Master of Public Health

Master de Santé Publique

The association between socioeconomic position and the child's diet in the first two years of life and the potential mediating role of the maternal and paternal diets

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Class and year of the Master:
EHESP MPH, 2023

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ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my supervisors, Marion and Sandrine. Your invaluable support and expertise have been instrumental at every stage of this journey. I am truly grateful for your guidance in data analysis and in reporting scientific findings with meticulousness and efficiency.

I extend my heartfelt thanks to the EaroH team for providing such a wonderful working environment.

I am indebted to the EHESP and the exceptional professors I have encountered along the way. Your lectures and discussions have profoundly shaped my understanding of public health and its significance. I am grateful to the school for fostering an international environment, as true progress in public health necessitates international cooperation.

To my remarkable wonderful EHESP colleagues, I am grateful for the knowledge I have gained through your shared experiences and the diverse perspectives you have offered. Being surrounded by all of you in the past two yours has been invaluable.

To Juliette and Alissar, my eternal pillars of support, I cannot thank you enough. This journey would have been much more challenging without your unwavering love and encouragement.

A special thank you goes to Briana, my fantastic internship buddy. Your presence added colour and joy to my internship days.

To my office companions, thank you for the laughter, fun, and friendship we have shared. I deeply appreciate it.

I want to express my deepest gratitude to my partner and my best friends, for being an unwavering support system throughout this endeavour.

Lastly, I would like to thank my family, for always being there for me, supporting my decisions, and accompanying me every step of the way. Your belief in me has been an incredible source of strength.

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
CU	Consumption Unit
DOHaD	Developmental Origins of Health and Disease
DP/DPs	Dietary pattern/patterns
$DP1_{9m}$	Child dietary pattern 1 at 9 months: Diversified diet
$DP2_{9m}$	Child dietary pattern 2 at 9 months: Discretionary Sweet foods
$DP3_{9m}$	Child dietary pattern 3 at 9 months: Baby cereals and Yoghurt
$DP1_{2y}$	Child dietary pattern 1 at 2 years: Balanced/Diversified
$DP2_{2y}$	Child dietary pattern 1 at 2 years: Discretionary consumption
EDEN	L'étude des déterminants pré et postnatals du développement de la santé de l'enfant
Elfe	Étude Longitudinale Française depuis l'Enfance
FFQ	Food frequency questionnaire
Insee	The Institut National de la Statistique et des Études Économiques
NDE	Natural Direct Effects
NEMs	Natural Effect Models
NIE	Natural Indirect Effects
OECD	The Organisation for Economic Co-operation and Development
PCA	Principal Component Analysis
SEP	Socioeconomi position
TE	Total Effects
VIF	Variance inflation factor

ABSTRACT

Context: Socioeconomic position (SEP) is an important factor influencing both parental and children's diets, with migration acting as a moderator of the association between maternal education and maternal dietary patterns (DPs). However, the mechanisms underlying these associations require further investigation. **Objective:** The aim of this study was, thus, to test hypotheses on the potential mediating role of parental DPs in the association between parental SEP, as measured by parental education and household income, and children's DPs. **Methodology:** This study utilised data from the Elfe birth cohort (18, 329 children, 18, 040 mothers). Our study sample was divided in two (maternal and paternal), due to the vast differences in their dietary data availability. After excluding missing data, the maternal subsample had 6,915 observations at 9 months and 9, 176 at 2 years, while the paternal subsample consisted of 726 and 825 observations at the respective time points. Data used in this study were self-reported, with maternal and paternal SEP as exposures, their DPs as potential mediators, children's DPs as outcomes, migration status as a potential moderator, and adjusted for confounders. Multivariable linear regressions and mediation analyses (using natural effect models from "medflex") were employed. **Results:** Mediation analyses showed that both maternal and paternal DPs partially mediated the association between parental SEP and children's DPs. Maternal migration status moderated the association in the mediation analysis involving maternal DPs. The largest indirect effect size was observed for the maternal "Balanced" DP, mediating half of the association between maternal SEP and children's "Balanced/diversified" DP at 2 years among non-immigrants. Additionally, paternal "Balanced" DP mediated partially mediated relationship between paternal SEP and children's "Balanced/diversified" and "Discretionary consumption" DPs. **Conclusion:** Our study emphasizes the importance of both maternal and paternal diets in the relationship between parental socioeconomic position and children's dietary patterns, underscoring the need for comprehensive family-based health promotion programs. Understanding mechanisms underlying the association between parental SEP and children's diets provides a leverage point for public health interventions to address social disadvantages in children's diets.

Keywords: the first 1000 days, diet, social disadvantages, mediation

RÉSUMÉ

Contexte : Le niveau socioéconomique influence l'alimentation des parents et des enfants, avec la migration agissant comme modérateur de l'association entre l'éducation maternelle et les habitudes alimentaires maternelles. Cependant, les mécanismes sous-jacents nécessitent des investigations supplémentaires. **Objectif :** Ainsi, cette étude visait à tester les hypothèses sur le rôle médiateur potentiel des habitudes alimentaires parentales dans l'association entre le niveau socioéconomique parentale, mesurée par l'éducation des parents et le revenu du ménage, et les habitudes alimentaires des enfants. **Méthodologie :** Cette étude a utilisé les données de la cohorte Elfe (18 329 enfants, 18 040 mères). Notre échantillon d'étude a été divisé en deux parties (maternelle et paternelle), en raison des différences importantes dans la disponibilité des données alimentaires. Après exclusion des données manquants, le sous-échantillon maternel comptait 6 915 observations à 9 mois et 9 176 à 2 ans, tandis que le sous-échantillon paternel était composé de 726 et 825 observations aux périodes respectives. Les données utilisées dans cette étude étaient autodéclarées, avec le niveau socioéconomique maternelle et paternelle en tant qu'expositions, leurs habitudes alimentaires en tant que médiateurs potentiels, les habitudes alimentaires des enfants en tant qu'issues, le statut de migration en tant que modérateur potentiel, ajusté pour les facteurs de confusion. Des régressions linéaires multivariables et des analyses de médiation (en utilisant les modèles d'effets naturels du package « medflex ») ont été réalisées**. Résultats :** Les habitudes alimentaires maternelles et paternelles médiatisaient partiellement l'association entre le niveau socioéconomique parentale et les habitudes alimentaires des enfants. Le statut de migration maternel modérait l'association dans l'analyse de médiation. Nous avons trouvé un effet indirect le plus important pour l'alimentation maternelle « Équilibrée », médiatisant la moitié de l'association entre le niveau socioéconomique maternelle et l'habitude alimentaire « Équilibrée/diversifiée » des enfants à 2 ans chez les non-immigrants. De plus, l'habitude alimentaire paternelle « Équilibrée » médiatise une partie de la relation entre le niveau socioéconomique paternelle et les habitudes alimentaires des enfants. **Conclusion** : L'étude souligne l'importance des habitudes alimentaires des enfants, soulignant la nécessité de programmes de promotion de la santé familiale. Des recherches supplémentaires sont nécessaires pour comprendre les mécanismes sous-jacents et développer des interventions efficaces en santé publique. La compréhension de ces mécanismes constitue un levier pour les interventions de santé publique visant à remédier aux désavantages sociaux dans l'alimentation des enfants.

Mots clés : les 1000 premiers jours, alimentation, médiation, les inégalités sociales

1. INTRODUCTION

The developmental origins of health and disease (DOHaD) theory postulates that the mother's environment and nutritional intake before and during pregnancy can impact fetal development and disease risk in adulthood through epigenetic processes (1,2). Epigenetic processes are the heritable changes, starting from conception onwards, that influence DNA packaging into chromatin, thereby regulating DNA accessibility and gene expression (3–5). In the French EDEN birth cohort, associations between maternal dietary patterns before conception and differentially methylated regions of genes involved in functions related to embryonic development were discovered (6). Both nutritional restriction and caloric excess, as well as the quality of diet during pregnancy in terms of macro, oligo, and micronutrients, as well as additives found in ultra-processed foods, are linked to increased susceptibility to chronic disease and dysfunction later in life (1,2,7–12). Additionally, the early postnatal environment can also influence an individual's susceptibility to noncommunicable chronic diseases later in life through epigenetic processes (13). Addressing prenatal or early-life risk factors can hence achieve a much larger risk reduction and cost-effectiveness compared to the prevention strategies applied at school age or later in life (14).

The first 1000 days of a child's life, spanning from conception to the child's second birthday (15,16), are an important window to encourage healthy dietary habits and practices among parents and young children (8). Dietary preferences emerge as early as infancy, are associated with sociodemographic characteristics (17,18), and tend to persist into childhood. The most notable consequence of social inequalities early in life is the higher prevalence of overweight among the most socially disadvantaged children, starting as early as preschool age (19). Nutritional practices associated with childhood adiposity, such as introducing solids before 4 months of age, feeding infants predominantly formula during the first 6 months of age, and offering children food dense in energy with low nutritional value are more frequent among families of low socioeconomic position (SEP) in high-income countries (20). Parents of low SEP also report that long working hours and financial constraints as the main obstacles to incorporating healthful eating habits into their children's routines (21).

The most common dimensions of SEP described in the literature are the level of education, household income, percentage below the poverty line, occupation, neighbourhood socioeconomic characteristics, past socioeconomic experiences, or a composite score (20,22). Given that different dimensions of SEP are not interchangeable and each of them entails a different aspect of SEP, it is recommended to use multiple variables whenever possible to accurately capture SEP (20,22,23). Michael Marmot elaborated that, contrary to the common categorization, the dimensions of SEP cannot be merely reduced to binary variables (i.e. either the presence or absence of poverty), but they are more likely to follow a gradient (24). Parental education is one of the most stable and easy-to-measure dimensions of SEP that captures lifestyle and behaviour throughout the child's life. It is also the most stable variable during the child's upbringing, making it a useful proxy of SEP (20,23). However, racial, and ethnic differences in income at a given educational level suggest that individuals having similar income or level of education might not be comparable based on those dimensions alone thus outcome and social group-specific approach should be taken when using SEP measurements in research (22).

Furthermore, SEP is a crucial factor in predicting the quality of parents' diets (25–35). Most of the research examining the association between maternal SEP and diet quality in expectant mothers found that older age, higher levels of education, and higher income are predictors of better diet quality and higher adherence to dietary guidelines (25–30,34,36). Conversely, pregnancy is a period during which diet quality and adherence to dietary guidelines tend to deteriorate, especially among younger women and those of lower socioeconomic status (33). Furthermore, multiparity and lower SEP as measured by educational attainment or household income have consistently been found to contribute to poorer dietary choices among expectant mothers (27,29,30,36,37). It is also worth noting that there is a social gradient characterising the quality of both mothers' and fathers' diets (26,27,35,38), with both being socially conditioned and tending to follow similar patterns within a couple or family (35). De Lauzon-Guillain et al.(26) recently published a study underscoring a moderate positive association between maternal and paternal diets in the Elfe cohort (26). Additionally, in fathers, older age and higher educational attainment were associated with balanced dietary patterns, as well as dietary patterns high in industrially processed foods, consumption of alcohol, and "bread and cheese" dietary pattern, typical for traditional French diet. Unemployment was associated with increased alcohol consumption in fathers while living in rural areas was linked to poorer dietary choices (26).

Results from the French Elfe birth cohort also revealed that the association between maternal diet quality and education level was moderated by migration status (27). For the non-immigrant population, a mother's education level was shown to be a key factor in predicting whether she followed a healthy or unhealthy diet, with those of the lowest educational attainment being the least likely to eat healthily. However, this relationship was not significant for immigrant women and was only borderline significant for healthy dietary patterns among descendants of immigrants (27). Yu et al. (29) also explored the effect of migration on the mother's diet in the population of Canadian women. Among immigrant women in their cohort, visible minority women followed healthier diets (measured through a Canadian adaptation of healthy eating index 2010: HEI-C) compared to white women. Furthermore, among non-white women, immigrant women had healthier diets than non-immigrant women (29). Othman et al.

(39) explored how time since migration in the US and race/ethnicity shapes food parenting practices and child diet quality among participants from White, Hmong, Latino, and Somali/Ethiopian racial groups. They demonstrated that immigrants of different ethnic backgrounds can have better or worse dietary quality than the non-immigrant population depending on how long they had lived in their new country and the consequent level of acculturation (39). Acculturation is explained as a process of cultural and psychological change taking place as a result of contact between two or more cultural groups (40). Additionally, in the Elfe cohort acculturation was observed among mothers concerning specific dietary patterns. Descendants of immigrants in high-income households showed an acculturation effect, adopting the processed dietary pattern and becoming more similar to non-immigrants, compared to immigrants (27).

Both parents have an immense influence on their children's eating habits, acting as food providers, role models, and decision-makers (41–44). This influence is particularly important before the age of 2 when children are forming their sense of self. Moreover, this period is characterised by the substantial amount of time that children spend with their parents, further emphasising the impact parents have on their children's dietary choices. Gasser et al. (41) identified parental low fruit and vegetable intake as a predictor of least healthy dietary patterns in children aged 0-14, and this association was significant for both parents. Similarly, maternal and paternal intake of fruit and vegetables, taken as a proxy of healthful eating, has been shown to strongly predict that of their children across various European countries (43,44).

Lioret et al. (25) postulated that maternal dietary patterns may mediate the association between maternal education and children's dietary patterns. Their study was conducted on 421 mother-infant dyads, assessing infants' dietary intake at 9 months. It revealed that mothers who adhered closely to the "Fruit and vegetables" dietary pattern had children with higher scores in the "Balanced weaning" pattern and lower scores in the "Formula" pattern. Additionally, there was a negative association between maternal education and children's "Formula" pattern. Finally, they found that mothers' "Fruit and vegetables" dietary pattern was a partial mediator of the association between maternal education and two infant dietary patterns "Balanced weaning" and "Formula" (25).

Building on the latter findings, and given the similar socio-economic gradients characterising maternal and paternal diets (35), as well as the influence of similar socioeconomic factors on both parents' dietary quality (26,27), we hypothesized that both maternal and paternal dietary patterns could act as mediators in the relationship between SEP and children's diet. However, the understanding of the underlying mechanisms connecting parental SEP to children's diet remains limited. This study, henceforth, aims to shed light on the association between parental SEP, as measured by their education level and household income, and children’s dietary patterns at 9 months and 2 years, while considering maternal and paternal diets as potential mediators. The objectives of this study are:

1. To test the hypothesis that maternal dietary patterns during pregnancy partly mediate the relationship between maternal SEP (assessed based on maternal education level and household income) and child dietary patterns at both 9 months and 2 years.
   i) To test associations between maternal and children’s diets.
   ii) To test associations between maternal SEP and children’s diets.
   iii) To test the potential moderating role of migration.
2. The latter hypotheses will also be tested using paternal SEP (paternal education level and household income) and paternal dietary patterns.

2. METHODS

2.1. Elfe Study

This research project is based on the French longitudinal birth cohort Elfe *(Étude Longitudinale Française depuis l'Enfance)*, which was initiated in 2011. The recruitment of participants occurred over a 25-day period, divided into 4 selected periods (waves) that covered all four seasons of the year. A total of 349 maternity units from mainland France were randomly selected to participate in the study, out of which 320 agreed to participate. Inclusion criteria included single or twin live births at 33 weeks of gestation or more, mothers aged 18 years or older, and no plans to leave metropolitan France within 3 years of inclusion. Informed consent was signed by the parents, or the mother alone, with the father being informed of his right to deny the consent for participation. Information and consent were provided in multiple languages commonly spoken in metropolitan France, including French, Arabic, Turkish, and English. Of the 37,494 eligible women invited to participate, 51% (N=18,040) agreed to (wave 1, N= 2,676; wave 2, N= 4,471; wave 3, N= 5,022; wave 4, N= 5,489;). Ultimately, the cohort included 18,329 children born to 18,040 participating mothers (45,46).

Ethical approvals for data collection were obtained from The National Committee on Information Processing in Health Research (*Comité Consultatif sur le Traitement de information en matière de Recherche dans la Domaine de la Santé*), The National Data Protection Authority (*Commission Nationale Informatique et Liberté*), The National Committee for Statistical Information, and The Committee for Protection of Persons Engaged in Research (*Comité de Protection des Personnes*), in cases involving invasive data collection (biological samples) (45). The Elfe study received funding from the Ministries of Environment, Health and Research, as well as from the national 'Investment for the Future' research funding program(45).

2.2. Data Collection

Data for this study were obtained from several questionnaires administered at inclusion and follow-ups. Parental characteristics were collected at birth and 2 months using self-reported questionnaires, face-to-face interviews, and food frequency questionnaires (FFQs). Questionnaires administered during the mother's stay at the maternity ward included a face-to-face interview with the mother, an FFQ, and lifestyle questionnaire for the mother, and an FFQ and lifestyle questionnaire for the father. The two-month post-partum follow-up involved telephone interviews with 17,850 families (47). To assess children's dietary patterns, we used FFQs provided by parents at 9 months and 2 years: "Children's diet from 6-10 months" and

“Children’s diet at 2 years”. All necessary data for this study had already been collected and were readily available for analyses.

2.2.1. Exposure – Education and income

The exposure variables used in the study were parental education level and household income as proxies for SEP. Both variables were collected from a detailed questionnaire administered 2 months after birth. Maternal and paternal education status were both categorized into 3 categories: low, intermediate, and high. Low education status included education up to the upper secondary level (high school graduates or *baccalauréat* in the French educational system). Intermediate education status included university education for up to 2 years (bachelor or *licence* in the French educational system), whereas high education status entailed 3-year university degrees and above.

The household income variable was obtained from the detailed questionnaire completed at 2 months post-partum, from which household income per consumption unit (CU) was calculated. *The Institut National de la Statistique et des Études Économiques* (Insee) uses the OECD scale to compare living standards among households of different sizes. This scale divides the household income by the number of CU, allocating 1 CU for the first adult in the household, 0.5 CU for each additional person aged 14 years or older, and 0.3 CU for children under 14 years of age(48). Initially, the variable was continuous, but it was later categorized due to the non-linear relationship observed between household income and dependent variables. The categorizations were based on the standards of living in France and household income per CU in 2011 (49). For the binary variable, income below the poverty line was used as a threshold, which was estimated to be 977 € in 2011 (49). The multicategorical variable was based on the median value (D5 = 19,600 €/year) and deciles (D1=10,500 €/year, D9=37,500 €/year reported by Insee (49). To calculate the first and third quartiles, the sum of the first decile and a fractional proportion of the interval multiplied by the interval between the decile and the median was used as follows:

Q1 = D1 + (1/4 * Interval between D1 and D5) = 10,500 + 0.25*9,100 = 12,775

Q3 = D5 + (3/4 * Interval between D5 and D9) = 19,600 + 0.75*17,900 = 33,025

The values obtained for Q1 and Q3 were then divided by 12 to calculate monthly household income amounts per consumption unit. Q1 was estimated to be around 1,064.58 €, and Q3 was estimated to be 2,752.08 €. Subsequently, these values were used to categorize household income into 3 categories as follows: low (<=Q1), intermediate (> Q1, <=Q3), and high (> Q3) income. The analyses were performed using both variables, but considering the potential gradient between categories, the results of both multivariable and mediation analyses using the three-category grouping were reported.

2.2.2. Outcome – Children's dietary patterns

The outcome variables in this study were the scores representing children’s dietary patterns (DPs) at 9 months and 2 years of age. These variables had been previously derived using principal component analysis (PCA) and were interpreted as the higher the scores, the higher the adherence to the given dietary pattern (DP). PCA is a method that condenses information from numerous correlated factors into a smaller number of independent dimensions (or components) (50). The number of DPs for children was determined based on eigenvalues greater than 1.0, the scree plot, and interpretability. Variables strongly correlated with the pattern and those with factor loadings (correlation of each standardized variable with a specific dietary pattern) greater than 0.3 were considered for labelling and interpretation of the patterns. For children aged 9 months, the PCA for DPs was based on the standardized consumption frequencies of 10 food groups (cereals, starchy foods, bread, vegetables, meat and eggs, fish, cheese, yoghurt, fruits, and discretionary sweet foods), as well as 2 drink groups: water, and sugar-sweetened beverages. For children aged 2 years, the analyses included 16 groups: 15 food groups (cereals, starchy foods, bread, meat and eggs, fish, cheese, dairy products, compotes, cooked vegetables, raw vegetables, fresh fruit, discretionary sweet foods, fries, processed meat, discretionary savoury foods) and 1 drink group comprising sugar-sweetened beverages.

Three DPs were identified using PCA at 9 months:

- $DP1_{9m}$ had relatively high factor loadings for all groups except for sugar-sweetened beverages and baby cereals and was labelled “Diversified diet”.
- $DP2_{9m}$ had high factor loadings for sugar-sweetened beverages, discretionary sweet foods, bread, and cheese, while it had negative factor loadings for fruit, vegetables, and fish, and was labelled “Discretionary sweet foods”.
- $DP3_{9m}$ had high factor loadings for baby cereals, yoghurt, and water, while it had negative factor loadings for bread, and it was labelled “Baby cereals and yoghurt”.

At 2 years, 2 DPs were identified using PCA:

- $DP1_{2y}$ had high factor loadings for legumes, bread, meat, fish, cheese, compotes, cooked vegetables, and fruit, and it was labelled “Diversified and balanced”.

- $DP2_{2y}$ had high positive factor loadings for sugar-sweetened beverages, sweets, fries, processed meat, and discretionary savoury foods and negative factor loadings for vegetables, and it was labelled “Discretionary consumption”.

2.2.3. Mediator – Maternal and Paternal dietary patterns

The potential mediators were maternal and paternal DPs during the perinatal period. Maternal dietary intake during the last three months of pregnancy was collected at birth using a validated semi-quantitative 125-item FFQ (27). Five *a posteriori* dietary patterns were identified using PCA: “Western”, “Balanced”, “Bread and toppings”, “Processed”, and “Milk and Breakfast Cereals”. Detailed information on factor loadings and pattern identification can be found elsewhere (27). Higher dietary pattern scores indicate greater adherence to each respective DP.

For fathers, dietary data were collected shortly after the child’s birth using a short, non-validated 41-item FFQ focused on the months preceding pregnancy. Six *a posteriori* dietary patterns were previously identified using PCA: “Diverse”, “Balanced”, “Alcohol”, “Snacking”, “Bread and cheese”, and “Processed products” (26). Similar to the mothers, DP scores for fathers were continuous variables, where higher scores reflected greater adherence to the pattern.

2.2.4. Potential moderator - Migration

Migration was explored as a potential moderator of the relationship between SEP of parents, parental DPs and children’s DPs, based on previous findings (27). Data on both mother’s and father’s migration status were collected 2 months post-partum and were initially a multicategorical variable comprising 4 categories: non-French parent, French parent - descendant of two immigrant parents, French parent - descendant of one immigrant parent, and French parent. By merging two groups of French parents, descendants of immigrants, we regrouped the variable as follows: Immigrant, Descendant of Immigrant, and Non-Immigrant.

2.2.5. Other variables of interest

The set of confounders for adjustment in multivariable regressions and mediation analysis was selected based on the thorough literature review and the Directed acyclic graph (DAG) we created (Figure S1). Depending on the analysis performed, the status of the variable (covariate or exposure) changed. The variable status change is explained in paragraph 2.4.3.

Age

Both maternal and paternal ages were collected at inclusion (birth) and kept continuous for all the subsequent analyses.

Education & Household Income

Maternal and paternal education, as well as household income, were categorized as explained earlier and used in analyses as either exposures or covariates (see paragraph 2.4.3).

Parity

Parity, a variable collected for the LifeCycle project that the Elfe birth cohort is a part of (51), was a multi-categorical variable with 5 categories, but it was recategorized for this study as binary: Primiparous/Multiparous women.

Migration

The migration variable was categorized as explained earlier. Its change of status between moderator and covariate is explained in paragraph 2.4.3.

Child's sex

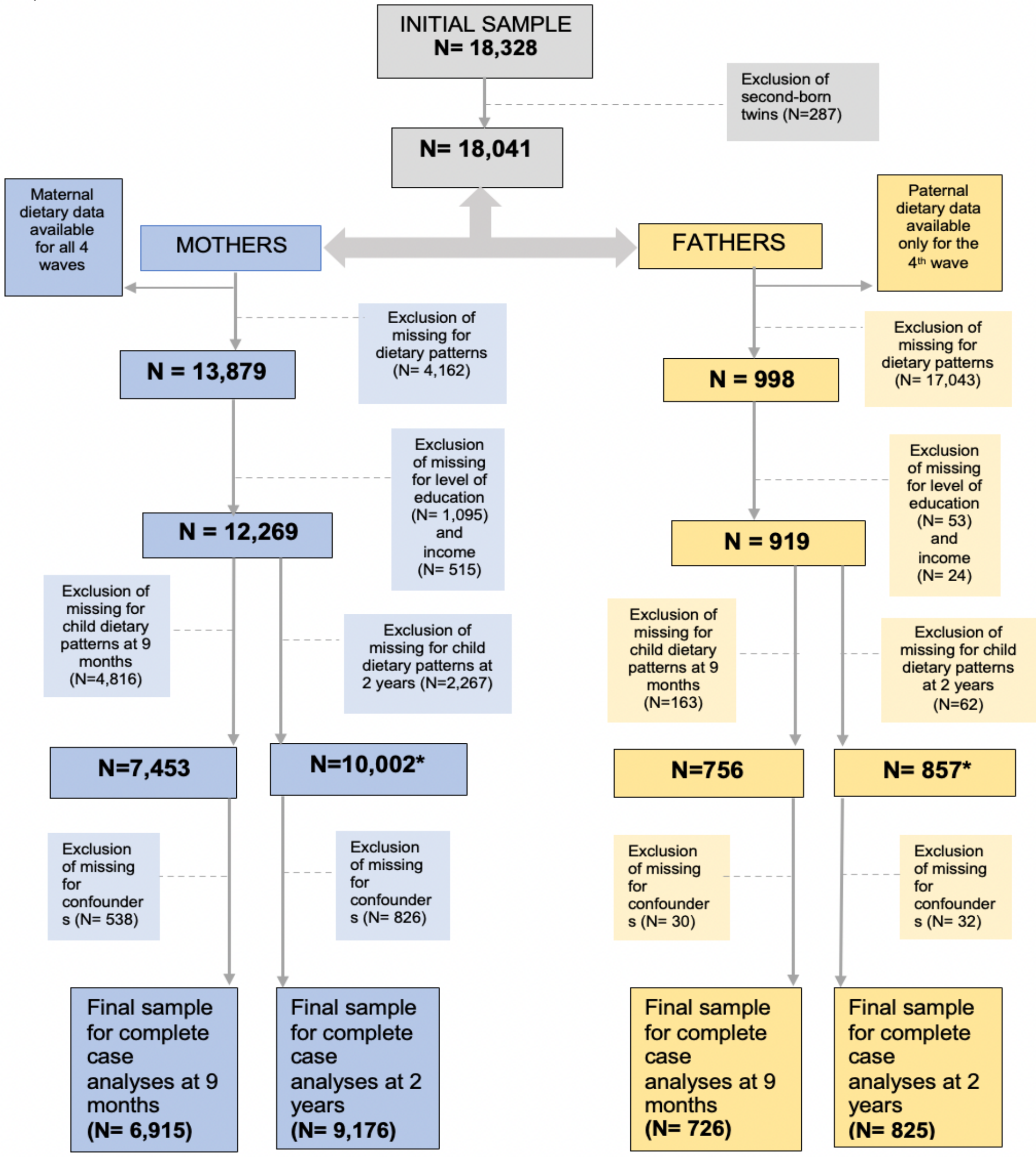
All data collected at inclusion and follow-ups were compared to create a categorical binary variable for sex (male/female).

2.3. Population selection

The initial sample included 18,328 children, from which 287 second-born twins were excluded. The remaining sample for analyses was 18,041 participants. While maternal dietary intake was collected through all 4 waves of data collection, paternal dietary intake was collected only during the 4th wave of data collection. Due to different waves of data collection for maternal and paternal dietary intake, data was split into two sub-samples, maternal (n= 13,879) and paternal (n= 998). The final sample sizes for descriptive analyses, after excluding missing data for maternal dietary patterns, level of education, and household income were 12,269 for mothers and 919 for fathers. Further reductions of the sample size occurred for the missing data on children's DPs and confounding variables, resulting in the complete case sample used for the first step of the analysis. The final samples for complete case analyses at 9 months and 2 years were 6,915 and 9,176 for mothers, and 726 and 825 for fathers, respectively. Data exclusion decisions and final sample sizes are depicted in Figure 1.

Figure 1. Procedure flowchart

*The number of observations at 2 years is higher than the number of observations at 9 months due to the study design. At 9 months, parents were given an online questionnaire, whereas, at 2 years, they were interviewed via telephone which resulted in more responses.



2.4. Statistical analyses

2.4.1. Descriptive statistics and bivariate analysis

Descriptive statistics were employed to describe the initial sample, as well as the samples of complete cases for maternal and paternal dietary patterns, and SEP factors. Characteristics were described using mean (± SD) and % (N), with median values of the included sample also being reported. Bivariate analyses were conducted to compare the sample of parents having available information for DPs and SEP factors with the excluded observations from the initial sample. Statistical tests were selected based on the data type, utilizing Welsch's t-test to compare means of normally distributed continuous variables, and the Wilcoxon Rank/Sum test to compare ranks of non-normally distributed continuous variables. The chi-square ($\chi 2$) test was used to compare two categorical variables, ensuring that more than 80% of cells containing expected values were 5 or greater.

2.4.2. Multivariable linear regression

Multivariable analyses were conducted to assess associations between exposure and outcome (path c, total effect), exposure and mediator (path a), and mediator and outcome (path b) while adjusting for a predetermined set of covariates outlined in the following paragraph. We used linear regression models to assess the different associations as the dependent variables (parental and children's DP scores) were continuous, and the relationship with the independent variable was linear.

2.4.3. Adjustment for covariates in multivariable analyses

Following a comprehensive selection process based on the literature review, as well as the DAG we created, multivariable analyses were adjusted for the following confounders:

Table 1. Confounders adjusted for in the multivariable analyses.

Maternal sample	Maternal education	Paternal education	Income	Maternal age	Paternal age	Migration	Child sex	Parity
Maternal diet ~ Education		X		X		X		X
Maternal diet ~ Income	X			X		X		X
Child DPs ~ Maternal DPs	X		X	X		X	X	X
Child DPs ~ Education		X		X		X	X	X
Child DPs ~ Income	X			X		X	X	X
Paternal sample								
Paternal DPs ~ Education	X				X	X		X
Paternal DPs ~ Income		X			X	X		X
Child DPs ~ Paternal DPs		X	X		X	X	X	X
Child DPs ~ Education	X				X	X	X	X
Child DPs ~ Income		X			X	X	X	X

*Education refers to maternal education in the maternal sample and paternal education in the paternal sample, both collected 2 months after birth. Income refers to household income per unit of consumption collected 2 months after birth.

In the analyses using income as a proxy of SEP, it was deemed important to adjust for paternal/maternal education status because we hypothesized that education may influence household income. In the analyses using parental level education as a proxy, we adjusted for the partner's education level, as a variable accounting for family life, based on the literature review. The DAGs on which adjusting for confounders is based are displayed in Figure S1. Additionally, all regression models initially included a multiplicative interaction term between parental education and migration status, in the models where education was exposure, or for the multiplicative interaction term between household income and migration in the models where household income was exposure. Followingly, for all the models having a significant interaction term (alpha value threshold <= 0.05), the results were presented as stratified by migration status in 3 strata.

Multicollinearity tests

The multivariable regression models created for paths a, b, and c were tested for multicollinearity using the "mctest" package in R software (52,53). The models reported variance inflation factor (VIF) < 5 for all covariates included, therefore no major collinearity was observed.

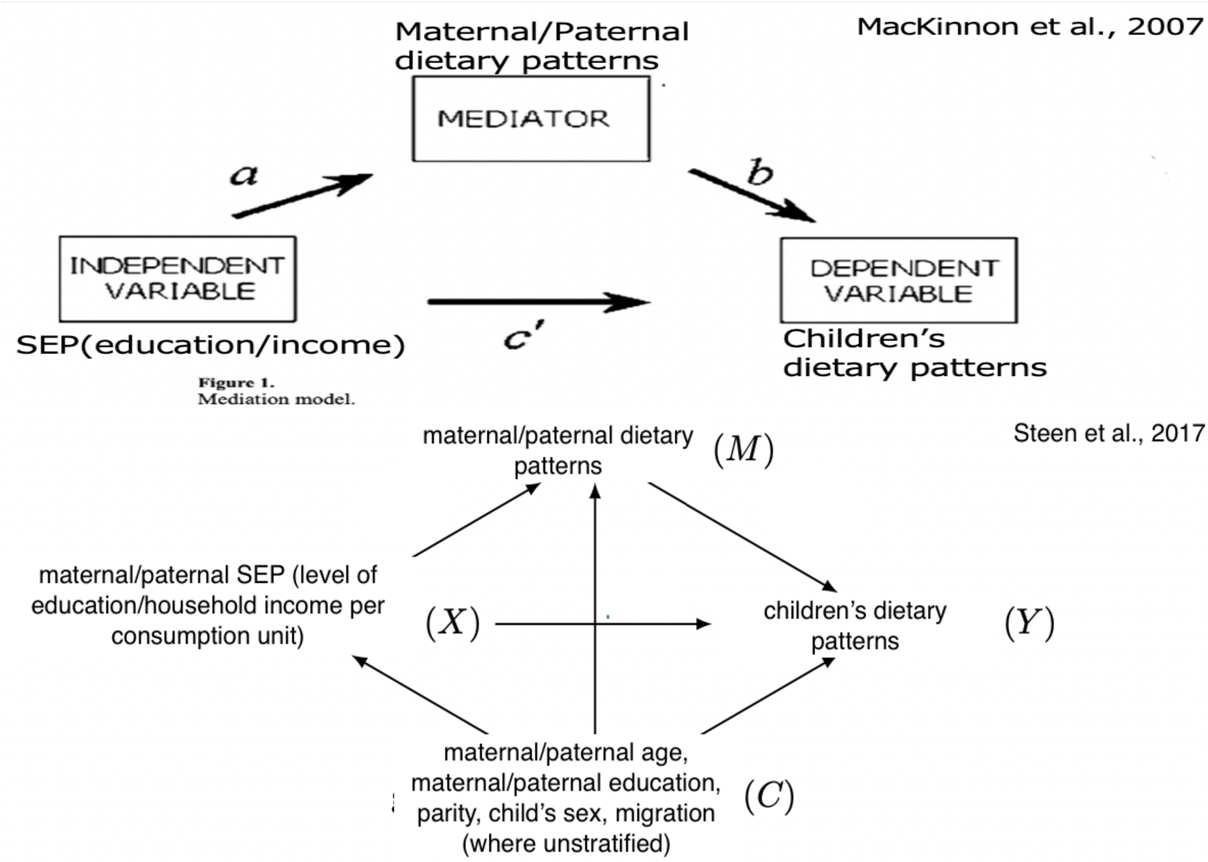
2.4.4. Mediation analyses

2.4.4.1. Mediation theories and strategy justification

The main aim of mediation analysis is to decompose the total effect (path c) of an association into direct (path c') and indirect (ab) effects. The direct effect corresponds to the effect of the exposure on the outcome while accounting for the mediator, which in this study refers to the effect that operates via factors other than parental DPs. The indirect effect captures the effect operating through the mediating variable, which in this study is parental DPs. Baron and Kenny's seminal paper in 1986 introduced a simplified theory for decomposing total effects into direct and indirect effects (54). MacKinnon's approach, a commonly used adaptation of Baron and Kenny's approach sets two main requirements for mediation: i) significant association between exposure and mediator (path a), ii) significant association between mediator and outcome, while adjusting for the exposure (path b) (55). Figure 2 provides a visual representation of mediation analysis applied to our data, alongside explanations of the paths involved. It is important to note that the traditional approach to mediation, as outlined by Baron and Kenny (54) and MacKinnon (55), is based on the linear structural equation models and is applicable only in linear settings (56). The traditional models also assume the normality of the distribution and the absence of exposure-mediator interaction (55,57,58). However, assuming the absence of exposure-mediator interaction may lead to invalid inferences (57–60). Furthermore, the traditional approach (58) faces challenges in the presence of mediator-outcome confounding, and mediator-outcome confounding affected by exposure. To address these limitations and the inability to verify the strong assumptions of the traditional approach, we opted for the counterfactual approach to mediation.

Figure 2. Schematical representation of mediation using the figures from MacKinnon's traditional approach (up) and Steen et al.'s natural effect models (down) applied to the context of our study.

a = coefficient associating a given SEP variable (X) with a given parental DP (M),
b = coefficient connecting a given parental DP (M) with a given child's DP (Y),
c`= direct effect of non-mediated effect of the relation between a given SEP variable and a given child's DP after accounting for parental DPs,
c = total effect of the association between a given SEP (X) and a given child's DP (Y)



*X = exposure, M = mediator, Y = outcome, C = confounders

In a recent scoping review on mediation methodology, the use of the counterfactual approach to mediation for observational data was encouraged because of its ability to account for exposure-mediator interactions and provide guidance when strict assumptions do not hold (61). The counterfactual approach enables decomposition of the total effects into natural direct (NDE) and natural indirect effects (NIE), applicable to both linear and non-linear settings (56,57). The NDE represents the effect of changing the exposure while keeping the mediator fixed at the level it would have, had the exposure not been changed. The NIE captures the effect of changing the mediator, i.e., as if the exposure had been changed without actually altering the exposure itself (62). The sufficient conditions for the non-parametric identification of natural effects are:

i) no uncontrolled/unmeasured confounding in the relationships between exposure-outcome, exposure-mediator, and mediator-outcome after adjusting for exposure,

ii) positivity – for any values of confounders, all exposures have a non-zero probability to occur and for any value of confounders and exposures, all mediator values have a non-zero probability,

iii) consistency – assuming that the nested counterfactuals will take the observed values when the exposure and mediator are actively set to the values they would naturally have had in the absence of an intervention,

iv) no confounder of the mediator-outcome relationship is affected by the exposure (60,62,63).

A variation of the counterfactual approach described as natural effect models (NEMs), and available in R as a part of the “medflex” (64) package, phrases a mediation analysis as a multiple regression problem. The problem of causality, framed as the missing data problem in NEMs is addressed using the imputation-based approach recommended by Vandteelandt et al. (64,65). This approach is particularly suitable for continuous mediators. It entails creating an outcome model conditioned on confounders, exposure, and mediator, duplicating the original dataset, and creating an artificial exposure (X*) that matches the original exposure for the first replication and is the opposite of the actual exposure in the second. The imputation process then imputes possible outcomes for the rows where X is not equal to X*, based on the predicted functionality. The values of exposure are set to X* in the imputation process, mediators and confounders are set to their observed values, while outcomes are set to their imputed values (62). Finally, a mediation model is fitted to the imputed dataset (62,64).

2.4.4.2. Mediation pathways, covariates, standard error

The variables included in the mediation analyses were chosen based on two criteria proposed by MacKinnon(55) and the results of multivariable analyses. Only variables yielding significant results for both paths a and b in the multivariable analyses were selected for mediation analyses.

To adjust for potential confounders, the mediation analyses were conducted with the same set of baseline covariates as used in the multivariable linear regression. These covariates were selected based on the findings from Kadawathagedara et al. (27), as well as a comprehensive literature review. Additionally, based on the results of multivariable linear regression models including the significant multiplicative interaction term between exposure and migration status, maternal “Balanced” and “Processed” DPs were stratified by the three categories of migration status.

In mediation analysis, the default glm standard error (SE) obtained from generalized linear models tends to be downwardly biased. To address this issue, the “medflex” package provides SE estimation using bootstrapping and sandwich estimator for robust SE (64,66). For the maternal subsample, confidence intervals were obtained using bootstrapping (with 1,000 bootstraps), which involves repeating the modelling and randomly resampling the data a total of 1,000 times. However, for the paternal sample, due to the exclusion of missing data, bootstrapped confidence intervals were not feasible. Instead, robust SE was used to estimate confidence intervals for the paternal subsample.

2.4.4.3. Comparison of traditional and counterfactual approaches to mediation

After confirming the absence of exposure-mediator interactions in our mediation pathways and considering the large size of the maternal sample, as well as the continuous nature of mediators and outcomes, we decided to test several pathways using the traditional approach to mediation by MacKinnon (55). We examined the associations between maternal education and the following children’s DP: “Discretionary sweet foods” at 9 months, “Balanced/diversified” and “Discretionary consumption” at 2 years, with the following potential mediators: “Western”, “Balanced” in non-immigrants, “Bread and toppings”. Our analysis was based on Hayes and Preacher’s seminal article (67) on mediation analysis with multicategorical independent variables. To account for the multiple tests conducted and mitigate type-1 error inflation, we applied a Bonferroni correction, using the 97.5% CI criterion to reject null hypotheses, instead of 95% CI (67). The “lavaan”(68) package in R software was employed for the mediation analysis.

2.4.5. Dealing with missing data

The initial analyses were conducted on a sample excluding participants with missing data for the exposures, mediators, outcomes, and covariates of interest. A complete case dataset assumes data are missing completely at random and can thus be excluded. Multiple imputations for missing data on baseline covariates will be employed using the “mice” package in R software as the next stage of the project and will be reported in the scientific article.

2.4.6. Software

For data management and descriptive statistics, SAS 9 software was used through the AIX 7.2 (AIX 64) platform. For bivariate, multivariate, mediation, and sensitivity analyses, as well as for multiple imputations, R Studio software version 4.2.1 was used.

3. RESULTS

3.1. Descriptive and bivariate analyses

Our sample included 12,269 observations for the maternal sample and 919 observations for the paternal sample. The median age of mothers was 30.7 years, with 95%CI (27.5, 34.1), while that of fathers was 33.1 years (30.1, 36.9). Mothers included in the analyses had on average higher income, and higher education levels, and were non-immigrants in a higher proportion than mothers excluded from analyses. In the included sample 37.6% of mothers had a low education level, 24.1% intermediate education level, and 38.4% high education level. In the excluded sample, those proportions were 55.7%, 15.5%, and 28.7% for low, intermediate, and high education levels, respectively. Almost 20% of mothers in the excluded sample were immigrants, while there were only 7% of immigrant mothers in the included sample. Included fathers also had on average higher income, and higher education levels, and a higher percentage of them belonged to the non-immigrant population, compared to the excluded fathers. The detailed description of the sample, alongside the results of bivariate analyses of included and excluded samples, is displayed in Table 2.

Table 2. Descriptive statistics of maternal and paternal samples and bivariable analyses of included vs excluded samples.
**Statistical tests used: chi2, Welch's t-test/Wilcoxon Rank/Sum*

	% (N) Included/ Mean (±sd)	% (N) Excluded/ Mean (±sd)	Median/Included (q1, q3)	p-value
Maternal characteristics				
Maternal age	N= 12,240	N= 5,606		
At inclusion	30.9 (±4.8)	30.1 (±5.5)	30.7 (27.5, 34.1)	<.0001
Missing	0.2 (29)			
Maternal education level	N=12,269	N=3,750		
Low	37.6 (4,611)	55.7 (2,089)		<.0001
Intermediate	24.1 (2,951)	15.5 (583)		
High	38.4 (4,859)	28.7 (1,078)		
Missing	0			
Maternal migration status	N= 12,269	N= 3,873		
Immigrant	7.3 (900)	19.4 (751)		<.0001
Descendants of Immigrant	10.1 (1,239)	11.6 (451)		
Non-Immigrant	82.6 (10,130)	69.0 (2,671)		
Missing	0			
Mother's country of origin	N= 12,269	N=5,631		
France	92.3 (11,329)	75.3 (4,242)		<.0001
EU	2.0 (244)	2.6 (146)		
North Africa & Turkey	2.5 (301)	10.3 (581)		
SubSaharan Africa	1.8 (244)	7.9 (444)		
Other	1.5 (180)	3.9 (218)		
Missing	0			
Household income	N= 12,269	N= 3,023		
€ per unit of consumption at 2 months	1,665.3 (±932.5)	1,508.9 (± 1,272.9)	1,523.81 (1,166.7, 1,944.4)	<0.001
Missing	0			
Household income				
€ per unit of consumption				

	% (N) Included/ Mean (±sd)	% (N) Excluded/ Mean (±sd)	Median/Included (q1, q3)	p-value
Low	19.3 (2,369)	17.7 (1,024)		0.199
Intermediate	72.5 (8,921)	30.5 (1,762)		
High	8.1 (999)	4.1 (237)		
Missing	0	2,749		
Living in a couple	N= 12,188	N= 3,953		
Yes	97.1 (11,833)	91.9 (3,633)		<0.001
No	2.9 (355)	8.1 (320)		
Missing	0.7 (81)			
Parity	N= 12,135	N= 5,537		
Primiparous	45.5 (5,521)	46.8 (2,593)		0.098
Multiparous	54.5 (6,614)	53.2 (2,944)		
Missing	1.1 (134)			
Paternal characteristics	N= 919	N= 17,122		
Paternal age	N= 909	N= 16,163		
At inclusion	33.7 (±5.3)	33.3 (±6.3)	33.1 (30.1, 36.9)	0.06
Missing	1.1 (10)			
Paternal education level	N=919	N=12,691		
Low	36.5 (335)	50.2 (6,368)		<0.001
Intermediate	21.1 (194)	17.8 (2,256)		
High	42.4 (390)	32.0 (4,067)		
Missing	0			
Paternal migration status	N= 904	N= 12,408		
Immigrant	0.7 (6)	5.8 (716)		<0.001
Descendant of Immigrant	9.6 (87)	17.5 (2,166)		
Non-Immigrant	89.7 (811)	76.8 (9,526)		
Missing	1.6 (15)			
Father’s country of origin	N= 919	N=16,282		
France	96.3 (885)	87.3 (14,217)		<0.001
EU	1.6 (15)	1.9 (303)		
North Africa & Turkey	1.0 (9)	6.0 (974)		
SubSaharan Africa	0.5 (5)	3.3 (535)		
Other	0.5 (5)	1.6 (253)		
Missing	0			
Household income	N= 919	N= 14,373		
€ per unit of consumption at 2 months	1840.7 (±776.1)	1,621.2 (±1,022.6)	1,666.67 (1,388.89, 2,182.19)	<0.001
Missing	2.5 (24)			
Household income				
€ per unit of consumption at 2m				
Low	10.2 (94)	19.3 (3,299)		0.099
Intermediate	78.7 (723)	58.1 (9,940)		
High	11.1 (102)	6.6 (1,134)		
Missing	0	2,749		
Living in a couple	N= 909	N= 15,232		
Yes	99.8 (907)	95.6 (14,559)		<0.001
No	0.2 (2)	4.4 (673)		
Missing	1.1 (10)			
Parity	N= 914	N= 16,758		
Primiparous	53.2 (486)	45.5 (7,628)		<0.001
Multiparous	46.8 (428)	54.5 (9,130)		
Missing	0.5 (5)			

3.2. Multivariable analyses and mediation analyses

Multivariable analyses for the paths a, b, and c for maternal and paternal samples were conducted using linear regressions. Based on the results of Kadawathagedara et al., the analyses for maternal "Balanced" and "Processed" DPs were stratified by migration status as follows: Immigrants, Descendants of Immigrants, and Non-Immigrants. For each regression model, multiple R-squared and adjusted R-squared yielded similar values, indicating there were no fitting issues with our models.

3.2.1. Path a – association between parental SEP and dietary patterns

3.2.1.1. Maternal sample

In a previous study by Kadawathagedara et al (27), positive associations were found between high maternal education level and the following DPs: "Balanced" and "Processed" in non-immigrants, "Bread and toppings", "Milk and breakfast cereals". Negative associations were observed between higher maternal education and "Western" DP. Higher levels of household income were positively associated with the following maternal DPs: "Balanced" in non-immigrants, "Bread and toppings", and "Processed" in descendants of immigrants, while they were negatively associated with the maternal "Western" DP. We reran the analyses for path a in our sample, for which results are displayed in Table S1.

3.2.1.2. Paternal sample

In the study by de Lauzon – Guillain et al.(26), positive associations were found between a high paternal education level and the "Balanced" DP and a negative association between high education and the "Processed products" DP. We repeated the paternal path a analyses, using the categorisation explained in paragraph 2.2.1. and low education/income as the reference category. Alongside the positive association of high education with paternal "Balanced" DP, we also found positive associations between high income and the "Processed products" DP. Negative associations were found between high vs low paternal education and "Bread and cheese" DP, as well as between high vs low household income and "Diverse" DP. Additionally, a negative association was found between higher income and "Alcohol" DP scores. There seemed to be a negative trend between high education and "Processed products", but the association was not significant based on the alpha level of 0.05. The results of these analyses are displayed in Table S2.

3.2.2. Path b – association between parental diet and children's diet

3.2.2.1. Maternal sample

After controlling for education and confounders, maternal "Western" DP was positively associated with the following children's dietary patterns "Diversified" at 9 months (β (95%CI) = 0.23 (0.18, 0.28)) and "Balanced/diversified" at 2 years (β = 0.07 (95% CI 0.05, 0.09)), "Discretionary sweet foods" at 9 months (β = 0.04 (95% CI 0.01, 0.07)) and "Discretionary consumption" at 2 years (β = 0.26 (95% CI 0.24, 0.28)). For every 1-unit increase in maternal "Balanced" dietary pattern, the average score for children's "Diversified" DP at 9 months increased by 0.12 (95% CI 0.07, 0.18) and "Balanced/diversified" at 2 years by 0.27 (95%CI 0.25, 0.28), among the stratum of non-immigrants. Similar positive associations were observed across the other two strata of migration (Table 3). Among descendants of immigrants, for every one-unit increase in the mother's score for the "Processed" DP, the mean score for children's "Diversified" DP at 9 months decreased by 0.22 (95%CI -0.38, -0.05), while that for "Baby cereals and yoghurt" increased by 0.11 (95%CI 0.02, 0.20). Additionally, the maternal "Processed" DP was positively associated with children's "Baby cereals and yoghurt" and "Discretionary consumption" at 2 years. When we controlled for the household income as an exposure in the path b analyses, the results remained consistent with those reported above (Table S3). Based on the adjusted R^2, between 2% and 3.6% of the variation in the children's DPs at 9 months was explained by the maternal DPs. At 2 years, on the other hand, the maternal DPs explained 8.5% of the variation in the "Balanced/diversified" DP and 19.5% of the variation in the "Discretionary consumption" DP.

3.2.2.2. Paternal sample

Holding education and confounders constant, a 1-unit increase in the father's "Diverse" DP score increased the average score for children's "Diversified" diet at 9 months by 0.20 (95%CI 0.07, 0.33). Similarly, paternal "Diverse" and "Balanced" DPs were positively associated with children's "Balanced/diversified" DP at 2 years, with an average score increase of 0.18 (95%CI 0.12, 0.25) and 0.08 (95%CI 0.01, 0.15), respectively. Additionally, a 1-unit increase in paternal "Balanced" DP score decreased the average score for children's "Discretionary consumption" DP at 2 years by 0.13 (95%CI -0.18, -0.07). The paternal "Bread and cheese" DP was negatively associated with children's "Balanced/diversified" DP at 2 years (Table 4). When we adjusted for the household income as exposure in the path b analyses, the results remained consistent with those reported above (Table S4). Based on the adjusted R^2, between 1.9% and 2.7% of the variation in the children's DPs at 9 months was explained by paternal DPs. At 2 years, paternal DPs explained 5.3% of the variation in the children's "Balanced/diversified" DP and 13.4% of the variation in the children's "Discretionary consumption" DP.

3.2.3. Path c – association between parental SEP and children's diet

3.2.3.1. Maternal sample

Holding confounders constant, children whose mothers had intermediate and high education levels had a smaller average score for the "Discretionary sweet foods" DP at 9 months of -0.19 (95%CI -0.26, -0.11) and -0.22 (95%CI -0.33, -0.15), respectively, compared to children of mothers who had low education. Likewise, at 2 years, children of mothers having intermediate and high maternal education levels, compared to low, had lower scores for the "Discretionary consumption" pattern β = 0.34 (95%CI -0.39, -0.29) and β = 0.41 (95%CI -0.46, -0.37), respectively. Additionally, children of mothers with intermediate and high education, compared to the low, scored higher on average on the "Balanced/diversified" DP: β = 0.11 (95%CI 0.05, 0.16) and β = 0.20 (95%CI 0.15, 0.20), respectively.

In contrast to path a, where household income and level of education yielded similar results, path c revealed an additional positive association between household income and children's "Diversified" DP at 9 months. Children of mothers having intermediate and high income adhered more to the "Diversified" DP at 9 months: β = 0.21 (95%CI 0.08, 0.33) and β = 0.23 (95%CI 0.04, 0.42), respectively, compared to children of mothers who had low income. There was a gradient across different income levels (Table S5). Based on the adjusted R^2, between 1.5% and 2.6% of the variation in children's DPs except for children's "Discretionary consumption" DP at 2 years for which differences in SEP explained 12.6 % of the variation. The R^2 values were similar between models including education and income as exposure.

3.2.3.2. Paternal sample

Children of fathers having intermediate and high education levels scored lower on average on the "Discretionary consumption" DP at 2 years, β = -0.18 (95%CI -0.31, -0.05) and β = -0.31 (95%CI -0.44, -0.19), respectively, compared to the children of fathers who had low education level. Likewise, at 9 months, children of fathers who had high education scored on average lower on the "Discretionary sweet foods" DP, β = -0.26 (95%CI -0.47, -0.04), compared to children of fathers who had low education. Additionally, children of fathers having a high education level had a higher average score for "Balanced/diversified" DP, β = 0.17 (95%CI 0.00, 0.33), compared to the children of fathers having a low education level. When household income was considered as the exposure, the results remained consistent for the "Discretionary consumption" DP at 2 years, with a bigger effect size (Table S6). Based on the adjusted R^2, between 1.1% and 2.2 % of the variation in children's DP was explained by differences in maternal SEP, except for children's "Discretionary consumption" DP at 2 years for which differences in SEP explained 11,4% of the variation. Results were consistent between models including income and education as exposure.

Table 3. Coefficients (95% CI) of the multivariable linear regression analysis for the maternal subsample: associations between maternal dietary patterns and children's dietary patterns as the dependent variable (path b), adjusted for maternal education.

	CHILDREN'S DIETARY PATTERNS				
	at 9 months			at 2 years	
MATERNAL DPs	Diversified	Discretionary sweet foods	Baby cereals &Yoghurt	Balanced/ Diversified	Discretionary consumption
Western	**0.23 (0.18, 0.28)**	**0.04 (0.01, 0.07)**	**-0.05 (-0.08, -0.02)**	**0.07 (0.05, 0.09)**	**0.26 (0.24, 0.28)**
Balanced in Immigrants	**0.35 (0.12, 0.58)**	0.02 (-0.14, 0.11)	-0.09 (-0.21, 0.02)	**0.24 (0.16, 0.32)**	0.07 (-0.01, 0.15)
Balanced in Descendants of Immigrants	**0.24 (0.09, 0.40)**	0.02 (-0.08, 0.11)	-0.07 (-0.16, 0.02)	**0.30 (0.23, 0.37)**	**-0.10 (-0.18, -0.03)**
Balanced in non-Immigrants	**0.12 (0.07, 0.18)**	**-0.04 (-0.07, -0.01)**	**-0.04 (-0.07, -0.01)**	**0.27 (0.25, 0.29)**	**-0.12 (-0.15, -0.10)**
Bread & Toppings	0.03 (-0.02, 0.08)	0.03 (-0.00, 0.06)	0.02 (-0.01, 0.05)	**0.05 (0.03, 0.07)**	**-0.04 (-0.06, -0.02)**
Processed in Immigrants	-0.08 (-0.27,0.11)	0.00 (-0.10, 0.11)	**0.12 (0.02, 0.21)**	-0.07 (-0.15, 0.02)	-0.02 (-0.10, 0.07)
Processed in Descendants of Immigrants	**-0.22 (-0.38, -0.05)**	0.00 (-0.09, 0.10)	**0.11 (0.02, 0.20)**	-0.00 (-0.08, 0.07)	-0.05 (-0.13, 0.03)
Processed in non-Immigrants	0.03 (-0.02, 0.07)	-0.03 (-0.06, 0.00)	**0.04 (0.01, 0.07)**	0.02 (-0.00, 0.04)	**0.03 (0.01, 0.05)**
Milk & Breakfast Cereals	-0.04 (-0.08, 0.01)	-0.04 (-0.07, -0.01)	0.05 (0.02, 0.07)	0.01 (-0.00, 0.03)	-0.09 (-0.10, -0.07)

*Confounders adjusted for maternal education, paternal education, child's sex, maternal age, parity, and migration status (for unstratified analyses).

Table 4. Coefficients (95% CI) of the multivariable linear regression analysis for the paternal subsample: associations between paternal dietary patterns and children's dietary patterns as the dependent variable (path b), adjusted for paternal education.

	CHILDREN'S DIETARY PATTERNS				
	9 months			2 years	
PATERNAL DPs	Diversified	Discretionary sweet foods	Baby cereals &Yoghurt	Balanced/ Diversified	Discretionary consumption
Diverse	**0.21 (0.08, 0.34)**	0.02 (-0.07, 0.11)	-0.05 (-0.14, 0.03)	**0.18 (0.12, 0.25)**	0.05 (-0.00, 0.10)
Balanced	-0.10 (-0.24, 0.04)	-0.03 (-0.13, 0.06)	0.08 (-0.01, 0.16)	**0.08 (0.01, 0.15)**	**-0.13 (-0.18, -0.08)**
Alcohol	-0.00 (-0.13, 0.12)	0.02 (-0.07, 0.10)	-0.03 (-0.11, 0.05)	-0.03 (-0.10, 0.03)	-0.01 (-0.06, 0.03)
Snacking	0.03 (-0.10, 0.16)	-0.01 (-0.10, 0.08)	0.02 (-0.06, 0.10)	0.02 (-0.05, 0.08)	0.00 (-0.05, 0.05)
Bread and cheese	-0.09 (-0.22, 0.03)	0.03 (-0.06, 0.11)	-0.03 (-0.11, 0.05)	**-0.08 (-0.15, -0.02)**	0.01 (-0.04, 0.06)
Processed products	0.07 (-0.05, 0.19)	-0.00 (-0.09, 0.08)	0.06 (-0.02, 0.13)	-0.04 (-0.11, 0.02)	-0.02 (-0.06, 0.03)

* Confounders adjusted for paternal education, maternal education, child's sex, paternal age, parity, and migration status.

3.2.4. Mediation analysis – parental SEP, parental diet, children's diet

3.2.4.1. Maternal sample

For the relation between intermediate and high education levels compared to the low and **children's "Diversified" DP at 9 months**, the natural indirect effects (NIE) of maternal "Balanced" DP were β = 0.02 (95%CI 0.01, 0.03) and β = 0.04 (95%CI 0.02, 0.06), respectively; while those of the "Western DP were β = -0.03 (95%CI -0.05, -0.02) for both levels of education (Table 5a). We reported that a higher maternal education level was associated with a lower likelihood of children adhering to the "**Discretionary sweet foods" DP** at 9 months, however, mediation analysis revealed that the association was not mediated by the maternal "Western" DP. We observed a negative natural direct effect (NDE): β = -0.18 (95%CI -0.26, -0.11) close to the total effect (TE) (β = -0.19 (95%CI -0.26, -0.11)) for intermediate vs low education and NDE: β = -0.22 (95%CI -0.30, -0.15), TE: β = -0.22 (95%CI -0.29, -0.15) for high vs low education level (Table 5a). Similar associations with no significant mediating effects of maternal DPs were found for the relationship between household income and children's DPs at 9 months. However, we observed relatively large negative NDE and TE for associations between household income and "Discretionary sweet foods", as well as positive NDE and TE for the association with children's "Diversified" DP (Table S7).

At 2 years, we reported a positive TE of intermediate β = 0.11 (95%CI 0.05, 0.16) and high β = 0.20 (95%CI 0.15, 0.26) maternal education on the children's **"Balanced/diversified" DP** (Table 5b). That association was partially negatively mediated by maternal "Western" DP, NIE: β = -0.02 (95%CI -0.02, -0.01) and β = -0.02 (95%CI -0.03, -0.01), respectively, as well as partially positively mediated by maternal "Bread and toppings" DP, NIE: β = 0.01 (95%CI 0.01, 0.02) for high vs low maternal education. Additionally, TE of maternal education level on children's "Balanced/diversified" DP in the strata of non-immigrants were respectively β = 0.10 (95%CI 0.04, 0.16) and β = 0.17 (95%CI 0.12, 0.23) for intermediate and high vs low maternal education and more than half of those associations were mediated by maternal "Balanced" DP, NIE: β = 0.06 (95%CI 0.04, 0.08) and β = 0.09 (95%CI 0.07, 0.12), respectively. Among descendants of immigrants, half of that association was mediated through the maternal "Balanced" diet when we compared intermediate and low levels of education, and around a fifth for high vs low education. Furthermore, at 2 years, a negative association between an intermediate and high maternal education compared to low and children's **"Discretionary consumption" DP** was partially mediated by maternal "Western" DP, NIE: β = -0.05 (95%CI -0.06, -0.04). Among non-immigrants, a moderate portion of the TE was mediated by maternal "Balanced" diet, for both intermediate (NIE: β = -0.02 (95%CI -0.03, -0.01)) and high (NIE: β = -0.04 (95%CI -0.05, -0.03)) levels of education showing negative associations compared to low.

Table 5a. Mediation analysis results using natural effect models for the maternal sample; exposure: maternal education, mediator: maternal dietary patterns, outcome: children’s dietary patterns at 9 months.

Exposure (vs reference – low)		Intermediate	High	Intermediate	High	Intermediate	High	Intermediate	High	Intermediate	High
Children’ DPs	Mediator	Maternal Western DP		Balanced DP in Descendants of Immigrant Mothers		Balanced DP in non-Immigrant mothers		Processed DP in Descendant of Immigrant mothers		Processed DP in non-Immigrant mothers	
Diversified DP	TE β (95%CI)	0.08 (-0.05, 0.20).	-0.04 (-0.17, 0.07)	0.36 (-0.06, 0.80)	**0.38** **(0.01, 0.74)**	0.05 (-0.08, 0.18)	-0.08 (-0.21, 0.04)	0.35 (-0.08, 0.79)	**0.40** **(0.02, 0.78)**		
	NDE β (95% CI)	0.11 (-0.01, 0.23).	-0.01 (-0.13, 0.11)	0.31 (-0.11, 0.76)	0.34 (-0.03, 0.70).	0.03 (-0.10, 0.16)	-0.12 (-0.24, 0.01).	0.38 (-0.05, 0.82).	**0.44** **(0.06, 0.82)**		
	NIE β (95% CI)	**-0.03** **(-0.05, -0.02)**	**-0.03** **(-0.05, -0.02)**	0.04 (-0.01, 0.09)	0.04 (-0.01, 0.09)	**0.02** **(0.01, 0.03)**	**0.04** **(0.02, 0.06)**	-0.03 (-0.08, 0.02).	-0.04 (-0.09, 0.02).		
Discretion ary sweet foods DP	TE β (95%CI)	**-0.19** **(-0.26, -0.11)**	**-0.22** **(-0.30, -0.15)**			**-0.14** **(-0.23, -0.06)**	**-0.19** **(-0.26,-0.11)**				
	NDE β (95% CI)	**-0.18** **(-0.26, -0.11)**	**-0.22** **(-0.29, -0.15)**			**-0.14** **(-0.22, -0.05)**	**-0.17** **(-0.25, -0.09)**				
	NIE β (95% CI)	-0.01 (-0.01, -0.00)	-0.01 (-0.01, 0.00)			-0.01 (-0.02, -0.00)	-0.01 (-0.02, -0.00)				
Baby cereals and Yoghurt DP.	TE β (95%CI)	0.05 (-0.02, 0.12)	0.05 (-0.02, 0.12)			0.05 (-0.02, 0.12)	0.06 (-0.02, 0.13)	0.02 (-0.20, 0.24)	-0.11 (-0.31, 0.10)	0.05 (-0.02, 0.13)	0.06 (-0.02, 0.13)
	NDE β (95% CI)	0.05 (-0.03, 0.12)	0.04 (-0.02, 0.11)			0.06 (-0.01, 0.13)	0.07 (-0.01, 0.14)	0.01 (-0.21, 0.22)	-0.13 (-0.33, 0.08)	0.05 (-0.02, 0.12)	0.05 (-0.02, 0.12)
	NIE β (95% CI)	0.01 (0.00, 0.01)	0.01 (0.00, 0.01)			-0.01 (-0.01, -0.00)	-0.01 (-0.02, -0.00)	0.01 (-0.01, 0.04)	0.02 (-0.01, 0.05)	0.01 (0.00, 0.01)	0.01 (0.00, 0.01)

*Only analyses yielding significant results for paths a and b were considered for mediation analyses.
* Confounders adjusted for maternal education, child’s sex, maternal age, parity, and migration status (for unstratified analyses).

Table 5b. Mediation analysis results using natural effect models for the maternal sample; exposure: maternal education, mediator: maternal dietary patterns, outcome: children's dietary patterns at 2 years.

Exposure (vs reference – low)		Intermediate	High	Intermediate	High	Intermediate	High	Intermediate	High	Intermediate	High
Children's DP		Maternal Western DP		Balanced DP in Descendants of Immigrant mothers		Balanced DP in non-Immigrant mothers		Maternal Bread & Toppings DP		Processed DP in non-Immigrant mothers	
Balanced/Diversified DP	TE β (95%CI)	**0.11 (0.05, 0.16)**	**0.20 (0.15, 0.26)**	0.15 (-0.04, 0.32).	**0.40 (0.21, 0.58)**	**0.10 (0.04, 0.16)**	**0.17 (0.12, 0.23)**	**0.11 (0.05, 0.16)**	**0.20 (0.14, 0.26)**		
	NDE β (95% CI)	**0.13 (0.07, 0.18)**	**0.22 (0.17, 0.28)**	0.07 (-0.12, 0.24).	**0.33 (0.15, 0.51)**	**0.04 (-0.02, 0.10)**	**0.08 (0.02, 0.14)**	**0.10 (0.05, 0.15)**	**0.19 (0.13, 0.24)**		
	NIE β 95% CI)	**-0.02 (-0.02, -0.01)**	**-0.02 (-0.03, -0.01)**	**0.08 (0.02, 0.15)**	**0.07 (0.00, 0.14)**	**0.06 (0.04, 0.08)**	**0.09 (0.07, 0.12)**	0.01 (0.00, 0.01)	0.01 (0.01, 0.02)		
Discretionary consumption DP	TE β (95%CI)	**-0.35 (-0.40, -0.29)**	**-0.42 (-0.47, -0.37)**	**-0.55 (-0.73, -0.37)**	**-0.59 (-0.77, -0.43)**	**-0.31 (-0.37, -0.26)**	**-0.38 (-0.43, -0.33)**	**-0.34 (-0.39, -0.29)**	**-0.41 (-0.46, -0.37)**	**-0.31 (-0.37, -0.26)**	**-0.38 (-0.43, -0.33)**
	NDE β (95% CI)	**-0.30 (-0.35, -0.25)**	**-0.37 (-0.41, -0.32)**	**-0.53 (-0.71, -0.34)**	**-0.58 (-0.75, -0.42)**	**-0.29 (-0.34, -0.24)**	**-0.34 (-0.39, -0.29)**	**-0.34 (-0.39, -0.29)**	**-0.41 (-0.46, -0.37)**	**-0.32 (-0.37, -0.26)**	**-0.38 (-0.43, -0.33)**
	NIE β (95% CI)	**-0.05 (-0.06, -0.04)**	**-0.05 (-0.07, -0.04)**	-0.02 (-0.05, 0.01).	-0.02 (-0.04, 0.01).	**-0.02 (-0.03, -0.01)**	**-0.04 (-0.05, -0.03)**	-0.00 (-0.00, 0.00)	-0.00 (-0.01, 0.01)	0.00 (0.00, 0.01)	0.00 (0.00, 0.01)

*Only analyses yielding significant results for paths a and b were considered for mediation analyses.
* Confounders adjusted for paternal education, child's sex, maternal age, parity, and migration status (for unstratified analyses).

Table 6. Mediation analysis results using natural effect models for the paternal sample; exposure: paternal education, mediator: paternal dietary patterns, outcome: children's dietary patterns.

Exposure (vs reference – low)		High	Intermediate	High
Children's DP		Paternal Bread and Cheese DP	Paternal Balanced DP	
Balanced/Diversified DP at 2 years	TE β (95%CI)	**0.17 (0.01, 0.33)**	0.04 (-0.15, 0.22)	**0.17 (0.01, 0.33)**
	NDE β (95% CI)	0.16 (-0.00, 0.32)	0.02 (-0.16, 0.20)	0.14 (-0.02, 0.30).
	NIE β (95% CI)	0.01 (-0.00, 0.03)	0.02 (-0.00, 0.03).	**0.03 (0.00, 0.06)**
Discretionary consumption DP at 2 years	TE β-(95%CI)		**-0.18 (-0.32, -0.04)**	**-0.31 (-0.42, -0.20)**
	NDE β (95% CI)		**-0.15 (-0.29, -0.02)**	**-0.27 (-0.38, -0.15)**
	NIE β (95% CI)		-0.02 (-0.05, -0.00)	**-0.05 (-0.07, -0.02)**

*Only analyses yielding significant results for paths a and b were considered for mediation analyses – multivariable analyses yielded significant results only for high vs low paternal education and "Bread and cheese" DP, hence only this was tested in mediation analyses.
* Confounders adjusted for maternal education, child's sex, paternal age, parity, and migration status.

When we considered household income as exposure, only the associations between high maternal education and children's "Balanced/diversified" and "Discretionary consumption" DPs were partially mediated by maternal "Balanced" DP, NIE: β = 0.05 (95%CI 0.02, 0.08) and NIE: β = -0.02 (95%CI -0.04, -0.01) (Table S8).

3.2.4.2. Paternal sample

For the paternal sample, we reported a negative association between intermediate β = -0.18 (95%CI -0.32, -0.04) and high β = -0.31 (95%CI -0.42, -0.20) paternal education, compared to low and children's **"Discretionary consumption" DP**. This association was partially mediated by paternal "Balanced" dietary pattern with negative NIE: β = -0.02 (95%CI -0.05, -0.00) and β = -0.05 (95%CI -0.07, -0.02), respectively for intermediate and high education levels. There was a borderline significant positive NIE for paternal "Balanced" DP β = 0.03 (95%CI 0.00, 0.06), for the association between high vs low paternal income and children's **"Balanced/diversified" DP** at 2 years (Table 6). For household income, there was a large negative NIE between high versus low income children's **"Diversified" DP** score at 9 months through paternal "Diverse" diet: β = -0.17 (95%CI -0.33, -0.01). An association of a smaller effect was observed for intermediate income compared to low, but it was not significant based on the 95%CI. Additionally, a negative NIE: β = -0.07 (95%CI -0.14, -0.01) of paternal "Diverse" DP was observed for the association between high income and children's "Balanced/diversified" DP (Table S9).

3.2.5. Sensitivity analyses

We analysed a subset of mediation pathways, where education was exposure, using the traditional approach to mediation. The analysis yielded results consistent with those obtained using natural effect models. The results are displayed in Table S10.

4. DISCUSSION

4.1. Summary of results

This study provides important insights into associations between parental and children's dietary patterns that have not yet been published in the French context. It also identifies both maternal and paternal “Balanced” DPs and maternal “Western” DP as potential intermediary variables in the association between parental SEP and children's “Balanced/diversified” and “Discretionary consumption” DPs at 2 years. These findings are important as they offer leverage points for interventions promoting healthful diets and aiming to reduce social inequalities. Additionally, this study shows that migration is a moderating factor in the association between maternal SEP and children's diet mediated through maternal dietary patterns. Our results also show that children's discretionary DPs, even if strongly associated with maternal SEP are not mediated by maternal DPs. Finally, this study provides an outlook on focus of the future research and implications for public health.

The associations between parental dietary patterns and children's dietary patterns were tested separately for mothers and fathers. We revealed that maternal healthier DPs were positively associated with healthier diets in children, and negatively associated with discretionary DPs and “Baby cereals and yoghurt”. Additionally, maternal “Western” DP was positively associated with healthier children's DPs at both 9 months and 2 years, but also with discretionary diet at 2 years. Associations between paternal healthier diets and children's healthier and discretionary DPs were similar to the ones found in mothers. Additionally, we found a negative association between paternal “Bread and cheese” DP and children's “Balanced/diversified” DP. Our results are in line with previous publications. One study reported that children aged 0-10 years whose primary caregivers reported lowest fruit and vegetable intake had 4.4x higher odds of adhering to the least healthy dietary trajectory, compared to the children of parents with highest fruit and vegetable intake (41). Furthermore, the quality of maternal diet was previously reported to be a key factor influencing children's diets (44,69–71). Previous studies also reported that the children were more likely to consume fresh fruit and vegetable if their fathers' intake of fruit and vegetables was high or if they reinforced healthy foods (42,43), which is consistent with our findings about paternal healthy dietary patterns. Interestingly, the father's “Balanced” diet was negatively associated with the children's “Diversified” diet at 9 months, although this association wasn't significant ($\beta = -0.10$ (95%CI -0.24, 0.04)). On the other hand, the father's “Diverse” diet was positively associated with the children's “Diversified” diet. This difference likely arises from differences in DPs, where the “Diverse” father's diet encompasses both healthy and unhealthy foods, while the “Balanced” represents an epitome of a healthful diet. Among mothers, those who followed the “Processed” DP were more likely to provide “Baby cereals and yoghurt” to their 9-month-olds.

This association is a particularly interesting one, as both DPs are characterised by convenient foods, possibly indicating time constraints. Another proof in support of that argument would be that mothers with higher income had on average higher scores for “Processed” DP in our sample – assuming that mothers with higher income also work more, hence have less time to prepare food. In their systematic review and meta-analysis, Yee et al. (72) concluded that parental modelling behaviour, which refers to the demonstration of correct behaviours which observers can learn through imitation (73), was significantly positively correlated with children’s nutritional intake, both for healthy and unhealthy foods. In line with these findings, our study also revealed that children of parents who followed the “Balanced” DP, exhibited higher scores for the “Balanced/diversified” DP at 2 years of age. This suggests a positive modelling of healthy eating by parents, underscoring their influence during the first 1000 days of life.

Regarding the associations between parental SEP and children’s dietary patterns, our study revealed that children of mothers with intermediate and high SEP, as measured by education and income, were more likely to follow the “Balanced/diversified” dietary pattern at 2 years and were less likely to consume discretionary foods at both 9 months and 2 years, compared to children of mothers with low SEP. One previous publication reported that children from lower socioeconomic status, as measured by maternal education, had lower fruit intake and higher discretionary food intake as early as 9 months of age, with differences in vegetable intake emerging around 3.5 years publication (32), which is similar to our findings. Our study extended maternal findings to include the association of the father’s SEP with children’s DPs, indicating that higher paternal SEP was associated with healthier dietary patterns in children. These results are consistent with the conclusions drawn by Vasquez et al. (20) who reported a poorer dietary quality to be more prevalent among children of lower SEP, as well as Lee et al.(74), who reported higher maternal income to be negatively associated to their young children’s fast food intake. The latter study results are also consistent with our finding that mothers with higher income had children who were less likely to have high scores for discretionary foods.

Our mediation analyses reveal that parental diet may mediate the association between parental SEP and children’s DPs at 9 months and 2 years. Consistent with Lioret et al.’s findings of maternal “Fruit and vegetables” DP partially mediating association between maternal education and children’s “Balanced weaning” DP at 9 months, our results also suggest maternal “Balanced” DP is an intermediary variable affecting children’s “Diversified” and “Balanced/diversified” DPs at 9 months and 2 years, respectively. In our study, we found this association to be the strongest in the strata of non-immigrants where maternal “Balanced” DP mediated a half of the total effect. However, it is important to note that the total effect of this association was of relatively small size. While the mediating effects of “Balanced” DP in the strata of descendants of immigrants were significant for the association between maternal education and “Balanced/diversified” DP at 2 years, this was not the case for children’s “Diversified” DP at 9 months. We assume this discordance might be due to the power constraints stemming from missing data exclusion – while at 2 years our complete case sample of mothers, descendants of immigrants, included around 800 women, at 9 months, this number was closer to 500.

Lioret et al. also found maternal “Fruit and vegetables” DP to negatively mediate the relationship between maternal education and children’s formula pattern. Although not the same, we could draw connections between these results and the negative mediating effects of maternal “Balanced” diet in the association between maternal SEP and DPs loading high for discretionary foods. We also find maternal “Western” diet to negatively mediate the association between maternal SEP and the following children’s DPs: “Diversified” at 9 months, “Balanced/diversified” at 2 years, and “Discretionary consumption” at 2 years. Even though this finding might seem counterintuitive because the “Western” diet has high factor loadings for processed, starchy and fried foods, it also loads relatively high for eggs, poultry, fish, cooked vegetables, and fruit juice which might partially explain this association. However, the reader should keep in mind that PCA-derived dietary patterns were based on self-reported dietary data and hence these associations might also be a result of measurement error.

The novelty of our study lies in conducting mediation analysis for paternal SEP, paternal dietary patterns, and children’s dietary patterns. We observed that the paternal “Balanced” dietary pattern partly mediated the association between high paternal education and children’s “Balanced/diversified” (positive indirect effect) and “Discretionary consumption” (negative indirect effect) DPs at 2 years of age. This indicates that paternal diet plays a substantial role in determining children’s dietary patterns, especially at 2 years, compared to 9 months. This observation aligns with the emergence of children’s self-perception around the age of 2 and the significance of family meals as children become aware of themselves. Furthermore, it underscores the important role of both mothers and fathers as role models, demonstrating healthy eating habits to their (72). Our results suggest that health promotion efforts during the perinatal period should be extended to the entire family rather than solely focusing on mothers.

In a multicentric study conducted across 8 European countries, Lehto et al. (75) explored the association between parental educational level and children’s diet. They proposed various mediators of the association such as fruit and vegetable availability, liking of fruits and vegetables, knowledge of dietary recommendations, as well as self-efficacy and facilitation to eat them. Some of these mediators may also play a role in mediating our observed total effects, in addition to parental dietary patterns. Even more importantly, these or other mediators may play a role in mediating the negative association between intermediate and high maternal SEP and "Discretionary consumption" at 2 years. In our study, we observed a substantial total effect for this association but found that it was only partially or not mediated by maternal dietary patterns. Further exploration of these potential mediators is needed to gain a deeper understanding of the underlying mechanisms involved. It is also important to note that mediators identified by Lehto et al.(75) differed between countries, suggesting our results might also be country-specific. This highlights the need for considering cultural and contextual factors in understanding the relationship between parental education and children's dietary patterns.

Finally, in our study, we did not test the mediation hypotheses in the strata of immigrants due to non-significant results of paths a and b. However, we acknowledge that exploring the potential mediation effects in immigrant populations would be interesting and valuable. It would be worthwhile to investigate if the trends observed in descendants of immigrants and non-immigrants also apply to immigrants. Based on the previous studies based on Elfe cohort data, we would assume there are other mediation pathways in play, involving mediators specific for social norms, family meals, and dietary intake. Our study highlights the importance of considering different social groups as separate entities when designing public health interventions. The findings suggest that interventions targeting dietary patterns should be tailored to the unique needs and characteristics of each social group. By recognizing and addressing these differences, public health efforts can be more effective in promoting healthier diets, improving overall health across diverse populations, and contributing to the reduction of associated social inequalities.

Overall, our study provides new and comprehensive insights into the association between parental SEP and children's dietary patterns, highlighting the importance of socioeconomic factors in shaping dietary patterns in early childhood, as well as providing leverage points, through maternal and paternal dietary patterns, to alleviate social disadvantages in children's diets.

4.2. Limitations and strengths

The study acknowledges the limitations associated with self-reported dietary data. These can be subject to measurement errors, such as memory (reducing precision) and systematic biases related to social desirability. However, the use of a validated FFQ for the maternal sample enhanced the accuracy of dietary intake and portion size estimation.

It is important to note that the analyses were done on a complete case sample, meaning that only participants with complete data for all variables of interest from the Elfe study were included. Based on the results of bivariate analysis, the chosen sample differed significantly from the excluded sample in various aspects, including age, wealth, education, and immigrant status. This introduces the possibility of a differential information bias in the study results, and readers should consider this when interpreting the findings. We deem that DPs presented in our study are less contrasted than they would be if we better represented parents from lower SEP.

Similarly, the exclusion of missing values for the variables of interest may have also resulted in a loss of power in the subsample of fathers and the strata of immigrants and descendants of immigrants. We expect we would have more power to detect mediating effects in the strata of descendants of immigrants if it weren't for missing data exclusion. We expect our results based on imputed data sets to improve both information bias and power issues present in this study.

The study acknowledges the assumptions and limitations associated with mediation analysis. No unmeasured confounders of exposure-mediator, mediator-outcome, and exposure-outcome relationships, as well as no unmeasured confounders of a mediator-outcome relationship affected by exposure, are strong assumptions on which our study results posit. However, we expect to run sensitivity analyses to unmeasured confounders as the next step of the project. We refrained from starting our study with the traditional approach to mediation due to its inability to account for possible exposure-mediator interactions and lack of guidance for situations where its strong assumptions do not hold. After confirming the absence of such interactions, we repeated the traditional approach on the subset of mediation pathways and the results were rather confirmative of our results using natural effect models showing that our hypotheses were quite reasonable for both approaches.

The study's strengths include its large sample size, which contributes to accurate results and sufficient power to detect significant differences between dependent and independent variables. Another strength of this is its longitudinal design, which is particularly important when conducting mediation analysis on observational data because of temporality. Additionally, the study results are consistent with previous findings regarding the interconnectedness of parental and children's dietary patterns, as well as social differences in certain children's dietary patterns. To the best of our knowledge, this is the second study to carry out a mediation analysis between maternal SEP, maternal dietary patterns, and children's dietary patterns, and the first to conduct such an analysis for fathers.

4.3. Implications for public health interventions

In summary, while parental socioeconomic position appears to have a stronger influence on children's dietary patterns at 9 months and 2 years compared to parental diet, the insights gained from understanding this mechanism can inform future public health interventions. Our study findings support the need for interventions that promote healthy diets to expecting families. As reported by Lioret et al.(76), effective strategies targeting families experiencing socio-economic disadvantage should ideally target first-time mothers, and involve professional delivery agents, multidisciplinary teams, and peer groups.

4.4. Conclusions

Our study highlights maternal and paternal diets as potentially modifiable factors of the relationship between parental socioeconomic position and children's dietary patterns. It underscores the importance of considering fathers' diet alongside mothers', which reflects the complex dynamics within families. This finding supports the need for comprehensive health promotion programs that target the entire family, rather than solely focusing on mothers. Although the mediating effect of parental diets seems to be relatively small, it still represents a valuable opportunity for future public health interventions. Further research should explore additional potential mediators, including income, facilitation of fruit and vegetable consumption, knowledge of dietary recommendations, and more. By elucidating the underlying mechanisms connecting parental SEP and children's diet, we can establish a solid foundation for effective health-promoting interventions.

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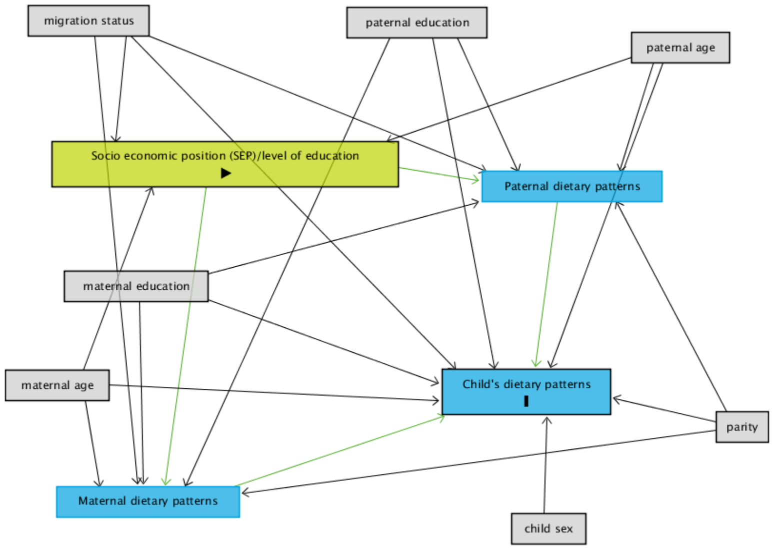
6. APPENDICES

Figure S 1. a) DAG 1, parental level of education is exposure. b) DAG 2, parental household income is exposure.



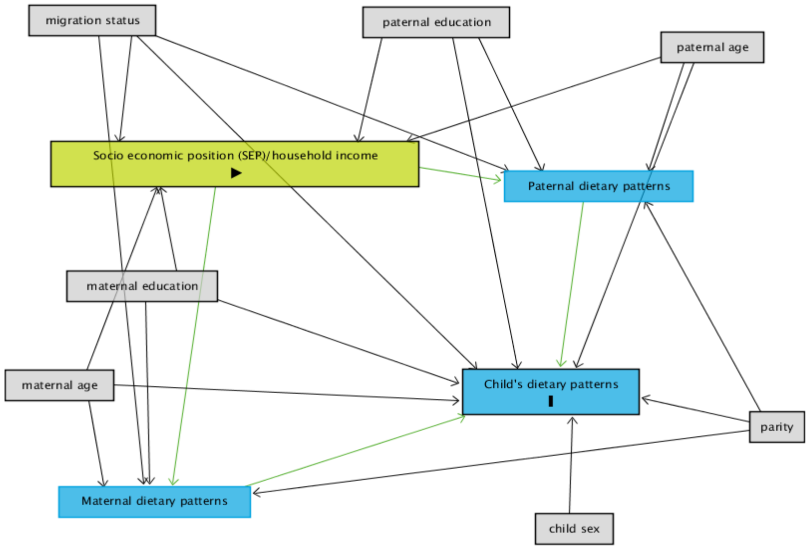


Table S 1. Coefficients (95% CI) of the multivariable linear regression analysis for the maternal subsample: associations between maternal SEP and maternal dietary patterns as the dependent variable (path a).

		Western DP	Balanced DPin Immigrants	Balanced DP in Descendants of Immigrants	Balanced DP in non-Immigrants	Bread & Toppings DP	Processed DP in Immigrants	Processed DP in Descendants of Immigrants	Processed DP in non-Immigrants	Milk&Breakfast Cereals DP
Education	Intermediate vs low	**-0.21 (-0.41, -0.01)**	-0.40 (-0.63, -0.18)	**0.17 (0.02, 0.33)**	**0.19 (0.14, 0.24)**	**0.52 (0.32, 0.71)**	0.16 (-0.08, 0.40)	0.14 (-0.01, 0.29)	**0.16 (0.11, 0.22)**	-0.02 (-0.22, 0.19)
	High vs Low	**-0.19 (-0.34, -0.04)**	-0.08 (-0.27, 0.11)	**0.18 (0.02, 0.34)**	**0.31 (0.26, 0.35)**	**0.34 (0.19, 0.48)**	0.04 (-0.17, 0.24)	**0.19 (0.04, 0.34)**	**0.17 (0.11, 0.22)**	0.12 (-0.03, 0.28)
Income	Intermediate vs Low	-0.08 (-0.21, 0.06)	-0.01 (-0.18, 0.15)	0.03 (-0.11, 0.17)	**0.06 (0.01, 0.11)**	**0.36 (0.23, 0.49)**	0.11 (-0.06, 0.28)	**0.31 (0.17, 0.44)**	**0.10 (0.04, 0.15)**	-0.10 (-0.24, 0.04)
	High vs Low	-0.09 (-0.32, 0.14)	-0.23 (-0.52, 0.06)	0.01 (-0.25, 0.27)	**0.16 (0.08, 0.24)**	**0.29 (0.06, 0.52)**	0.11 (-0.18, 0.41)	**0.46 (0.21, 0.71)**	**0.16 (0.08, 0.25)**	-0.05 (-0.29, 0.19)

* Adjusted for maternal age, maternal education (where income was exposure), paternal education (where education was exposure), parity, and migration status (for unstratified analyses).

Table S 2. Coefficients (95% CI) of the multivariable linear regression analysis for the paternal subsample: association between paternal SEP and paternal dietary patterns as the dependent variable (path a).

		Diverse DP	Balanced DP	Alcohol DP	Snacking DP	Bread & Cheese DP	Processed products DP
Education	Intermediate vs Low	-0.01 (-0.19, 0.17)	**0.19 (0.02, 0.35)**	-0.06 (-0.25, 0.12)	-0.07 (-0.25, 0.11)	-0.08 (-0.26, 0.10)	-0.00 (-0.19, 0.18)
	High vs Low	-0.06 (-0.22, 0.10)	**0.37 (0.22, 0.53)**	-0.08 (-0.24, 0.09)	0.11 (-0.06, 0.27)	**-0.18 (-0.35, -0.02)**	-0.14 (-0.30, 0.03)
Income	Intermediate vs Low	-0.13 (-0.35, 0.09)	0.19 (-0.02, 0.40)	**-0.25 (-0.47, -0.02)**	0.08 (-0.14, 0.31)	0.18 (-0.04, 0.40)	**0.27 (0.04, 0.50)**
	High vs Low	**-0.32 (-0.63, -0.02)**	0.20 (-0.09, 0.49)	**-0.37 (-0.68, -0.06)**	0.11 (-0.20, 0.42)	0.13 (-0.17, 0.44)	**0.32 (0.01, 0.63)**

* Adjusted for paternal age, paternal education (where income was exposure), maternal education (where education was exposure), parity, and migration status.

Table S 3. Coefficients (95% CI) of the multivariable linear regression analysis for the maternal subsample: associations between maternal dietary patterns and children's dietary patterns as the dependent variable (path b), adjusted for household income as exposure.

strohigCHILDREN'S DIETARY PATTERNS

MATERNAL DIETARY PATTERNS	at 9 months			at 2 years	
	Diversified	Discretionary sweet foods	Baby cereals &Yoghurt	Balanced/ Diversified	Discretionary consumption
Western	**0.24 (0.19, 0.29)**	**0.04 (0.00, 0.07)**	**-0.05 (-0.08, -0.02)**	**0.07 (0.05, 0.09)**	**0.25 (0.23, 0.27)**
Balanced in immigrants	**0.24 (0.05, 0.43)**	-0.02 (-0.13, -0.08)	-0.06 (-0.15, 0.03)	**0.24 (0.17, 0.31)**	0.04 (-0.03, 0.11)
Balanced in descendants of immigrants	**0.22 (0.06, 0.37)**	-0.02 (-0.11, 0.07)	-0.07 (-0.15, 0.01)	**0.28 (0.22, 0.35)**	**-0.12 (-0.19, -0.05)**
Balanced in non-immigrants	**0.14 (0.09, 0.19)**	**-0.05 (-0.08, -0.02)**	**-0.03 (-0.06, -0.01)**	**0.27 (0.25, 0.30)**	**-0.14 (-0.16, -0.12)**
Bread & toppings	0.02 (-0.02, 0.07)	**0.04 (0.01, 0.07)**	0.02 (-0.01, 0.05)	**0.04 (0.02, 0.06)**	**-0.03 (-0.05, -0.02)**
Processed in immigrants	-0.10 (-0.28, 0.08)	-0.01 (-0.11, 0.09)	0.07 (-0.02, 0.15)	-0.07 (-0.15, 0.01)	-0.02 (-0.09, 0.06)
Processed in descendants of immigrants	**-0.18 (-0.35, -0.02)**	0.01 (-0.09, 0.10)	**0.**08 (-0.01, 0.16)	-0.01 (-0.08, 0.07)	-0.03 (-0.11, 0.04)
Processed in non-immigrants	0.01 (-0.03, 0.06)	-0.02 (-0.05, 0.01)	**0.04 (0.01, 0.06)**	0.02 (-0.00, 0.04)	**0.03 (0.01, 0.05)**
Milk & breakfast cereals	-0.04 (-0.08, 0.00)	-0.04 (-0.07, -0.01)	**0.05 (0.02, 0.07)**	0.01 (-0.01, 0.03)	**-0.09 (-0.10, -0.07)**

*Adjusted for income, maternal age, maternal education, parity, sex, and migration status (for unstratified analyses).

Table S 4. Coefficients (95% CI) of the multivariable linear regression analysis for the paternal subsample: associations between maternal dietary patterns and children's dietary patterns as the dependent variable (path b), adjusted for household income as exposure.

CHILDREN'S DIETARY PATTERNS

PATERNAL DIETARY PATTERNS	9 months			2 years	
	Diversified	Discretionary sweet foods	Baby cereals &Yoghurt	Balanced/ Diversified	Discretionary consumption
Diverse	**0.20 (0.07, 0.33)**	0.01 (-0.08, 0.09)	-0.04 (-0.12, 0.03)	**0.18 (0.12, 0.25)**	0.03 (-0.02, 0.08)
Balanced	-0.12 (-0.26, 0.02)	-0.04 (-0.13, 0.06)	0.06 (-0.02, 0.15)	**0.08 (0.01, 0.15)**	**-0.12 (-0.17, -0.07)**
Alcohol	0.01 (-0.12, 0.13)	0.01 (-0.08, 0.10)	-0.03 (-0.11, 0.05)	-0.03 (-0.10, 0.03)	-0.02 (-0.07, 0.03)
Snacking	0.01 (-0.11, 0.14)	-0.01 (-0.10, 0.08)	0.04 (-0.04, 0.11)	0.02 (-0.04, 0.08)	-0.01 (-0.05, 0.04)
Bread and cheese	-0.08 (-0.21, 0.05)	0.02 (-0.07, 0.11)	-0.03 (-0.11, 0.04)	**-0.08 (-0.15, -0.02)**	0.01 (-0.04, 0.06)
Processed products	0.07 (-0.05, 0.20)	0.00 (-0.08, 0.09)	0.06 (-0.01, 0.14)	-0.04 (-0.11, 0.02)	-0.01 (-0.05, 0.04)

*Adjusted for income, paternal age, paternal education, parity, sex, and migration status.

Table S 5. Coefficients (95% CI) of the multivariable linear regression analysis for the maternal subsample: associations between maternal SEP and children's dietary patterns as the dependent variable (path c).

		at 9 months			at 2 years			at 9 months			at 2 years	
		Diversified	Discretionary sweet foods	Baby cereals and yoghurt	Balanced/ diversified	Discretionary consumption		Diversified	Discretionary sweet foods	Baby cereals and yoghurt	Balanced/ diversified	Discretionary consumption
EDUCATION	Intermediate vs Low	0.08 (-0.04, 0.19)	**-0.19 (-0.26, -0.11)**	0.05 (-0.02, 0.12)	**0.11 (0.05, 0.16)**	**-0.34 (-0.39, -0.29)**	INCOME	**0.21 (0.08, 0.33)**	**-0.24 (-0.33, -0.16)**	0.08 (0.00, 0.15)	**0.11 (0.05, 0.17)**	**-0.26 (-0.31, -0.21)**
	High vs Low	-0.04 (-0.16, 0.07)	**-0.22 (-0.30, -0.15)**	0.05 (-0.02, 0.11)	**0.20 (0.15, 0.25)**	**-0.41 (-0.46, -0.37)**		**0.23 (0.04, 0.42)**	-0.42 (-0.54, -0.30)	0.06 (-0.05, 0.17)	**0.17 (0.08, 0.26)**	**-0.37 (-0.45, -0.29)**

*Confounders adjusted for when education was exposure are maternal age, paternal education, parity, child's sex, and migration status.
*Confounders adjusted for when income was exposure are maternal age, maternal education, parity, child's sex, and migration status

Table S 6. Coefficients (95% CI) of the multivariable linear regression analysis for the paternal subsample: associations between paternal SEP and children's dietary patterns as the dependent variable (path c).

		at 9 months			at 2 years			at 9 months			at 2 years	
		Diversified	Discretionary sweet foods	Baby cereals and yoghurt	Balanced/ diversified	Discretionary consumption		Diversified	Discretionary sweet foods	Baby cereals and yoghurt	Balanced/ diversified	Discretionary consumption
EDUCATION	Intermediate vs Low	-0.25 (-0.61, 0.10)	-0.15 (-0.40, 0.09)	0.07 (-0.15, 0.28)	0.03 (-0.14, 0.21)	**-0.18 (-0.31, -0.05)**	INCOME	-0.03 (-0.46, 0.41)	-0.11 (-0.41, 0.18)	0.06 (-0.21 0.33)	-0.05 (-0.28, 0.18)	**-0.26 (-0.43, -0.09)**
	High vs Low	-0.08 (-0.40, 0.24)	**-0.26 (-0.47, -0.04)**	-0.10 (-0.29, 0.10)	**0.17 (0.00, 0.33)**	**-0.31 (-0.44, -0.19)**		0.04 (-0.55, 0.63)	-0.21 (-0.61, 0.19)	0.22 (-0.14, 0.58)	0.01 (-0.30, 0.32)	**-0.30 (-0.53, -0.07)**

*Confounders adjusted for when education was exposure are paternal age, maternal education, parity, child's sex, and migration status.
*Confounders adjusted for when income was exposure are paternal age, paternal education, parity, child's sex, and migration status.

Table S 7. Mediation analysis results using natural effect models for the maternal sample; exposure: household income, mediator: maternal dietary patterns, outcome: children's dietary patterns at 9 months.

Exposure (vs reference – low)		*Intermediate*	*High*	*Intermediate*	*High*	*Intermediate*	*High*	*Intermediate*	*High*
	Mediator	Balanced DP in Non-Immigrant mothers		Maternal Bread & Toppings DP		Processed DP in Descendant of Immigrant mothers		Processed DP in non-Immigrant mothers	
Diversified DP	TE β(95%CI)	**0.27 (0.12, 0.43)**	**0.30 (0.10, 0.51)**			0.35 (-0.08, 0.78)	0.35 (-0.08, 0.79)		
	NDE β(95% CI)	**0.26 (0.11, 0.43)**	**0.28 (0.08, 0.49)**			0.38 (-0.05, 0.82)	0.38 (-0.05, 0.82)		
	NIE β(95% CI)	0.01 (-0.01, 0.02)	0.02 (0.00, 0.04)			0.03 (-0.08, 0.02)	-0.03 (-0.08, 0.02)		
Discretionary sweet foods DP	TE β(95%CI)	**-0.14 (-0.23, -0.06)**	**-0.14 (-0.23, -0.06)**	**-0.21 (-0.31, -0.12)**	**-0.38 (-0.50, -0.26)**				
	NDE β(95% CI)	**-0.14 (-0.22, -0.05)**	**-0.14 (-0.22, -0.05)**	**-0.22 (-0.32, -0.14)**	**-0.39 (-0.51, -0.27)**				
	NIE β(95% CI)	-0.01 (-0.02, -0.00)	-0.01 (-0.02, -0.00)	0.01 (0.00, 0.02)	0.01 (0.00, 0.02)				
Baby cereals and Yoghurt DP	TE β(95%CI)	0.09 (-0.00, 0.18)	0.05 (-0.08, 0.17)					0.09 (-0.00, 0.18)	0.05 (-0.08, 0.17)
	NDE β(95% CI)	0.09 (-0.00, 0.18)	0.05 (-0.07, 0.17)					0.08 (-0.00, 0.17)	0.04 (-0.09, 0.16)
	NIE β(95% CI)	-0.00 (-0.01, 0.00)	-0.01 (-0.01, 0.00)					0.00 (-0.00, 0.01)	0.01 (-0.00, 0.01)

*Only analyses yielding significant results for paths a and b were considered for mediation analyses.

* Confounders adjusted for maternal education, child's sex, maternal age, parity, and migration status (for unstratified analyses).

Table S 8. Mediation analysis results using natural effect models for the maternal sample; exposure: household income, mediator: maternal dietary patterns, outcome: children's dietary patterns at 2 years.

Exposure (vs reference – low)		Intermediate	High	Intermediate	High	Intermediate	High
Children's DPs		Balanced DP in Non-Immigrant mothers		Maternal Bread & Toppings DP		Processed DP in non-Immigrant mothers	
Discretionary sweet foods	TE β (95%CI)	**-0.22 (-0.29, -0.14)**	**-0.34 (-0.43, -0.25)**	**-0.25 (-0.32, -0.18)**	**-0.37 (-0.45, -0.29)**	**-0.22 (-0.29, -0.14)**	**-0.34 (-0.42, -0.25)**
	NDE β (95% CI)	**-0.21 (-0.28, -0.13)**	**-0.32 (-0.40, -0.23)**	**-0.25 (-0.32, -0.18)**	**-0.37 (-0.45, -0.29)**	**-0.22 (-0.29, -0.15)**	**-0.34 (-0.43, -0.26)**
	NIE β (95% CI)	-0.01 (-0.02, -0.00)	-0.02 (-0.04, -0.01)	-0.00 (-0.01, 0.01)	-0.00 (-0.01, 0.00)	0.00 (0.00, 0.01)	0.00 (0.00, 0.01)
Balanced/Diversified	TE β (95%CI)	**0.12 (0.05, 0.19)**	**0.17 (0.07, 0.28)**	**0.11 (0.05, 0.18)**	**0.16 (0.08, 0.26)**		
	NDE β (95% CI)	**0.09 (0.03, 0.17)**	**0.12 (0.03, 0.22)**	**0.10 (0.36, 0.17)**	**0.15 (0.07, 0.25)**		
	NIE β 95% CI)	0.02 (0.00, 0.04)	**0.05 (0.02, 0.08)**	**0.01 (0.01, 0.02)**	0.01 (0.00, 0.02)		

*Only analyses yielding significant results for paths a and b were considered for mediation analyses.
* Confounders adjusted for maternal education, child's sex, maternal age, parity, and migration status (for unstratified analyses).

Table S 9. Mediation analysis results using natural effect models for the paternal sample; exposure: household income, mediator: paternal dietary patterns, outcome: children's dietary patterns.

Exposure (vs reference – low)		Intermediate	High	Intermediate	High
Children's DPs		Paternal Diverse DP		Paternal Balanced DP	
Diversified dietary pattern at 9 months	TE β (95%CI)	-0.12 (-0.61, 0.37)	-0.10 (-0.66, 0.47)		
	NDE β (95% CI)	-0.03 (-0.51, 0.45)	0.07 (-0.51, 0.64)		
	NIE β (95% CI)	**-0.09 (-0.18, -0.00)**	**-0.17 (-0.33, -0.01)**		
Balanced/Diversified at 2 years	TE β (95%CI)	0.04 (-0.15, 0.22)	0.02 (-0.28, 0.31)	-0.05 (-0.28, 0.18)	0.02 (-0.28, 0.31)
	NDE β (95% CI)	0.05 (-0.13, 0.23)	0.09 (-0.21, 0.38)	-0.07 (-0.30, 0.15)	-0.00 (-0.30, 0.28)
	NIE β (95% CI)	-0.01 (-0.05, 0.02)	**-0.07 (-0.14, -0.01)**	0.02 (-0.00, 0.05)	0.02 (-0.01, 0.06)
Discretionary consumption	TE β (95%CI)			**-0.25 (-0.46, -0.04)**	**-0.29 (-0.53, -0.04)**
	NDE β (95% CI)			-0.21 (-0.42, -0.00)	**-0.25 (-0.49, -0.01)**
	NIE β (95% CI)			-0.04 (-0.07, -0.00)	-0.03 (-0.08, 0.00)

*Only analyses yielding significant results for paths a and b were considered for mediation analyses, paternal Balanced DP was borderline significant and correlated with many children's DPs, thus it was included in the mediation analyses.
*Confounders adjusted for paternal education, child's sex, maternal age, parity, and migration status (for unstratified analyses).

Table S 10. Mediation analysis results using the traditional approach: analysis of the subset of associations; exposure: maternal education, mediator: maternal dietary patterns (Western, Balanced, Bread and Toppings), outcome: children's dietary patterns at 2 years and Discretionary sweet foods at 9 months.

CHILDREN'S DIETARY PATTERNS

		at 9 months			*at 2 years*					
MATERNAL DPs	Level of education	Discretionary sweet foods DP			Balanced/Diversified DP			Discretionary consumption		
		Total effect	Direct effect	Indirect effect	Total effect	Direct effect	Indirect effect	Total effect	Direct effect	Indirect effect
Western	Intermediate	**-0.18 (-0.28, -0.07)**	**-0.18 (-0.26, -0.10)**	-0.01 (-0.01, -0.00)	**0.11 (0.05, 0.16)**	**0.13 (0.07, 0.19)**	**-0.02 (-0.03, -0.01)**	**-0.34 (-0.39, -0.29)**	**-0.30 (-0.37, -0.24)**	**-0.04 (-0.06, -0.03)**
	High	**-0.22 (-0.30, -0.11)**	**-0.22 (-0.30, -0.14)**	-0.01 (-0.01, 0.00)	**0.20 (0.15, 0.20)**	**0.22 (0.16, 0.28)**	**-0.02 (-0.03, -0.01)**	**-0.41 (-0.46, -0.37)**	**-0.37 (-0.42, -0.32)**	**-0.05 (-0.07, -0.03)**
Balanced in non-immigrants	Intermediate	**-0.14 (-0.23, -0.06)**	**-0.13 (-0.22, -0.04)**	-0.01 (-0.03, -0.00)	**0.10 (0.04, 0.16)**	0.06 (-0.01, 0.12)	**0.05 (0.03, 0.07)**	**-0.31 (-0.37, -0.26)**	**-0.29 (-0.36, -0.24)**	**-0.02 (-0.03, -0.01)**
	High	**-0.19 (-0.26,-0.11)**	**-0.17 (-0.26, -0.08)**	-0.01 (-0.03, -0.00)	**0.17 (0.12, 0.23)**	**0.10 (0.03, 0.16)**	**0.08 (0.05, 0.10)**	**-0.38 (-0.43, -0.33)**	**-0.34 (-0.41, -0.28)**	**-0.04 (-0.05, -0.03)**