OPEN ACCESS

Original research

Early-life diet and risk of inflammatory bowel disease: a pooled study in two Scandinavian birth cohorts

Annie Guo ,[1] Johnny Ludvigsson ,[2,3] Anne Lise Brantsæter ,[4] Sofia Klingberg ,[5] Malin Östensson ,[6] Ketil Størdal ,[7,8] Karl Mårild [1,9]

► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/gutjnl-2023-330971).

For numbered affiliations see end of article.

Correspondence to
Annie Guo, Department of Pediatrics, University of Gothenburg, Gothenburg 405 30, Sweden; annie.guo@gu.se

KS and KM are joint senior authors.

Received 23 August 2023
Accepted 23 December 2023
Published Online First 30 January 2024

Watch Video
gut.bmj.com

ABSTRACT

Objective We assessed whether early-life diet quality and food intake frequencies were associated with subsequent IBD.

Design Prospectively recorded 1-year and 3-year questionnaires in children from the All Babies in Southeast Sweden and The Norwegian Mother, Father and Child Cohort Study were used to assess diet quality using a Healthy Eating Index and intake frequency of food groups. IBD was defined as >2 diagnoses in national patient registers. Cox regression yielded HRs adjusted (aHRs) for child's sex, parental IBD, origin, education level and maternal comorbidities. Cohort-specific results were pooled using a random-effects model.

Results During 1 304 433 person-years of follow-up, we followed 81 280 participants from birth through childhood and adolescence, whereof 307 were diagnosed with IBD. Compared with low diet quality, medium and high diet quality at 1 year of age were associated with a reduced risk of IBD (pooled aHR 0.75 (95% CI=0.58 to 0.98) and 0.75 (95% CI=0.56 to 1.00)). The pooled aHR per increase of category was 0.86 (0.74 to 0.99). Pooled aHR for children 1 year old with high versus low fish intake was 0.70 (95% CI=0.49 to 1.00) for IBD, and showed association with reduced risk of UC (pooled aHR=0.46; 95% CI=0.21, 0.99). Higher vegetable intake at 1 year was associated with a risk reduction in IBD. Intake of sugar-sweetened beverages was associated with an increased risk of IBD. Diet quality at 3 years was not associated with IBD.

Conclusion In this Scandinavian birth cohort, high diet quality and fish intake in early life were associated with a reduced risk of IBD.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Studies in adult populations suggest that poor diet quality may increase the risk of later IBD.
⇒ Research on childhood diet and IBD is scarce and has been restricted to retrospective data.

WHAT THIS STUDY ADDS

⇒ In this first prospective examination of early-life diet, high diet quality at 1 year of age was associated with reduced risk of subsequent IBD.
⇒ High intake of fish and vegetables was associated with a reduced risk of IBD, while a high intake of sugar-sweetened beverages was associated with an increased risk of IBD in children 1 year old.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ These novel findings suggest that early-life diet, particularly at 1 year of age, is important for later IBD development and support further research in this field to understand the role of diet in the prevention of IBD.

INTRODUCTION

IBD, mainly including the subtypes Crohn's disease (CD) and UC, is a globally rising immune-mediated disease characterised by relapsing inflammation in the GI tract. Although the reason for the increased incidence of IBD is unknown, changes in environmental factors, such as diet, may partially explain the recent increase in the incidence IBD.[1]

Studies in adult populations have suggested that a high intake of sugar,[2] fat[3] and red meat[4] increases the risk of IBD. In contrast, high consumption of fruits,[5 6] vegetables[5] and fish,[7] as well as high diet quality,[8] are associated with reduced risk of IBD. Although diet in early life is critical for the development of the gut microbiome and gut immune tolerance,[9] diet has primarily been assessed in adulthood and few studies have assessed childhood diet in IBD risk (online supplemental table 1). Retrospective data of adolescents' diet suggest that high intake of vegetables and polyunsaturated fatty acids (PUFAs) may lower risk of IBD, whereas a high intake of sugary soft drinks increases the risk of IBD.[10] The association between diet during the first 3 years of life and later IBD development has not been examined using prospective data, which may improve causal inference of results.

To our knowledge, this is the first study to prospectively investigate the association between early-life diet quality and intake frequency of specific food groups and later IBD risk by using two Scandinavian birth cohort studies.

MATERIALS AND METHODS

Study population

We used data from the All Babies in Southeast Sweden (ABIS) Study and The Norwegian Mother, Father and Child Cohort Study (MoBa), which are parallel birth cohorts with large similarities in design and data characteristics (figure 1).[11 12] Briefly, all 21 700 children born in Southeast Sweden from October 1997 to October 1999 were invited to participate in

Linked
► http://dx.doi.org/10.1136/gutjnl-2023-331849

Check for updates

To cite: Guo A, Ludvigsson J, Brantsæter AL, *et al*. *Gut* 2024;**73**:590–600.

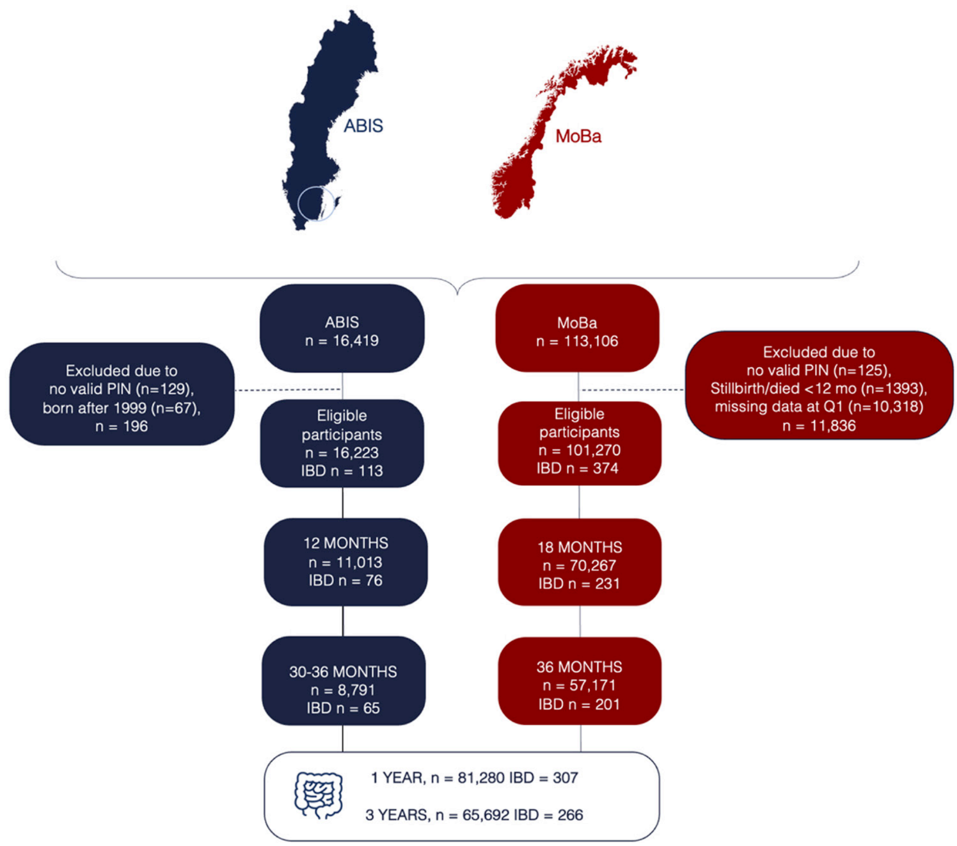

Figure 1 Flow chart of the study population in the All Babies in Southeast Sweden (ABIS) and The Norwegian Mother, Father and Child Cohort Study (MoBa). There were no available data on stillbirths/death <12 months of age in ABIS. PIN, personal identification number.

