# Maternal and Early Postnatal Nutrition and Mental Health of Offspring by Age 5 Years: A Prospective Cohort Study

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**Objective:** Diet quality is related to the risk for depression and anxiety in adults and adolescents; however, the possible impact of maternal and early postnatal nutritional exposures on children's subsequent mental health is unexplored. **Method:** The large prospective Norwegian Mother and Child Cohort Study recruited pregnant women between 1999 and 2008. Data were collected from mothers during pregnancy and when children were 6 months and 1.5, 3, and 5 years of age. Latent growth curve models were used to model linear development in children's internalizing and externalizing problems from 1.5 to 5 years of age as a function of diet quality during pregnancy and at 1.5 and 3 years. Diet quality was evaluated by dietary pattern extraction and characterized as "healthy" or "unhealthy." The sample comprised 23,020 eligible women and their children. Adjustments were made for variables including sex of the child, maternal depression, maternal and paternal age, maternal educational attainment, household income, maternal smoking before and during pregnancy, mothers' parental locus of control, and marital status. **Results:** Higher intakes of unhealthy foods during pregnancy predicted externalizing problems among children, independently of other potential confounding factors and childhood diet. Children with a high level of unhealthy diet postnatally had higher levels of both internalizing and externalizing problems. Moreover, children with a low level of postnatal healthy diet also had higher levels of both internalizing and externalizing problems. **Conclusion:** Among this large cohort of mothers and children, early nutritional exposures were independently related to the risk for behavioral and emotional problems in children. J. Am. Acad. Child Adolesc. Psychiatry, 2013;■(■):■–■. **Key Words:** anxiety, diet, depression, externalizing, internalizing

Although the World Health Organization has identified unipolar depressive disorders as accounting for the largest burden of disability in middle- and high-income countries,[1] psychiatry currently lacks effective universal public health strategies for the prevention of mental illness. Importantly, given that half of mental illnesses first manifest before 14 years of age,[2] identification of early-life risk factors and, hence, targets for prevention is imperative. This is particularly cogent in the context of the "double hit" hypothesis, wherein detrimental neonatal exposures may predispose to adult psychopathology in the presence of later environmental risk factors.[3]

The fundamental contribution made by habitual dietary behaviors to the risk for, and progression of, chronic noncommunicable physical illnesses is now well understood; however, it is only in the last 3 years that credible evidence has been generated indicating that dietary quality also contributes to the risk for the common mental illnesses, depression, and anxiety, in both adults and adolescents.[4-9] However, the possible impact of very early life nutritional exposures on children's subsequent mental health is unexplored. Given the known impact of maternal and early life nutrition on later physical health in offspring,[10] this is a notable gap in the knowledge base.

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Deficiencies of certain nutrients during critical phases in brain development may result in irreversible functional changes to the brain, the most vulnerable period being pregnancy and the first 2 to 3 years of life, in which there is rapid brain growth.[11] Maternal exposure to famine during pregnancy results in an elevated risk for major depression in offspring,[12,13] supporting a link between maternal nutrition and children's neurodevelopment. Moreover, a rapidly developing evidence base from preclinical studies indicates an important role for maternal diet in influencing the development of neurotransmitter systems in offspring,[14,15] while maternal and early infant nutrition modulates the immunologic development of offspring,[16] which may in turn influence the risk for later mental health problems.[17,18] A maternal "western" diet, high in fats and sugars, and obesity increased sympathetic nervous system activity and hyperactivity in rodent offspring that persisted into adulthood,[19] indicating a direct causal relationship between maternal dietary exposures and lifetime behavioral outcomes related to mood disorders.[20] Moreover, deficiencies in omega-3 fatty acids during in utero development and early life reduce brain plasticity and increase anxiety-like behaviors in adult mice.[21] Synaptic plasticity and neurotrophin levels are of particular relevance to mood disorders in human beings.[22,23]

Taken together with the previous observational findings, these data indicate a role for early-life nutritional exposures in the vulnerability to mental health problems in children. Therefore, in this study, we aimed to examine the relationship between the quality of both mothers' diets during pregnancy and children's diets in the first years of life, and behavioral markers of mental health problems in children, taking into account other variables that may explain such relationships. We hypothesized that both a low intake of healthy, nutrient-dense foods, and a high intake of unhealthy foods by mothers during pregnancy and children during early childhood would be independently related to children's internalizing and externalizing behaviors from 18 months to age 5 years.

## METHOD

The large, ongoing Norwegian Mother and Child Cohort Study (MoBa) is conducted by the Norwegian Institute of Public Health.[24] Between 1999 and 2008, invitations were sent by mail to pregnant women across Norway concurrent with the routine ultrasound examination offered to all pregnant women at their local hospital around week 17 of pregnancy. The participation rate was 38.5%, with more than 108,000 births enrolled during the recruitment period. When pregnant mothers consented to participate, approximately 78% of the fathers also consented. Informed consents and approvals by the Regional Committee for Medical Research Ethics and Norwegian Data Inspectorate were obtained. Self-report questionnaires were sent to the mothers and fathers at 17 weeks of gestation, and to mothers only later in pregnancy and at intervals after birth when children were 6 months, 1.5, 3, and 5 years old. Response rates during pregnancy were 91% to 95%, and response rates for assessments after birth were 84.8%, 72.4%, 58.5%, and 53.4%, respectively. Pregnancy and birth records from the Medical Birth Registry of Norway (MBRN) were linked to the MoBa database.[25] The current study is based on version 6 of the data files, released for research in 2011. Our final sample comprised all of the 23,020 eligible women and their children that had received the 5-year questionnaire.

### Maternal Diet

A food frequency questionnaire (FFQ) was specifically developed for assessment of maternal diet in MoBa. The MoBa FFQ[26] has been used from February 2002 and onward. It is semiquantitative and designed to capture dietary habits and intake of dietary supplements during the first 4 to 5 months of pregnancy. The frequency of consumption was given per day, per week, and/or per month, depending on the food item. Food frequencies were converted into food amounts (g/day), and daily intakes of the 255 food and beverage items in the FFQ were aggregated into 58 nonoverlapping food groups and used as input variables for extraction of dietary patterns using principal components analysis.[27] Two major dietary patterns, a "healthy" pattern characterized by high intake of vegetables, fruit, high-fiber cereals, and vegetable oils, and an "unhealthy" pattern characterized by high intake of processed meat products, refined cereals, sweet drinks, and salty snacks. The dietary patterns identified in the current study parallel those identified and described in more detail in a previous MoBa study.[28] The MoBa FFQ has been thoroughly validated against a dietary reference method and several biological markers.[29]

### Child Diet

Mothers described the current diets of their children at 18 months using a 36-item FFQ comprising dietary items on types of foods and drinks such as dairy products, cereal-based porridge, and fruit juice.[30] Response categories ranged from "never" to "5 or more times a day" for drinks, and from "never" to "3 or more times a day" for foods. At 3 years, mothers answered questions on a food frequency questionnaire with 37 items. For each food and drink item, mothers