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The impact of diet during adolescence on the neonatal health of offspring: evidence on the importance of preconception diet. The HUNT study

Original Article

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Abstract

Emerging evidence suggests that parents' nutritional status before and at the time of conception influences the lifelong physical and mental health of their child. Yet little is known about the relationship between diet in adolescence and the health of the next generation at birth. This study examined data from Norwegian cohorts to assess the relationship between dietary patterns in adolescence and neonatal outcomes. Data from adolescents who participated in the Nord-Trøndelag Health Study (Young-HUNT) were merged with birth data for their offspring through the Medical Birth Registry of Norway. Young-HUNT1 collected data from 8980 adolescents between 1995 and 1997. Linear regression was used to assess associations between adolescents' diet and later neonatal outcomes of their offspring adjusting for sociodemographic factors. Analyses were replicated with data from the Young-HUNT3 cohort (dietary data collected from 2006 to 2008) and combined with Young-HUNT1 for pooled analyses. In Young-HUNT1, there was evidence of associations between dietary choices, meal patterns, and neonatal outcomes, these were similar in the pooled analyses but were attenuated to the point of nonsignificance in the smaller Young-HUNT3 cohort. Overall, energy-dense food products were associated with a small detrimental impact on some neonatal outcomes, whereas healthier food choices appeared protective. Our study suggests that there are causal links between consumption of healthy and unhealthy food and meal patterns in adolescence with neonatal outcomes for offspring some years later. The effects seen are small and will require even larger studies with more state-of-the-art dietary assessment to estimate these robustly.

Introduction

Non-communicable diseases (NCDs) account for almost 86% of premature mortality and 77% of disease burden in Europe[1]. This high morbidity heavily impacts both individual quality of life and global health expenditures that will continue to rise unless action is taken[1]. It is therefore important to identify not only *which* interventions and actions will prevent NCDs but also *how* these can bring the greatest public health impact most cost-effectively[1,2].

Good maternal health during pregnancy can have positive effects on long-term risk of NCDs in the next generation[3,4]. However, emerging evidence indicates that this influence starts even before a mother becomes pregnant[3,4]. Diet and nutritional status have been shown to modify gene expression in both female and male germ cells in animal models, suggesting that the nutritional status of *both* parents at the time of conception shape their offspring's health trajectory[4–6]. Further, maternal and paternal diet, nutrition, and weight status prior to conception play an important role in embryonic development, placentation, and fetal/child growth trajectories [4–8].

Given that people rarely plan a pregnancy several years in advance, it is of utmost importance to establish healthy dietary habits and good nutritional status before people reach reproductive age[3,9]. Adolescence is a critical period of life characterized by high demands for energy and nutrients to support rapid physical growth and development. Adolescents begin to have more autonomy over their lifestyle which often results in the adoption of unhealthy behaviors[10,11]. Dietary patterns developed during adolescence track into adulthood and determine health later in life and thus future generations[12]. A dietary pattern high in energy-dense and nutrient-poor foods and low in essential food groups, as observed in European adolescents, is therefore of great concern[11].

Dietary interventions during adolescence offer a triple benefit by improving adolescents' own health both in the short and long term, as well as the health of the next generation[13]. Adolescence might therefore provide a window of opportunity to improve health years before the next generation is conceived. There is, however, currently little evidence as to *how* dietary patterns in adolescence might be linked to health in the next generation, and *whether* and *to what degree* the maternal versus paternal diet differ in their mechanism of action and impact[3]. This gap in research can only be addressed via prospective longitudinal studies where dietary data are collected from adolescents who are then followed up to adulthood to assess health outcomes of their offspring. To our knowledge, the data to enable this linkage exist only in Norway. The aim of this study was therefore to examine how men's and women's diets measured when they were adolescents predict the neonatal health of their offspring when they become parents in adulthood. This study provides a first insight into the complex relationship between dietary patterns in adolescence and preconception and health outcomes of the offspring at birth. The study used dietary data from the Young-Health Study in Nord-Trøndelag (Young-HUNT) and neonatal data from the Medical Birth Registry of Norway (MBRN).

Methods

Design and setting

The Young-HUNT study is the adolescent cohort (13- to 19-year-olds) within the HUNT study, a large population-based health study in the county of Nord-Trøndelag, Norway[14]. Nord-Trøndelag is a mostly rural county located in the middle of Norway that has a population size of about 130 000 inhabitants but lacks large cities. Overall, the county is representative of Norway with respect to geography, economy, industry, sources of income, age distribution, morbidity, and mortality[14,15]. Young-HUNT comprises two population-based cohorts born approximately 11 years apart. The Young-HUNT surveys took place for the first cohort in 1995–1997 (Young-HUNT1), with a 4-year follow-up in 2000–2001 (Young-HUNT2) and for the second cohort in 2006–2008 (Young-HUNT3). The surveys assessed a broad range of health indicators including dietary behaviors from self-reported questionnaires and anthropometrical measurements[14]. The Young-HUNT1 cohort was used for the main analysis in this study; the Young-HUNT3 cohort was used as a replication cohort. Neonatal data for children born to participants in the Young-HUNT1 and Young-HUNT3 cohorts were obtained from the MBRN[16], a national registry of pregnancy and birth outcomes in Norway from 1967 onward. The Young-HUNT cohorts were linked to MBRN data using their unique national ID numbers.

Participants over 19 years were excluded (0.7%) since this was outside the target exposure period of adolescence. Subsequent and plural pregnancies by the same mother were excluded to avoid, respectively, confounding influences of the interpregnancy interval on mothers' nutrition status and twin bias on the relationship between adolescent preconception diet and neonatal outcomes[17].

Recruitment and data collection

Recruitment for the Young-HUNT cohort was organized through schools. Principals of each of the 66 schools in the county gave written consent for their school's participation. Pupils then received an information sheet about the study and data use, addressed to both pupils and parents or guardians, approximately 1 month before data collection. All participants and parents or guardians of those under 16 years gave informed written consent.

The questionnaire was completed by pupils during school hours under quiet assessment conditions. Within a month of questionnaire completion, specially trained nurses visited the schools for the anthropometrical measurements using standardized protocols and equipment. Pupils absent on the day of the questionnaire were encouraged to complete the questionnaire during the nurse visit day. Adolescents identified by the county records as out of school were invited to the study by post. For these participants, the questionnaire was included with an invitation to attend the clinical part of the study at one of the study sites for the adult cohort of the Young-HUNT study[14].

Birth information was obtained through record linkage with the MBRN. All live births and stillbirths in Norway from the 16th week of gestation (12th week since 2002) are recorded for the MBRN by the attending midwife or obstetrician. Antenatal records are kept with the mother until delivery and then transferred to the birth records for MBRN. Additional data are derived from the pediatric examination during the infant's first days of life and, since 1999, also by records from neonatal intensive care units for all infants transferred to such units after birth[16].

Measures

Child neonatal outcomes

Birth weight (g), length (cm), head circumference (cm), placenta weight (g), and gestational length (weeks) were obtained from the MBRN. Rohrer' Ponderal index was used as an indicator of newborn adiposity and calculated via the following formula ((birth weight (g)/birth length^3 (cm))*100). Gestational length was based on the mother's reported last menstrual date and, if missing, on ultrasound-based estimations. Outliers (mean ± three standard deviations (SD)) of the outcome variables were excluded (i.e. resulting in max. 1.5% of cases for the different outcome variables).

Dietary exposures

Adolescents' diets were assessed using self-reported questionnaire items: "How often do you drink or eat the things listed below?" Answer categories ranged from never (0) to more than once a day (4) and were recoded into number of servings/portions per week (0 = never, seldom = 0.5, every week but not every day = 3.5, once a day = 7, 14 = more than once a day) following established practice[18]. The frequency of consumption of sugar-sweetened soft drinks, potato chips (crisps), candy, chocolate, and other sweets was recorded as indicators of a suboptimal diet, whereas fruit, vegetables, and whole-grain bread were indicators of a healthy dietary pattern. These patterns were present in both the Young-HUNT1 and Young-HUNT3 cohorts[19,20].

Questionnaire items assessing meal patterns asked how often adolescents usually ate breakfast, lunch, and dinner. Answer categories ranged from never (0) to daily (3) and were dichotomized into daily versus less than daily consumption. These diet and meal variables were based on assessments used in the Health Behavior of School-aged Children (HBSC) study that were found to be reliable and valid[18,21]. Zero imputation (i.e., assumption of no

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consumption) was used for food and meal items that were left blank; 5%–15% of the participants had one or more missing food items.

Potential confounders

The following *a priori* defined covariables were considered as potential confounders due to a known association with diet and/or neonatal outcomes[3,22]. Adolescents' age, education plans ("higher education such as university/college" vs "no higher education"), snuff (tobacco) use ("ever" vs "never"), smoking ("ever" vs "never"), and alcohol use ("ever" vs "never") were assessed via self-reported questionnaires. Following established practice[23], adolescents' education plans were used as an indicator of future socioeconomic status. Adolescents' weight and height were collected by public health nurses at schools according to standardized protocols using the Heine Professional 7800 Precision electronic scale and KaWe person-check height measuring device. Weight and height were measured to the nearest 0.5 kg and 0.5 cm, with pupils being barefoot and wearing light clothes.[14] BMI-for-age z-scores (BMIz-scores) were calculated using the WHO criteria[24].

Statistical analyses

Main analysis

Analyses were run separately for mother–offspring and father–offspring dyads. Descriptive statistics for Young-HUNT1 data were produced (see Table 1). Analyses were conducted on complete cases, and therefore included only participants who had valid measurements for all exposures, covariables, and neonatal outcomes. To investigate the associations between adolescents' dietary exposures (i.e., soft drinks, crisps, sweets, fruit, vegetables, and whole-grain bread) and their offspring neonatal outcomes (i.e., birth weight, length, head circumference, placenta weight, gestational length, and ponderal index), a set of linear regression models were estimated. First, an unadjusted model (model 1); second, a model adjusting for adolescents' age (continuous), BMI z-score (continuous), smoking (dichotomous), alcohol use (dichotomous), snuff (tobacco) use (dichotomous), and education plans (dichotomous) (model 2); and finally, a model that included the covariables adjusted for in model 2 plus additional adjustment for the other – non-indicator – diet items or meal items (model 3). To allow comparisons across outcomes and exposures, we present both unstandardized (see Tables 2–7) and standardized coefficients (see Appendices 1–4).

Replication and pooled analyses

Since this study is the first to explore associations between diet in adolescence and neonatal outcomes some years later, multiple comparisons were planned. Analyses were replicated with the Young-HUNT3 cohort to reduce the chance that any associations were found by chance. In addition, pooled analyses were conducted combining both Young-HUNT1 and Young-HUNT3 data sets.

Sensitivity analysis

Sensitivity analyses were performed to evaluate the robustness of the findings (see Appendixes 5–10) by rerunning the analyses with ≥4 SD outlier exclusion for the continuous variables and including all cases, regardless of missing values. Generally, findings were similar under these conditions and therefore will not be commented on further. Factor analyses were conducted to identify dietary indices based on all food items using the principal component method and varimax/orthogonal rotation. The following three dietary indices were denoted i) a fruit and vegetable index (i.e., sum of fruit and vegetable intake, ii) a fibre index (i.e., sum of fruit, vegetable, and whole-grain bread intake), and iii) an excess index (i.e., sum of crisps, sweets, and sugared soft drink intake).

Software package SPSS 21.0 was used to conduct all analyses.

Results

Description of sample

Fig. 1 shows a flowchart of participants in the Young-HUNT1-MBRN cohorts. In the Young-HUNT1 survey, 8980 pupils (response rate 88%) completed the questionnaire. After exclusions due to age, non-singleton pregnancies or no registered birth, 6191 parent–child dyads remained (61%). The final complete-case analysis sample comprised 5087/6191 dyads (82%). In the Young-HUNT3 survey (2006–2008), 8199 pupils (response rate 78%) completed the questionnaire. After exclusions due to age, non-singleton pregnancies or no registered birth, 1659 dyads remained (20%). The final complete-case analysis sample comprised 1241/1659 dyads (75%).

Table 1 presents the demographics, diet items, and neonatal outcomes for the mother–offspring and father–offspring dyads of the Young-HUNT1 cohort. The mean age of participants at the time of the Young-HUNT1 questionnaire was 16.0 years, and the mean age of becoming a parent was 25.8 years for girls and 26.1 years for boys. On average, participants had a slightly higher BMI than the WHO mean, and less than a third planned to continue their studies into higher education. The Young-HUNT3 cohort yielded similar demographics for both the mother–offspring (mean age = 16.2 ± 1.7, higher education plans = 39.9%, mean BMI = 0.47 ± 0.95) and father–offspring datasets (mean age = 16.3 ± 1.5, higher education plans = 21.7%, mean BMI = 0.6 ± 0.99), except for a lower mean age of becoming a parent due to the cohort itself being much younger (mean age of mother = 21.8 ± 2.5; mean age of father = 22.06 ± 3.04).

When checking for the social patterning of diet in the Young-HUNT1 cohort (Tables A11, 12 in appendix), we found clear differences in food and meal patterns according to socioeconomic and behavioral covariables in both the mother–offspring and father–offspring dyads.

Mother–offspring associations

Associations between the mother's diet in adolescence and neonatal outcomes are shown in Tables 2–4. In Young-HUNT1, infants born to mothers with higher crisp intakes during adolescence were on average slightly lighter and shorter at birth and had a slightly lighter placenta; an extra serving of crisps per week was associated with a 12 g reduction in birth weight (95% CI: −23 to −1 g). There was little support for these associations in the smaller replication cohort (Young-HUNT3), the associations here were all much closer to the null (Table 3). When data were pooled, these associations were still evident although slightly weaker (Table 4).

In Young-HUNT1, there was a pattern of slightly shorter gestational length among mothers who reported a higher vegetable intake and having an evening meal every day during adolescence. These findings were not replicated in Young-HUNT3 (Table 3). The effect of vegetable intake was evident although weaker in the pooled analyses (Table 4). Similarly, eating breakfast every day was associated with a higher placenta weight among Young-HUNT1 mothers, but not in Young-HUNT3 mothers (Table 3), though pooled analyses supported this association (Table 4).

Table 1. Descriptive characteristics of the Young-HUNT1-MBRN data sets (only first and single pregnancies included, outliers >3 SD applied for outcomes)

	Young-HUNT1-MBRN Mother–offspring dyads (*n* = 2947*)		Young-HUNT1-MBRN Father–offspring dyads (*n* = 2140*)	
	Mean ± SD or %	Median (IQR)♯	Mean ± SD or %	Median (IQR)♯
Demographics Young-HUNT				
Age	16.0 ± 1.7	15.9 (14.6, 17.4)	16.0 ± 1.6	16.0 (14.7, 17.4)
Education plans				
No higher education	65.9		73.6	
Higher education	31.1		26.4	
BMI z-score (WHO)	0.19 ± 0.90	0.14 (−0.41, 0.73)	0.15 ± 0.95	0.14 (−0.44, 0.72)
Dietary items Young-HUNT				
Soft drinks (servings per week)	3.9 ± 2.9	3.5 (3.5, 3.5)	5.0 ± 3.6	3.5 (3.5, 7.0)
Crisps (servings per week)	2.3 ± 1.9	3.5 (0.5, 3.5)	2.7 ± 2.1	3.5 (0.5, 3.5)
Sweets (servings per week)	3.4 ± 2.2	3.5 (3.5, 3.5)	3.7 ± 2.6	3.5 (3.5, 3.5)
Fruit (servings per week)	6.5 ± 4.4	3.5 (3.5, 7.0)	5.6 ± 4.3	3.5 (3.5, 7.0)
Vegetables (servings per week)	5.2 ± 3.8	3.5 (3.5, 7.0)	4.9 ± 3.9	3.5 (3.5, 7.0)
Whole-grain bread (servings per week)	8.9 ± 4.9	7.0 (3.5, 14.0)	9.2 ± 5.2	14.0 (3.5, 14.0)
Daily breakfast	64.1		75.1	
Daily lunch	60.5		70.4	
Daily dinner	71.4		81.0	
Demographics MBRN				
Maternal age at delivery	25.8 ± 4.4	26.0 (22.0, 29.0)	26.1 ± 4.3	26.0 (23.0, 29.0)
Child neonatal outcomes MBRN				
Birth weight (g)	3505 ± 514	3510 (3190, 3830)	3503 ± 498	3510 (3210, 3830)
Birth length (cm)	50.1 ± 2.2	50.0 (49.0, 51.0)	50.1 ± 2.2	50.0 (49.0, 52.0)
Ponderal index (equation)	2.8 ± 0.25	2.8 (2.6, 3.0)	2.8 ± 0.25	2.8 (2.6, 2.9)
Birth head circumference (cm)	35.0 ± 1.6	35.0 (34.0, 36.0)	35.0 ± 1.6	35.0 (34.0, 36.0)
Birth placenta weight (g)	663 ± 154	650 (560, 752)	662 ± 151	650 (560, 750)
Gestational length (weeks)	39.6 ± 1.7	40.0 (39.0, 41.0)	39.6 ± 1.6	40.0 (39.0, 41.0)

*Based on complete cases, excluding all IDs with missing data for at least one covariate.
♯IQR, interquartile range.

Pooled analyses also showed an association between maternal whole-grain bread consumption and a slightly increased head circumference and longer gestational length. There was no evidence for associations between mothers' intake of soft drinks, sweets, and fruit in adolescence with any neonatal outcomes. No association was observed between the diet indices and neonatal outcomes (Appendix A9).

Father–offspring associations

Associations between the father's diet in adolescence and neonatal health outcomes are shown in Tables 5–7. In Young-HUNT1, paternal fruit intake during adolescence was associated with an increase in placenta weight; an extra serving of fruit per week was associated with a 2.4 g increase in placenta weight (95% CI: 0.3–4 g). This association was not observed in the Young-HUNT3 cohort, though the pooled analyses supported this finding. A slightly shorter birth length and lower ponderal index were observed in offspring of fathers in Young-HUNT1 who reported higher vegetable and whole-grain bread consumption during adolescence. No evidence of this was found in Young-HUNT3, but associations remained in the pooled analyses. Eating lunch regularly in adolescence was associated with an increase in head circumference in the offspring of Young-HUNT1 fathers. These associations replicate neither in Young-HUNT3 nor in the pooled analysis (see Tables 6 and 7).

No additional associations were found in the pooled analyses for father–offspring dyads. In addition, there was no evidence for an association between fathers' intake of soft drinks, crisps, breakfast, and dinner and neonatal outcomes in the different analyses. Fathers' fruit and vegetable index and fiber index were inconsistently associated with the ponderal index of their offspring; a higher fruit and vegetable index was positively associated with this neonatal outcome while the fiber index was inversely related (Appendix 10).

Discussion

To our knowledge, this is the first study worldwide that examined the relationship between diet prospectively measured in

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Table 2. Associations between maternal diet exposures and child neonatal outcomes (outliers >3 SD excluded) in the Young-HUNT1-MBRN cohort (only first and single births included, complete cases*)

		Weight			Length			Ponderal Index			Head circumference			Placenta weight			Gestational length		
		n = 2905			*n* = 2850			*n* = 2841			*n* = 2881			*n* = 2766			*n* = 2882		
		B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI
Soft drinks (per extra serving/ week)	Model 1	−2.68	0.4	−9.01;3.7	−0.022	0.1	−0.05;0.01	0.001	0.4	−0.002;0.005	−0.006	0.6	−0.026;0.014	1.25	0.2	−0.734;3.24	−0.012	0.3	−0.034;0.009
	Model 2	−2.68	0.4	−9.08;3.71	−0.020	0.1	−0.048;0.007	0.001	0.5	−0.002;0.004	−0.003	0.8	−0.023;0.017	1.24	0.2	−0.762;3.25	−0.015	0.2	−0.036;0.007
	Model 3	−1.77	0.6	−8.80;5.27	−0.018	0.2	−0.048;0.012	0.001	0.4	−0.002;0.005	−0.001	0.9	−0.024;0.021	1.57	0.2	−0.632;3.78	−0.010	0.4	−0.034;0.014
Crisps (per extra serving/week)	Model 1	**−12.1**	**0.02**	**−22.0; −2.20**	**−0.050**	**0.02**	**−0.09; −0.01**	−0.001	0.6	−0.006;0.004	−0.023	0.1	−0.054;0.008	−2.396	0.1	−5.50;0.704	−0.032	0.06	−0.065;0.001
	Model 2	−9.80	0.05	−19.7;0.165	−0.044	0.046	−0.087; −0.001	−0.001	0.8	−0.006;0.004	−0.018	0.3	−0.050;0.013	−1.969	0.2	−5.10;1.16	−0.030	0.08	−0.063;0.003
	Model 3	**−11.9**	**0.04**	**−23.1; −0.743**	**−0.050**	**0.04**	**−0.098; −0.002**	−0.001	0.7	−0.007;0.004	−0.028	0.1	−0.063;0.007	**−3.681**	**0.04**	**−7.16; −0.205**	−0.028	0.1	−0.065;0.010
Sweets (per extra serving/week)	Model 1	−0.10	1.0	−8.45;8.25	0.005	0.8	−0.03;0.40	−0.001	0.7	−0.005;0.003	0.009	0.5	−0.017;0.035	0.961	0.5	−1.63;3.55	−0.009	0.5	−0.037;0.019
	Model 2	2.02	0.6	−6.43;10.5	0.011	0.6	−0.025;0.047	0.000	0.8	−0.005;0.004	0.014	0.3	−0.013;0.041	1.448	0.3	−1.18;4.07	−0.007	0.6	−0.036;0.021
	Model 3	6.55	0.2	−2.89;16.0	0.034	0.1	−0.006;0.074	−0.001	0.8	−0.005;0.004	0.024	0.1	−0.006;0.054	1.914	0.2	−0.989;4.82	0.005	0.7	−0.026;0.037
Fruit (per extra serving/week)	Model 1	−1.16	0.6	−5.44;3.13	−0.003	0.7	−0.02;0.02	−0.000	1.0	−0.002;0.002	0.001	0.8	−0.012;0.015	0.571	0.4	−0.75;1.89	−0.001	0.9	−0.015;0.013
	Model 2	−1.18	0.6	−5.50;3.13	−0.005	0.6	−0.024;0.013	0.000	0.8	−0.002;0.002	0.000	1.0	−0.014;0.013	0.575	0.4	−0.752;1.90	0.000	1.0	−0.014;0.014
	Model 3	0.707	0.8	−4.91;6.32	0.006	0.6	−0.018;0.030	0.000	0.8	−0.002;0.003	0.002	0.8	−0.016;0.020	1.113	0.2	−0.611;2.84	0.012	0.2	−0.007;0.031
Vegetables (per extra serving/ week)	Model 1	−2.87	0.3	−7.75;2.02	−0.013	0.2	−0.03;0.01	0.000	0.9	−0.003;0.002	−0.002	0.8	−0.017;0.013	−0.192	0.8	−1.70;1.31	−0.014	0.1	−0.030;0.003
	Model 2	−2.67	0.3	−7.57;2.25	−0.015	0.2	−0.036; 0.006	0.000	0.9	−0.002;0.002	−0.003	0.7	−0.018;0.012	−0.134	0.9	−1.65;1.38	−0.013	0.1	−0.029;0.004
	Model 3	−3.34	0.3	−9.77;3.09	−0.020	0.1	−0.048;0.007	0.000	1.0	−0.003;0.003	−0.007	0.5	−0.027;0.014	−0.904	0.4	−2.88;1.07	**−0.024**	**0.03**	**−0.046; −0.003**
Whole-grain bread (per extra serving/week)	Model 1	0.44	0.8	−3.40;4.28	0.005	0.5	−0.01;0.02	−0.001	0.4	−0.003;0.001	0.010	0.09	−0.002;0.023	0.029	1.0	−1.15;1.21	0.004	0.5	−0.009;0.017
	Model 2	0.52	0.8	−3.36;4.40	0.005	0.6	−0.012;0.021	−0.001	0.5	−0.003;0.001	0.009	0.1	−0.003;0.021	0.193	0.8	−1.00;1.39	0.006	0.4	−0.007;0.019
	Model 3	0.71	0.7	−3.30;4.71	0.006	0.5	−0.012;0.023	−0.001	0.5	−0.003;0.001	0.010	0.1	−0.003;0.022	0.214	0.7	−1.02;1.44	0.007	0.3	−0.006;0.021
Breakfast (daily versus not daily)	Model 1	−10.7	0.6	−49.6;28.4	0.042	0.6	−0.13;0.21	−0.013	0.2	−0.032;0.006	0.065	0.3	−0.057;0.188	7.424	0.2	−4.60;19.4	0.002	1.0	−0.129;0.132
	Model 2	0.398	1.0	−39.6;40.4	0.055	0.5	−0.117;0.227	−0.007	0.5	−0.027;0.012	0.067	0.3	−0.058;0.193	12.158	0.05	−0.161;24.5	0.035	0.6	−0.098;0.169
	Model 3	10.4	0.6	−32.5;53.4	0.067	0.5	−0.117;0.251	−0.002	0.8	−0.024;0.019	0.080	0.2	−0.055;0.215	**15.750**	**0.02**	**2.52;29.0**	0.079	0.3	−0.065;0.222
Lunch (daily versus not daily)	Model 1	−28.5	0.1	−66.7;9.76	−0.015	0.9	−0.18;0.15	−0.018	0.06	−0.037;0.000	0.009	0.9	−0.111;0.129	−8.835	0.1	−20.6;2.92	−0.066	0.3	−0.193;0.062
	Model 2	−20.3	0.3	−59.0;18.5	0.000	1.0	−0.167;0.166	−0.015	0.1	−0.034;0.004	0.013	0.8	−0.109;0.135	−5.4	0.4	−17.3;6.53	−0.044	0.5	−0.174;0.085
	Model 3	−20.6	0.3	−62.6;21.3	−0.015	0.9	−0.195;0.165	−0.014	0.2	−0.035;0.007	0.002	1.0	−0.130;0.134	−11.234	0.09	−24.2;1.70	−0.036	0.6	−0.176;0.105
Dinner (daily versus not daily)	Model 1	−27.1	0.2	−68.5;14.3	−0.036	0.7	−0.21;0.14	−0.008	0.4	−0.029;0.012	−0.062	0.4	−0.192;0.068	−0.024	1.0	−12.7;12.7	**−0.179**	**0.01**	**−0.317; −0.041**
	Model 2	−18.2	0.4	−60.1;23.7	−0.027	0.8	−0.207;0.153	−0.003	0.8	−0.024;0.017	−0.060	0.4	−0.192;0.071	2.746	0.7	−10.1;15.7	**−0.161**	**0.02**	**−0.301; −0.021**
	Model 3	−15.3	0.5	−58.6;28.0	−0.037	0.7	−0.223;0.149	0.001	1.0	−0.021;0.022	−0.077	0.3	−0.213;0.060	2.437	0.7	−10.9;15.8	**−0.168**	**0.02**	**−0.313; −0.023**

*Results in the table are for complete cases (*n* = 2947).B, unstandardized beta coefficient.
Model 1: the crude model.
Model 2: adjusted for age, BMI z-score, smoking (ever/never), alcohol use (ever/never), snuff (tobacco) use (ever/never), and education plans measured via Young-HUNT1.
Model 3: model 2 adjustments plus food items for each food item and meals items for each meal item.

Table 3. Associations between maternal diet exposures and child neonatal outcomes (outliers >3 SD excluded) in the Young-HUNT3-MBRN cohort (only first and single births included, complete cases*)