ABIS (79% participation rate). MoBa is a population-based pregnancy cohort conducted by the Norwegian Institute of Public Health. Pregnant women were recruited throughout Norway from 1999 to 2008 (41% participation rate). The cohort includes 114 500 children, 95 200 mothers and 75 200 fathers.[13] We took advantage of ABIS questionnaires administered at birth, age 12 and 30–36 months and MoBa questionnaires administered during pregnancy, age 6, 18 and 36 months (online supplemental figure 1). The cohorts also contain individual-level data linked through personal identity numbers from the national health registers of Sweden[14–16] and Norway.[17 18] This study restricted participation to 81 280 and 65 692 children with any food data recorded at age 1 or 3 years (figure 1).

Early-life diet

Information about early-life diet was obtained from specific food questions included in comprehensive questionnaires administered at 12 and 30–36 months in ABIS and at 18 and 36 months in MoBa. The questionnaires contained information on the child's upbringing and lifestyle habits, including the child's food intake at the time of filling in the questionnaires. The food questions cover intake of meat, fish, fruits, vegetables, breast milk, porridge, baby foods, sweets and snacks, and beverages and have been used in several studies of diet-outcome associations.[13 19–23] Due to lack of data, they have not been compared with any other dietary assessment tool. In both cohorts, parents reported the child's current intake frequency of a standard portion of specified food items with four to seven response alternatives ranging from never to ≥4 times per day. Each questionnaire contained 40–50 food items, and we converted all data to weekly frequency intake. To reduce the risk of erroneously recorded data, the child's food intake level was within each cohort modelled as a trichotomous exposure variable. A more detailed description is provided in the online supplemental file 1.

Because of the wording of the food questions and in line with previous studies,[24 25] children with incomplete food data but information from at least one food group were categorised into the lowest frequency category. Among those 1 year old included in the analyses, 73% and 95% had complete data on food groups in ABIS and MoBa, respectively. Only 2% (ABIS) and <1% (MoBa) had data on less than half of the food groups. To reduce the influence from erroneously reported food intake frequencies, 1613 children (<0.1%) in ABIS and MoBa were excluded from at least one food group analysis (eg, intake of >88 portions of dairy per week was assumed to be implausibly high).

We examined two measures of the child's diet at 1 and 3 years of age: diet quality and nine specific food groups.

Measure 1. *Diet quality* was examined using a modified version of the Health Eating Index (HEI) developed to specifically measure the child's diet.[26] The modified HEI reflects the child's overall dietary quality, rather than food quantity and energy intake. This index included the intake of seven food groups: 'fruits and vegetables', 'dairy foods', 'meat', 'fish and eggs', 'soft drinks', 'salty snacks' and 'sweet snacks' (online supplemental tables 2 and 3).[26] The intake of each food group was categorised by ranking weekly intake frequency by quartiles with a score of 1–4. Based on WHO dietary recommendations for children,[27] being in the lowest intake category for 'healthy food groups' (eg, fruits and vegetables and fish and eggs) was assigned 1 point, the highest intake category was assigned 4 points, and vice versa for unhealthy foods, such as salty snacks and sweet snacks. Finally, the total HEI score, ranging from 7 to 28, with a higher score indicating a higher dietary quality, was divided into thirds representing low, medium and high diet quality.

Measure 2. We assessed the intake frequencies of the following *food groups* previously examined in relation to IBD[10 28]: meat, fish, dairy, fruits, vegetables, grains, potatoes, sugar-dense and fat-dense food, and sugar-sweetened beverages (SSBs) (online supplemental tables 3 and 4). We refer to food intake as the weekly intake frequency of each food group. All intake of food groups was divided into thirds representing low, medium and high food intake, except for the intake of SSBs at 1 year of age, which was dichotomised into no or some intake (≥0.5 serving/week).

Inflammatory bowel disease

We defined IBD as a minimum of two International Classification of Disease 10th Revision (ICD-10) codes for IBD in the Swedish National Patient Register[15] (ABIS) and the Norwegian Patient Registry[17] (MoBa) (online supplemental table 5). These registers contain nationwide data on inpatient and hospital-based outpatient care.[17 29] Data on IBD were captured until 31 December 2020 in ABIS and 31 December 2021 in MoBa. We used subtype-specific ICD codes to define CD and UC. Cases with a mix of ICD codes for CD and UC during the last 5 years of study follow-up were defined as IBD-unclassified (IBD-U). While included in the outcome of any IBD, we a priori decided not to assess IBD-U as a separate outcome because of the limited number of cases and risk of misclassification. In Sweden, this register-based definition of IBD has a positive predictive value of 93.0% on medical record review.[30 31]

Other data

We used ABIS parental-reported questionnaire data administered at the child's birth up to 12 months of age, MoBa questionnaire data reported at pregnancy week 15 up to 6 months of age and register-based data to retrieve information on the child's sex, parental origin, parental education level, parental IBD, maternal comorbidities, delivery mode, maternal smoking during pregnancy, maternal age at delivery, birth weight, gestational age and full breastfeeding duration (online supplemental table 6). Data were captured at one time point, except for maternal smoking which in MoBa was captured throughout the pregnancy and the first 6 months after birth (online supplemental table 6). Based on previous literature,[32] maternal immune-mediated comorbidity was considered a potential confounder and included type 1 diabetes (T1D (insulin-treated diabetes before or during pregnancy (MoBa) or T1D/insulin-treated diabetes (ABIS)), autoimmune thyroid disease or rheumatoid arthritis. Parental origin was defined as the mother's native language (MoBa) or the parent's country of birth (ABIS). Data on age at weaning, antibiotic use and formula intake were reported at age 12 (ABIS) and 18 months (MoBa). We also captured data on household income, defined by annual gross income.

Statistical analyses

Cox regression was used to estimate HRs and 95% CIs for IBD, CD and UC. Subanalyses for the outcome CD ignored events of other IBD subtypes and vice versa in UC-specific analyses. The proportional hazard assumption was tested using Schoenfeld residuals[33] by graphically assessing the data and exploring interactions with time. The assumption was valid for all IBD analyses. The heterogeneity between the two cohorts was examined by using the Cochran Q test and I^2 test. Due to low/moderate heterogeneity for all IBD analyses, pooled HRs were calculated using a random-effects model.[34] Follow-up started at the child's age of 1 and 3 years and ended at the time of first IBD diagnosis or censoring at the end of data capture (31 December 2020 in ABIS and 31 December 2021 in MoBa).

Our main analyses were adjusted for the child's sex, parental IBD, origin, education level and maternal comorbidities (model 1). Model 2 was additionally adjusted for delivery mode, maternal smoking during pregnancy, maternal age at delivery, birth weight, gestational age and full breastfeeding duration. Preplanned subanalyses considered the risk of childhood-onset IBD diagnosed <18 years of age. We also performed sensitivity analyses excluding children with incomplete dietary data. Finally, we reran our analyses for the child's diet quality at 1 year of age after excluding children diagnosed with IBD <6 years of age, which often constitutes a highly genetically determined subtype of IBD.[35] Statistical analyses were performed using SPSS (V.29) and R Statistical Software (V.4.1.3 and 4.2.2), including the R packages survival, survminer, meta and metafor. We did not adjust for multiple comparison as all analyses shared an underlying hypothesis.[36]

Post hoc analyses

To reduce the risk of residual confounding, we additionally adjusted for household income level, intake of formula at 1 year of age and antibiotics exposure. We assessed the potential interaction between diet quality at 1 year of age and breast feeding, parental IBD, child's sex and maternal education. To test the robustness of UC and CD-specific analyses, we reran our analyses after changing the definition of IBD-U to only include children with a mix of codes in the last 2 years of follow-up.

Patient and public involvement

No patients participated in the design of the study.

