ENCYCLOPEDIA
on Early Childhood
Development

Nutrition – Pregnancy

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Synthesis

How Important Is It?

Pregnancy, infancy and early childhood are the most significant periods of growth and development in the human life cycle. Poor nutrition during these critical growth and developmental periods places infants and children at risk of impaired emotional and cognitive development and adverse health outcomes.

The Canadian National Population Health Study (1998/1999) reported that over 10% of Canadians were living in food-insecure households. Food insecurity, which involves worrying about not having enough money to buy food, compromises the quality and quantity of food. Approximately 35% of Canadians in low-income households and 14% in middle-income households experience some form of food insecurity.[1] Since poor and malnourished women find it difficult to achieve adequate nutrition, their health is compromised during their reproductive years. Women who enter each pregnancy with depleted physical resources perpetuate a cycle of mother-child malnutrition.

In Canada, two well-known programs, the Canada Prenatal Nutrition Program (CPNP) and the Community Action Program for Children (CAPC), have been implemented to support the prenatal/post-natal nutrition, health and development of women and young children. As national community-based health-promotion interventions, both the CPNP and the CAPC help community groups to establish and deliver services that address the health and nutritional needs of at-risk groups.[2]

What Do We Know?

Quantity and quality of nutrients are essential to infant and child development. Many studies on nutrition have associated poor prenatal and early post-natal nutrition or malnutrition with a variety of developmental outcomes. Preterm and low-birth-weight (LBW) infants are especially vulnerable and more likely to experience some of these problems:

- growth retardation (weight, height, head size)

- delayed psychosocial development
- cognitive, educational and/or behavioural problems
- an increased risk of later psychiatric disorders

There is some evidence that the adverse effects of poor early nutrition can be reduced. Nutrient-enriched formulas have been shown to reduce motor and mental developmental deficits in preterm and LBW infants in the first 18 months of life. Although limited, psychosocial stimulation of growth-restricted infants helps improve their cognitive abilities. Other evidence supports the fact that LBW infants who are fed their mother's milk, compared to those fed bovine-based formula, have better short-term visual and developmental outcomes, although variables such as daily intake and duration of breastfeeding should also be considered.

While it is essential to improve preterm and LBW infants' development, research should also focus on the prevention of premature and low-weight births.

What Can Be Done?

Improving maternal and child nutrition requires a range of strategies and interventions designed to ensure adequate diets prior to pregnancy, during pregnancy, breastfeeding, early childhood and all stages of the life cycle. Researchers strongly recommend the integration of services such as family planning, post-partum and breastfeeding support, nutritional and health-care services, with all services provided in one locale. The U.S. Supplemental Nutrition Program for Women, Infants and Children (WIC) is a highly regarded example of an integrated program that provides 1) supplemental foods; 2) nutrition education; and 3) referrals to health-care and social-service providers.

Education is an essential element in maintaining proper nutritional health. Caregivers need to be aware of how early feeding experiences, appetite regulation and dietary patterns affect the development of healthy eating habits and adult health, and the fact that these patterns can be passed down to the next generation. Healthy eating habits are formed in early infancy and depend on positive interactions between infant and caregiver. It is the caregiver's role to ensure that mealtimes are consistent, pleasant, family-oriented, social occasions that give children the opportunity to try a variety of nutritional foods required for healthy development. Additional

research is needed on the familial and environmental influences, including cultural and transgenerational factors, that affect the development of healthy eating patterns.

Policy-makers and planners can greatly assist the improved nutritional health of women and children by supporting the development of evidence-based dietary guidelines and effective prevention and intervention services, especially for socio-economically disadvantaged families. They can also help by making maternal and child nutrition an integral part of comprehensive programs that serve women and children.

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Long-Term Effects of Prenatal and Early Postnatal Nutrition on Adult Psychosocial Outcomes

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Introduction

The existence of acute and chronic malnutrition in populations across the world is of concern both because of the immediate effects on morbidity and mortality and because of the possible long-term implications. These effects could be especially pronounced after exposure to malnutrition during fetal growth or in early infancy, because of potentially irreversible structural and biochemical changes to the growing brain. Nutritional deprivation during these critical periods might thereby have long-term effects on psychosocial development and behaviour.

Problems

For obvious reasons, the effects of impaired nutrition cannot be established in experimental studies that offer investigator control of the degree of nutrition. Estimates are therefore usually based on observations of malnourished infants and well-nourished controls. As the social, economic, and family conditions associated with malnutrition are also related to impaired development, it is difficult to separate the effects of nutrition from the effects of the concomitant conditions. Such a separation of attributes may only be feasible under special circumstances. Statistical control provides a partial solution to the confounding problem by examining various attributes of social background, but these are often incompletely measured and residual confounding cannot be excluded. Comparison with sibling controls offers tighter control of the confounding effects of family background, however few studies have available siblings. These and other issues have been well reviewed by Pollitt and Thomson,[1] Rush,[2] and Grantham-McGregor.[3] Researchers can evaluate with greater accuracy the effects of nutrition supplementation efforts initiated in infancy.

Research Context

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The role of early nutrition in human development has been clarified using observational, quasi-experimental, and intervention studies.

Observational studies of early postnatal malnutrition often show developmental delays in infants hospitalized with protein energy malnutrition (marasmus and kwashiorkor) and severe growth retardation in infants between 0 and 2 years, followed until ages 8 to 10. Intellectual performance has been compared to controls selected from non-hospital settings (creche, school) or to healthy siblings. Some typical studies were carried out in the South Africa[4,5] and Jamaica (mid-to-late 1950s),[6,7] Barbados (late 1960s),[8-10] and the Philippines[11] and Peru (late 1980s).[12] The magnitude of these studies varied between 40 and 250 subjects. In some studies, malnourished infants showed a 10- to 15-point deficit in intelligence scores around ages 8 to 10 compared to controls,[5,12] but they also came from markedly underprivileged backgrounds and living conditions[5] or had parents who were less educated[12] compared to controls. These attributes complicate the interpretation of the results. In studies with better controls for social background at the time of illness or in studies with sibling controls, recorded differences were smaller or non-existent.[4,6,7]

In an early observational study of the combined effects of prenatal and postnatal nutrition across a wide range of nutritional intakes among the women, children, and infants enrolled in the WIC (Women Infants Children) supplemental food program in the United States, supplemented children showed better intellectual performance at age 6 compared to non-supplemented older siblings.[13] These findings could not be confirmed in a subsequent national WIC evaluation of program participation of over 2,300 children aged 4 to 5 on outcomes of simple tests of behaviour, vocabulary, and memory since the control families tended to be more privileged, and the WIC recipients only did better on selected cognitive development tests after an adjustment for socio-demographic indicators. It was therefore not possible to definitively establish that WIC supplementation was related *per se* to child cognition and behaviour.[14]

During the Dutch Hunger (the winter of 1944–1945), urban populations in the Western Netherlands were exposed to acute starvation because of wartime occupation conditions. These conditions represented a quasi-experiment in that the famine was imposed by an occupying army upon a civilian population solely defined by time and place. Comparing exposed and non-exposed infants, there was no relation between prenatal or early postnatal famine exposure and subsequent intellectual performance in over 300,000 military recruits aged 18.[15]

Elsewhere, the impact of nutritional interventions during pregnancy and early childhood on mental behaviour and function through the 7th year of life were assessed in over 1,000 children between 1969 and 1977 in four rural villages in Guatemala.[16,17] In the first two villages, ad libitum feeding of a high-protein maize (atole) was provided and in the other two, a protein-free sweet fruit (fresco) drink was provided. Both supplements contained vitamins and minerals, but the fruit drink contained only one-third of the calories in the atole. Although protein supplementation was linked to improved child development in some reports of this study, the effects of supplementation were inconsistent in other reports.[2] Other problems in interpreting the study results arise because the women who took the supplements for themselves and their infants lived under better social conditions than those who did not. The duration of pregnancy could also confound the observed associations as gestation time limited the quantity of calories a mother could add to her regular diet.[2]

The association between prenatal nutrition and postnatal development was further explored in a randomized two-level trial of calorie and protein supplementation given to pregnant women in a poor black New York City population. Little if any association was seen between prenatal supplementation and measures of development at age 1.[18] In a smaller cognitive intervention study of children hospitalized for protein energy malnutrition in Jamaica, outcomes were compared between the 18 children who received extra daily play visits in the hospital and after discharge, and the 21 children who did not receive play visits. Near normal performance on a mental development scale was seen in starved children if cognitive stimulation was given in addition to nutritional rehabilitation. This effect was sustained for at least one year after discharge.[19]

Key Research Questions

The problems of confounding by self-selection and by unmeasured socio-economic attributes in investigations of prenatal or early postnatal nutrition and psychosocial performance in childhood are now well recognized. There is also an understanding that the role of nutrition per se is likely to be limited. These insights have stimulated more comprehensive approaches that view interactions between nutrition and the social environment as important determinants in a psychosocial development. This rationale is the basis for an evaluation of the benefits of behavioural interventions at an early age. In special study populations with a limited risk of confounding, the follow-up for psychosocial changes over the life course continues.

Recent Research Results

In Jamaica, interventions with nutrition rehabilitation and cognitive stimulation among 129 growth-retarded infants aged 9 to 24 months showed continued benefits after two years of follow-up. Four study groups were compared: controls, supplemented infants, stimulated infants, and infants with both supplementation and stimulation. A group of matched non-shunted controls was also available for comparison. Benefits from supplementation alone were no longer apparent at 11 years of age, although the benefits from stimulation remained.[20] In the Netherlands, the prenatal famine exposure in utero of 18-year old military recruits was associated with an increased risk of anti-social personality disorder (ASPD).[21] Admissions to psychiatric hospitals in the Netherlands of men and women born in 1944–1945 suggest an increased risk of schizophrenia and of affective psychosis after prenatal famine exposure in mid-pregnancy.[22,23] An overview of these follow-up studies is given elsewhere.[24] Analyses from the British 1946 national birth cohort and the United States Collaborative Perinatal Project show an association between birthweight and school age IQ, even within the normal range of birthweight.[25,26] It is not clear whether these outcomes are driven by differences in prenatal nutrition that affect infant size at birth or whether there are other explanations.

Conclusions

Many studies to date have shown associations between prenatal and early postnatal malnutrition and growth retardation on the one hand and delayed cognitive and psychosocial development on the other. It is also clear that most of these differences in outcome cannot be attributed exclusively to the effects of poor nutrition or growth. Observational studies in particular are likely to be confounded by self-selection and by unmeasured socio-economic attributes of early nutrition. These problems were already well recognized several decades ago[1,15,18] and can only be avoided through improved research designs that use sibling comparisons or include interventions beyond the control of the study subjects. Recent follow-up studies of infants born during the Dutch famine suggest that prenatal nutrition may play a role in the origin of some cases of schizophrenia or other neuropsychiatric outcomes.

Implications for Services and Policy Perspectives

Optimal psychosocial development requires adequate nutrition and social and emotional stimulation. In nearly all circumstances, these elements are intimately intertwined and not easily

separated. Therefore, nutritional supplementation alone is no easy fix.

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Nutrition and Its Impact on Psychosocial Child Development: Preterm Infants

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Introduction

Advances in technologies for the support of preterm (<37 weeks gestation), low birthweight (<2,500 grams), and very low birthweight (<1,500 grams birthweight) infants following delivery and during care in intensive care units has led to a dramatic increase in survival rates. Poor maternal nutrition and prenatal care, along with pregnancy complications affecting nutrient delivery to the fetus contribute to intrauterine growth retardation. Consequently, preterm and low birthweight infants are at increased risk for major handicaps, as well as below-average cognitive abilities and above-average behavioural problems at school age, even among infants without obvious neurological deficits. Volumetric measurements of brain regions in children born preterm have shown disproportionately smaller volumes of the sensorimotor cortex amygdala, hippocampus, basal ganglia, and impaired development in other areas associated with lower cognitive abilities, behavioural problems, and an increased risk of ADHD (Attention Deficit Hyperactivity Disorder).[1,2] Hypoxic, metabolic, and nutritional insults are among the important factors that contribute to growth and developmental problems in these infants. Problems in providing and sustaining the optimal nutritional environment for the rapidly developing third trimester brain *ex utero* and during post-term infant development are likely to contribute to these developmental delays.

Problems

Our current understanding of the nutrient requirements of preterm and IUGR (Intrauterine Growth Retardation) infants is incomplete. On one hand, the transfer of nutrients across the human placenta is difficult to study, on the other hand, the requirements of preterm infants are markedly different from those of the fetus, owing to the need to facilitate the maturation and functioning of postnatal organ systems (eg, lungs, intestines), and to provide nutrition via the intestine (through the digestion, absorption, and metabolic assimilation of complex molecules). Nutrient delivery is

often compromised by volume restrictions during early hospitalization, and concurrent drug treatments, in addition to immaturity, alter an infant's metabolism. Hypoglycaemia, including asymptomatic neonatal hypoglycaemia, increases the risk of reduced mental and motor developmental scores in preschool children.[3] The nutritional needs of preterm infants are not met by human breast milk, formulas designed for term infants, or parenteral nutrition. Most preterm infants with <29 weeks of gestation are discharged from hospital with significant growth retardation,[4] and due to a lack of well-developed resources to maximize catch-up growth potential, deficits in height, weight, and head circumference continue throughout childhood.[5-7] Deficits in growth and head size are associated with poorer educational and cognitive outcomes.[7] Children whose growth is restricted during their first two years of life score significantly lower than do non-growth restricted children on a wide range of cognitive tests, and although their scores can be improved through psychosocial stimulation, performance remains comparatively impaired.[8]

Key Research Focus

The requirements for classical nutrients and other biologically active dietary factors that maximize the developmental potential of the human brain, together with development of clinical products to provide these in parenteral and enteral nutrition are key research foci. Clinical products and practices should be developed to provide optimal nutritional support and prevent neural and physical growth stunting, while supporting and encouraging feeding with the mother's milk through at least the first 4 to 6 months post term. Research should be conducted to develop effective strategies for early identification and intervention of at-risk infants experiencing feeding and growth difficulties, and potential micronutrient deficiencies.

Research Context

The transition from the neonatal intensive care unit to home can be stressful. Preterm and very low birthweight infants often have unpredictable behaviour and have a variety of problems which result in feeding difficulties.[9] Most preterm infants born after <29 weeks of gestation are discharged from hospital with significant growth retardation.[4] Post-discharge growth impairment is common and its onset can be remarkably rapid.[6] Due to a lack of well-developed identification and intervention resources, catch-up growth potential is not achieved in many preterm infants and deficits in height, weight, and head circumference continue throughout childhood.[5,6,7] Assessments of growth during the first three years assessed by adjusted (rather than chronological) age,[10] and attention to feeding and nutrition are essential elements in combating deficits in growth and

failure to achieve catch-up.

Recent Research Results

The impact of nutrition on the psychosocial development of children born prematurely has been the subject of observational studies, case-control studies, and randomized trials with specific nutritional interventions. A meta-analysis of case-control studies of preterm infants evaluated after their 5th birthdays shows significantly lower weighted mean differences in cognitive scores of 10.9 points in preterm compared to control-term infants, and a greater prevalence of internalizing and externalizing behaviours and ADHD.[11] Mean cognitive test scores are lower among children of lower gestational age and lower weight at birth. Similarly, cohort studies have shown that preterm infants are at serious disadvantage for reduced school performance, requiring more special education and experiencing more behavioural problems than children born at term.[12]

Linguistic skills, including comprehension of logical grammatical constructions, phonemes and word fluency are also poorer in preterm infants[13] and recent work has suggested an increased risk of everyday memory difficulties at 5 years of age in children born before 32 weeks gestation.[14] Newer imaging techniques have shown reduced volumes in sensorimotor and other brain regions in preterm infants (even in the absence of reduced head size), which are related to cognitive deficits.[1,2] Neonatal nutritional support includes the dramatic shift from transplacental to intravenous or alimental nutrient delivery; periods of energy, macronutrient, and micronutrient deficits; metabolic complications such as hypoglycaemia; and the use of drugs such as steroids, which profoundly alter nutrient metabolism and head growth. Deficits in energy and essential nutrients during brain growth can impair cell division, myelination, and neural functional development.

Human milk and formulas for term infants do not meet the high nutrient and energy needs of preterm or low birthweight infants. Feeding nutrient-enriched formulas with higher protein, energy, calcium, phosphorous, iron, zinc, and other micronutrients reduces deficits in motor and mental developmental indices at 18 months, with the advantage in verbal and overall IQ maintained at school age.[15] Feeding nutrient-enriched formulas post-discharge for 9 months or longer also improves nutritional status, linear growth and occipitofrontal head circumference gains in preterm infants.[16] Preterm infants are at risk of deficiency with regard to many nutrients which are critical to central nervous system development. Irrespective of weight for gestational age,

preterm infants show evidence of iron deficiency before 4 months post-term, whereas term infants do not show iron deficiency at this age.[17] Iron deficiency (even in the presence of iron therapy) during infancy impairs a variety of cognitive processes and increases behavioural problems, persisting into later childhood.[18] A meta-analysis of data from randomized studies with preterm infants fed formulas supplemented with the long chain essential fatty acids, docosahexaenoic acid and arachidonic acid (which are crucial components of retinal and neuronal membranes) has shown a significant benefit in visual development.[19] Randomized controlled trials have also shown a significant advantage in psychomotor and language developmental tests among preterm newborns weighing <1250 grams supplemented with these fatty acids.[20]

Conclusions

Our current understanding of the biological, environmental, and psychosocial mechanisms involved in the cognitive and behavioural deficits of preterm children is incomplete. Failure to provide and sustain the energy, protein, and essential micronutrients needed to support the complex process of human brain development is an important contributing factor. Therefore, improved strategies are required for early identification and intervention in growth and feeding problems, and the development of feeding strategies to provide the nutrient enrichment needed to maximize potential for catch-up.

Implications

The decrease in cognitive test scores of 9 to 10 points in meta-analysis,[11] broad-based behavioural problems, and increased prevalence of ADHD among preterm infants have profound implications for concerned individuals and populations. Available data indicate that preterm children are 50% more likely to be enrolled in special education classes, and when extrapolated from US data from 1988,[21] this intervention alone conservatively costs an extra $37 million per year in Canada.

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Nutrition and Its Impact on Psychosocial Child Development: Perspective on Preterm Infants

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Introduction

Early nutrition, both the amount and the quality of nutrients, is increasingly recognized as having a major influence on the growth and development of preterm infants. Importantly, inadequate early nutrition may profoundly impact preterm infants' neurodevelopment causing impairments in educational and cognitive competency throughout childhood and young adulthood.[1,2] This paper will highlight new research that links specific aspects of nutrition in early life with benefits for early growth and brain function in preterm infants.

Subject

While breastfeeding is associated with optimal neurodevelopment and mother's own milk is universally recommended for preterm infants,[3-5] mothers may elect not to breastfeed or their milk supply is insufficient to meet the baby's needs. If mother's milk is not available, preterm infants are usually fed with commercial formula designed to meet their nutritional needs. However, donor human milk is now being advocated as a substitute for infant formula for in-hospital feeding,[4,6] potentially providing another source of the special components of human milk that are associated with benefits to neurodevelopment.

Problems

Research has consistently found that preterm infants who are fed their mother's milk early in life have greater visual acuity, language skills and developmental outcomes (up to 24 months of age) than do a comparable group of infants fed cow milk-based infant formula or even donor human milk.[3,4,7,8] Further research is necessary to define the specific nutrient(s) and/or socio-environmental factors related to feeding practices that may explain the observed developmental advantages associated with feeding mother's milk.

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Research Context

Due to ethical constraints, there are no randomized controlled trials (RCT) comparing the neurodevelopmental outcomes in preterm infants fed mother's milk versus formula or mixed feeding. However, reviews of prospective and retrospective data are consistent with an overall beneficial effect of mother's milk on brain development and cognitive functioning into childhood compared to infant formula.[4,9] Since required processing of donor milk renders it different to mother's milk, a separate assessment of the effect of donor milk compared to mother's milk on neurodevelopmental outcomes is needed.

Over the past two decades, research has focused on long-chain polyunsaturated fatty acids (LCPUFA), particularly docosahexaenoic acid (DHA) and arachidonic acid (AA), as the factors in mother's milk responsible for neurodevelopmental benefits. DHA and AA play a key role in the structure and function of retinal (eye) and neural (brain) tissues. Preterm birth disrupts the most significant accretion of DHA and AA that occurs during the second and third trimester. Thus, preterm infants must receive these fatty acids in their diet after birth due to insufficient endogenous synthesis.[10] Studies on the effect of LCPUFA on neurodevelopmental outcomes have had inconsistent results due to many variations in study design. Despite current standard practice in many countries that infant formula products contain DHA and AA, cognitive, language and motor advantages still appear to be greater in infants fed mother's milk compared to formula supplemented with LCPUFA.

Key Research Questions

The key research question is whether feeding preterm infants their mother's own milk benefits neurobehavioural development, which in turn, affects intellectual programming and social behaviour; and if so, by what mechanism (nutrients and/or feeding behaviour). If nutrients unique to human milk are found to confer neurobehavioural benefits, then the sequential research question is which (if any) of these factors are inactivated or destroyed during the processing (heating, freezing, thawing) of donor milk. Accordingly, it must be determined whether components labile to processing can be added back to donor milk or infant formula in amounts that will support the same developmental benefits as in fresh mother's own milk.

Recent Research Results

Mother's milk: The observed positive benefits of breastfeeding compared to formula feeding on short-term visual and developmental outcomes are summarized in several reviews.[4,7,9,11] Persistent beneficial effects of mother's milk during the early postnatal period on cognitive functioning are apparent for preterm infants up to 18,[8] 24[3] and 30 months of age.[12] A dose-response effect for mother's milk has been described in preterm infants, where each 10 mL/kg/day increase in mother's milk results in a 0.59 point increase in the Mental Developmental Index (MDI), a 0.56 point increase in the Psychomotor Developmental Index and the total behaviour percentile score increased by 0.99 points.[12] However, sometimes it is difficult to compare findings across studies due to differences between studies in partial and exclusive breastfeeding, use of fortified and unfortified human milk, differences in the type of cognitive assessments and the age at which they were conducted.

Donor milk: Fresh mother's own milk contains many components that may directly or indirectly facilitate the growth and development of the nervous system.[4] Awareness of the benefits of mother's milk has led to the increased use of donor milk. However, recent studies revealed that donor milk does not confer benefits to neurodevelopment compared to formula in preterm infants. In a recent Canadian RCT (n=363), donor milk-fed preterm infants did not achieve higher cognitive composite scores at 18 months' corrected age compared to formula-fed infants.[5] Furthermore, language and motor composite scores were not different between donor milk and formula-fed infants. Pooled data from a Cochrane systematic review of 9 studies (n=1070) also supports the fact that donor milk does not confer any neurodevelopmental advantage over formula.[13]

LCPUFA supplements: Evidence is inconsistent regarding whether LCPUFA supplementation in early life provides a cognitive advantage in infancy and later childhood. On the positive side, preterm infants who received mother's milk supplemented with DHA and AA compared to mother's milk alone from birth to 9 weeks of age had better recognition memory and higher problem-solving scores at 6 months of age.[14] Further, breastfed preterm infants with higher circulating DHA levels at 4 weeks of age had improvements in psychomotor development at 5 years of age.[15] In contrast, in a large multi-centre RCT (n=657) in Australia, the MDI at 18 months corrected age did not differ in infants supplemented with DHA versus those receiving a standard diet.[16] In the same cohort at 7 years of age (n=604), DHA supplementation did not result in any improvements in overall IQ scores.[17] Interestingly, in a subgroup analyses girls in the high-DHA group showed improvements in the MDI scores at 18 months of age[16] but at 7 years of age had

poorer parent-reported executive function and behaviour.[17] Thus, LCPUFA supplementation may accelerate the pace of neurodevelopment in preterm infants without offering any significant advantage in overall developmental outcome, as suggested by a recent systematic review and meta-analysis of 11 RCTs and 2272 participants.[18]

Research Gaps

The specific factor(s) in fresh mother's own milk that confers a developmental advantage for preterm infants remains to be identified. If it is not a specific neurotrophic factor in human milk that contributes to improvements in neurodevelopmental outcomes, thought should be given to how the nutrition source (mother's own milk, donor milk, formula) may be influencing other neonatal morbidities[19] (i.e., extended periods of parenteral nutrition, sepsis, necrotising enterocolitis, bronchopulmonary dysplasia, etc.) that could interfere with neurodevelopment.

Conclusions

Studies published to date provide evidence that mother's own milk confers a developmental advantage when compared to infant formula in preterm infants, but it is not likely that LCPUFA are solely responsible for this benefit. It is absolutely essential for brain and retinal development that preterm infants receive target amounts of LCPUFA (comparable to in utero accretion rates), but there is no strong evidence to support dietary supplementation with high levels of LCPUFA to improve cognitive, language or motor functioning.

Given that some studies have reported no difference in neurodevelopmental outcomes between donor milk and formula (with/without LCPUFA), it is possible that the beneficial effects of human milk are specific to mother's own fresh milk. A consensus on whether donor milk confers any neurodevelopmental advantage over formula is needed, and if it can be considered comparable to mother's own milk.

Implications for Policy and Services

Despite lack of supporting evidence, pregnant and breastfeeding mothers are increasingly encouraged to supplement their diet with LCPUFA to optimize brain development in their offspring. Clear guidelines that detail sufficient, but not excessive, intakes need to be established and communicated to mothers. Recent results suggest that high levels of omega-3 LCPUFA in the perinatal period may even have a negative impact on behaviour[17] and respiratory health in

preterm infants.[20] Other long-term morbidities potentially associated with LCPUFA supplementation may not be apparent yet given that many of the LCPUFA supplementation trials over the past decade have not had lengthy follow-up periods.

Development of infant nutrition products specifically for preterm infants should consider the influence of specific nutrients on neurodevelopment and not just somatic growth. In order to adequately assess the efficacy of the macronutrient balance, micronutrient levels and other neurotrophic ingredients on neurodevelopmental outcomes, tests are needed that are more sensitive to diet-induced alteration in behavioural and cognitive functions, both in early life and at school age.

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The Impact of Prenatal and Early Postnatal Nutrition on Child Development: Comments on Lumey and Susser, Innis and Atkinson

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April 2004

Long-Term Effects of Prenatal and Early Postnatal Nutrition on Adult Psychosocial Outcomes. Comments on the article by Lumey and Susser.

Introduction

The Lumey and Susser article discusses the research on the long-term impacts of prenatal and postnatal nutrition with a focus on the psychosocial and behavioural consequences in adulthood. This is an important health and well-being issue for the general population. Inadequate nutrition in the first months of life, during pregnancy or shortly after birth, can affect the development of the brain in ways that leave traces into adulthood.[1] The research on social inequalities and population health shows how significant early-life circumstances are in the long term.[2,3] This research is important because it identifies the factors that cause health and well-being problems so that we can intervene as early as possible to prevent these problems from arising.

Research and conclusions

The authors' interpretations are based on the literature they present. The subject has not been studied extensively, and the comparability of the findings is problematic. It is always risky to attempt to draw conclusions when mixing the findings of studies on individuals who have experienced famine, studies in developing countries where malnutrition is rampant and more recent studies on poor families in developed countries. I therefore agree that it would be important to plan studies that control for the variables which may be at play in these relationships. I do not agree that the studies done to date suggest that poor nutrition or growth are not likely to be involved in the relationship under investigation. For example, clinical studies on anaemia show that anaemic children have trouble concentrating at school and tend to be hyperactive.[4,5,6] Similarly, we must not overlook the effects of stress in poor families, where food is

scarce.[7]

Implications for policies and services

I agree with the conclusions the authors draw. Children living in precarious conditions which may negatively affect the nutrition of their mothers during the prenatal period, and their own nutrition postnatally, also have other needs - physical, emotional, and psychological. Merely giving nutritional supplements to the children without regard for the other deficits in the family environment would be ethically unacceptable. We know, for instance, that poor families that lack food experience highly stressful situations which may limit the ability of the parents to respond to the many other stimulation needs of their children. Support programs that target poor pregnant women need to address not only their physical and nutritional needs, but the issues of low self-esteem, lack of autonomy and stress that are a day-to-day reality for people who have to beg for food or who live in fear of having nothing to eat.[8] At the same time, children who are adequately stimulated but inadequately nourished also experience certain deficits which affect their nutritional status in addition to the effects of hunger and food deprivation. Neglected children who are fed irregularly adapt by ignoring the physiological signals of hunger and satiation, and end up, in the long run, developing eating disorders. Clearly, nutritional supplementation for needy families must be accompanied by psychosocial and economic support, and vice versa.

Nutrition and Its Impact on Psychosocial Child Development: Preterm Infants. Comments on the article by Innis

Introduction

The author deals with the relationship between nutrition and child development in preterm children. This is an important matter because preterm children exhibit both eating problems and growth profiles that are different from other babies. To counter growth deficiencies that can have more or less permanent sequela for these children, we need to understand the role played by nutrition. The proportion of premature infants who survive is steadily increasing thanks to technological and medical advances in infant care. It is imperative that we find better ways of dealing with the problems that will be faced by the increasing number of surviving premature or underweight infants.

Research and conclusions

The author's interpretations refer primarily to the physiological aspect of child development as it relates to nutrition. The studies mentioned do not put the other confounding aspects of nutrition, premature birth and low birth weight into perspective. For example, other factors such as maternal smoking during pregnancy, which is positively and progressively associated with poverty, may play a role in cognitive development deficiencies and even growth deficiencies.[9-12] In underprivileged environments, where food is scarce and of poor quality, the lack of food may also contribute to the fact that the children fail to catch up to full-term children by school age. Also, in a given population, children who are underweight at birth tend to gain more weight in their first year, compared to children who weigh more at birth.[13,14] This weight "recovery" whereby children who are underweight at birth end up weighing more than other children at one year of age is inconsistent with the findings presented by the author.

Implications for policies and services

The author does not provide enough support for his/her implications. He/she only considers the economic aspect, i.e., the intervention costs for these children. There are individual and social implications that should have been mentioned. For example, children who suffer from cognitive deficits will be less likely to succeed in school and to reach as high a social position in adulthood, with foreseeable health implications, since social position is positively and progressively associated with health status and life expectancy.[2] There are also ethical questions that need to be asked in this type of approach. Since it goes without saying that parents who are expecting a child will want everything to be done to keep their child alive if he or she is born prematurely, we must come to grips with the broader implications of using technologies that make it possible for children who will experience a variety of problems to survive regardless of the cost.

Nutrition and Its Impact on Psychosocial Child Development: Perspective on Preterm Infants. Comments on the article by Atkinson

Introduction

This article examines the relationship between nutrition in the first months of life and child development. Certain studies have indeed observed a relationship between breastfeeding and subsequent development in children. It is not clear whether or not the constituents of breast milk make a difference in and of themselves (as essential to development), or if the difference comes from other non-nutritional characteristics associated with breastfeeding. This discussion is

important for the promotion of breastfeeding and the development of better quality products (infant formulas) for children who are not breastfed.

Research and conclusions

I agree with the author's interpretations. Breast milk does contain substances that can play a role in the development of preterm children, and we need to continue advocating breastfeeding as a maternal behaviour that has other benefits as well. However, the findings of the studies are contradictory, because they are based on different research protocols that fail to give a continuous picture. We need a better description of the relationship between breast milk and the development of preterm children based on more standardized study designs that isolate the effect of breast milk from the related psychosocial and socio-economic aspects.

Implications for policies and services

The policy implications described by the author present a broad perspective that encompasses the long-term health and well-being of children. The implications for the development of nutrition policies and programs are also important. For example, the recommendations on breastfeeding are important for children who are born prematurely or with a low birth weight. If it is important to develop products to make up for deficiencies in preterm children, it is just as essential that we work to prevent children from being born prematurely and/or with a low birth weight in the population, especially given that these births continue to be more frequent in socio-economically disadvantaged families where less importance is attached to breastfeeding.[13]

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Effective Nutritional Practices and Policies for Childbearing and Childrearing Women

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Introduction

Adequate nutrition in women is one of the most crucial components of a healthy society. Many of the chronic, ongoing problems that women experience in the areas of health, employment, and productivity can be alleviated if they receive adequate nutrition throughout their life cycle. This paper will present the programs that reduce the prevalence of malnutrition in women at a macro (or societal) level, or that are effective at a micro (or individual) level, and those that emphasize the importance of maternal nutrition from a life-course perspective.

Subject Relevance

Poor nutrition in women creates a self-perpetuating cycle. Infants born with low birth weight or presenting with retarded growth are at risk for higher-than-average rates of morbidity and mortality during infancy and childhood, and rate lower-than-average in their productivity as adults.[1,2] Women who were malnourished as children, or who are currently malnourished as evidenced by underweight Body Mass Index (BMI), enter their reproductive years with inadequate nutritional stores, a strong predictor of low infant birth weight and increased infant mortality.[3,4] Nutritional supplementation in childhood has been shown to have a significant effect not only on a girl's growth, but also on her subsequent children.[5] Stunted growth in infants (the strongest marker for inadequate nutritional status) is more closely related to inadequate prenatal nutrition in mothers than it is to postnatal environmental factors.[6] In addition, malnourished women with short inter-pregnancy intervals enter each pregnancy with depleted physical resources, thereby perpetuating the cycle of mother–child malnutrition.[7]

Problems

No single method for ensuring adequate nutrition to childbearing women has been identified to date. Indeed, nutritional counselling for malnourished women during pregnancy or during inter-

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pregnancy intervals has not been shown to be an effective method for reducing malnutrition.[8] The supplemental ingestion of important nutrients such as iron, folate, and calcium is contingent upon the availability of supplements, the purchasing power of poor women, and their toleration of side effects from some supplements such as iron.[9] Some authors argue for a social ecological approach to ensure that reproductive-aged women receive sufficient folic acid supplementation prior to conception and during the first trimester.[10] The diets of pregnant women have been shown to have no significant differences, in regards to micronutrients, from the diets of non-pregnant women; pregnant women also have inadequate knowledge of general and prenatal nutrition.[11,12] The reduction of protein energy malnutrition (PEM) is contingent upon adequate supplies of high-quality food that may also be beyond the purchasing power of poor families. It is difficult for impoverished, malnourished women to achieve adequate nutrition, especially if they lack access to education that could increase their knowledge of health and nutrition.

Research Context

Research has been conducted regarding the improvement of women's nutrition at the macro (or societal) level as well as the micro (or individual) level. At this time, the majority of studies conducted have been pilot projects or program projects, with little research regarding large, society-wide programs for women.[13] A recent review of the Special Supplemental Nutrition Program for Women, Infants and Children (WIC program, a large program in the United States) examining the records of 60,731 pregnant women, demonstrates that WIC has notable cost-savings outcomes for infants.[14] However, the documented positive outcomes for mothers were limited to a reduction in days of postpartum hospitalization. Other authors report that WIC has a positive impact on children' health, but maternal health outcomes are rarely reported, and have been confined to reduction in iron deficiency anemia.[15-17] Most often, nutrition programs targeting women have used infant outcomes as their measures of success rather than the health outcomes of their women subjects.[18]

Recent Research Results

Mora and Nestel[18] have provided a summary of policy initiatives in developing countries that can improve prenatal nutrition. They concluded that increasing policy support for women's education, legislating for women's nutrition, financing health services for women, and integrating women into the planning systems for health care and nutrition services can effectively reduce the life cycle of malnutrition among women and children. Studies examining the effects of micronutrient

supplementation during pregnancy have demonstrated positive effects in infant weight, size, and length of gestational age,[19-22] but few studies have examined the impact of supplementation on maternal health.[23] A comprehensive view of women's health and nutrition should acknowledge the importance of women's education as the primary step in reducing malnutrition.[24,25] Lengthening inter-pregnancy intervals by providing contraception in a culturally sensitive manner can also reduce the depletion of a woman's nutritional stores due to frequent pregnancies. Family planning services must therefore be integrated into postpartum services. In addition, support must be provided for breastfeeding—an important contributor to child survival in developing countries.[26]

Similarly, nutritional services should be integrated into health care services. Existing programs that target women and children's health should also be integrated, so that a woman can receive care for herself, her children, and nutritional supplementation during one visit or in one locale. These programs should be desired and supported by the community, and the community should have a say in the services provided through these programs. Children's diets tend to resemble their mothers,[23] so obtaining diet histories for either a mother or child may be a feasible way to screen for adequate nutrition for the maternal child pair. Dietary counselling and nutrition information also needs to be provided in a culturally competent manner, as research has demonstrated that grandmothers, eating customs, and locally available foods often determine what foods are consumed by mothers and children.[27,28]

The most efficient and effective way to increase the levels of iron, folate, and calcium in women appears to be through the nutritional supplementation of certain foods in their diets.[29] Research conducted in Denmark demonstrated that a minority of pregnant women took 400 mcg of folic acid during the peri-conceptual period. The authors conclude that folic acid fortification of foods is the best way to reach a majority of women.[30] Since 1998, all enriched grains and cereals in the United States have been fortified with 140 micrograms of folate per 100 grams of grains or cereal.[31] In fact, it can now be said that the prevalence of iron-deficiency anaemia in women of reproductive age has been reduced largely through the nutritional supplementation of breakfast cereals in the U.S.[9,32] In England, low-income mothers who consumed breakfast cereals fortified with folate and iron were more than twice as likely to have an adequate diet as a group of low-income mothers who did not consume breakfast cereals.[8] Food manufacturers are also adding calcium to a variety of foods (e.g., orange juice) in the U.S., allowing women who consume inadequate amounts of dairy products to increase their calcium consumption.

Fetal programming

Fetal programming is the hypothesis that maternal and fetal nutrition can have a profound, lifelong effect on the health of the child as an adult.[33-37] Much of the recent literature concerning women's nutrition during pregnancy is focused on the impact of the maternal diet on the intra-uterine environment, and the effect that in turn has on the developing fetus. Fetal nutritional deprivation is seen as a strong stimulus for development of heart disease, hypertension, and type 2 diabetes,[38,39] structural defects of the hippocampus,[40] defects in immune function,[41] and development of depression in later life.[34] Some researchers think that efforts to address the increasing obesity epidemic may be most effective if they are addressed through public-health policies ensuring adequate nutrition to all women, and not from an individual-focused approach.[42-44]

Conclusions

Reducing malnutrition and avoiding obesity among childbearing women should not be confined to interventions during pregnancy. A life cycle approach to women's nutrition will acknowledge that adequate nutrition for women is not only important to their health but also to the health of their children and families. Women should be assessed for diet adequacy during family planning visits (e.g., haemoglobin measurement, diet history, BMI measurement); education should be provided in elementary and secondary schools on nutrition and health care, and women should be advised to space pregnancies at least 18 to 24 months apart to allow their bodies to recover their nutritional stores.[6] Pregnant adolescents are an especially vulnerable group as their risk of maternal mortality is two to five times greater than that of older women.[45] The most effective dietary interventions for reducing malnutrition center on public health approaches such as food fortification, comprehensive nutritional supplementation programs for all low-income women, community-based provision of health care, and education for all about the importance of nutrition. The most effective approaches for reduction of obesity focus on public-health infrastructure issues such as promotion of physical activity in the environment, availability of high quality foods at fast food venues and vending machines, and provision of low calorie beverages.[46]

Implications for Development and Policy

In the US, lack of political support for a broad-based approach to nutrition has hampered the practical application of research. The provision of high quality nutrition for women during their life cycle should be seen as an investment in the health of the population and not just a method to increase the birth weights of infants during pregnancy. The fetal programming hypothesis supports the view that fetal under or over nutrition will impact obesity and levels of chronic

diseases for generations in the future. Further support for research is needed to define adequate diets for non-pregnant, pregnant, lactating, and postpartum women. More research is also required to determine how anthropometrics and laboratory values should be used as indicators of malnutrition or over nutrition. Political support is necessary to address the disparities in nutrition found in wealthy, developed countries and to create culturally sensitive methods of delivering nutritional services. Behavioural studies must be conducted to examine women's eating patterns and determine effective ways of changing dietary habits. Finally, as policy is often driven by program cost, nutritional programs must integrate methods of cost analysis to demonstrate the cost effectiveness of providing adequate nutrition for women throughout their life cycles.

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Program and Services to Improve the Nutrition of Pregnant Women, Infants and Young Children

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Introduction

Pregnancy, infancy and early childhood are periods of rapid physiological growth and development. Insufficient nutrition during these critical growth and developmental periods places infants and children at risk of impaired emotional and cognitive development and adverse health outcomes. As a result, many programs and services educate pregnant and postpartum women about the importance of good nutrition and encourage them to feed their children and families healthy and nutritious foods.

Probably the largest and most visible program providing services to improve the nutritional status of pregnant women and children is the U.S. Supplemental Nutrition Program for Women, Infants, and Children (WIC). WIC provides supplemental foods, nutrition education, and health care and social service referrals to low-income pregnant, breastfeeding, and postpartum women, to infants, and to children one to four years of age who are at nutritional risk. In the United States, almost half of all infants and one-quarter of all children one to four years of age participate in the WIC program.[1]

Subject

The purpose of the WIC program is "to provide supplemental nutritious food as an adjunct to good health care during such critical times of growth and development in order to prevent the occurrence of health problems and improve the health status of these persons" (U.S. Public Law 95-627). To accomplish this, the WIC program provides three main benefits to participants: (1) supplemental foods, (2) nutrition education, and (3) referrals to health care and social service providers.

Supplemental foods are provided in food packages designed to provide specific nutrients thought to be lacking in the diets of eligible WIC participants—protein, vitamin A, vitamin C, calcium, and

iron. Supplemental food is provided in the form of a food instrument (either a voucher or check) that can be exchanged for specific foods in stores. This food instrument lists the quantities of food items, sometimes including brand names, which can be obtained. WIC food packages for pregnant and postpartum women, infants and children include iron-fortified formula, milk and cheese, eggs, iron-fortified ready-to-eat cereals, fruit and vegetable juices, dried peas or beans and peanut butter. The WIC food packages are designed for seven categories of participants: (1) pregnant and breastfeeding women (basic); (2) postpartum, non-breastfeeding women; (3) breastfeeding women (enhanced); (4) infants from birth through three months of age; (5) infants from four through 12 months of age; (6) children one through four years of age; and (7) women, infants, and children with special dietary needs. About 80 percent of WIC funds are used to provide these supplemental food packages.

WIC also provides nutrition education to program participants. WIC nutrition education focuses on the relationship between nutrition and good health and helps participants to achieve positive changes to dietary practices. At least two nutrition education sessions must be provided in each six-month certification period. Participants cannot be denied food instruments, however, if they fail to attend the nutrition education sessions.

The WIC program also promotes good health care by referring participants to health-care providers and advising them on how to receive health care and why it is important. Referrals to both health-care and social-service providers are expected to address the full range of health and nutrition needs of low-income women and their children. WIC funds, however, cannot be used to provide health care to participants. Many WIC clinics are located at or near public health clinics.

WIC eligibility is based on categorical criteria, income and evidence of nutritional risk. To be categorically eligible, an individual must be either (1) a pregnant woman, (2) non-breastfeeding woman up to 6 months postpartum, (3) a breastfeeding woman up to one year postpartum, (4) an infant up to one year of age, or (5) a child under age five. All of the U.S. states use 185 percent of the poverty income level as the income eligibility criterion, though adjunctive eligibility is also used for applicants who participate in other selected public assistance programs. Finally, program applicants must be determined to be at nutritional risk based on a medical or nutritional assessment by a “competent professional”, such as a physician, nutritionist or nurse.

Problems

The WIC program has been the focus of numerous and varied evaluations. In general, these studies have shown the effectiveness of WIC participation, especially for pregnant women and infants. Almost all of these studies compare the outcomes for a group of WIC participants with outcomes for a similar group of income-eligible non-participants. Such study designs almost always have the potential of selection bias, which occurs when underlying and unobservable differences between program participants and a comparison group of non-participants create differences in outcomes that are incorrectly attributed to program participation. For example, if WIC participants are more motivated and concerned about health and nutrition than non-participants, birth outcomes of WIC participants may be better than those of non-participants even in the absence of the WIC program. