Received: 1 December 2016 | Revised: 19 April 2017 | Accepted: 9 May 2017

DOI: 10.1111/mcn.12471

WILEY | Maternal & Child Nutrition

ORIGINAL ARTICLE

Timing of solid food introduction and association with later childhood overweight and obesity: The IDEFICS study

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Funding information
Sixth RTD Framework Program, Grant/Award Number: 016181 (FOOD)

Abstract

This study investigated associations between timing of solid food introduction and childhood obesity and explored maternal characteristics influencing early feeding practices. Cross-sectional data from children 2–9 years (n = 10,808; 50.5% boys) residing in 8 European countries of the IDEFICS study (2007–2008) were included. Late solid food introduction (≥7 months of age) was associated with an increased prevalence of later childhood overweight/obesity among exclusively breastfed children (OR [odds ratio]: 1.38, 95% CI [confidence interval] [1.01, 1.88]). In contrast, early solid food introduction (<4 months of age) was associated with lower prevalence of overweight/obesity among children that ceased exclusive breastfeeding earlier than 4 months (OR: 0.63, 95% CI [0.47, 0.84]). Children that were introduced to solids right after 6 months exclusive breastfeeding and continued to receive breastmilk (≥12 months) were less likely to become overweight/obese (OR: 0.67, 95% CI [0.51, 0.88]) compared to children that discontinued to receive breastmilk. Analyses were adjusted for age, sex, country, birth weight, parental education level, parental body mass index, tobacco use in pregnancy, gestational weight gain, and gestational diabetes. Underweight mothers, overweight mothers, mothers who reported daily smoking during pregnancy, and low-educated mothers were less likely to follow recommendations on breastfeeding and timely solids introduction. Future studies should examine whether guidelines for solid food introduction timing have to distinguish between exclusively breastfed, formula fed, and too early exclusive breastfeeding-ceased infants. There is also need for more prospective studies; recall bias was an important current limitation. In conclusion, health professionals should emphasize benefits of breastfeeding and appropriate solid food introduction, especially to mothers that are less likely to follow recommendations.

KEYWORDS

breastfeeding, childhood, maternal, obesity, overweight, solid food introduction

1 | INTRODUCTION

In the United States, recent studies suggest that prevalence of childhood obesity is decreasing, however with a disparity among different race or ethnic and socioeconomical status subgroups of the population (Kamali, Hameed, Shih, & Simon, 2017; Karnik & Kanekar, 2012; Krueger & Reither, 2015). In Europe, escalating childhood obesity rates are considered a major public health problem again with a disparity among countries and socioeconomical statues within populations; higher prevalence is observed in southern countries (Ahrens et al., 2014; WHO, 2013). Maternal factors such as prepregnancy overweight, weight gain, and tobacco use during pregnancy, gestational diabetes as well as child's birth weight are associated with early childhood overweight and obesity (Brisbois, Farmer, & McCargar, 2012; Desai, Beall, & Ross, 2013; Sparano et al., 2013). Furthermore, breastfeeding (BF) compared to milk formula feeding is associated with

a decreased risk of overweight in childhood and a dose dependent decreased risk has been suggested (Harder, Bergmann, Kallischnigg, & Plagemann, 2005; Hörnell, Lagström, Lande, & Thorsdottir, 2013). In a previous report of the IDEFICS (identification and prevention of dietary and life style induced health effects in children and infants) study, it was revealed that exclusive breastfeeding (EBF), for 4 to 6 months, protects from obesity later in life (Hunsberger et al., 2013). The World Health Organization (WHO) recommends EBF for the first 6 months of life followed by the introduction of nutritionally adequate complementary foods, whereas infants continue to being breastfed up to 2 years of age or more (WHO, 2001). The European Society for Paediatric Gastroenterology Hepatology and Nutrition's Committee on Nutrition defines complementary feeding as the consumption of solid and liquid foods other that breast milk or infant milk formula or other follow-on formulas and suggests EBF up to the weaning period, which should be between 17 to 26 weeks of age, around 4 to 6 months (Agostoni et al., 2008). The association between timing of complementary feeding in infancy and obesity during childhood is still unclear. Some evidence suggests that early solid food (SF) introduction, before 4 months of age, is associated with an increased risk for obesity in childhood; however, other studies failed to demonstrate such association (Pearce, Taylor, & Langley-Evans, 2013). Complementary feeding in the literature mostly refers to both SFs and energy-providing liquids (EPL) other than breast milk and milk formula, such as fruit juice or sweetened beverages. However, the timing of SF introduction is nutritionally crucial as requirements for nutrients such as iron and zinc are greater during the second half of infancy. The association between timing of SF introduction and childhood obesity, apart from EPL consumption, has not been fully elucidated (Moorcroft, Marshall, & McCormick, 2011). Therefore, this study aims to contribute to the limited understanding of timing of SF introduction and childhood overweight/obesity within a large multinational European cohort of children as well as to explore whether the sociodemographic status of mothers influences their commitment to recommended feeding practices.