RESULTS

We included a total of 81 280 children, 11 013 (48% girls) from ABIS and 70 267 (49% girls) from MoBa, with any dietary data at 1 year of age (figure 1). During 1 304 433 person-years of follow-up, 307 children were diagnosed with IBD (CD, n=131; UC, n=97; IBD-U, n=79), corresponding to an incidence rate of 32 per 100 000 person-years in ABIS and 22 per 100 000 person-years in MoBa (online supplemental table 7). Age at weaning was for most children at 4–6 months (table 1 and online supplemental table 8). The median follow-up time from 1 year of age was 21.3 years (ABIS) and 15.2 years (MoBa), and was related to the varying length of follow-up for these cohorts (online supplemental table 8). A total of 65 692 children remained with any food data recorded at 3 years of age. In MoBa, but not in ABIS, low maternal and paternal education levels were more common in children with low diet quality at 1 year of age (table 1). Maternal age, smoking status and incidence of IBD were similar in children with dietary data compared with all cohort participants (online supplemental table 9). The distribution of diet quality categories and food intake frequency partially changed between 1 and 3 years of age in particular with increased intake of SSBs and fruits observed in ABIS and MoBa, respectively (online supplemental table 10).

Diet quality

Accounting for the child's sex, parental IBD, origin, education level and maternal comorbidities (model 1), a high versus low diet quality at 1 year of age was associated with an adjusted HR (aHR) of 0.61 (95% CI=0.33 to 1.14) for IBD risk in ABIS and

Table 1 Characteristics of children at 1 year of age in the ABIS and MoBa birth cohorts

	ABIS (n=11 013)			MoBa (n=70 267)		
	Diet quality at 1 year of age			Diet quality at 1 year of age		
Characteristics	Low (n=4549)	Medium (n=3437)	High (n=3027)	Low (n=21 389)	Medium (n=26 637)	High (n=22 241)
IBD*	37 (0.8)	25 (0.7)	14 (0.5)	91 (0.4)	75 (0.3)	65 (0.3)
CD	18 (0.4)	8 (0.2)	3 (0.1)	35 (0.2)	36 (0.1)	31 (0.1)
UC	14 (0.3)	13 (0.4)	8 (0.3)	24 (0.1)	21 (0.1)	17 (0.1)
Child's sex						
Girls	2213 (48.6)	1617 (47.0)	1460 (48.2)	10 242 (47.9)	13 086 (49.1)	11 012 (49.5)
Boys	2336 (51.4)	1820 (53.0)	1567 (51.8)	11 147 (52.1)	13 551 (50.9)	11 229 (50.5)
Follow-up (years)						
Mean (SD)	21.2 (1.0)	21.7 (0.8)	21.3 (0.9)	15.6 (1.9)	15.2 (2.0)	14.9 (1.9)
Median (IQR)	21.3 (20.9–21.6)	21.4 (20.9–21.7)	21.4 (21.0–21.8)	15.7 (14.7–16.8)	15.2 (14.2–16.2)	14.7 (13.7–15.6)
Parental origin†						
Sweden/Norway	3958 (87.0)	3089 (89.9)	2695 (89.0)	20 232 (94.6)	25 105 (94.2)	20 783 (93.4)
Missing data	98 (2.2)	76 (2.2)	66 (2.2)	187 (0.9)	212 (0.8)	187 (0.8)
Maternal education level (years)‡						
≤11	393 (8.6)	222 (6.5)	174 (5.7)	1710 (8.0)	1554 (5.8)	969 (4.4)
12	2509 (55.2)	1879 (54.7)	1583 (52.3)	6976 (32.6)	7069 (26.5)	5147 (23.1)
≥13	1543 (33.9)	1255 (36.5)	1208 (39.9)	12 437 (58.1)	17 686 (66.4)	15 861 (71.3)
Missing data	104 (2.3)	81 (2.4)	62 (2.0)	266 (1.2)	328 (1.2)	264 (1.2)
Paternal education level (years)‡						
≤11	629 (13.8)	392 (11.4)	377 (12.5)	2560 (12.0)	2355 (8.8)	1539 (6.9)
12	2658 (58.4)	2047 (59.6)	1685 (55.7)	9075 (42.4)	10 046 (37.7)	7527 (33.8)
≥13	1106 (24.3)	867 (25.2)	863 (28.5)	8946 (41.8)	13 265 (49.8)	12 351 (55.5)
Missing data	156 (3.4)	131 (3.8)	102 (3.4)	808 (3.8)	971 (3.6)	824 (3.7)
Parental IBD§						
Yes	59 (1.3)	51 (1.5)	31 (1.0)	532 (2.5)	641 (2.4)	537 (2.4)
Maternal comorbidities¶						
Yes	140 (3.1)	123 (3.6)	122 (4.0)	877 (4.1)	1092 (4.1)	884 (4.0)
Maternal smoking in pregnancy						
Yes	473 (10.4)	300 (8.7)	236 (7.8)	2218 (10.4)	1992 (7.5)	1307 (5.9)
Missing	103 (2.3)	79 (2.3)	65 (2.1)	264 (1.2)	311 (1.2)	292 (1.3)
Maternal age at delivery (years)**						
<25	735 (16.1)	462 (13.4)	358 (11.8)	2514 (11.7)	2458 (9.2)	1667 (7.5)
25–34	3221 (70.6)	2525 (73.5)	2171 (71.7)	15 384 (71.9)	19 330 (72.5)	16 349 (73.5)
35–44	528 (11.6)	377 (10.9)	453 (15.0)	3485 (16.3)	4837 (18.2)	4208 (18.9)
Missing data	75 (1.6)	73 (2.1)	45 (1.5)	6 (0.0)	12 (0.0)	17 (0.1)
Delivery mode						
Vaginal	3694 (81.2)	2756 (80.2)	2455 (81.1)	18 284 (85.5)	22 779 (85.5)	18 926 (85.1)
Caesarean	515 (11.3)	404 (11.8)	321 (10.6)	3105 (14.5)	3858 (14.5)	3315 (14.9)
Missing data	340 (7.5)	277 (8.1)	251 (8.3)	0 (0.0)	0 (0.0)	0 (0.0)
Birth weight (g)††						
Mean (SD)	3571 (554)	3592 (2)	3580 (533)	3596 (578)	3577 (576)	3540 (580)
Missing data	49 (1.1)	35 (1.0)	26 (0.9)	6 (0.0)	16 (0.1)	17 (0.1)
Gestational age (weeks)‡‡						
Mean (SD)	39.7 (1.8)	39.7 (1.7)	39.8 (1.7)	39.4 (1.8)	39.4 (1.9)	39.4 (1.9)
Missing data	85 (1.9)	56 (1.6)	53 (1.8)	84 (0.4)	118 (0.4)	87 (0.4)
Full breast feeding (months)						
<4	1087 (23.9)	845 (24.6)	743 (24.5)	8717 (40.8)	10 360 (38.9)	8564 (38.5)
4–6	1387 (30.5)	1077 (31.3)	938 (31.0)	9424 (44.1)	11 711 (44.0)	9426 (42.4)
>6	630 (13.8)	456 (13.3)	431 (14.2)	2456 (11.5)	3574 (13.4)	3415 (15.4)
Missing data	1445 (31.8)	1059 (30.8)	905 (30.2)	792 (3.7)	992 (3.7)	836 (3.8)
Age at food introduction (months)						
<4	2716 (59.7)	1757 (51.1)	1426 (47.1)	1511 (7.1)	1391 (5.2)	829 (3.7)
4–6	1810 (39.8)	1675 (48.7)	1600 (52.9)	18 543 (86.7)	23 580 (88.5)	19 979 (89.8)
>6	22 (0.5)	5 (0.1)	1 (0.0)	543 (2.5)	674 (2.5)	597 (2.7)

Continued

Table 1 Continued

Characteristics	ABIS (n=11 013)			MoBa (n=70 267)		
	Diet quality at 1 year of age			Diet quality at 1 year of age		
	Low (n=4549)	Medium (n=3437)	High (n=3027)	Low (n=21 389)	Medium (n=26 637)	High (n=22 241)
Missing data	1 (0.0)	0 (0.0)	0 (0.0)	792 (3.7)	992 (3.7)	836 (3.8)

Data are shown as numbers (percentages) unless indicated otherwise.
*Including IBD-U events.
†Mother's native language (MoBa)/parent's country of birth (ABIS).
‡Education at time of birth.
§Defined as having at least one parent with IBD.
¶Type 1 diabetes (insulin-treated diabetes before or during pregnancy (MoBa) or type 1 diabetes/insulin-treated diabetes (ABIS)), autoimmune thyroid disease or rheumatoid arthritis.
**<15 years was defined as missing in ABIS (not applicable in MoBa) and >44 years was changed to missing in both cohorts.
††<270 or >6999 g was changed to missing. <22 or >45 weeks was changed to missing.
‡‡<22 or >45 weeks was changed to missing.
ABIS, All Babies in Southeast Sweden; CD, Crohn's disease; IBD-U, IBD-unclassified; MoBa, The Norwegian Mother, Father and Child Cohort Study.

