



Overview on child health, nutrition and food hazards during the first thousand days of life[☆]

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ABSTRACT

This article discusses the issue of food hazards and child health during the first thousand days of life. The aim is to raise the attention of decision makers, healthcare officers and professionals, including pediatricians, pediatric surgeons, obstetricians, nurses, midwives, dieticians and lactation consultants, on the importance of protecting infants and their families during a most critical period for the mother-child binomial. The conclusions emphasize the importance of encouraging the adoption of integrated strategies, useful at establishing adequate preventive efforts and a game-changing perspective shift in order to develop and adopt efficient monitoring strategies and procedures, able to minimize the risks due to hazards in food throughout the first thousand days of life, as a first line of prevention in children's health.

Introduction

Awareness regarding the notion of food safety has raised globally and significantly in recent years, engaging the stakeholders involved in regulating and actively supervising this issue at all levels^{1,2,3}. In parallel, the expectations of consumers and advocacy groups have grown for a progressively increased and interventional role of governments, policy-makers, industry, researchers and healthcare professionals in this area of public health. Their demand to the stakeholders in decision making is for addressing food safety issues and developing adequate solutions and actions pointing at further protecting the health of food users.

It is currently an established and commonly accepted notion⁴ that food safety is not absolute, and that food safety refers to a "reasonable certainty that no harm will result from intended uses under the anticipated conditions of consumption". This definition recognizes that zero tolerance of risks is realistically not feasible for the majority of foods and the majority of safety contexts, including food chains.

An area of food safety particularly sensitive due to its social implications refers to child nutrition, involving in particular all natural and

commercial products that are related to the food provided to infants during the first thousand days of life. Therefore, including food consumed by mothers during pregnancy and infant formula, cereal-based product, fruit-based product, vegetable-based product, meat-based product consumed by infants and children during their first two years of life. The need for effective and continuously updated methods of monitoring food safety during the crucial period of the first 1000 days of life, is increasingly considered of paramount importance in public health to protect the mother-child binomial⁵. The monitoring of hazards in foodstuff, covers the infant food chain from the production of primary products (fruits, vegetable and animal-derived raw materials), throughout the consumer's use (process, storage, packaging)⁵.

The aim of this article is to raise the attention of decision makers, healthcare officers and professionals, including pediatricians, pediatric surgeons, obstetricians, nurses, midwives, dieticians and lactation consultants, on the importance of protecting infants and their families during a most critical period for the mother-child binomial. In particular, authors encourage the adoption of integrated strategies, useful at establishing adequate preventive efforts and a game-changing perspective shift in order to develop and adopt efficient monitoring strategies

Abbreviations: NCDs, non-communicable diseases; CNS, central nervous system; WHO, World Health Organization; EU, European Union; SAFFI, Safe Food for Infants.

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and procedures able to minimize the risks due to hazards in food during throughout the first thousand days of life, as the first line of prevention in children's health.

The central developmental periods characterizing the first 1000 days

Three distinct periods can be identified during the first thousand days⁶. They include preconception, pregnancy, and infancy, which have been identified as critical in promoting better outcomes in children's lives [3.] Evidence has highlighted the impact that poor parental health and well-being can have on conceptus^{7,8,9}, prior to and from the time of conception^{6,7}. Specific programs and strategies have been developed to ensure that during the preconception period, biomedical, behavioral, and social risks can be identified and modified to protect women's health or pregnancy outcomes through appropriate prevention and management measures, the purpose of which is to address gestational and pediatric adverse illnesses⁵. Preconception care programs include distinct approaches that ensure adequate nutritional and physiological support for mothers and their developing conceptus to ensure all they need for optimal health. Minimizing toxic exposures and monitoring the risk of any type of hazard that may predispose to adverse outcomes is an additional important element characterizing preconception care programs^{9,10}. Preconception is also regarded as an opportunity for mothers to adopt lifestyle changes⁵. A subset of preconception care for mothers planning additional pregnancies is interconception care, which is provided to women from delivery through the birth of a subsequent child. It addresses the continuity of risks from one pregnancy to the next^{9,10}.