Key messages

- The optimal practice for childhood obesity prevention is in direct support of WHO recommendations for 6 months exclusive breastfeeding and prolonged breastfeeding in combination with solid food introduction from the age of 6 months.
- Late solid food introduction (≥7 months of age) was associated with an increased prevalence of overweight/obesity in later childhood among exclusively breastfed children, whereas early solid food introduction (<4 months of age) was associated with lower prevalence of overweight/obesity among children that ceased exclusive breastfeeding earlier than the age of 4 months.
- Future studies should distinguish in detail the milk feeding pattern and the transition to different solid food groups during infancy.

2 | PARTICIPANTS AND METHODS

2.1 | Participants

This report is based on the baseline IDEFICS study with 16,228 participants from eight European countries: Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain, and Sweden. The IDEFICS study started in September of 2006 and ended in February of 2012. The IDEFICS study aims to understand the association of unbalanced dietary habits, an increasingly sedentary lifestyle, and a changing social environment with health and well-being of children to develop effective prevention strategies. In specific, during the survey, parents reported sociodemographic, behavioural, medical, nutritional, and other lifestyle data for their children and families. Examinations of children included anthropometry, blood pressure, fitness, accelerometry, DNA from saliva, and physiological markers in blood and urine. The built environment, sensory taste perception, and other mechanisms of children's food choices and consumer behaviour were studied in subgroups. The IDEFICS study also developed and implemented community intervention programs for primary prevention of obesity in a controlled study design. The baseline study was conducted in 2007–2008 (September 2007–May 2008), whereas a full follow-up study took place 2 years after (September 2009–May 2010) as well as a questionnaire-based follow-up study in 2010 (September 2010–November 2010) to assess children's development and evaluate the effects of the primary prevention programme. More detailed information on design, sampling, and procedures of the IDEFICS baseline survey can be retrieved in a previous publication (Ahrens et al., 2011). The study protocol was approved by each local institutional review board. Written informed consent was obtained from all parents or legal guardians of participating children.

2.2 | Infant feeding practices

From the IDEFICS population, children were included in the present analysis if information about the timing of SF introduction, back during infancy, was available, if exposure to EBF or combination of BF and milk formula could be defined, and if information regarding age, height, and weight was available. In detail, EBF and/or combination with other feeding types, formula feeding, and the age of SF introduction were defined from several variables reported in the parental questionnaire. Specifically, parents were asked to define (a) starting and ending age of EBF, (b) starting and ending age of BF in combination with other types of feeding, (c) starting and ending age of milk formula, (d) starting and ending age of other types of infant feeding (and defining the feeding type), (e) starting age of introducing cereals or food containing rye, wheat, or barley, (f) starting age of introducing vegetables, (g) starting age of introducing fruits, (h) starting age of introducing meat, and (i) starting age of introducing milk (other than infant formula). Parents reported starting and ending age as whole months. Age of SF introduction was calculated from answers “d,” “e,” “f,” “g,” “h,” and “i”. EPL aside from milk were not included as they were not specifically addressed,

that is, sweetened tea, fruit juice, vegetable juice, and sugared beverages. However, cereal creams/purees, vegetable soups, fruit purees, potatoes, eggs, fish, milk products, and soy products (other than soy special infant milk formulae) that parents reported as "other types of infant feeding" were grouped as solids (response "d"). Reports of special hypo-allergic or high digestibility specialized infant milk formulas to answer "d" were merged to answer "c." Cases were excluded: (a) if weight and height were not available (N = 3), (b) if no information on SF introduction timing was available (N = 3,818), (c) if no information on BF duration was available or information was implausible, that is, BF was reported to start later that the month it ended (N = 1,733), (d) if solids were introduced after 12 months of age (N = 89), (e) if BF or infant formula feeding started on the second month or later and nothing was reported before or if parents reported that BF or infant formula feeding ended but there was no indication of complementary feeding introduction after that (N = 161). Finally, premature children (gestational age <37 weeks) were excluded (N = 1,004). The final sample consisted of 10,808 children 2 to <10 years of age; none of them was still BF.

2.3 | Measurement of childhood overweight

Children's weights, at the IDEFICS baseline examination, were measured in light underwear using an electronic scale (TANITA BC 420 SMA, Tanita Europe GmbH, Sindelfingen, Germany) and height was measured without shoes using a stadiometer (Seca 225, Birmingham, UK). Body mass index (BMI; kg/m^2) for age was calculated and categorized using the proposed procedures and cut-offs by International Obesity Task Force (Cole & Lobstein, 2012). Physical examinations were performed by trained fieldworkers.

2.4 | Background variables

Parental age, weight, and height as well as child's birth weight were reported by the parents. Maternal gestational weight gain and presence of gestational diabetes was reported as well. The International Standard Classification of Education (ISCED) was used as indicator for socioeconomic status using reported parental education level (UNESCO, 2006). The maximum ISCED level of both parents was included in analysis (low, medium, and high). Mothers also reported smoking of cigarettes or other tobacco products during pregnancy: (a) never, (b) rarely, at maximum once a month, (c) several occasions a week, and (d) daily. For statistical analysis, "several occasions" and "daily" were grouped together.

2.5 | Statistical analysis

All statistical calculations were performed using SPSS software, version 20.0. Continuous variables are presented as mean ± standard deviation. Age group (2–<6 years, 6–<10 years), gender, and geographical area ("Mediterranean countries" meaning Cyprus, Spain, and Italy vs. "Central/North Europe Area" meaning Belgium, Estonia, Germany, Hungary, and Sweden) were examined for potential interaction effects; as none were found, children were analysed as one group, whereas age, gender, and country were treated as covariates. Logistic regression analysis with 95% confidence intervals (CIs) was used to estimate the odds of being overweight/obese in relation to different infant feeding patterns. For associations, two models were fitted. Results were at first adjusted for child's age, sex, and country (model 1) and then additionally adjusted for birth weight, parental education level (ISCED categories), tobacco use in pregnancy (categorical), fathers' and mothers' self-reported BMI, gestational diabetes (categorical), maternal gestational weight gain, and for BF duration if applicable (model 2).

3 | RESULTS

Characteristics of the study sample and parental demographic characteristics are shown in Table 1. Overall, 42.3% of children met recommendations for 4- to 6-month EBF followed by SF introduction. The mean age of SF introduction was 5.1 ± 1.7 months. Mean duration of BF (exclusive and/or in combination to milk formula) was 7.9 ± 6.1 months; 16.1% of the study sample were not breastfed at all. Table 2 presents in detail a fully adjusted model, which revealed that underweight mothers, overweight mothers, and those who smoked during pregnancy were less likely to follow recommendations on EBF and timing of SF introduction; on the contrary, parents with greater education were more likely to follow recommendations.

Table 3 presents the association of overweight in children with different feeding practices in infancy (timing of SF introduction, duration of BF if any, and EBF). Children who were introduced to solids prior the age of 4 months were less likely to become overweight/obese (odds ratio [OR] = 0.80, 95% CI [0.66, 0.96]) after adjusting for several confounding risk factors (age, sex, country, birth weight, parental BMI, tobacco use in pregnancy, parental educational level, maternal gestational weight gain, and gestational diabetes). Exclusively breastfed children that continued BF after SF introduction when compared with children that discontinued BF when introduced to solids were further protected from overweight (OR = 0.67, 95% CI [0.51, 0.88]). Table 4 presents the association between overweight and obesity in childhood and timing of SF introduction by EBF duration (vs. formula-fed children). After adjusting for all confounding factors, it was shown that (a) there was no association between SF introduction and future overweight/obesity among formula fed infants, (b) early SF introduction was associated with lower prevalence of overweight/obesity among children that ceased EBF earlier than the age of 4 months, and (c) late SF introduction was associated with higher prevalence of overweight/obesity among children that ceased EBF at the age of 4–6 months. Finally, there was no association between SF introduction and future overweight/obesity among children that were breastfed in combination with formula (results for breastfed children in combination with formula are not presented in tables).

4 | DISCUSSION

Our study revealed that children who were breastfed exclusively for 6 months and were introduced to solids while continuing BF until the age of 12 months or more were less likely to be overweight or obese at the age of 2–9 years. Findings also revealed that children who ended EBF before the age of 4 months and were then introduced to solids

TABLE 1 Characteristics of the study sample

	N	Mean ± *SD* or % (of the total study sample) as appropriate
Child's characteristics		
Mean age at assessment (years)	10,808	5.9 ± 1.8
Gender		
Male	5,454	50.5
Female	5,354	49.5
Mean infant birth weight (g)	10,714	3407 ± 497
BMI categories by Cole and Lobstein (2012)		
Underweight	1,206	11.2
Normal weight	7,531	69.6
Overweight	1,318	12.2
Obese	753	7.0
Early feeding info		
Month of solid food introduction	10,808	5.1 ± 1.7
Age category at the time of solid food introduction		
1–3 months	1,324	12.2
4–6 months	8,198	75.9
7–12 months	1,286	11.9
Not breastfed at all	1,736	16.1
Duration of (exclusive/combination) breastfeeding (months)	9,072	7.9 ± 6.1
Breastfeeding (exclusive/combination)	9,072	83.9
Duration exclusive breastfeeding (months)	7,954	4.3 ± 1.8
Exclusively breastfed		
Birth through 3 months	2,521	23.3
4–6 months	4,918	45.5
≥7 months	507	4.7
Exclusive breastfeeding 4–6 month followed by the introduction of SF	4,576	42.3
Exclusive breastfeeding for 6 months followed by the introduction of SF and continuous breastfeeding ≥ 12 months	1,006	9.3%
Maternal demographic characteristics		
Mean age (years)	10,760	35.2 ± 5.2
Self-reported BMI		
Underweight (<18.5 kg/m^2)	415	3.8
Normal weight (18.5–24.9 kg/m^2)	6,939	64.2
Overweight (25–29.9 kg/m^2)	2,109	20.3
Obese (≥30 kg/m^2)	953	8.8
Tobacco/cigarettes consumption during pregnancy		
None	9,103	84.2
Rarely/once a month	383	3.5
Daily/several times a week	1,061	9.8
Paternal demographic characteristics		
Mean age (years)	10,039	38.1 ± 5.8
Self-reported BMI		
Underweight (<18.5 kg/m^2)	20	0.2
Normal weight (18.5–24.9 kg/m^2)	3,669	33.9
Overweight (25–29.9 kg/m^2)	4,472	41.4
Obese (≥30 kg/m^2)	1,376	12.7
Parental highest level of education (ISCED)		
Low	1,003	9.3
Medium	5,379	49.8
High	4,326	40.0

Note. SF = solid food; BMI = body mass index; ISCED = International Standard Classification of Education.

TABLE 2 Factors associated with not following recommendations on early infant feeding (exclusive BF for 4–6 months followed by the introduction of SF) by maternal demographic characteristics and parental highest level of education

	n = 10,177
Maternal self-reported BMI	
Underweight (<18.5 kg/m^2)	**1.27 (1.03–1.57)**
Normal weight (18.5–24.9 kg/m^2)	1 (ref)
Overweight and/or obese (≥25 kg/m^2)	**1.37 (1.26–1.50)**[a]
Tobacco/cigarettes consumption during pregnancy	
Never	1 (ref)
Rarely/once a month	**1.39 (1.12–1.73)**[b]
Daily/several times a week	**2.03 (1.75–2.35)**[b]
Parental highest level of education (ISCED)	
Low	1 (ref)
Medium	**0.73 (0.63–0.85)**[c]
High	**0.60 (0.51–0.70)**[c]

Note. BF = breastfeeding; SF = solid food; BMI = body mass index; ISCED = International Standard Classification of Education.