0.79 (95% CI=0.57 to 1.10) in MoBa (online supplemental table 11). In pooled analyses, children 1 year old with medium or high diet quality (vs low diet quality) had a reduced risk of later IBD (pooled HR=0.74 (95% CI=0.57 to 0.97) and 0.73 (95% CI=0.55 to 0.97), respectively; figure 2). Estimates remained largely unchanged in model 1 (medium diet quality, pooled aHR=0.75 (95% CI=0.58 to 0.98); high diet quality, pooled aHR=0.75 (95% CI=0.56 to 1.00); figure 2) and further in model 2 adjusting for full breastfeeding duration and perinatal characteristics (online supplemental table 12). Cohort-specific estimates for CD and UC are reported in online supplemental table 13. The pooled analyses of high versus low diet quality at 1 year of age showed no association with later CD (figure 3) or UC (figure 4).

High versus low diet quality at age 3 years was not associated with later IBD in neither cohort-specific (online supplemental table 15) nor pooled analyses (pooled aHR=1.02 (95% CI=0.76 to 1.37); online supplemental figure 2). Likewise, diet quality at 3 years was not associated with CD or UC risk (online supplemental tables 16 and 17 (cohort-specific results); online supplemental figures 3 and 4) (pooled results)).

Food groups

The meta-analysis of estimates across the cohorts showed that children with high versus low fish intake at 1 year were at a reduced risk of later IBD (pooled HR=0.66 (95% CI=0.46 to 0.93); per category increase, pooled HR=0.82 (95% CI=0.70 to 0.97); figure 2). This estimate remained largely unchanged after adjustments in model 1 (pooled aHR=0.70 (0.49 to 1.00); figure 2) and model 2 (online supplemental table 12). Pooled analyses of high versus low fish intake at 1 year yielded an aHR of 0.67 (95% CI=0.39 to 1.17; figure 3) for CD and 0.46 for UC (95% CI=0.21 to 0.99; figure 4). Cohort-specific estimates of fish intake for children 3 years old and IBD, CD and UC risk are presented in online supplemental tables 15–17. The pooled aHR for IBD risk among children with high versus low fish intake at 3 years of age was 0.78 (95% CI=0.55 to 1.09; model 1; online supplemental figure 2). A high versus low fish intake at 3 years of age was associated with a reduced risk of UC (pooled aHR=0.46 (95% CI=0.24 to 0.90); model 1; online supplemental figure 4) but not CD (online supplemental figure 3).

The pooled analyses demonstrated that medium and high versus low vegetable intake at 1 year of age were associated with a reduced risk of IBD (medium, pooled HR 0.66 (95% CI=0.49 to 0.89); high, 0.72 (95% CI=0.55 to 0.95), respectively; figure 2), with similar estimates in model 1 (figure 2). Pooled analyses showed no association between vegetable intake at 3 years and later risk of IBD or its subtypes (online supplemental figures 2–4).

At age 1 year, 72% (n=58 730 of 81 280) reported intake of SSBs. Cohort-specific aHRs for IBD, CD and UC risk of some versus no intake of SSBs at 1 year of age are presented in online supplemental tables 11–13. The pooled aHRs showed that having some versus no intake of SSBs at 1 year of age was associated with an increased risk of later IBD (pooled aHR=1.42 (95% CI=1.05 to 1.90); model 1; figure 2). Pooled aHRs were 2.10 (95% CI=0.56 to 7.88; model 1) for CD and 0.92 (95% CI=0.25 to 3.26; model 1) for UC (figures 3 and 4). In contrast, cohort-specific and pooled analyses did not show any association between intake of SSBs at 3 years of age and later risk of IBD or its subtypes (online supplemental figures 2–4 and online supplemental tables 15–17).

Pooled analyses (figures 2–4 and online supplemental figures 2–4) and cohort-specific analyses (online supplemental tables 11, 13–17) showed no association between the other examined food groups, including meat, dairy, fruits, grains, potatoes and sugar-dense and fat-dense food, and risk of IBD, CD or UC.

Subanalyses

In line with our main results, childhood-onset IBD (<18 years) was inversely associated with diet quality at age 1 year, but not diet quality at age 3 years (online supplemental table 18).

Results were also largely unchanged in analyses excluding children with incomplete dietary data (online supplemental tables 19 and 20). Excluding children with very early-onset IBD diagnosis (<6 years, n=28) resulted in unchanged estimates (online supplemental table 21).

Post hoc analyses

Additionally, adjustment for (1) formula intake, (2) household income and (3) antibiotic use by age 1 year, all yielded essentially unchanged results (online supplemental tables 22–24). Also, there was no significant interaction between diet quality and IBD risk for any of the examined variables (online supplemental table 25). Changing the IBD-U definition from having a mix of codes in the last 5 years to the last 2 years of follow-up resulted in largely unchanged estimates (online supplemental table 26).

Diet exposure	Total N	IBD Event	Unadjusted HR (95%CI)	Model 1 aHR (95%CI)
Diet quality				
Low	25,935	128	*Reference*	*Reference*
Medium	30,069	99	**0.74 (0.57, 0.97)**	**0.75 (0.58, 0.98)**
High	25,268	79	**0.73 (0.55, 0.97)**	0.75 (0.56, 1.00)
Per increase in category			**0.84 (0.73, 0.97)**	**0.86 (0.74, 0.99)**
Meat				
Low	20,276	95	*Reference*	*Reference*
Medium	33,074	108	0.76 (0.58, 1.00)	0.78 (0.59, 1.04)
High	27,930	104	0.89 (0.67, 1.19)	0.94 (0.70, 1.27)
Per increase in category			0.95 (0.82, 1.11)	0.99 (0.85, 1.15)
Fish				
Low	18,464	101	*Reference*	*Reference*
Medium	37,382	135	0.79 (0.60, 1.03)	0.82 (0.62, 1.08)
High	25,434	71	**0.66 (0.46, 0.93)**	0.70 (0.49, 1.00)
Per increase in category			**0.82 (0.70, 0.97)**	0.85 (0.71, 1.00)
Dairy				
Low	26,302	95	*Reference*	*Reference*
Medium	26,402	90	0.93 (0.70, 1.24)	0.99 (0.74, 1.32)
High	28,576	122	1.12 (0.86, 1.47)	1.16 (0.89, 1.53)
Per increase in category			1.07 (0.93, 1.22)	1.08 (0.94, 1.25)
Fruits				
Low	23,230	91	*Reference*	*Reference*
Medium	44,147	143	0.92 (0.58, 1.47)	0.99 (0.53, 1.85)
High	13,903	73	0.94 (0.53, 1.66)	0.96 (0.48, 1.92)
Per increase in category			0.98 (0.70, 1.38)	1.00 (0.68, 1.48)
Vegetables				
Low	19,270	89	*Reference*	*Reference*
Medium	25,543	81	**0.66 (0.49, 0.89)**	**0.68 (0.50, 0.93)**
High	36,467	137	**0.72 (0.55, 0.95)**	0.77 (0.58, 1.03)
Per increase in category			**0.85 (0.74, 0.98)**	0.88 (0.76, 1.02)
Grains				
Low	26,695	116	*Reference*	*Reference*
Medium	25,943	80	0.79 (0.54, 1.17)	0.80 (0.56, 1.15)
High	28,642	111	0.91 (0.63, 1.32)	0.94 (0.67, 1.32)
Per increase in category			0.94 (0.82, 1.08)	0.96 (0.84, 1.11)
Potatoes				
Low	13,401	69	*Reference*	*Reference*
Medium	36,990	132	1.16 (0.78, 1.74)	1.19 (0.78, 1.83)
High	30,889	106	0.80 (0.57, 1.12)	0.84 (0.59, 1.20)
Per increase in category			0.88 (0.75, 1.02)	0.89 (0.76, 1.05)
Sugar–and fat–dense food				
Low	24,543	88	*Reference*	*Reference*
Medium	30,044	119	1.19 (0.90, 1.57)	1.19 (0.89, 1.58)
High	26,693	100	1.05 (0.78, 1.41)	1.05 (0.78, 1.41)
Per increase in category			1.03 (0.89, 1.18)	1.03 (0.89, 1.19)
Sugar–sweetened beverages				
No intake	22,550	88	*Reference*	*Reference*
Some intake	58,730	219	1.46 (0.94, 2.27)	**1.42 (1.05, 1.90)**

