 2 y, but the association was no longer present at 3, 4, 7, and 9 y. Age of introduction to fruit was not associated with later fruit intake in the other cohorts. Late introduction to vegetables was related to lower vegetable intake in ALSPAC, and the association appeared consistent throughout childhood (Figure 6). However, in the 3 other cohorts, the association between the age of introduction to vegetables and later vegetable intake was not significant.

Additional adjustment for maternal fruit or vegetable intake in ALSPAC (assessed at 47 mo), Generation XXI (assessed at 48 mo), and EDEN (assessed during pregnancy) did not modify the results (data not shown). A sensitive analysis was run in EuroPrevall in the subsample of 221 children with data on all confounding variables, and the results were similar (data not shown).

DISCUSSION

The current study, based on 4 European birth cohorts, highlighted great differences across European countries in early feeding practices and in fruit and vegetable intake in preschool children. Nevertheless, longer breastfeeding duration was found to be consistently related and significantly so in 2 cohorts, to higher fruit and vegetable intake in young children, whereas associations with age of introduction to fruit and vegetables were weaker and less consistent across the cohorts. The relation between breastfeeding and fruit and vegetable intake were attenuated but remained after adjustment for maternal fruit and vegetable intake in the 3 cohorts where data were available.

Earlier introduction to complementary foods was seen in the United Kingdom (ALSPAC: peak frequency at 4 mo), with later age in Portugal (Generation XXI: 5 mo) and in Greece (EuroPrevall: 6 mo). A recent review (23) reported that, despite the WHO recommendations to introduce solid foods at 6 mo (24), it is common for parents in countries such as the United Kingdom to introduce solid foods before this age, as found in ALSPAC. However, ALSPAC was the earliest of the 4 cohorts, beginning in 1991–1992, whereas the 3 others cohorts recruited infants from 2004 to 2007. Indeed, the UK Infant Feeding Surveys, carried out in 2000 and 2005, indicated that the proportion of mothers introducing solid foods by 4 mo decreased from 85% to just >50% between 2000 and 2005 (25). Although many countries adopted the WHO recommendations of 6 mo of exclusive breastfeeding, some countries continue to recommend introduction of complementary food from 4 to 6 mo (26, 27); even within the same country, advisory bodies may disagree (26). Even if the 4 cohorts are not representative samples of infants of each country, the disagreements in guidelines could explain part of the discrepancies in parental feeding practices across the 4 cohorts.
With the exception of the results from the Portuguese cohort, all other cohorts reported very low intakes of fruit and vegetables; most children consumed less than the 5-A-day recommendation. These results agreed with previous studies conducted in Europe (1, 2, 4, 28, 29). The high vegetable intake in Generation XXI was mainly explained by a high intake of vegetable soups.
The association between longer breastfeeding duration and higher fruit and vegetable intake later in life was found in previous studies (15). Another study showed that breastfeeding duration was negatively related to food neophobia and pickiness in young girls (30). An explanation could be that familiarization of breastfed infants to flavors transmitted via breast milk from the

FIGURE 5. Age of introduction to fruit and high fruit intake (>1 serving/d) in 4 European cohorts: ALSPAC, EDEN, EuroPrevall, and Generation XXI. Logistic regressions adjusted for any breastfeeding duration, age of introduction to other foods, child’s age and sex, maternal educational level, and, except in the Greek EuroPrevall study, maternal age and smoking during pregnancy. ALSPAC, Avon Longitudinal Study of Parents and Children; EDEN, Etude des Déterminants pré et postnatals de la santé et du développement de l’Enfant.

FIGURE 6. Age of introduction to vegetables and high vegetable intake (>1 serving/d; except in Generation XXI, >3 serving/d) in 4 European cohorts: ALSPAC, EDEN, EuroPrevall, and Generation XXI. Logistic regressions adjusted for any breastfeeding duration, age of introduction to other foods, child’s age and sex, maternal educational level, and, except in the Greek EuroPrevall study, maternal age and smoking during pregnancy. ALSPAC, Avon Longitudinal Study of Parents and Children; EDEN, Etude des Déterminants pré et postnatals de la santé et du développement de l’Enfant.
range of flavors consumed by the mother leads to an increase in acceptance of the flavors of fruit and vegetables when they are offered to the infant (31). There is evidence that a sensitive period, before 6 mo, exists when young infants accept a large range of flavors more easily (32), and one study suggested that breastfeeding was associated with higher acceptance of a food only if lactating mothers were regularly eating that particular food (33). A study showed that children with a higher level of control over their own feeding appeared to have lower levels of food pickiness and higher energy intake than did children with a lower level of control over their own feeding (34). Finally, longer breastfeeding tends to be related to higher maternal educational level and higher diet quality, which could confound the association between breastfeeding and later fruit and vegetable intake in children. However, our analyses were adjusted for potential confounders, we found no consistent associations across the 4 cohorts. An older age of introduction to vegetables for potential confounders, we found no consistent associations across ages and cohorts with different mean intakes of fruit and vegetables in children is an argument against major confounding of the results.

Considering the importance of the early critical window in later fruit and vegetable acceptance, we hypothesized that earlier introduction to fruit and vegetables would be related to higher fruit and vegetable intakes later in life. However, after adjustment for potential confounders, we found no consistent associations across the 4 cohorts. An older age of introduction to vegetables was related to lower vegetable intake in children up to 13 y in ALSPAC, but not in the other cohorts. The larger sample size in ALSPAC may enhance its power to detect relations of small magnitude. Regarding fruit intake, there was an association in ALSPAC only in 2-y-old children and not in later life and no associations in the other cohorts. The Québec Longitudinal Study of Child Development found an association between age of introduction to vegetables and later vegetable intake, but this was removed by adjustment for potential confounders (15). Considering the findings from the current study and the Québec Longitudinal Study, evidence of a relation between age of introduction of fruit and vegetables and later fruit and vegetable intake by children is currently inconclusive. Moreover, aspects of complementary feeding other than timing itself could be related to later fruit and vegetable intake, such as diversity of foods offered in the early period or the use of home-prepared or ready-prepared baby foods. In a previous analysis, ALSPAC found that the frequency of home-prepared fruit and vegetable consumption at 6 mo was positively related to fruit and vegetable intake at 7 y, whereas the frequency of ready-prepared fruit and vegetable consumption was not (17). Furthermore, when vegetables were introduced later, more frequent consumption at 6 mo was related to larger intake at 7 y (17). Unfortunately, data were not available to analyze the specific influence of exposure to home-prepared or ready-prepared baby food exposure on fruit and vegetable intakes in the other cohorts in this study.

This study has used data collected in 4 different European countries by carrying out the same analysis in parallel with, as much as possible, the same confounders. Because the only common dietary assessment tool used in all 4 cohorts was the FFQ, it was the instrument used to assess fruit and vegetable intakes, even if it is not the most precise dietary method for such an assessment. However, in 2 of the cohorts (Generation XXI and ALSPAC), diet diaries were also collected at 47–48 mo in a subsample of the cohort, and the correlation between both assessment of fruit and vegetable intake was satisfactory. It was not possible to combine the data directly because each country used its own individual FFQ to assess the diet of the young children, and each FFQ varied in the number of questions asked about fruit and vegetable consumption. To ensure comparability between the analyses in the different countries, the outcome variables were simplified to whether children did or did not achieve a certain frequency of fruit or vegetable intake per day. Further parallel analyses were also preferable because of the disparities in sample size, the slightly different ages at which outcomes were measured and the differing availability of some of the confounding or mediating variables. The advantage of a parallel analysis is that confounding structure is likely to be different between the countries, thus similar observations made in each cohort provide stronger evidence of a real effect. In this study we took advantage of the fact that 2 of the cohorts had data at different ages in the same children so that we can assess whether effects are likely to persist.

In conclusion, a longer breastfeeding duration was related to a higher fruit and particularly vegetable intake in young children consistently across 4 European cohorts, in contrast with other feeding practices such as age at complementary feeding with fruit and vegetables. The association with breastfeeding was not explained by maternal fruit and vegetable intake. The concordant association with breastfeeding duration in different cultural contexts favors an independent specific effect.

We are indebted to all participants for providing the data used in the 4 birth cohorts. We are grateful to Sylvie Issanchou for her coordination of the HabEat project.

The authors’ responsibilities were as follows—BdL-G, LJ, AO, GM, CL, PM, YM, PE, and MAC: study concept and design; BdL-G, LJ, AO, GM, CL, PM, YM, NGP, PE, and MAC: acquisition of data; BdL-G, LJ, AO, GM, AB, CL, PM, YM, NGP, PE, and MAC: analysis and interpretation of the data, critical revision of the manuscript for important intellectual content, and final approval of the version to be published; and BdL-G: drafting of the manuscript. None of the authors had any financial relationships or conflicts of interest to disclose.

REFERENCES