Results in bold: *p*-value <0.05.

[a]Adjusted for mother's age, country, tobacco use (cat), and parental highest level of education (cat).

[b]Adjusted for mother's age, country, maternal self-reported BMI (cat), and parental highest level of education (cat).

[c]Adjusted for mother's age, country, maternal self-reported BMI (cat), and tobacco (cat).

were less likely to become overweight or obese in childhood, compared to the children to whom breast milk was substituted with milk formula alone and no solids. On the other hand, late SF introduction at 7 months of age or later among exclusively breastfed children was associated with an increased prevalence of overweight and obesity in later childhood. Mothers who did not breastfeed their children for at least 4 months and did not timely introduce them to solids were those of low-educational level, abnormal weight status, and/or smokers during the gestational period.

Previous studies showed no clear association between timing of SF introduction with obesity in infancy, childhood or adolescence (Barrera, Perrine, Li, & Scanlon, 2016; Burdette, Whitaker, Hall, & Daniels, 2006; Durmus et al., 2014; Lin, Leung, Lam, & Schooling, 2013; Przyrembel, 2012; Reilly et al., 2005). After adjusting for confounding factors, an older study reported that early introduction of solids (<4 months of age) was associated with lower BMI *z* scores at 12 months of age (van t Hof Msc, 2000). On the contrary, a more recent study demonstrated that early introduction of SF prior to the age of 4 months, among milk formula-fed children, was associated with a sixfold increased risk for obesity at 3 years of age (Huh, Rifas-Shiman, Taveras, Oken, & Gillman, 2011). Different findings in literature in such a complex field of study may be accounted for many reasons: adjustment for very few confounders, inappropriate sample size, different population origin, and/or different methodology. Moss and Yeaton (2014) compared breastfed versus milk formula fed children and reported that delayed SF introduction combined with BF, reduced obesity odds. Different from our study though, Moss and Yeaton did not distinguish exclusively breastfed and partially breastfed infants and categorized late SF introduction at 6 months of age or later. Other studies termed "late solids introduction" at 4 months of age or later (Moorcroft et al., 2011); the disagreement on definitions for "late" and "early" SF introduction among studies make results difficult to compare and interpret.

TABLE 3 Logistic regression models to evaluate the association of overweight/obesity in children with different feeding practices in infancy

Feeding practices	Model 1	Model 2
Solid food introduction timing	*n* = 10,808	*n* = 8,801
1–3 months[a]	**0.85 (0.73–0.99)**	**0.80 (0.66–0.96)**
4–6 months	1 (ref)	1 (ref)
7–12 months	**1.19 (1.03–1.38)**	1.15 (0.97–1.37)
Breast feeding (exclusive or in combination)	*n* = 10,808	*n* = 8801
Formula fed only	1 (ref)	1 (ref)
1–3 months BF[b]	**0.84 (0.72–0.99)**	0.90 (0.74–1.09)
4–6 months BF	0.94 (0.82–1.10)	1.06 (0.88–1.26)
7–12 months BF	**0.79 (0.68–0.92)**	0.93 (0.78–1.12)
>12 months BF	**0.70 (0.58–0.86)**	0.84 (0.67–1.06)
Exclusive breast feeding	*n* = 9,682	*n* = 7,890
Formula fed only	1 (ref)	1 (ref)
1–3 months EBF[c]	**0.84 (0.72–0.98)**	0.88 (0.66–1.17)
4–6 months EBF	**0.79 (0.69–0.91)**	0.79 (0.60–1.05)
≥7 months EBF	1.03 (0.81–1.30)	0.82 (0.63–1.07)
	n = 10,808	*n* = 8,801
Exclusive breastfeeding 4–6 months followed by the introduction of SF	**0.82 (0.75–0.91)**	0.89 (0.80–1.01)
All other children not following recommendations	1 (ref)	1 (ref)
	n = 2,243	*n* = 1,884
Exclusive breastfeeding for 6 months followed by the introduction of SF and continuous breastfeeding ≥12 months	**0.63 (0.50–0.80)**	**0.67 (0.51–0.88)**
Exclusive breastfeeding for 6 months followed by the introduction of SF and continuous breastfeeding <12 months	1 (ref)	1 (ref)

Note. BF = breastfeeding; EBF = exclusive breastfeeding; SF = solid food.

Model 1: adjusted for age, sex, and country.

Model 2: adjusted as in model 1 and additionally for birth weight, parental highest level of education (cat) tobacco use in pregnancy (cat), maternal self-reported BMI, paternal self-reported BMI, gestational diabetes (cat), and maternal gestational weight gain.

Results in bold: *p*-value <0.05.

[a]Parents reported the nearest whole number of months regarding solid food introduction timing.

[b]Parents reported the nearest whole number of months regarding ending and starting age of breastfeeding.

[c]Parents reported the nearest whole number of months regarding ending and starting age of exclusive breastfeeding.

Termination of EBF before the age of 4 months should be discouraged according to the results mentioned above. BF seems to promote self-regulation of an infant's energy intake and enables the mother to learn her infant's hunger and satiety cues, and thus, she is able to feed her infant when the infant is hungry. Formula-fed children, however,

TABLE 4 Logistic regression models to evaluate the association of overweight in children with timing of solid food introduction; sensitivity analyses by duration of exclusive breastfeeding

Solid food introduction	Formula fed only	Exclusive BF 1–3 months	Exclusive BF 4–6 months
Model 1	*n* = 1,736	*n* = 2,521	*n* = 4,918
1–3 months	0.78 (0.58–1.05)	**0.67 (0.53–0.85)**	
4–6 months	1 (ref)	1 (ref)	1 (ref)
7–12 months	1.01 (0.75–1.61)	1.05 (0.70–1.59)	**1.35 (1.02–1.79)**
Model 2	*n* = 1,341	*N* = 1,990	*n* = 4,153
1–3 months	0.88 (0.62–1.24)	**0.63 (0.47–0.84)**	
4–6 months	1 (ref)	1 (ref)	1 (ref)
7–12 months	1.02 (0.65–1.61)	1.01 (0.62–1.66)	**1.38 (1.01–1.88)**

Note. BF = breastfeeding.

Model 1: adjusted for age, sex, and country.

Model 2: adjusted as in model 1 and additionally for birth weight, parental highest level of education (cat), tobacco use in pregnancy (cat), self-reported maternal body mass index (BMI), self-reported paternal BMI, gestational diabetes (cat), and maternal gestational weight gain.

Results in bold: *p*-value <0.05.

are more likely to be fed on a schedule, regardless of hunger and satiety cues, resulting in higher obesity odds (Mihrshahi, Battistutta, Magarey, & Daniels, 2011). Self-regulation of energy intake might be "disturbed" when EBF ceases early and is replaced with formula "bottle" feeding; this might result in a greater than required energy intake taken easily through the "bottle." As such, milk formulas have been linked to increased risk of overweight later in life (Bonuck, Huang, & Fletcher, 2010; Gibbs & Forste, 2013; Gooze, Anderson, & Whitaker, 2011). According to Hörnell, Hofvander, and Kylberg (2001), the introduction of solids after EBF decreases BF frequency only gradually, as the infant explores new foods and textures; in contrast, introducing the infant to milk formula after a period of EBF it is possible that the infant will consume large amounts of calories and decrease its demand on breast milk (Hörnell, Hofvander, & Kylberg, 2001). In agreement with current findings, Huh et al. (2011) suggest that BF children and formula-fed children may react differently to early SF introduction. Therefore, future research should distinguish exclusively formula-fed children from children breastfed for a short period and from children that were exclusively milk formula fed, as this may have important implications in regards to SF introduction and risk for future adiposity.