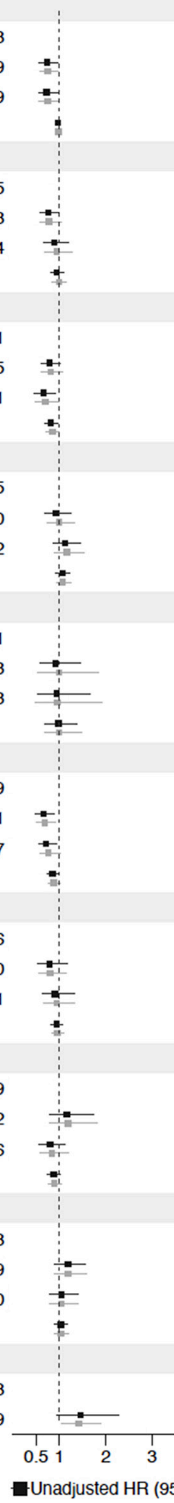

Figure 2 Pooled HRs of diet quality and food intake frequency at 1 year of age and risk of IBD. Adjusted HRs (aHRs) were adjusted for the child's sex, parental IBD, origin, education level and maternal comorbidities.

DISCUSSION

In this pooled study of two Scandinavian birth cohorts, children with high diet quality at 1 year of age had a reduced risk of IBD compared with children with low diet quality. In addition, a high intake of fish and vegetables at age 1 year was associated with a reduced risk of IBD, whereas an intake of SSBs was associated with an increased risk of IBD. By contrast, at 3 years of age, only fish intake was associated with later IBD, particularly UC.

Although the gut microbiome is likely an important factor in the pathogenesis of IBD[37] and early-life diet has a significant impact on gut microbiota composition,[9] few studies have assessed diet in early life and risk of IBD. Our findings suggest that high diet quality, including a high intake of fish

Diet exposure	Total N	CD Event	Unadjusted HR (95%CI)	Model 1 aHR (95%CI)
Diet quality				
Low	25,860	53	*Reference*	*Reference*
Medium	30,014	44	0.74 (0.34, 1.62)	0.78 (0.40, 1.53)
High	25,223	34	0.63 (0.27, 1.47)	0.70 (0.33, 1.45)
Per increase in category			0.75 (0.41, 1.37)	0.78 (0.46, 1.33)
Meat				
Low	20,216	35	*Reference*	*Reference*
Medium	33,020	54	0.93 (0.39, 2.23)	0.95 (0.41, 2.21)
High	27,868	42	0.83 (0.32, 2.14)	0.89 (0.36, 2.24)
Per increase in category			0.86 (0.49, 1.53)	0.89 (0.51, 1.57)
Fish				
Low	18,407	44	*Reference*	*Reference*
Medium	7,299	58	0.72 (0.48, 1.10)	0.77 (0.50, 1.20)
High	25,392	29	0.60 (0.35, 1.01)	0.67 (0.39, 1.17)
Per increase in category			0.76 (0.59, 0.98)	0.80 (0.61, 1.03)
Dairy				
Low	26,243	36	*Reference*	*Reference*
Medium	26,347	35	0.95 (0.60, 1.52)	1.09 (0.55, 2.15)
High	28,514	60	1.45 (0.96, 2.20)	1.62 (0.85, 3.11)
Per increase in category			1.23 (1.00, 1.52)	1.28 (0.96, 1.70)
Fruits				
Low	23,176	37	*Reference*	*Reference*
Medium	44,070	66	0.99 (0.66, 1.48)	1.01 (0.67, 1.53)
High	13,858	28	0.86 (0.44, 1.68)	0.83 (0.40, 1.69)
Per increase in category			0.97 (0.73, 1.29)	0.97 (0.72, 1.30)
Vegetables				
Low	19,215	34	*Reference*	*Reference*
Medium	25,500	38	0.59 (0.18, 1.94)	0.66 (0.24, 1.80)
High	36,389	59	0.61 (0.20, 1.87)	0.70 (0.27, 1.81)
Per increase in category			0.82 (0.52, 1.31)	0.91 (0.65, 1.26)
Grains				
Low	26,630	51	*Reference*	*Reference*
Medium	25,899	36	0.76 (0.50, 1.17)	0.81 (0.53, 1.25)
High	28,575	44	0.80 (0.54, 1.20)	0.84 (0.55, 1.26)
Per increase in category			0.89 (0.73, 1.10)	0.91 (0.74, 1.13)
Potatoes				
Low	13,362	30	*Reference*	*Reference*
Medium	4,217	56	1.17 (0.38, 3.65)	1.06 (0.21, 5.38)
High	30,828	45	0.66 (0.23, 1.89)	0.74 (0.17, 3.15)
Per increase in category			0.79 (0.45, 1.42)	0.81 (0.42, 1.58)
Sugar–and fat–dense food				
Low	24,495	40	*Reference*	*Reference*
Medium	29,972	47	1.21 (0.52, 2.81)	1.29 (0.53, 3.13)
High	26,637	44	1.05 (0.44, 2.50)	1.09 (0.44, 2.71)
Per increase in category			1.02 (0.79, 1.32)	1.03 (0.83, 1.28)
Sugar–sweetened beverages				
No intake	22,494	32	*Reference*	*Reference*
Some intake	58,610	99	2.13 (0.47, 9.71)	2.10 (0.56, 7.88)

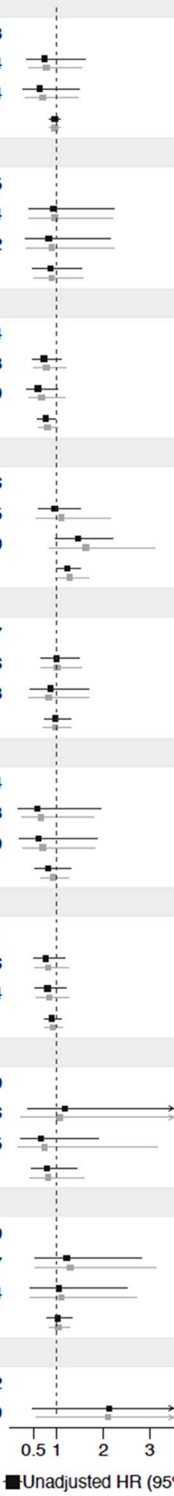

Figure 3 Pooled HRs of diet quality and food intake frequency at 1 year of age and risk of Crohn's disease (CD). Adjusted HRs (aHRs) were adjusted for the child's sex, parental IBD, origin, education level and maternal comorbidities.

and vegetables at 1 year, may reduce the risk of later IBD development. In agreement with our results, a retrospective Italian study found that children aged 2–17 years with UC compared with healthy controls had significantly poorer adherence to a Mediterranean-style diet.[28] This diet is characterised by a higher intake of fruits, vegetables and fish and a lower intake of sweets and fast food.[28] Similarly, in a prospective cohort study of adults, high adherence to a modified Mediterranean diet was associated with a lower risk of CD, but not UC.[38] A higher fish intake in children and adolescents has also been associated with a reduced risk of CD.[39] The content of PUFAs or vitamin D in fish may be of special importance for IBD, as adult studies have observed an inverse association between a high intake of PUFAs[3] and later UC and a high intake of vitamin D and CD.[40]

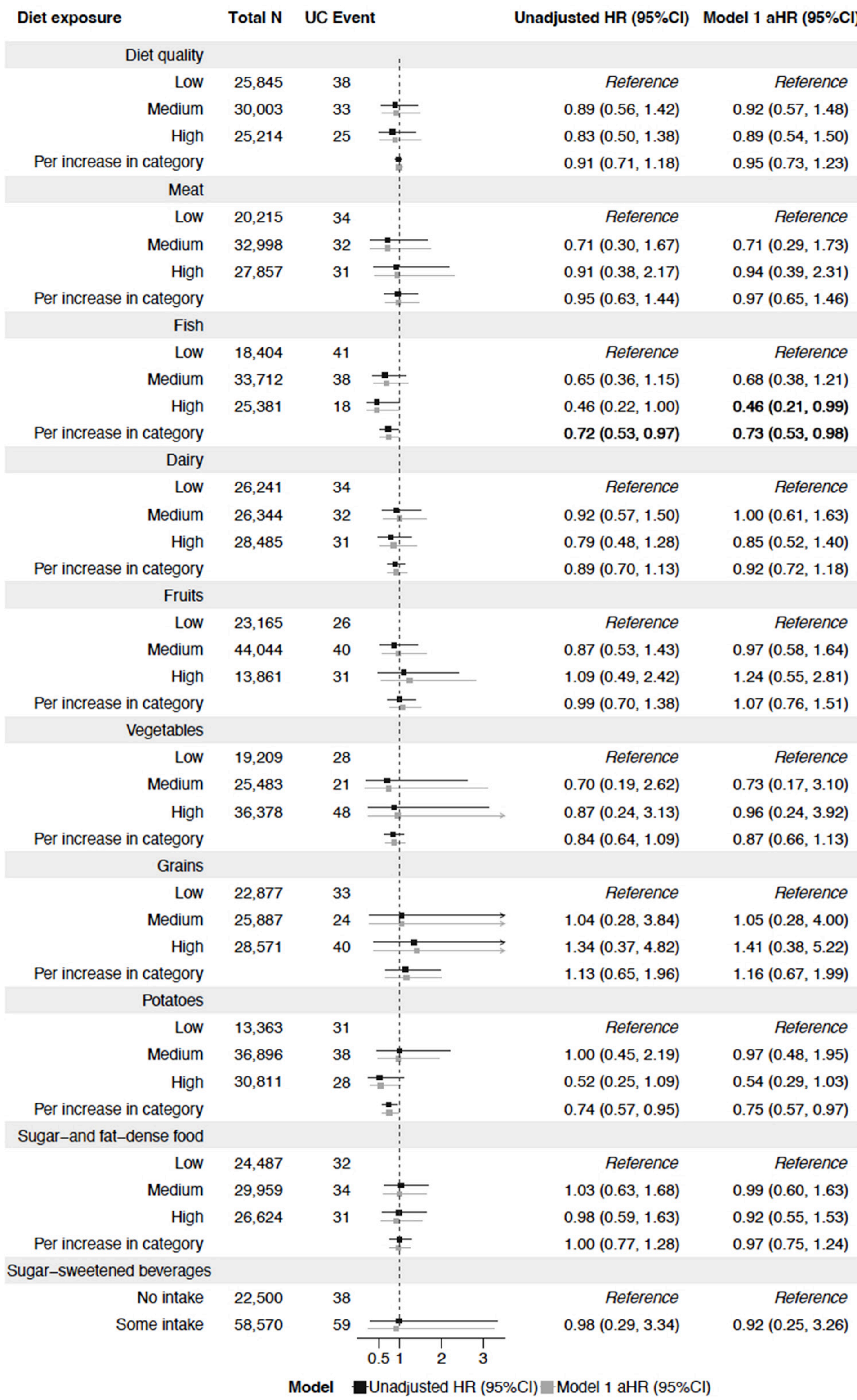

Figure 4 Pooled HRs of diet quality and food intake frequency at 1 year of age and risk of UC. Adjusted HRs (aHRs) were adjusted for the child's sex, parental IBD, origin, education level and maternal comorbidities.

Vegetable consumption in childhood has been suggested to be associated with a reduced risk of IBD.[10] It has been hypothesised that intake of vegetables and vegetable fibres may have programming effects on the immune system, reducing the risk of IBD.[41] However, few studies have assessed the early-life intake of vegetables in the context of IBD, and because overall diet is multifactorial, there are several challenges to identifying the influence of a single diet component. Moreover, a type 2 error might be introduced for analyses of CD and UC, related to fewer events in those analyses and a higher risk of misclassification between subtypes.

In this study, any versus no intake of SSBs in children at 1 year of age was associated with an increased risk of IBD. Another paediatric study found that soft drink consumption four or more times a week in children <15 years was associated with an increased risk of CD, independent of socioeconomic characteristics.[10] This is also supported by a systematic review that found soft drink consumption to increase the risk of UC in adults.[42] Animal data suggest that dietary sugar reduces the diversity of the gut microbiome[43] and negatively affects the mucosal immune response and barrier.[44] Also, artificial additives have been suggested to cause dysbiosis and to induce chronic inflammation and dysfunctional immune response associated with IBD.[45] However, since other studies have not found an association between SSBs and later IBD,[46] future prospective studies are warranted to investigate the relationship between early-life intake of SSBs and subsequent IBD risk.

Dietary habits at 3 years of age were mostly not associated with later IBD risk in our two cohorts, suggesting that the influence of diet on IBD risk may be age dependent. The early-life gut microbiome undergoes significant changes until it converges to a stabilised, more adult microbiome after age 2 and 3 years.[47] Since the gut microbiome seems to develop very early in life,[47 48] diet at 1 year rather than at 3 years may have a stronger impact on the microbiome. Regrettably, the lack of microbiome data prevented the study of whether changes in microbial composition mediated the IBD risk related to early-life diet.

Strengths and limitations

This study is unique to prospectively assess childhood diet, limited to the first 3 years of life, and later risk of IBD. The prospectively collected data reduced the risk of reverse causation. Our study population of >80 000 children, including 307 IBD cases, with long-term follow-up, allowed a more precise estimation of risks than examining association in one cohort only. We found an association between child's diet quality at 1 year of age and any IBD diagnosis, but not CD or UC diagnosis specifically. However, the smaller number of CD and UC events, as well as the challenges to clinically differentiate these subtypes, may have prevented us from finding any true associations (type 2 error), particularly in the subtype-specific analyses. Our population-based approach minimised selection bias. Diagnoses of IBD were defined based on a register-based algorithm, which previously has shown a positive predictive value of 93.0% on medical record review in Sweden,[30 31] with a similar validity in Norway.[49] To reduce the risk of misclassification between CD and UC, we defined IBD-U as cases with no clear distinction between CD and UC during the last 5 years of follow-up. However, even when changing the definition of IBD-U to a mix of codes during the last 2 years of follow-up, it did not show any difference in the results.

Data retrieved from repeated questionnaires and national registers allowed adjustment of potential confounders, including breastfeeding duration, formula intake, sociodemographics and antibiotic exposure. Still, we cannot exclude the possibility that unmeasured or residual confounding from other health behaviours may have influenced our results. Also, we did not have sufficient data about ultra-processed foods or food additives, other than SSBs and other ultra-processed foods contributing to low diet quality.

The food questions in ABIS and Moba have been used in several studies to assess a child's dietary patterns,[13 19–23] and as recommended when assessing the overall diet–disease relationship,[50] we captured overall dietary quality rather than quantity and intake of energy and micronutrients. However, the prospective nature of this study ensures that any misclassification of dietary data should be unrelated to the risk of IBD and therefore not cause erroneous associations.