		Weight			Length			Ponderal Index			Head circumference			Placenta weight			Gestational length		
		n = 843			*n* = 834			*n* = 832			*n* = 840			*n* = 843			*n* = 844		
		B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI
Soft drinks (per extra serving/ week)	Model 1	−0.206	1.0	−8.45; 8.04	−0.012	0.5	−0.049;0.024	0.003	0.2	−0.001;0.007	−0.006	0.6	−0.031;0.019	−0.688	0.6	−3.09;1.71	0.013	0.3	−0.013;0.038
	Model 2	1.33	0.8	−7.12;9.77	−0.005	0.8	−0.042;0.033	0.002	0.3	−0.002;0.006	0.002	0.9	−0.024;0.027	−0.745	0.6	−3.21;1.72	0.015	0.3	−0.011;0.041
	Model 3	3.76	0.4	−5.25;12.8	0.005	0.8	−0.035;0.045	0.003	0.3	−0.002;0.007	0.014	0.3	−0.013;0.041	0.007	1.0	−2.62;2.64	0.026	0.07	−0.002;0.054
Crisps (per extra serving/week)	Model 1	−4.37	0.5	−18.5;9.76	−0.031	0.3	−0.096;0.033	0.002	0.7	−0.006;0.009	−0.031	0.2	−0.074;0.011	−2.02	0.3	−6.22;2.19	−0.005	0.8	−0.049;0.039
	Model 2	−0.815	0.9	−15.3;13.7	−0.011	0.7	−0.077;0.054	0.001	0.9	−0.007;0.008	−0.019	0.4	−0.063;0.026	−2.05	0.4	−6.37;2.28	−0.001	1.0	−0.046;0.044
	Model 3	3.80	0.7	−14.9;22.5	−0.008	0.9	−0.092;0.077	0.003	0.5	−0.006;0.013	0.000	1.0	−0.056;0.056	−1.05	0.7	−6.61;4.52	0.024	0.4	−0.034;0.082
Sweets (per extra serving/week)	Model 1	−7.82	0.2	−20.3;4.64	−0.028	0.3	−0.084;0.028	−0.001	0.7	−0.007;0.005	−0.038	0.05	−0.075;0.000	−1.79	0.3	−5.44;1.85	−0.028	0.2	−0.067;0.010
	Model 2	−4.48	0.5	−17.3;8.36	−0.007	0.8	−0.064;0.051	−0.002	0.5	−0.009;0.004	−0.027	0.2	−0.066;0.012	−1.86	0.3	−5.63;1.90	−0.025	0.2	−0.065;0.015
	Model 3	−7.28	0.4	−24.0;9.41	0.000	1.0	−0.074;0.075	0.003	0.2	−0.014;0.003	−0.030	0.2	−0.080;0.020	−1.04	0.7	−5.93;3.85	−0.047	0.07	−0.099;0.005
Fruit (per extra serving/week)	Model 1	6.58	0.07	−0.614;13.8	0.029	0.08	−0.003;0.061	0.001	0.5	−0.002;0.005	0.019	0.08	−0.002;0.041	1.10	0.3	−0.98;3.18	0.008	0.5	−0.014;0.030
	Model 2	5.81	0.1	−1.49;13.1	0.025	0.1	−0.007;0.058	0.001	0.5	−0.002;0.005	0.017	0.1	−0.005;0.039	1.03	0.3	−1.09;3.14	0.006	0.6	−0.016;0.029
	Model 3	6.18	0.2	−3.94;16.3	0.021	0.4	−0.024;0.067	0.002	0.4	−0.003;0.007	0.006	0.7	−0.024;0.037	−0.212	0.9	−3.19;2.77	0.005	0.8	−0.026;0.036
Vegetables (per extra serving/ week)	Model 1	5.11	0.2	−3.02;13.2	0.025	0.2	−0.011;0.061	0.001	0.8	−0.004;0.005	0.022	0.07	−0.002;0.047	1.64	0.2	−0.71;3.99	0.006	0.6	−0.019;0.031
	Model 2	3.83	0.4	−4.43;12.1	0.018	0.3	−0.018;0.055	0.001	0.7	−0.003;0.005	0.019	0.1	−0.006;0.044	1.53	0.2	−0.88;3.93	0.004	0.7	−0.021;0.030
	Model 3	−2.14	0.7	−13.6;9.28	−0.009	0.7	−0.060;0.042	0.000	1.0	−0.006;0.006	0.007	0.7	−0.028;0.042	1.05	0.5	−2.31;4.41	−0.007	0.7	−0.043;0.028
Whole-grain bread (per extra serving/week)	Model 1	5.03	0.1	−1.39;11.5	**0.035**	**0.02**	**0.006;0.063**	−0.002	0.2	−0.005;0.001	**0.026**	**0.007**	**0.007;0.046**	1.58	0.1	−0.28;3.44	**0.022**	**0.03**	**0.002;0.042**
	Model 2	4.58	0.2	−2.00; 11.2	**0.031**	**0.04**	**0.002;0.060**	−0.002	0.3	−0.005;0.001	**0.023**	**0.02**	**0.003;0.043**	1.78	0.07	−0.13;3.70	**0.022**	**0.03**	**0.002;0.043**
	Model 3	3.76	0.3	−3.28;10.8	0.028	0.08	−0.003;0.059	−0.002	0.2	−0.006;0.001	**0.020**	**0.06**	**−0.001;0.042**	1.53	0.1	−0.52;3.58	**0.025**	**0.02**	**0.003;0.047**
Breakfast (daily versus not daily)	Model 1	38.2	0.3	−30.2;107	0.191	0.2	−0.114;0.496	−0.004	0.8	−0.038;0.030	0.081	0.4	−0.124;0.286	4.10	0.7	−15.7;23.9	0.136	0.2	−0.075;0.347
	Model 2	32.4	0.4	−38.1;103	0.159	0.3	−0.155;0.472	−0.001	1.0	−0.036;0.034	0.060	0.6	−0.152;0.272	3.54	0.7	−17.02;24.1	0.130	0.2	−0.088;0.349
	Model 3	23.5	0.5	−53.2;100	0.093	0.6	−0.247;0.433	0.006	0.8	−0.032;0.044	0.010	1.0	−0.221;0.240	3.66	0.7	−17.8;26.1	0.036	0.8	−0.202;0.273
Lunch (daily versus not daily)	Model 1	35.1	0.3	−33.4;104	0.296	0.06	−0.009;0.600	−0.025	0.2	−0.059;0.009	0.128	0.2	−0.077;0.334	1.04	0.9	−18.8;20.9	**0.247**	**0.02**	**0.036;0.458**
	Model 2	24.5	0.5	−45.7;94.8	0.240	0.1	−0.072;0.551	−0.023	0.2	−0.058;0.012	0.112	0.3	−0.099;0.323	0.355	1.0	−20.1;20.8	**0.236**	**0.03**	**0.019;0.453**
	Model 3	7.06	0.9	−71.6;85.7	0.238	0.2	−0.110;0.587	−0.034	0.09	−0.073;0.005	0.079	0.5	−0.157;0.315	−1.74	0.9	−24.6;21.1	0.191	0.1	−0.052;0.435
Dinner (daily versus not daily)	Model 1	42.0	0.3	−34.8;119	−0.011	1.0	−0.354;0.333	0.024	0.2	−0.014;0.062	0.112	0.3	−0.119;0.343	5.79	0.6	−16.5;28.1	0.206	0.09	−0.031;0.444
	Model 2	38.7	0.3	−40.3;118	0.000	1.0	−0.353;0.352	0.019	0.4	−0.021;0.058	0.133	0.3	−0.105;0.371	2.88	0.8	−20.1;25.9	0.188	0.1	−0.057;0.432
	Model 3	29.8	0.5	−54.6;114	−0.112	0.6	−0.488;0.263	0.30	0.2	−0.013;0.072	0.101	0.4	−0.152;0.355	2.54	0.8	−22.1;27.1	0.107	0.4	−0.154;0.368

*Results in the table are for complete cases (*n* = 850).B, unstandardized beta coefficient.
Model 1: the crude model.
Model 2: adjusted for age, BMI z-score, smoking (ever/never), alcohol use (ever/never), snuff (tobacco) use (ever/never), and education plans measured via Young-HUNT3.
Model 3: model 2 adjustments plus food items for each food item and meals items for each meal item.

Table 4. Associations between diet exposures and child neonatal outcomes (outliers >3 SD excluded) in the pooled Young-HUNT1 and 3-MBRN mother–offspring dyads (only first and single births included, complete cases*)

		Weight			Length			Ponderal Index			Head circumference			Placenta weight			Gestational length		
		$n = 3748$			$n = 3684$			$n = 3673$			$n = 3721$			$n = 3609$			$n = 3726$		
		B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI
Soft drinks (per extra serving/ week)	Model 1	−1.78	0.5	−6.67;3.11	−0.018	0.1	−0.039;0.003	0.002	0.1	−0.001;0.004	−0.005	0.5	−0.021;0.010	0.502	0.5	−0.995;2.00	−0.003	0.7	−0.019;0.013
	Model 2	−1.01	0.7	−5.95;3.92	−0.014	0.2	−0.035;0.008	0.002	0.2	−0.001;0.004	−0.002	0.8	−0.017;0.013	0.541	0.5	−0.973;2.05	−0.003	0.7	−0.019;0.013
	Model 3	0.210	0.9	−5.17;5.59	−0.009	0.4	−0.032;0.014	0.002	0.2	−0.001;0.005	0.003	0.7	−0.013;0.020	0.995	0.2	−0.650;2.64	0.004	0.7	−0.014;0.022
Crisps (per extra serving/week)	Model 1	**−9.61**	**0.02**	**−17.7; −1.52**	**−0.044**	**0.02**	**−0.079; −0.009**	0.000	0.9	−0.004;0.004	**−0.026**	**0.04**	**−0.051; −0.001**	−2.28	0.08	−4.78;0.231	−0.023	0.09	−0.050;0.003
	Model 2	−7.17	0.09	−15.4;1.03	−0.036	0.05	−0.071;0.000	0.000	0.9	−0.004;0.004	−0.020	0.1	−0.045;0.006	−1.98	0.1	−4.53;0.558	−0.021	0.1	−0.048;0.006
	Model 3	−9.16	0.06	−18.6;0.316	**−0.044**	**0.04**	**−0.085; −0.003**	0.000	0.8	−0.005;0.004	−0.026	0.09	−0.055;0.004	**−3.12**	**0.04**	**−6.02; −0.210**	−0.019	0.2	−0.050;0.012
Sweets (per extra serving/week)	Model 1	−2.45	0.5	−9.40;4.49	−0.005	0.7	−0.035;0.025	−0.001	0.6	−0.004;0.003	−0.005	0.6	−0.027;0.017	0.095	0.9	−2.03;2.22	−0.015	0.2	−0.038;0.008
	Model 2	0.097	1.0	−6.95;7.15	0.005	0.8	−0.026;0.035	−0.001	0.7	−0.004;0.003	0.001	0.9	−0.021;0.023	0.461	0.7	−1.70;2.62	−0.013	0.3	−0.036;0.011
	Model 3	3.68	0.4	−4.46;11.8	0.026	0.1	−0.009;0.061	−0.001	0.5	−0.005;0.003	0.011	0.4	−0.015;0.036	1.27	0.3	−1.20;3.74	−0.007	0.6	−0.034;0.020
Fruit (per extra serving/week)	Model 1	0.798	0.7	−2.88;4.48	0.005	0.6	−0.011;0.021	0.000	0.8	−0.002;0.002	0.006	0.3	−0.005;0.017	0.706	0.2	−0.408;1.82	0.001	0.9	−0.011;0.013
	Model 2	0.586	0.8	−3.12;4.29	0.003	0.8	−0.013;0.019	0.000	0.6	−0.001;0.002	0.004	0.5	−0.007;0.016	0.680	0.2	−0.444;1.80	0.002	0.8	−0.011;0.014
	Model 3	1.86	0.5	−3.04;6.75	0.009	0.4	−0.012;0.030	0.001	0.6	−0.002;0.003	0.003	0.7	−0.012;0.018	0.868	0.3	−0.621;2.36	0.010	0.2	−0.006;0.026
Vegetables (per extra serving/ week)	Model 1	−0.827	0.7	−5.01;3.35	−0.004	0.7	−0.022;0.014	0.000	1.0	−0.002;0.002	0.004	0.5	−0.009;0.017	0.295	0.6	−0.97;1.56	−0.009	0.2	−0.022;0.005
	Model 2	−0.982	0.6	−5.19;3.22	−0.006	0.5	−0.024;0.012	0.000	0.9	−0.002;0.002	0.003	0.7	−0.010;0.016	0.288	0.7	−0.99;1.56	−0.008	0.2	−0.022;0.005
	Model 3	−2.80	0.3	−8.38;2.78	−0.016	0.2	−0.040;0.008	0.000	1.0	−0.003;0.003	−0.003	0.7	−0.020;0.014	−0.457	0.6	−2.15;1.24	**−0.019**	**0.04**	**−0.038;0.001**
Whole-grain bread (per extra serving/week)	Model 1	1.66	0.3	−1.62;4.94	0.013	0.07	−0.001;0.027	−0.001	0.1	−0.003;0.000	**0.015**	**0.005**	**0.004;0.025**	0.446	0.4	−0.548;1.44	0.009	0.1	−0.002;0.020
	Model 2	1.59	0.4	−1.75;4.91	0.012	0.1	−0.002;0.026	−0.001	0.2	−0.003;0.001	**0.013**	**0.01**	**0.003;0.023**	0.603	0.2	−0.405;1.61	0.010	0.06	−0.001;0.021
	Model 3	1.64	0.4	−1.82;5.09	0.012	0.1	−0.003;0.027	−0.001	0.2	−0.003;0.001	**0.013**	**0.02**	**0.002;0.024**	0.569	0.3	−0.477;1.62	**0.012**	**0.04**	**0.001;0.023**
Breakfast (daily versus not daily)	Model 1	1.65	0.9	−32.0;35.3	0.080	0.3	−0.065;0.226	−0.011	0.2	−0.028;0.006	0.069	0.2	−0.035;0.174	6.59	0.2	−3.62;16.8	0.036	0.5	−0.074;0.147
	Model 2	8.10	0.6	−26.5;42.7	0.083	0.3	−0.066;0.233	−0.006	0.5	−0.024;0.011	0.068	0.2	−0.040;0.176	9.87	0.07	−0.651;20.5	0.058	0.3	−0.056;0.172
	Model 3	13.5	0.5	−23.8;50.7	0.075	0.4	−0.86;0.236	−0.001	0.9	−0.020;0.017	0.066	0.3	−0.050;0.182	**12.7**	**0.02**	**1.37;24.07**	0.069	0.3	−0.054;0.192
Lunch (daily versus not daily)	Model 1	−13.2	0.4	−46.4;20.1	0.060	0.4	−0.084;0.203	**−0.020**	**0.02**	**−0.036; −0.004**	0.037	0.5	−0.066;0.141	−6.34	0.2	−16.4;3.75	0.010	0.9	−0.100;0.119
	Model 2	−8.48	0.6	−42.3;25.4	0.064	0.4	−0.082;0.211	−0.017	0.05	−0.034;0.000	0.039	0.5	−0.067;0.144	−4.02	0.4	−14.3;6.26	0.024	0.7	−0.088;0.135
	Model 3	−11.9	0.5	−48.8;25.0	0.051	0.5	−0.109;0.211	−0.018	0.05	−0.036;0.000	0.025	0.7	−0.090;0.140	−9.08	0.1	−20.3;2.15	0.023	0.7	−0.098;0.145
Dinner (daily versus not daily)	Model 1	−11.9	0.5	−48.4;24.5	−0.030	0.7	−0.188;0.127	−0.001	0.9	−0.019;0.017	−0.024	0.7	−0.137;0.090	1.29	0.8	−9.77;12.4	−0.094	0.1	−0.214;0.025
	Model 2	−6.04	0.7	−43.0;31.0	−0.027	0.7	−0.187;0.133	0.002	0.8	−0.016;0.021	−0.022	0.7	−0.138;0.093	2.80	0.6	−8.45;14.0	−0.085	0.2	−0.206;0.037
	Model 3	−5.65	0.8	−44.0;32.7	−0.056	0.5	−0.222;0.110	0.007	0.4	−0.011;0.026	−0.043	0.5	−0.162;0.077	2.61	0.7	−9.08;14.3	−0.105	0.1	−0.232;0.021

*Results in the table are for complete cases ($n = 3797$).B, standardized beta coefficient.
Model 1: the crude model.
Model 2: adjusted for age, BMI z-score, smoking (ever/never), alcohol use (ever/never), snuff (tobacco) use (ever/never), and education plans measured via Young-HUNT.
Model 3: model 2 adjustments plus food items for each food item and meals items for each meal item.

Table 5. Associations between paternal diet exposures and child neonatal outcomes (outliers >3 SD excluded) in the Young-HUNT1-MBRN cohort (only first and single births included, complete cases*)

		Weight			Height			Ponderal Index			Head circumference			Placenta weight			Gestational length		
		n = 2905			*n* = 2850			*n* = 2841			*n* = 2881			*n* = 2766			*n* = 2882		
		B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI
Soft drinks (servings per week)	Model 1	0.902	0.8	−4.95;6.75	−0.004	0.8	−0.029;0.022	0.000	0.8	−0.003;0.003	−0.004	0.7	−0.022;0.015	0.991	0.3	−0.804;2.79	0.008	0.4	−0.012;0.027
	Model 2	1.15	0.7	−4.89;7.19	−0.002	0.9	−0.029;0.024	−0.001	0.7	−0.004;0.002	0.000	1.0	−0.020;0.019	1.19	0.2	−0.658;3.04	0.006	0.5	−0.013;0.026
	Model 3	3.30	0.3	−3.44;10.1	0.004	0.8	−0.026;0.033	−0.001	0.6	−0.004;0.002	0.007	0.5	−0.014;0.028	0.836	0.4	−1.23;2.90	0.011	0.3	−0.011;0.033
Crisps (servings per week)	Model 1	−5.06	0.3	−15.0;4.88	−0.020	0.4	−0.063;0.024	0.000	0.9	−0.005;0.005	−0.020	0.2	−0.051;0.012	1.40	0.4	−1.63;4.42	−0.018	0.3	−0.050;0.015
	Model 2	−3.01	0.6	−13.2;7.14	−0.012	0.6	−0.056;0.032	0.001	0.8	−0.004;0.006	−0.013	0.4	−0.045;0.019	2.17	0.2	−0.91;5.24	−0.018	0.3	−0.051;0.016
	Model 3	−1.12	0.9	−12.8;10.6	−0.003	0.9	−0.054;0.048	0.001	0.7	−0.005;0.007	−0.004	0.9	−0.041;0.034	1.33	0.5	−2.24;4.89	−0.025	0.2	−0.064;0.013
Sweets (servings per week)	Model 1	−7.22	0.09	−15.5;1.05	−0.024	0.2	−0.060;0.012	−0.001	0.7	−0.005;0.003	**−0.026**	**0.05**	**−0.052;0.000**	0.547	0.7	−1.99;3.08	0.000	1.0	−0.028;0.027
	Model 2	−5.89	0.2	−14.4;2.59	−0.019	0.3	−0.056;0.018	−0.001	0.8	−0.005;0.004	−0.020	0.1	−0.047;0.007	1.27	0.3	−1.33;3.87	−0.001	1.0	−0.029;0.027
	Model 3	−7.71	0.1	−17.8;2.39	−0.018	0.4	−0.062;0.025	−0.001	0.7	−0.006;0.004	−0.022	0.2	−0.054;0.010	−0.009	1.0	−3.09;3.08	0.003	0.9	−0.030;0.036
Fruit (servings per week)	Model 1	0.963	0.7	−4.01;5.93	−0.005	0.6	−0.027;0.016	0.002	0.1	−0.001;0.004	−0.003	0.7	−0.019;0.012	1.05	0.2	−0.47;2.56	0.001	0.9	−0.015;0.017
	Model 2	1.52	0.6	−3.59;6.63	−0.004	0.7	−0.026;0.018	0.002	0.09	0.000;0.005	−0.003	0.7	−0.020;0.013	1.34	0.09	−0.210;2.89	0.002	0.8	−0.015;0.019
	Model 3	5.84	0.1	−0.983;12.7	0.026	0.09	−0.004;0.055	0.002	0.3	−0.002;0.005	0.008	0.5	−0.014;0.029	**2.35**	**0.03**	**0.284;4.42**	0.012	0.3	−0.010;0.035
Vegetables (servings per week)	Model 1	−2.62	0.3	−8.01;2.77	**−0.029**	**0.02**	**−0.053; −0.006**	0.002	0.2	−0.001;0.004	−0.010	0.2	−0.027;0.007	−0.203	0.8	−1.85;1.44	−0.008	0.4	−0.026;0.009
	Model 2	−2.49	0.4	−7.99;3.01	**−0.030**	**0.01**	**−0.054; −0.006**	0.002	0.1	−0.001;0.005	−0.012	0.2	−0.029;0.006	0.006	1.0	−1.67;1.68	−0.008	0.4	−0.026;0.010
	Model 3	−5.96	0.1	−13.3;1.41	**−0.048**	**0.003**	**−0.080; −0.016**	0.001	0.4	−0.002;0.005	−0.017	0.2	−0.040;0.006	−1.48	0.2	−3.71;0.758	−0.017	0.2	−0.042;0.007
Whole-grain bread (servings per week)	Model 1	−1.72	0.4	−5.79;2.34	0.001	0.9	−0.017;0.019	**−0.002**	**0.02**	**−0.004;0.000**	0.002	0.8	−0.011;0.015	−0.94	0.1	−2.18;0.300	0.003	0.6	−0.010;0.016
	Model 2	−1.48	0.5	−5.57;2.61	0.001	1.0	−0.017;0.018	**−0.002**	**0.04**	**−0.004;0.000**	0.001	1.0	−0.012;0.014	−0.87	0.2	−2.11;0.379	0.004	0.5	−0.009;0.018
	Model 3	−1.34	0.5	−5.53;2.85	0.004	0.7	−0.014;0.022	**−0.003**	**0.01**	**−0.005; −0.001**	0.002	0.8	−0.011;0.015	−0.90	0.2	−2.18;0.378	0.005	0.5	−0.009;0.019
Breakfast (daily versus not daily)	Model 1	14.2	0.6	– −34.9;63.2	0.135	0.2	−0.078;0.349	−0.009	0.5	−0.033;0.016	0.097	0.2	−0.058;0.252	−6.49	0.4	−21.5;8.53	0.066	0.4	−0.096;0.227
	Model 2	20.1	0.4	−30.0;70.3	0.145	0.2	−0.073;0.364	−0.005	0.7	−0.030;0.020	0.086	0.3	−0.073;0.244	−6.07	0.4	−21.4;9.22	0.086	0.3	−0.079;0.251
	Model 3	20.2	0.5	−33.0;73.4	0.181	0.1	−0.051;0.413	−0.011	0.4	−0.037;0.016	0.045	0.6	−0.123;0.213	−5.32	0.5	−21.6;10.9	0.110	0.2	−0.065;0.285
Lunch (daily versus not daily)	Model 1	12.9	0.6	−33.6;59.4	0.007	0.9	−0.196;0.210	0.007	0.5	−0.016;0.031	**0.165**	**0.03**	**0.018;0.312**	−3.61	0.6	−17.8;10.6	−0.016	0.8	−0.169;0.137
	Model 2	19.0	0.4	−28.2;66.3	0.013	0.9	−0.193;0.220	0.012	0.3	−0.012;0.035	**0.159**	**0.04**	**0.010;0.308**	−2.61	0.7	−17.0;11.8	0.001	1.0	−0.155;0.157
	Model 3	21.3	0.4	−29.3;71.7	0.003	1.0	−0.219;0.224	0.014	0.3	−0.012;0.039	**0.160**	**0.05**	**0.001;0.320**	−0.31	1.0	−15.7;15.1	−0.006	0.9	−0.173;0.160
Dinner (daily versus not daily)	Model 1	−35.3	0.2	−89.3;18.7	−0.180	0.1	−0.416;0.056	0.006	0.7	−0.021;0.033	−0.011	0.9	−0.182;0.160	−5.80	0.5	−22.4;10.8	−0.121	0.2	−0.299;0.056
	Model 2	−31.6	0.3	−86.1;22.8	−0.180	0.1	−0.418;0.058	0.009	0.5	−0.018;0.037	−0.024	0.8	−0.196;0.149	−4.93	0.6	−21.7;11.8	−0.108	0.2	−0.287;0.072
	Model 3	−41.4	0.2	−97.7;15.0	−0.217	0.08	−0.463;0.029	0.008	0.6	−0.020;0.036	−0.075	0.4	−0.253;0.103	−3.74	0.7	−21.1;13.6	−0.129	0.2	−0.314;0.057

*Results in the table are for complete cases (*n* = 2140).B, unstandardized beta coefficient.
Model 1: the crude model.
Model 2: adjusted for age, BMI z-score, smoking (ever/never), alcohol use (ever/never), snuff (tobacco) use (ever/never), and education plans measured via Young-HUNT1.
Model 3: model 2 adjustments plus food items for each food item and meals items for each meal item.

Table 6. Associations between paternal diet exposures and child neonatal outcomes (outliers >3 SD excluded) in the Young-HUNT3-MBRN cohort (only first and single births included, complete cases*)

		Weight			Length			Ponderal Index			Head circumference			Placenta weight			Gestational length		
		n = 387			*n* = 382			*n* = 381			*n* = 384			*n* = 387			*n* = 387		
		B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI
Soft drinks (per extra serving/ week)	Model 1	−0.841	0.9	−10.4;8.74	−0.004	0.9	−0.047;0.040	0.001	0.7	−0.004;0.006	0.007	0.7	−0.024;0.037	1.43	0.3	−1.20;4.06	0.010	0.6	−0.023;0.042
	Model 2	−1.62	0.7	−11.5;8.30	−0.005	0.8	−0.051;0.040	0.001	0.7	−0.004;0.006	0.008	0.6	−0.023;0.040	1.21	0.4	−1.54;3.95	0.012	0.5	−0.021;0.046
	Model 3	1.46	0.8	−9.70;12.6	0.012	0.7	−0.040;0.063	0.001	0.8	−0.005;0.006	0.023	0.2	−0.012;0.058	0.952	0.5	−2.12;4.03	0.020	0.3	−0.018;0.058
Crisps (per extra serving/week)	Model 1	−9.79	0.3	−26.8;7.26	−0.001	1.0	−0.080;0.078	−0.004	0.4	−0.013;0.005	−0.028	0.3	−0.082;0.027	−1.131	0.6	−5.82;3.56	0.000	1.0	−0.058;0.058
	Model 2	−5.98	0.5	−23.6;11.6	0.011	0.8	−0.071;0.093	−0.003	0.6	−0.012;0.006	−0.020	0.5	−0.077;0.037	−0.890	0.7	−5.77;3.99	0.009	0.8	−0.052;0.069
	Model 3	−8.85	0.4	−31.1;13.3	0.037	0.5	−0.067;0.140	−0.006	0.3	−0.018;0.005	−0.017	0.6	−0.089;0.054	−2.863	0.4	−9.02;3.29	0.010	0.8	−0.066;0.086
Sweets (per extra serving/ week)	Model 1	−3.10	0.7	−19.2;13.0	−0.029	0.4	−0.104;0.045	0.001	0.9	−0.007;0.009	−0.024	0.4	−0.075;0.028	0.709	0.8	−3.72;5.14	−0.006	0.8	−0.061;0.048
	Model 2	−0.101	1.0	−16.7;16.5	−0.021	0.6	−0.980;0.057	0.002	0.6	−0.006;0.011	−0.014	0.6	−0.068;0.039	0.992	0.7	−3.60;5.59	0.000	1.0	−0.056;0.057
	Model 3	3.78	0.7	−17.5;25.1	−0.049	0.3	−0.149;0.051	0.005	0.4	−0.006;0.016	−0.020	0.6	−0.089;0.049	1.973	0.5	−3.94;7.88	−0.016	0.7	−0.089;0.057
Fruit (per extra serving/week)	Model 1	7.99	0.2	−3.95;19.9	0.041	0.1	−0.014;0.095	−0.001	0.8	−0.007;0.005	0.022	0.3	−0.016;0.059	0.097	1.0	−3.20;3.39	0.007	0.7	−0.034;0.048
	Model 2	9.76	0.1	−2.40;21.9	0.042	0.1	−0.014;0.098	0.000	1.0	−0.006;0.006	0.025	0.2	−0.014;0.063	0.274	0.9	−3.10;3.65	0.009	0.7	−0.033;0.050
	Model 3	6.81	0.4	−9.70;23.3	0.013	0.7	−0.062;0.089	0.003	0.5	−0.005;0.011	0.032	0.2	−0.020;0.084	1.636	0.5	−2.94;6.21	−0.009	0.8	−0.065;0.048
Vegetables (per extra serving/ week)	Model 1	7.83	0.2	−5.00;20.7	0.055	0.07	−0.004;0.113	−0.003	0.4	−0.010;0.003	0.011	0.6	−0.029;0.052	−0.940	0.6	−4.48;2.60	0.022	0.3	−0.022;0.065
	Model 2	9.25	0.2	−3.69;22.2	0.056	0.07	−0.004;0.115	−0.003	0.4	−0.009;0.004	0.011	0.6	−0.030;0.052	−0.779	0.7	−4.37;2.18	0.022	0.3	−0.022;0.067
	Model 3	3.66	0.7	−14.0;21.4	0.044	0.3	−0.038;0.125	−0.004	0.3	−0.013;0.005	−0.013	0.6	−0.069;0.043	−1.065	0.7	−5.99;3.86	0.029	0.3	−0.031;0.090
Whole-grain bread (per extra serving/week)	Model 1	5.75	0.2	−3.26;14.8	0.029	0.2	−0.012;0.070	0.000	0.9	−0.005;0.004	0.028	0.05	0.000;0.056	−1.500	0.2	−3.98;0.98	0.015	0.3	−0.015;0.046
	Model 2	5.10	0.3	−4.18;14.4	0.023	0.3	−0.020;0.065	−0.001	0.8	−0.005;0.004	0.022	0.1	−0.008;0.051	−1.776	0.2	−4.34;0.79	0.012	0.5	−0.020;0.044
	Model 3	3.26	0.5	−6.57;13.1	0.016	0.5	−0.029;0.061	0.000	0.9	−0.005;0.005	0.023	0.2	−0.008;0.054	−1.752	0.2	−4.48;0.97	0.013	0.5	−0.021;0.046
Breakfast (daily versus not daily)	Model 1	−2.11	1.0	−102;98.1	0.152	0.5	−0.305;0.608	−0.034	0.2	−0.085;0.016	0.106	0.5	−0.209;0.421	−9.692	0.5	−37.27;17.9	−0.038	0.8	−0.378;0.301
	Model 2	4.40	0.9	−99.2;108	0.154	0.5	−0.320;0.628	−0.033	0.2	−0.085;0.019	0.085	0.6	−0.244;0.414	−7.531	0.6	−36.3;21.2	−0.034	0.9	−0.388;0.321
	Model 3	−24.5	0.7	−140;91.1	−0.093	0.7	−0.622;0.435	−0.017	0.6	−0.075;0.042	0.103	0.6	−0.267;0.473	−7.201	0.7	−39.5;25.1	0.048	0.8	−0.349;0.446
Lunch (daily versus not daily)	Model 1	33.5	0.5	−66.9;134	0.380	0.1	−0.077;0.836	−0.039	0.1	−0.090;0.011	−0.002	1.0	−0.319;0.315	−11.027	0.4	−38.8;16.7	−0.152	0.4	−0.492;0.189
	Model 2	27.8	0.6	−74.8;130	0.345	0.1	−0.122;0.812	−0.042	0.1	−0.093;0.010	−0.057	0.7	−0.382;0.268	−10.966	0.5	−39.5;17.6	−0.176	0.3	−0.526;0.175
	Model 3	8.6	0.9	−108;125	0.196	0.5	−0.334;0.725	−0.032	0.3	−0.091;0.27	−0.168	0.4	−0.539;0.203	−14.763	0.4	−47.2;17.7	−0.207	0.3	−0.610;0.195
Dinner (daily versus not daily)	Model 1	94.4	0.2	−35.2;224	0.740	0.013	0.155;1.325	−0.034	0.3	−0.099;0.031	0.205	0.3	−0.202;0.613	14.760	0.4	−21.4;50.9	−0.057	0.8	−0.499;0.385
	Model 2	117	0.08	−15.4;249	0.821	0.007	0.222;1.419	−0.029	0.4	−0.095;0.038	0.234	0.3	−0.184;0.652	20.900	0.3	−16.3;58.1	−0.027	0.9	−0.483;0.429
	Model 3	122	0.09	−19.6;263	0.772	0.018	0.133;1.411	−0.010	0.8	−0.081;0.061	0.268	0.2	−0.179;0.714	29.314	0.1	−10.3;68.9	0.044	0.9	−0.443;0.531

*Results in the table are for complete cases (*n* = 391).B, unstandardized beta coefficient.
Model 1: the crude model.
Model 2: adjusted for age, BMI z-score, smoking (ever/never), alcohol use (ever/never), snuff (tobacco) use (ever/never), and education plans measured via Young-HUNT3.
Model 3: model 2 adjustments plus food items for each food item and meals items for each meal item.

Table 7. Associations between diet exposures and child neonatal outcomes (outliers >3 SD excluded) in the pooled Young-HUNT1 and 3-MBRN father–offspring dyads (only first and single births included, complete cases*)

		Weight			Length			Ponderal Index			Head circumference			Placenta weight			Gestational length		
		n = 2497			*n* = 2455			*n* = 2448			*n* = 2483			*n* = 2457			*n* = 2495		
		B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI	B	p-value	95%CI
Soft drinks (per extra serving/ week)	Model 1	−0.141	1.0	−4.96;4.68	−0.005	0.6	−0.026;0.016	0.000	0.9	−0.003;0.002	−0.002	0.8	−0.017;0.014	0.885	0.2	−0.568;2.338	0.003	0.7	−0.013;0.019
	Model 2	−0.126	1.0	−5.13;4.87	−0.005	0.6	−0.027;0.017	0.000	0.7	−0.003;0.002	0.001	0.9	−0.015;0.017	1.01	0.2	−0.495;2.516	0.003	0.7	−0.014;0.019
	Model 3	1.71	0.5	−3.85;7.28	0.000	1.0	−0.025;0.025	−0.001	0.7	−0.003;0.002	0.009	0.3	−0.009;0.026	0.671	0.4	−1.00;2.35	0.007	0.5	−0.011;0.025
Crisps (per extra serving/week)	Model 1	−6.56	0.1	−15.1;1.99	−0.016	0.4	−0.054;0.022	−0.001	0.7	−0.005;0.003	−0.022	0.1	−0.049;0.005	0.630	0.6	−1.93;3.19	−0.016	0.3	−0.045;0.012
	Model 2	−4.55	0.3	−13.3;4.18	−0.008	0.7	−0.047;0.030	−0.001	0.8	−0.005;0.004	−0.015	0.3	−0.043;0.012	1.33	0.3	−1.28;3.95	−0.016	0.3	−0.045;0.013
	Model 3	−3.11	0.6	−13.4;7.16	0.005	0.8	−0.041;0.050	−0.001	0.8	−0.006;0.004	−0.007	0.7	−0.040;0.025	0.423	0.8	−2.65;3.50	−0.021	0.2	−0.055;0.013
Sweets (per extra serving/week)	Model 1	−6.51	0.08	−13.9;0.84	−0.026	0.1	−0.058;0.007	−0.001	0.8	−0.004;0.003	**−0.026**	**0.03**	**−0.049; −0.003**	0.534	0.6	−1.68;2.75	−0.003	0.8	−0.027;0.021
	Model 2	−5.08	0.2	−12.6;2.45	−0.020	0.2	−0.053;0.013	0.000	0.9	−0.004;0.003	−0.020	0.1	−0.044;0.004	1.15	0.3	−1.12;3.43	−0.003	0.8	−0.028;0.022
	Model 3	−5.24	0.3	−14.3;3.83	−0.022	0.3	−0.062;0.018	0.000	1.0	−0.005;0.004	−0.022	0.1	−0.051;0.007	0.323	0.8	−2.41;3.05	0.002	0.9	−0.028;0.032
Fruit (per extra serving/week)	Model 1	1.99	0.4	−2.60;6.57	0.001	0.9	−0.019;0.021	0.001	0.2	−0.001;0.004	0.000	1.0	−0.014;0.015	0.908	0.2	−0.47;2.28	0.002	0.8	−0.013;0.017
	Model 2	2.85	0.2	−1.85;7.55	0.004	0.7	−0.017;0.024	0.002	0.1	0.000;0.004	0.001	0.9	−0.014;0.016	1.19	0.1	−0.22;2.60	0.003	0.7	−0.012;0.019
	Model 3	6.14	0.06	−0.150;12.4	0.025	0.08	−0.003;0.052	0.002	0.2	−0.001;0.005	0.011	0.3	−0.009;0.031	**2.30**	**0.01**	**0.42;4.18**	0.009	0.4	−0.012;0.030
Vegetables (per extra serving/ week)	Model 1	−1.10	0.7	−6.07;3.87	−0.017	0.1	−0.039;0.005	0.001	0.4	−0.001;0.004	−0.007	0.4	−0.023;0.008	−0.317	0.7	−1.81;1.17	−0.004	0.6	−0.021;0.012
	Model 2	−0.60	0.8	−5.66;4.46	−0.016	0.1	−0.039;0.006	0.001	0.3	−0.001;0.004	−0.008	0.3	−0.024;0.008	−0.123	0.9	−1.64;1.39	−0.003	0.7	−0.020;0.014
	Model 3	−4.53	0.2	−11.3;2.26	**−0.035**	**0.02**	**−0.065; −0.005**	0.001	0.7	−0.003;0.004	−0.016	0.1	−0.037;0.006	−1.47	0.2	−3.50;0.56	−0.011	0.3	−0.033;0.012
Whole-grain bread (per extra serving/week)	Model 1	−0.44	0.8	−4.14;3.27	0.006	0.5	−0.010;0.022	**−0.002**	**0.03**	**−0.004;0.000**	0.006	0.3	−0.005;0.018	−1.02	0.07	−2.14;0.09	0.005	0.4	−0.007;0.018
	Model 2	−0.24	0.9	−3.97;3.49	0.005	0.5	−0.011;0.021	−0.002	0.06	−0.004;0.000	0.005	0.4	−0.007;0.016	−0.984	0.09	−2.10;0.14	0.006	0.3	−0.006;0.019
	Model 3	−0.41	0.8	−4.26;4.43	0.007	0.4	−0.010;0.024	**−0.002**	**0.02**	**−0.004;0.000**	0.006	0.3	−0.006;0.018	−1.02	0.09	−2.17;0.14	0.007	0.3	−0.006;0.020
Breakfast (daily versus not daily)	Model 1	13.5	0.5	−30.2;57.2	0.145	0.1	−0.047;0.336	−0.012	0.3	−0.034;0.010	0.100	0.2	−0.038;0.238	−6.18	0.4	−19.3;6.99	0.067	0.4	−0.078;0.211
	Model 2	20.7	0.4	−24.1;65.5	0.162	0.1	−0.034;0.359	−0.009	0.4	−0.031;0.013	0.093	0.2	−0.049;0.234	−4.92	0.5	−18.4;8.56	0.083	0.3	−0.065;0.232
	Model 3	16.2	0.5	−31.8;64.3	0.158	0.1	−0.052;0.369	−0.012	0.3	−0.036;0.012	0.056	0.5	−0.095;0.208	−4.26	0.5	−18.7;10.2	0.115	0.2	−0.044;0.274
Lunch (daily versus not daily)	Model 1	17.9	0.4	−24.1;60.0	0.077	0.4	−0.108;0.262	0.000	1.0	−0.021;0.021	**0.137**	**0.04**	**0.004;0.270**	−4.45	0.5	−17.1;8.22	−0.027	0.7	−0.166;0.113
	Model 2	24.0	0.3	−18.7;66.7	0.087	0.5	−0.101;0.275	0.004	0.7	−0.018;0.025	0.130	0.06	−0.005;0.265	−3.23	0.6	−16.1;9.62	−0.016	0.8	−0.157;0.126
	Model 3	23.1	0.3	−23.1;69.4	0.053	0.6	−0.150;0.257	0.007	0.6	−0.017;0.030	0.119	0.1	−0.028;0.265	−1.86	0.8	−15.8;12.1	−0.028	0.7	−0.181;0.125
Dinner (daily versus not daily)	Model 1	−16.9	0.5	−66.7;32.9	−0.046	0.7	−0.265;0.173	0.000	1.0	−0.025;0.025	0.020	0.8	−0.137;0.177	−2.94	0.7	−18.1;12.2	−0.116	0.2	−0.281;0.049
	Model 2	−11.6	0.7	−61.9;38.7	−0.039	0.7	−0.260;0.182	0.003	0.8	−0.022;0.029	0.012	0.9	−0.147;0.171	−1.50	0.8	−16.7;13.7	−0.105	0.2	−0.272;0.062
	Model 3	−21.7	0.4	−73.9;30.5	−0.089	0.4	−0.318;0.141	0.004	0.8	−0.022;0.030	−0.034	0.7	−0.199;0.131	−0.017	1.0	−15.8;15.8	−0.122	0.2	−0.296;0.051

*Results in the table are for complete cases (*n* = 2531).B, standardized beta coefficient.
Model 1: the crude model.
Model 2: adjusted for age, BMI z-score, smoking (ever/never), alcohol use (ever/never), snuff (tobacco) use (ever/never), and education plans measured via Young-HUNT.
Model 3: model 2 adjustments plus food items for each food item and meals items for each meal item.

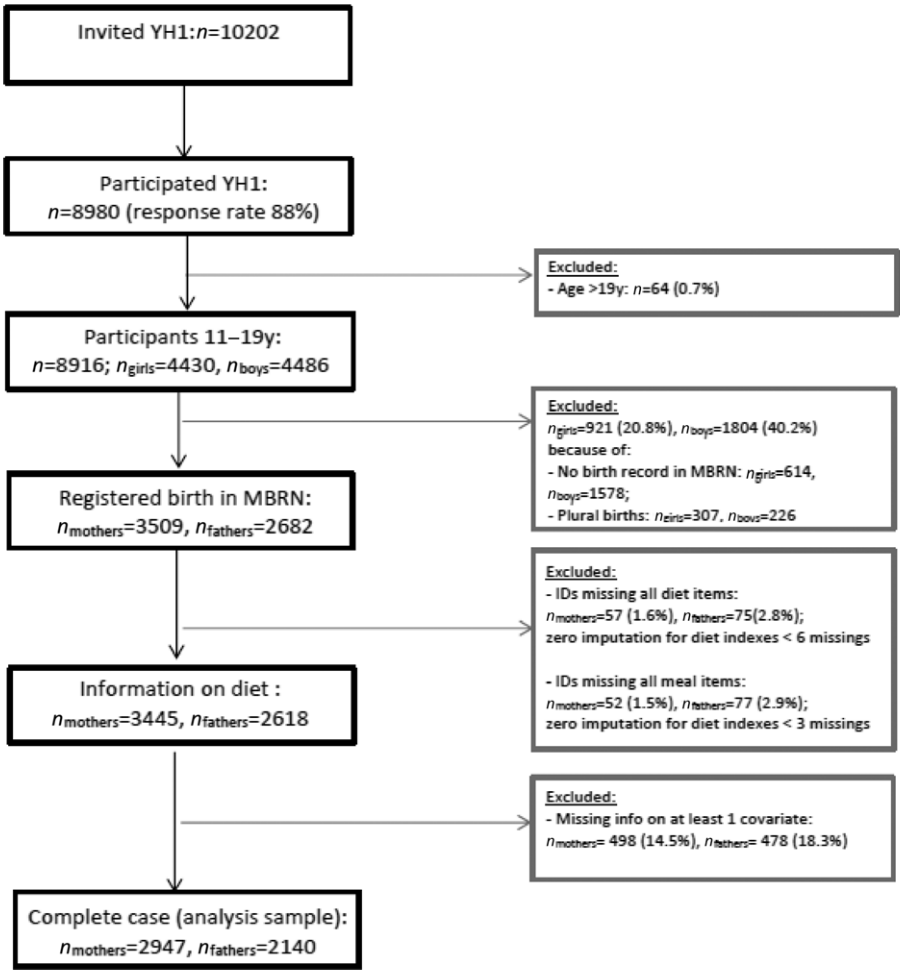

Fig. 1. Flowchart participants Young-HUNT1-MBRN datasets.

adolescence before conception and subsequent neonatal health outcomes. Our study showed several associations between adolescent diet and neonatal outcomes in the Young-HUNT1-MBRN cohort. Greater consumption of energy-dense foods (i.e., crisps, sweets) was associated with a lower birth weight, and more healthy food choices (e.g., whole grain bread, daily breakfast, and lunch) were associated with a slightly larger head circumference. While these results were mostly still evident when we pooled data from the Young-HUNT3 cohort, they were much closer to the null and showed no evidence when examined separately in the smaller Young-HUNT3 cohort. Findings for each exposure were not consistent across outcomes, and some findings were also in unexpected directions, for example, higher vegetable consumption among fathers during adolescence was associated with shorter birth length and among mothers it was associated with a slightly shorter period of gestation. The size of the associations was also small and the dietary exposures were socially patterned, hence even if one or two of the associations reflect a causal pathway between adolescent diet and neonatal outcomes, the effects are likely to be small.

Direct comparisons of our results with other studies are difficult as there are no precedents. Previous longitudinal cohort studies differed in target population and timing of the exposure and only studied birth weight, birth length, and preterm delivery[25,26]. In a US-based study of adolescent mothers ($n = 833$), where measures of diet and offspring neonatal outcomes were much closer together in time, no associations were identified between self-reported diet and birth weight and preterm delivery of offspring[25]. In an Australian cohort of women, lower diet quality 10–15 months before pregnancy (low vegetable and whole-grain intakes) was associated with lower birth weight but not with preterm delivery[27]. One small retrospective cross-sectional study ($n = 309$) found that a dietary pattern 12 months prior to conception that included protein-rich foods, fruit, and whole grains was associated with reduced likelihood for preterm delivery, while a dietary pattern that included energy-dense foods was associated with increased likelihood for preterm delivery and shorter birth length[26]. However, small sample size and retrospective dietary assessment (e.g., recall bias) temper the conclusions of the study. Some of the relationships found in our study complemented the previous studies[26,27], energy-dense foods appeared to have a (small) detrimental impact on certain neonatal outcomes and healthier dietary habits appeared somewhat protective. Nevertheless, some of our findings (i.e., harmful effects of vegetables and daily dinner) were unexpected and difficult to explain which alongside the number of comparisons made, hints at sampling variation as a likely explanation.

A major strength of this study is the large sample of parent–offspring dyads, the replication of analyses with the Young-HUNT3 cohort and pooled analyses, combined with the precise measures of the neonatal health outcomes from the MBRN provide an unparalleled data set to explore the research questions. The generalizability from Nord-Trøndelag to Norway is considered good; the region has representative geography, economy, industry, sources of income, age distribution, morbidity, and mortality[14,15]. However, the relative well-being and stable socioeconomic status of the Norwegian population, compared to non-Scandinavian countries with more diverse and high-risk populations and diet variability, could influence both study compliance and results[28].

Our study has several limitations. First, methods employed in the Young-HUNT survey raise some concerns. One-time measures of adolescents' diet may not accurately reflect actual dietary habits which may fluctuate over time[10]. Diet items were self-reported and may suffer from social desirability bias. Single items were used to measure diet which may increase measurement error and may not reflect overall diet quality. Nevertheless, measures showed adequate reliability and validity[18]. A five-point Likert scale might lack sensitivity to reflect accurately adolescents' complex dietary habits. Frequency distributions (data available on request) indicated that healthy food items were skewed toward the higher end of the scale, while unhealthy food items were skewed toward the lower end, except for adolescent boys' soft drink intake, which was skewed toward the higher end of the scale in contrast to the adolescent girls. More nuanced response categories could increase the discrimination capacity of diet items[29]. Periconceptual weight status and (un)healthy lifestyle behaviors are also known to impact neonatal health outcomes[3]. However, for this study, only covariates measured in adolescence were included and covariates in adulthood were not included, nor adjusted for. Second, diet habits of this cohort were not tracked into adulthood and their nutritional status was not assessed at either time point. It was not possible in the current study to confirm whether dietary patterns of the participants tracked into (preconception) adulthood, which may alter impact on neonatal outcomes[12]. Preconception nutritional status, instead of diet, might be a better predictor of the health of the next generation, and diet during adolescence is not synonymous with present and future nutritional status. Nutritional status is defined as an individual's health condition as influenced by the intake and utilization of nutrients[30]. Existing evidence highlights the impact of parents' periconceptual nutritional status on neonatal outcomes[4–7], whereas the influence of diet has been overlooked[3]. Future research therefore must consider both diet patterns and nutritional status in adolescence as well as adulthood. Another limitation entails the comparability of the Young-HUNT3 cohort in the replication study with the main cohort. Due to the more limited time frame between the data collection of the Young-HUNT3 cohort and our study, it is likely that not all included adolescent participants had the opportunity to have their first child resulting in a slightly younger maternal age at delivery in the Young-HUNT3 cohort.

The present study presents a unique prospective design examining the relationships between diet measured in adolescence and neonatal health of the next generation. Though we cannot confirm any specific effects of diet measured in adolescence on offspring health when individuals become parents in adulthood, we also cannot rule out an effect. If effects are present, then further longitudinal studies in larger samples and different populations with more current state-of-the-art dietary measures and different confounding structures are needed to replicate our findings with more precision.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/S2040174420001087

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Authors' contributions. WVL, FNV, ERH, NCO were involved in the design of the research (project conception and development of the research plan). WVL, AKW, NCO conducted the analyses on the data of Young-HUNT. WVL, AKW, FNV, ERH, NCO were involved in the interpretation of the analyses. WVL, AKW drafted the manuscript. All authors contributed to interpretation of the results and provided feedback on the drafts before submission. All authors approved the submitted manuscript.

Conflicts of interest. The authors declare no competing interests.

Ethical standards. The Young-HUNT study adhered to the Helsinki Declaration and was approved by the Norwegian Data Inspectorate, the Regional and National Committees for Medical and Health Research Ethics in Norway, and the Norwegian Directorate of Health. Additional consent for this specific study was provided by the Central Regional Committee for Medical and Health Research Ethics in Norway (Reference: 2017/1220/REK midt).

Data sharing. The Nord-Trøndelag Health Study (HUNT) has invited persons aged 13–100 years to three surveys between 1994 and 2008 and is now running a new survey (HUNT4) since 2017. Comprehensive data from more than 125,000 persons having participated at least once and biological material from 78,000 persons are collected. The data are stored in HUNT databank and biological material in HUNT biobank. HUNT Research Centre has permission from the Norwegian Data Inspectorate to store and handle these data. The key identification in the data base is the personal identification number given to all Norwegians at birth or immigration, while de-identified data are sent to researchers upon approval of a research protocol by the Regional Ethical Committee and HUNT Research Centre. To protect participants' privacy, HUNT Research Centre aims to limit storage of data outside HUNT databank and cannot deposit data in open repositories. HUNT databank has precise information on all data exported to different projects and is able to reproduce these on request. There are no restrictions regarding data export given approval of applications to HUNT Research Centre. For more information see: http://www.ntnu.edu/hunt/data.

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