Research on exact timing of introduction of different food groups and association to food consumption and food preferences in later life could be challenging. According to Grote et al. (2011), early introduction of SF in milk formula fed infants might increase their energy intake. Another report indicated that early introduction of SF is a risk factor for both cessation of BF and increased consumption of sugary foods at 1 year of age A study conducted in the United States reported that at 6 and 12 months of age, 4.8% and 66.2% of study population, respectively, had already consumed fatty and sugared foods (Grummer-Strawn, Scanlon, & Fein, 2008). However, researchers propose that "the quality of introduced solids is more influential that the timing" (Grote et al., 2011). An interesting theory was tested in rats where an over caloric sixfold fat postweaning diet of off springs increased significantly the relative weight of the visceral adipose tissue despite maternal diet pattern during pregnancy and lactation proposing a mechanism relating postweaning diet to visceral adipose tissue development (dos Santos Perez et al., 2015). As mentioned earlier, in our study introduction of solids prior the age of 4 months reduced overweight and obesity odds in childhood for children that terminated EBF earlier than recommended. Their diet during their first year of life was not however tested in current study. It is therefore crucial that future studies not only investigate the timing of SF introduction among breastfed and formula fed infants but also the quality and the type of foods introduced through the whole first year of life; assuming, that is, that a fibre rich diet, low in sugars and fat, during infancy could be beneficial when replacing formula but not breastmilk.

Furthermore, findings of our study suggest that mothers who smoke during pregnancy were twice as like not to follow recommendations on EBF for 4 to 6 months followed by introduction of SF. As expected, medium-educated and highly educated parents were more likely to follow infant feeding recommendations compared to those of low educational level. According to previous studies, adherence to recommendations is significantly higher among highly educated mothers (Durmus et al., 2014; Grummer-Strawn et al., 2008). Obese and overweight mothers failed to practice guidelines in agreement to other reports (Kitsantas, Gallo, Palla, Nguyen, & Gaffney, 2016). Overall, we suggest that health professionals should emphasize health benefits of BF and appropriate SF introduction especially to mothers of low-educational level, reproductive females that smoke, and finally, overweight and obese mothers that fail to achieve the recommended infant feeding practices.

Parental self-reported weight, height, gestational weight gain, and infant's birth weight must be acknowledged as limitations of this report. Requesting mothers to recall BF duration and timing of solid introduction for a time period of 1 to 8 years ago is also an important limitation. Recalls of infant feeding practices are considered sufficiently accurate for a couple of years after the practice (Launer et al., 1992; Li, Scanlon, & Serdula, 2005). A recall period more than 2 years lacks excellent accuracy especially for EBF; Burhnham et al. (2014) report that "exclusive breastfeeding practices 2 years after birth are often inaccurate and mothers tend to overestimate duration." However, the strengths of this study include the large multinational study sample and the analysis adjusting for several important confounding factors (birth weight, parental educational level and weight status, tobacco use during pregnancy, gestational diabetes, and maternal gestational weight gain).

Our findings suggest that the optimal practice for obesity prevention is in direct support of WHO recommendations for 6 months EBF and prolonged BF in combination with SF introduction from the age of 6 months. Still, the quality of solids introduced, especially for bottle-fed infants and infants that cease EBF earlier than recommended need to be further investigated. Health professionals should emphasize the WHO recommendations to mothers from all socioeconomic groups with attention for those that may be less likely to follow feeding recommendations; often, the most vulnerable populations are those with the fewest resources.

ACKNOWLEDGMENTS

This study was conducted as a part of the IDEFICS study and was published on behalf of its European Consortium (http://www.idefics.eu). We are grateful for the support provided by school boards, headmasters, teachers, school staff, and communities. We thank the IDEFICS children and their parents for participating in this extensive examination.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

CONTRIBUTIONS

SP conceptualized and designed the study, carried out the initial analyses, and drafted the initial manuscript. MH, SCS, HJ, and NM assisted with conceptualization and interpretation of data analyses, contributed to the acquisition of data, and reviewed and revised the manuscript. MT, WA, TV, DM, AS, LAM, and CH contributed to the acquisition of data and reviewed and revised the manuscript. All authors approved the final manuscript as submitted.

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How to cite this article: Papoutsou S, Savva SC, Hunsberger M, et al. Timing of solid food introduction and association with later childhood overweight and obesity: The IDEFICS study. *Matern Child Nutr*. 2018;14:e12471. https://doi.org/10.1111/mcn.12471