While the participation rate in ABIS was 79%, it was 41% in MoBa. Mothers in MoBa were older[51] and more educated than all Norwegian mothers.[52] Importantly, however, this self-selection has not been shown to affect exposure–outcome associations in the MoBa cohort.[51] Because the present data originate from Sweden and Norway, two high-income countries, our findings may not be generalisable to low-income or middle-income countries with other dietary habits. Reported incidence rates of childhood-onset IBD vary significantly across Nordic countries, ranging from 7.0 to 15.0 per 100 000 person-years,[31] and these differences may be explained by discrepancies of diagnostic method and type of data. We believe the difference in incidence rates of UC across ABIS and MoBa is explained by the distinct follow-up time. When accounting for varying lengths of follow-up across the cohorts, we found similar incidence rates of UC. Finally, as this study focused on early-life diet, our findings may not relate to dietary patterns later in life.

CONCLUSION

In this pooled study of two Scandinavian birth cohorts, children 1 year old with a high diet quality, particularly a high intake of fish and vegetables, were at a reduced risk of later IBD. In contrast, exposure to SSBs in early life was associated with an increased risk of IBD. While non-causal explanations for our results cannot be ruled out, these novel findings are consistent with the hypothesis that early-life diet, possibly mediated through changes in the gut microbiome, may affect the risk of developing IBD.

Author affiliations
[1]Department of Pediatrics, Institute of Clinical Sciences, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden
[2]Division of Pediatrics, Biomedical and Clinical Sciences, Linköping University, Linköping, Sweden
[3]Crown Princess Victoria Children's Hospital, Region Östergötland, Linköping, Sweden
[4]Department of Food Safety, Norwegian Institute of Public Health, Oslo, Norway
[5]Department of Internal Medicine and Clinical Nutrition, Institute of Medicine, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden
[6]Bioinformatics and Data Centre, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden
[7]Department of Pediatric Research, Faculty of Medicine, University of Oslo, Oslo, Norway
[8]Children's Center, Oslo University Hospital, Oslo, Norway
[9]Department of Pediatric Gastroenterology, Queen Silvia Children's Hospital, Gothenburg, Sweden

Acknowledgements We are grateful to all the families in Sweden and Norway who participated in these ongoing cohort studies. Thank you to Leslie Shaps, at Proofreading, Editing & Translation Global Services for language editing.

Contributors AG—conception and design of the study, statistical analysis and data interpretation, drafting and revision of the article and final approval. ALB, SK and MÖ—data interpretation, revision of the article and final approval. KS and JL—study concept, data interpretation, revision of the article and final approval. KM—responisble for data integrity, obtained funding, study concept, data interpretation, guarantor, revision of the article and final approval.

Funding The All Babies in Southeast Sweden Study is supported by Barndiabetesfonden (Swedish Child Diabetes Foundation; grant/award number: 0000); Swedish Council for Working Life and Social Research (grant/award numbers: FAS2004-1775, FAS2004–1775); Swedish Research Council (grant/award numbers: K2005-72X-11242-11A and K2008-69X-20826-01-4, K2008-69X-20826-01-4); Medical Research Council of Southeast Sweden (FORSS; grant/award number: 0000); JDRF Wallenberg Foundation (grant/award number: K 98-99D-12813-01A); ALF and LFoU grants from Region Östergötland and Linköping University, Sweden (grant/award number: 0000); and Joanna Cocozza Foundation (grant/award number: 0000). The Norwegian Mother, Father and Child Cohort Study is supported by the Norwegian Ministry of Health and Care Services and the Ministry of Education and Research. KM has received funding from the Swedish Society for Medical Research (S20-0007), the Swedish Research Council (2020-01980) and ALF (ALFGBG-915661). AG received grants from the Swedish Society for Medical

Research (TG-23-0002) and Henning and Johan Throne-Holst Foundation (grant/award number: 0000) to conduct this study.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval This study involves human participants. The establishment of The Norwegian Mother, Father and Child Cohort Study (MoBa) and the initial data collection were based on a licence from the Norwegian Data Protection Agency and approval from the Regional Committees for Medical and Health Research Ethics. MoBa is currently regulated by the Norwegian Health Registry Act. The Regional Committees for Medical and Health Research Ethics approved the present study in 2020 (REK ID: 153328). The current study uses version 12 of the quality-assured MoBa files released for research in 2019. The ABIS Study was approved at the Research Ethics Committees of the Faculty of Health Sciences at Linköping University, Sweden (1997/96 287 and 2003/03–092), and the Medical Faculty of Lund University, Sweden, and connection to national registers (Dnr 03-513 and 2013/253-32) and Research Ethics Committee of the Faculty of Health Sciences at Linköping University, Sweden. ABIS data storage at the University of Gothenburg has been approved by the Ethical Review Authority (Dnr 2020-06581). At the time of recruitment into ABIS and MoBa, broad informed consent was obtained from all participants after written and oral information.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The data collected for this article will be shared on reasonable request to the study's principal investigator, Karl Mårild (karlmarild@gmail.com).

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

ORCID iDs
Annie Guo http://orcid.org/0000-0003-4635-1183
Johnny Ludvigsson http://orcid.org/0000-0003-1695-5234
Anne Lise Brantsæter http://orcid.org/0000-0001-6315-7134
Sofia Klingberg http://orcid.org/0000-0002-9093-2826
Malin Östensson http://orcid.org/0000-0002-8184-9609
Ketil Størdal http://orcid.org/0000-0001-7826-8646
Karl Mårild http://orcid.org/0000-0003-2285-8713

