Editorial

Precision Nutrition

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Prenatal Nutrition and Developmental Origins of Health and Disease

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Compared with an average lifespan in the United States of 80 years, a full-term normal pregnancy lasts about 9 months, or roughly 1% of a person's entire lifespan. Yet, this relatively short fetal period is not only important for reproductive and perinatal health but also for child health, lifelong health, and intergenerational health for following reasons.[1] First, the fetal period is the most rapid period of human cell growth and differentiation, which begins with a single cell (fertilized egg) that undergoes rapid division and amazing transformations into different types of cells, organs, and systems, and leads to the birth of a lively newborn. During this sensitive time period, the fetus is highly susceptible to adverse *in utero* environmental exposures, which are affected by maternal health and nutritional status as well as her environmental exposures (home, neighborhood, and society). Second, research to date has revealed that the human epigenome, which regulates gene expression, is established during the fetal period when key DNA methylation and demethylation, or erasure of DNA methylation imprints, occur at two critical fetal stages: primordial germ cell and blastocyst development. DNA methylation occurs at the interface between the gene and environment and serves as an important biological mechanism by which environmental exposures such as nutrition, psychosocial stress, environmental pollutants, medication or drug use, and cigarette smoking, can affect not only fetal health but health across the lifespan.

In contrast to the long-held concept of "adult-onset diseases" such as obesity, diabetes, hypertension, heart disease, and stroke, Developmental Origins of Health and Disease (DOHaD) offers a new paradigm. DOHaD hypothesizes that chronic diseases in later childhood and adulthood are significantly affected by environmental factors during early life, including during the preconceptional, prenatal, and/or early childhood periods. After decades of debate, the DOHaD paradigm has gained global attention[2] and stimulated a new wave of prospective birth cohort studies across the globe, including the US national initiative, Environmental Influences on Child Health Outcomes (ECHO) Program.[3] To date, findings from available cohorts strongly support that human health occurs across a continuum and is the result of exposures and events that occur at each life stage, such that a person's health is a result of the accumulation of all their previous life experiences. Indeed, what we previously called adult-onset diseases, such as obesity, diabetes, hypertension, have all been pre-conditioned or programmed at the fetal stage.

Among a myriad of early life determinants of health, nutrition has been shown to be the single most important and modifiable factor. In particular, the importance of nutrition during the critical early life stages (pregnancy and lactation) for maternal and child short- and long-term health has been emphasized by the 2020–2025 US Dietary Guidelines for Americans produced by the US Department of Health and Human Services (HHS) and Agriculture (USDA).[4] These guidelines provide specific dietary recommendations for pregnant and lactating women, with a focus on the intake of nutrient-dense food groups such as vegetables, fruits, whole grains, seafood, eggs, low-fat dairy products, and poultry to achieve optimal macronutrient intake.

In this issue of *PN*, three prospective studies in the Boston Birth Cohort[5] have shed new light on the role of early life nutrition in future metabolic and neurodevelopmental health outcomes.

The study by Huang and colleagues[6] demonstrated distinct longitudinal patterns of body mass index percentile (BMIPCT) in children who were followed from birth up to 18 years of age. More importantly, the distinct patterns were already detectable in the first few years of life. The authors also showed that early longitudinal BMIPCT patterns can better predict future risk of overweight or obesity compared to traditional single time point BMIPCT values.

The study by Raghavan and colleagues[7] examined the association between maternal and cord pantothenate (vitamin B5) and cysteine levels and risk of autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD) and other developmental disabilities (DD) in children born term and preterm. They found that higher cord blood pantothenate levels, individually and in combination with higher cysteine or preterm birth, may be associated with increased risk of ASD and ADHD. Pantothenate, an essential micronutrient, is a precursor for coenzyme A (CoA) synthesis, which serves as a cofactor for hundreds of metabolic reactions, while cysteine is an amino acid in the CoA synthesis pathway. This study draws attention to

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

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this biologically plausible pathway in the development of ASD and ADHD.

The study by Che and colleagues[8] explored maternal prenatal intake of a Mediterranean-Style Diet (MSD) on child neurodevelopmental disabilities (NDD), especially in children born to mothers with metabolic disturbances (maternal obesity and/or diabetes). MSD is characterized by a moderate daily intake of grains, vegetables, fruits, low-fat dairy products, olive oil, nuts, and wine, a weekly intake of fish and legumes, and limited meat intake. They showed that adherence to an MSD was protective against NDD, especially among children born to mothers with obesity and/or diabetes.

Taken together, the findings from three studies in this current issue of PN lend further support for an association between early life nutritional indicators and children's physical and mental health. However, there are still many research gaps to be filled. For example, more studies are needed to comprehensively quantify maternal nutrient intake and nutritional status from both food intake and supplement use, as well as biomarkers. Nutritional biomarkers are measurements of specific molecules or metabolites in the biosample that can be used to assess a person's dietary intake, nutrient absorption, metabolism; and help to improve the accuracy of dietary recommendations, optimize nutrition interventions, and advance our understanding of the links between nutrition and health. Future studies are also needed to consider co-exposures to multiple nutrients, environmental chemicals or stressors, and their additive and/or interactive health effects.

In recent years, precision nutrition has emerged as a key focus for the next 10 years of national and global research.[9,10] Precision nutrition aims to optimize a person's nutritional recommendation by answering some fundamental questions such as: What should a person eat and what is the health effect of nutrition across a person's lifespan. A hallmark of precision nutrition, in contrast to the traditional "one size fits all" approach, is its emphasis on carefully considering a person's genetic susceptibility, co-exposure to other nutrients and environmental chemicals across life stages, pre-existing medical conditions and baseline nutritional status. To realize this goal, more dedicated studies are needed that incorporate exposome and multi-omics profiling (genomic, epigenomic, metabolomic, and proteomics) to gain deeper insight into individual nutrient needs and metabolism and gene–diet interactions in relation to health outcomes. Such new insights may help to inform more precise prevention and therapeutic targets.

Last but not the least, the success of precision nutrition hinges on studying diverse populations. It is important for future studies to increase the representation of historically underserved and marginalized populations in the United States and around the world. Each of the above-mentioned research efforts would represent an important advancement in the DOHaD paradigm and public health to benefit both current and future generations.

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Conflicts of Interest

None

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