The importance of safe development during the nine months of pregnancy has been widely recognized for some time¹¹. Factors that most affect the health and development of the conceptus during pregnancy include diet, stress, and exposure to environmental toxins³. Finally, the importance of supporting parents and infants in the first two years after birth has been emphasized for decades⁵. Several public health interventions in this area have been developed in many countries and the factors that influence health and development during this period are widely studied. However, the large amount of available data supporting the importance of establishing effective health services during a crucial period for the mother-child pair does not seem to have been effectively converted into comprehensive and integrated programs that allow adequate support for parents and infants during this period [5.]

Nutrition and health during the first 1000 days

An appropriate and adequate nutritional lifestyle in terms of quality and quantity makes it possible to prevent most non-communicable diseases (NCDs), including cardiovascular diseases (such as myocardial infarction, stroke), cancer, chronic respiratory diseases (such as asthma and obstructive pulmonary diseases) and diabetes, which is responsible for approximately 38 million deaths per year worldwide^{12,13}. Nutrition during the first 1000 days of life affects not only the child's bodily growth, but also its development and future intellectual abilities. In addition, an increasing number of studies emphasize that nutrients also play a major role in the maturation of the immune system and in the composition of the gut microbiota, now considered a truly metabolically and immunologically active organ^{14,15}.

Since the critical "1000 days" include not only the first 24 months of a child's life, but also the period of conception and that of pregnancy, attention must therefore be focused on both maternal and child nutrition, leading to a change of mentality in the approach to nutrition strategies for the mother-child pair during this sensitive period of their life. The mother begins to take care of her and her child's lifestyle and nutrition even before birth. Early childhood therefore represents a window of maximum vulnerability but also a great opportunity for the development of the child. In this period, in fact, the body and, in particular, the central nervous system (CNS), are plastic and therefore susceptible to possible epigenetic changes that are able to modify the

risk of disease in the long term. To this regard, NCDs are significantly influenced by diet and lifestyle, which are at the same time the main cause and the "easiest" factor on which to intervene to prevent their negative outcomes¹⁶.

Educating to a correct lifestyle and a balanced and safe diet since the earliest stages of life means laying the foundations for future health. It is also of fundamental importance to consider that a child is never a small adult and that, even more so, it is not so in the first years of life¹⁶. Therefore, providing consumers with safe and quality food must be a fundamental objective of the authorities responsible for food safety, in order to ensure that opportunities for adequate and safe growth are provided to infants and children.

Early Child Development is the result of the interaction between individual biological characteristics and the environment in which he or she is born, lives and grows. Therefore, a positive environment must first and foremost ensure adequate nutrition, implement relational processes (within and outside the family unit), ensure equity, opportunities and adequate social and health services to support the mother-child binomial. The characteristics of the theoretical model of this environment have been elaborated by the WHO Knowledge Network for Early Child Development^{17,18}. The early stages of life are crucial in order to set up early interventions for development and health status in later ages. Therefore, it is important to develop preventive strategies to ensure expansion of physical, cognitive, psychological and social-emotional skills leading to increased competence, autonomy and independence^{19,20}.

Pediatricians, caregivers, decision makers and local governments play a crucial role in promoting best practices in the early stages of child development. It is therefore of great preventive importance to identify biological risk factors that characterize this period and that include intrauterine factors (intrauterine growth retardation, inadequate maternal nutrition, maternal infections, use of tobacco and drugs), birth's factors (preterm birth, complications), child nutrition (insufficient breast feeding, caloric and protein malnutrition) and child infections (chronic diarrhea, parasitosis, human immunodeficiency Virus, malaria, micro-nutrient deficiency)^{19,20}

Nutrition in fertile age

A healthy lifestyle characterized by a varied and balanced diet associated with regular physical activity is a determinant of health for women of childbearing age and pregnancy, for future fathers and for the unborn child. In particular, the nutrition of women from childbearing age to pregnancy, represents one of the greatest challenges in public health as it involves not only the health of women, but also that of future generations. In recent years, several studies have shown that there is a close correlation between nutrition and reproductive capacity, both for men and women. Women who decide to plan a pregnancy should receive adequate nutritional counseling from the healthcare personnel in order to identify and correct risk factors and/or behaviors that could favor adverse reproductive outcomes. Hence, the need to create widespread awareness of nutritional issues, so that healthcare professionals can provide initial corrective guidance when necessary. Malnutrition in excess or in defect is associated with intrauterine developmental disorders of the fetus first and then of the newborn and increased risk of NCDs¹⁶. In reality, about 50% of pregnancies are unplanned and therefore the first contact with the doctor occurs around the 6th week, when fundamental stages in fetal organogenesis have already occurred. Several factors can negatively influence the reproductive outcome, including the pre-pregnancy, Body Mass Index, inadequate dietary pattern and unhealthy lifestyle, such as tobacco and alcohol habits¹⁸.

Nutrition in pregnancy and fetal programming

As in childbearing years, nutrition plays a fundamental role in pregnancy because it is responsible not only for the well-being of the woman herself but also for the well-being of the fetus during intra-uterine life, of the newborn, of the child and of the adult in extrauterine

life²¹. In fact, nutrients act as intra and extracellular messengers, capable of influencing the gene expression of the future individual through epigenetic mechanisms and consequently its growth potential and its susceptibility to disease. An inadequate dietary pattern in terms of quantity and quality is therefore able to negatively affect the outcome of pregnancy and the future health of the individual even before conception. Recent studies on a large sample of pregnant women show that even the main obstetrical diseases such as preeclampsia and premature birth have a lower incidence in those patients whose dietary pattern is characterized by a high consumption of fruits, vegetables, whole grains²². Conversely, a diet high in saturated fat (butter, animal fat), sugary drinks, and with reduced intake of fruits and vegetables increases the risk of fetal malformations (neural tube defects, congenital heart disease, cleft lip and palate) and adverse pregnancy outcomes²³. Gestational diabetes and maternal obesity increase the risk that the child in extrauterine life or as an adult will develop the so-called metabolic syndrome, which is characterized by the combination of three or more of the following conditions: abdominal obesity, hypertension, hypertriglyceridemia, low HDL values, and hyperglycemia^{24,25}. A varied, healthy and balanced diet is the essential prerequisite to promote a good outcome of pregnancy and lay the foundation for the future well-being of the new individual. Therefore, in pregnancy and lactation are contraindicated restrictive diets or exclusion in order to reduce the risk of nutritional deficiencies²⁶.

Nutrition of breastfeeding mothers and of the child up to 24 months of age

The nutrition of the breastfeeding woman, as already highlighted for pregnancy and childbearing age, has an important role in the growth and development of the child. Breast milk which is the natural food for the growth and development of the newborn in the first six months of life, can in fact satisfy all its nutritional needs and it is able to provide it with the essential components it needs for an optimal development. Breast milk is a dynamic food, which changes not only according to the age of the baby, but also during the same day and feeding, to adapt to the nutritional needs of the newborn: it is a real biological system^{18,27}. Its composition, as well as being influenced by genetic and environmental factors, can also vary according to the mother's diet: it is therefore important that mothers are ensured a safe diet and that the breastfeeding mother follows a healthy diet adequate to the nutritional needs of milk production. This is why it is of fundamental importance to adequately monitor the risks of contamination in food consumed by the mother during the breastfeeding period and of complementary foods that are introduced in the diet of children typically from 6 to 24 months^{18,27}.

Potential hazards in infant food

Biological, chemical, or physical hazards can be introduced into the food supply at any time during food collection, processing, transportation, preparation, storage, and service. Understanding the hazards associated with each of these steps can significantly reduce the potential for foodborne illness. All can be prevented through an effective food safety management system²⁸.

Biohazard occurs when food is contaminated with microorganisms. Many microorganisms are beneficial; however, under the right conditions, some can cause foodborne illness¹⁴. Foodborne illness can be caused by consumption of food or water contaminated with pathogenic microorganisms, which include bacteria and their toxins, fungi, viruses, and parasites^{15,29}. Food can be contaminated both at the source as raw material and during food processing, storage, and distribution. Infected or pathogen-carrying individuals and the environment, through food-contact surfaces and structures, can spread microorganisms into raw or processed foods²⁸.

Food contaminants include environmental contaminants, food processing contaminants, unapproved adulterants, food additives, and migrants from packaging materials³⁰. Generally, chemicals used for pest control or for cleaning and sanitizing food contact surfaces and food

preparation equipment can contaminate food. Persistent organic pollutants are a common and hazardous group of chemical contaminants that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse human health and environmental effects^{1,28} (Table 1).

A variety of foreign materials in food products are hazardous to individuals, causing illness or injury. Foreign items may be unintentionally introduced into food products, or naturally occurring items may not be separated along a food processing line and be excluded from consumption²⁸ (Table 2). Materials normally absent from food products include metal fragments in ground meat, bone chips, pieces of product

Table 1
MOST COMMON PERSISTENT ORGANIC POLLUTANTS (POPs) AND ASSOCIATED CONTAMINATED FOOD AND HEALTH HAZARDS

POPs	CONTAMINATED FOOD	POSSIBLE HAZARDS
Polyaromatic hydrocarbons (PAHs)	Dairy products, Grain, flour and bran, Rice, Fruit and vegetables, Oyster, Water	Mutagenicity/ carcinogenicity, DNA damage, oxidative stress, impaired male fertility, respiratory diseases, cognitive dysfunction among children and cancer (breast cancer)
Organochlorine pesticide (OCPs)	Eggs, Dairy products, Meat and meat products, Rice, Fruit and vegetables, Honey, Oil, Fish, Mussel, Water	Neurological symptoms, endocrine disruption, infertility and fetal malformation, diabetes, cancer (breast cancer, testicular, prostate and kidney cancer), reproductive problems, cardiovascular problems, high blood pressure, glucose intolerance and obesity
Polychlorinated biphenyls (PCBs)	Eggs, Dairy products, Meat and meat products, Rice, Fruit and vegetables, Oil, Fish, Mussel, Water	Endocrine disruption, neurological disorders, liver injury, diabetes, cancer (breast, prostate, testicular, kidney, ovarian and uterine), cardiovascular problems and obesity
Polybrominated diphenyl ethers (PBDEs)	Fish, Mussel,	Reproductive problems, cancer (testicular), diabetes, obesity and cardiovascular problems
Perfluorinated compounds (PFCs/PFOS and PFOA)	Eggs, Fish, Water	Breast cancer
Hexabromocyclododecanes (HBCDs)	Eggs, Oil, Fish,	Endocrine disruption, reproductive problems and behavioral disorders
Polychlorinated naphthalenes (PCNs)	Meat and meat products,	Cancers
Dioxins/furans	Eggs, Dairy products, Meat and meat products, Oil, Fish,	Language delay, disturbances in mental and motor development, cancer, diabetes, endocrine disruption, high blood pressure, glucose intolerance and cardiovascular problems

(From Pettoello-Mantovani et al, J Pediatr. 2021;229:315-316.e2, modified)

Table 2
TYPICAL SOURCES OF PHYSICAL HAZARDS IN FOOD

- **Metal:** fragments from equipment such as splinters, blades, needles, utensils, staples
- **Glass:** light bulbs, glass containers and glass food containers
- **Stones:** incorporated in field crops, such as peas and beans, during harvesting
- **Plastic:** material used for packaging, fragments of utensils used for cleaning equipment
- **Wood:** splinters from wood structures and wooden pallets used to store or transport ingredients or food products
- **Natural components of food:** hard or sharp parts of a food (e.g.: shells in nut products)
- **Metallic contaminants:** Natural and anthropogenic sources of heavy metal contamination include agricultural activities, such as pesticide and herbicide application, contaminated irrigation water, municipal waste used for fertilization and mineral fertilizer containing traces of heavy metals.

(From Pettoello-Mantovani et al, J Pediatr. 2021;229:315-316.e2, modified)

packaging, stones, glass or wood fragments, insects or other dirt, and personal items³¹. In addition, individuals may be exposed to metals and metal compounds as environmental pollutants from industrial or other human activities³¹. Heavy metals such as lead, arsenic, mercury, or cadmium may be considered a potential contaminant. These substances are of concern because of their toxicity²⁸, especially with long-term intake, because they can accumulate in the body and cause organ damage, especially in susceptible groups, including young children³¹.

Coaching families in the practice of healthy nutrition and lifestyles during the first thousand days

Health care professionals, including pediatricians and primary care physicians, are at the forefront of prescribing foods for infants and accompanying families in practicing healthy eating and lifestyles^{5,28}. Therefore, it is of central importance for them to be adequately informed about common risks involved in the food chain, such as environmental contamination, process contamination, contamination through packaging, including biological and chemical risk, and misuse^{5,28}. Hence, it is also of paramount importance for this group of stakeholders to be constantly updated and informed about current monitoring programs and new and additional effective procedures and methods that can achieve adequate food safety assessment and monitoring, which are being developed, made available and used by government and formal authorities to safeguard their communities^{5,28}.

Monitoring food safety in economically advanced countries. Europe

The food industry in economically advanced areas of the world, particularly Europe, has long been interested in the issue of food chain safety, and over time has developed adequate means for internal monitoring of safety processes^{5,28}. However, the international market is expanding and the European Union is overexposed to imports of non-EU products that often lack adequate safety procedures in the countries where imported baby food is produced, as well as serious uncertainty about quality assurance of the various steps involved in the food chain in non-EU countries (i.e., the cold chain and its logistics). In order to properly address this issues, the EU Commission has launched the Safe food for infants (SAFFI) project, within the frame of the Horizon 2020 program³². The scope of this EU project is to develop adequate monitoring systems and assist competent authorities and industry to further advance their control procedures and formulate appropriate decisions in this sensitive area of public health, while contributing strongly to further ensure the safety of the population and its perception of being adequately cared for. Establishing adequate technical measures useful to advance the monitoring of baby food safety, will further protect the European food industry from economic and reputational damage to the sector, possibly caused by health incidents due to the difficulty of adequately supervising the safety chain of imported baby food. .

Conclusions

As emphasized by recent reports, nutrition is a desperately neglected aspect of maternal, newborn, and child health, and the reasons for this neglect are understandable but not excusable^{33,34}. According to UNICEF, more than 200 million children living in both economically advanced and poor countries worldwide do not reach their developmental potential in the first 5 years of life because of poverty, inadequate nutrition, insufficient health services and psychosocial care.

Available scientific evidence confirms that the first 1,000 days of life are critical for proper physical and mental development and many preventive and/or curative interventions implemented early in this window of time lead to positive short, medium and long-term health outcomes for the individual and the community^{33,34}.

Due to population growth and global threats, the integrity and security of global food chains are at risk. In many countries, simply having enough to eat can be a problem, with poor quality food often contaminated with dangerous agents, while in developed countries the pressure to provide cheap and accessible food can affect quality and safety^{5,16}.

The fate of nations is determined by what they eat³⁵, and pediatricians are on the front lines of containing the risks of food hazards^{7,17}. They can play a key role if they actively collaborate and integrate their efforts with governments and local, state, federal, and global public health institutions and agencies to ensure that infants and children have access to nutritionally adequate diets and safe food^{5,16}.

Statement

The corresponding author states on behalf of the co-authors that all Authors have no conflict or competing of interests to declare.

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