REFERENCES

1 Kaplan GG, Ng SC. Understanding and preventing the global increase of inflammatory bowel disease. *Gastroenterology* 2017;152:313–21.
2 Racine A, Carbonnel F, Chan SSM, *et al*. Dietary patterns and risk of inflammatory bowel disease in Europe: results from the EPIC study. *Inflamm Bowel Dis* 2016;22:345–54.
3 Ananthakrishnan AN, Khalili H, Konijeti GG, *et al*. Long-term intake of dietary fat and risk of ulcerative colitis and Crohn's disease. *Gut* 2014;63:776–84.
4 Dong C, Chan SSM, Jantchou P, *et al*. Meat intake is associated with a higher risk of ulcerative colitis in a large European prospective cohort study. *J Crohns Colitis* 2022;16:1187–96.
5 Milajerdi A, Ebrahimi-Daryani N, Dieleman LA, *et al*. Association of dietary fiber, fruit, and vegetable consumption with risk of inflammatory bowel disease: a systematic review and meta-analysis. *Adv Nutr* 2021;12:735–43.
6 Li F, Liu X, Wang W, *et al*. Consumption of vegetables and fruit and the risk of inflammatory bowel disease: a meta-analysis. *Eur J Gastroenterol Hepatol* 2015;27:623–30.
7 Mozaffari H, Daneshzad E, Larijani B, *et al*. Dietary intake of fish, N-3 polyunsaturated fatty acids, and risk of inflammatory bowel disease: a systematic review and meta-analysis of observational studies. *Eur J Nutr* 2020;59:1–17.
8 Peters V, Bolte L, Schuttert EM, *et al*. Western and carnivorous dietary patterns are associated with greater likelihood of IBD development in a large prospective population-based cohort. *J Crohns Colitis* 2022;16:931–9.
9 Arrieta M-C, Stiemsma LT, Amenyogbe N, *et al*. The intestinal microbiome in early life: health and disease. *Front Immunol* 2014;5:427.
10 Jakobsen C, Paerregaard A, Munkholm P, *et al*. Environmental factors and risk of developing paediatric inflammatory bowel disease -- a population based study 2007-2009. *J Crohns Colitis* 2013;7:79–88.
11 Duchen K, Faresjö ÅO, Klingberg S, *et al*. Fatty fish intake in mothers during pregnancy and in their children in relation to the development of obesity and overweight in childhood: the prospective ABIS study. *Obes Sci Pract* 2020;6:57–69.
12 Magnus P, Birke C, Vejrup K, *et al*. Cohort profile update: the Norwegian mother and child cohort study (MoBa). *Int J Epidemiol* 2016;45:382–8.
13 Agnihotri N, Øverby NC, Bere E, *et al*. Childhood adherence to a potentially healthy and sustainable Nordic diet and later overweight: the Norwegian mother, father and child cohort study (Moba). *Matern Child Nutr* 2021;17:e13101.
14 Källén B, Källén K, Otterblad Olausson P. The Swedish medical birth register A summary of content and quality. Research report from Epc. n.d. Available: https://www.socialstyrelsen.se/globalassets/sharepoint-dokument/artikelkatalog/ovrigt/2003-112-3_20031123.pdf
15 Ludvigsson JF, Almqvist C, Bonamy A-KE, *et al*. Registers of the Swedish total population and their use in medical research. *Eur J Epidemiol* 2016;31:125–36.
16 Ludvigsson JF, Otterblad-Olausson P, Pettersson BU, *et al*. The Swedish personal identity number: possibilities and pitfalls in Healthcare and medical research. *Eur J Epidemiol* 2009;24:659–67.
17 Bakken IJ, Ariansen AMS, Knudsen GP, *et al*. The Norwegian patient Registry and the Norwegian Registry for primary health care: research potential of two nationwide health-care registries. *Scand J Public Health* 2020;48:49–55.
18 Irgens LM. The medical birth Registry of Norway. Epidemiological research and surveillance throughout 30 years. *Acta Obstet Gynecol Scand* 2000;79:435–9.
19 Huus K, Brekke HK, Ludvigsson JF, *et al*. Relationship of food frequencies as reported by parents to overweight and obesity at 5 years. *Acta Paediatr* 2009;98:139–43.
20 Jacka FN, Ystrom E, Brantsaeter AL, *et al*. Maternal and early postnatal nutrition and mental health of offspring by age 5 years: a prospective cohort study. *J Am Acad Child Adolesc Psychiatry* 2013;52:1038–47.
21 Kindgren E, Fredrikson M, Ludvigsson J. Early feeding and risk of juvenile idiopathic arthritis: a case control study in a prospective birth cohort. *Pediatr Rheumatol Online J* 2017;15:46.
22 Sørensen LMN, Aamodt G, Brantsæter AL, *et al*. Diet quality of Norwegian children at 3 and 7 years: changes, predictors and longitudinal association with weight. *Int J Obes (Lond)* 2022;46:10–20.
23 Vejrup K, Agnihotri N, Bere E, *et al*. Adherence to a healthy and potentially sustainable Nordic diet is associated with child development in the Norwegian mother, father and child cohort study (MoBa). *Nutr J* 2022;21:46.
24 Agnihotri N, Rudjord Hillesund E, Bere E, *et al*. Development and description of new Nordic diet scores across infancy and childhood in the Norwegian mother, father and child cohort study (MoBa). *Matern Child Nutr* 2021;17:e13150.
25 Cade J, Thompson R, Burley V, *et al*. Development, validation and utilisation of food-frequency questionnaires - a review. *Public Health Nutr* 2002;5:567–87.
26 Vilela S, Oliveira A, Ramos E, *et al*. Association between energy-dense food consumption at 2 years of age and diet quality at 4 years of age. *Br J Nutr* 2014;111:1275–82.
27 World Health Organization, Regional Office for Europe. *Food and nutrition policy for schools: a tool for the development of school nutrition programmes in the European Region*. Copenhagen: WHO Regional Office for Europe, 2006. Available: https://apps.who.int/iris/handle/10665/107797
28 Strisciuglio C, Giugliano F, Martinelli M, *et al*. Impact of environmental and familial factors in a cohort of pediatric patients with inflammatory bowel disease. *J Pediatr Gastroenterol Nutr* 2017;64:569–74.
29 Ludvigsson JF, Andersson E, Ekbom A, *et al*. External review and validation of the Swedish National inpatient register. *BMC Public Health* 2011;11:450.
30 Mouratidou N, Malmborg P, Järås J, *et al*. Identification of childhood-onset inflammatory bowel disease in Swedish Healthcare registers: a validation study. *Clin Epidemiol* 2022;14:591–600.
31 Östensson M, Björkqvist O, Guo A, *et al*. Epidemiology, validation, and clinical characteristics of inflammatory bowel disease: the ABIS birth cohort study. *BMC Gastroenterol* 2023;23:199.
32 Xu F, Dahlhamer JM, Zammitti EP, *et al*. Health-risk behaviors and chronic conditions among adults with inflammatory bowel disease - United States, 2015 and 2016. *MMWR Morb Mortal Wkly Rep* 2018;67:190–5.
33 Schoenfeld D. Partial residuals for the proportional hazards regression model. *Biometrika* 1982;69:239–41.
34 DerSimonian R, Laird N. Meta-analysis in clinical trials. *Control Clin Trials* 1986;7:177–88.
35 Kelsen JR, Sullivan KE, Rabizadeh S, *et al*. North American society for pediatric Gastroenterology, Hepatology, and nutrition position paper on the evaluation and management for patients with very early-onset inflammatory bowel disease. *J Pediatr Gastroenterol Nutr* 2020;70:389–403.
36 Rothman KJ. No adjustments are needed for multiple comparisons. *Epidemiology* 1990;1:43–6.

37 Guo F, Cai D, Li Y, *et al*. How early-life gut Microbiota alteration SETS Trajectories for health and inflammatory bowel disease. *Front Nutr* 2021;8:760443.
38 Khalili H, Håkansson N, Chan SS, *et al*. Adherence to a mediterranean diet is associated with a lower risk of later-onset Crohn's disease: results from two large prospective cohort studies. *Gut* 2020;69:1637–44.
39 Amre DK, D'Souza S, Morgan K, *et al*. Imbalances in dietary consumption of fatty acids, vegetables, and fruits are associated with risk for Crohn's disease in children. *Am J Gastroenterol* 2007;102:2016–25.
40 Ananthakrishnan AN, Khalili H, Higuchi LM, *et al*. Higher predicted vitamin D status is associated with reduced risk of Crohn's disease. *Gastroenterology* 2012;142:482–9.
41 Issa M, Saeian K. Diet in inflammatory bowel disease. *Nutr Clin Pract* 2011;26:151–4.
42 Piovani D, Danese S, Peyrin-Biroulet L, *et al*. Environmental risk factors for inflammatory bowel diseases: an umbrella review of meta-analyses. *Gastroenterology* 2019;157:647–59.
43 Zhernakova A, Kurilshikov A, Bonder MJ, *et al*. Population-based metagenomics analysis reveals markers for gut microbiome composition and diversity. *Science* 2016;352:565–9.
44 Khan S, Waliullah S, Godfrey V, *et al*. Dietary simple sugars alter microbial ecology in the gut and promote colitis in mice. *Sci Transl Med* 2020;12:eaay6218.
45 Raoul P, Cintoni M, Palombaro M, *et al*. Food additives, a key environmental factor in the development of IBD through gut dysbiosis. *Microorganisms* 2022;10:167.
46 Khalili H, Hakansson N, Chan SS, *et al*. No association between consumption of sweetened Beverages and risk of later-onset Crohn's disease or ulcerative colitis. *Clin Gastroenterol Hepatol* 2019;17:123–9.
47 Stewart CJ, Ajami NJ, O'Brien JL, *et al*. Temporal development of the gut microbiome in early childhood from the TEDDY study. *Nature* 2018;562:583–8.
48 Laue HE, Coker MO, Madan JC. The developing Microbiome from birth to 3 years: the gut-brain axis and neurodevelopmental outcomes. *Front Pediatr* 2022;10:815885.
49 Larsen JH, Anderson S, Perminow G, *et al*. Higher incidence of childhood-onset inflammatory bowel disease by increasing latitude in Norway, but stable incidence by age for cohorts born 2004-2012 [Manuscript submitted for publication]. 2023.
50 Ioannidis JPA. Implausible results in human nutrition research. *BMJ* 2013;347:f6698.
51 Nilsen RM, Vollset SE, Gjessing HK, *et al*. Self-selection and bias in a large prospective pregnancy cohort in Norway. *Paediatr Perinat Epidemiol* 2009;23:597–608.
52 Mårild K, Tapia G, Midttun Ø, *et al*. Smoking in pregnancy, cord blood cotinine and risk of celiac disease diagnosis in offspring. *Eur J Epidemiol* 2019;34:637–49.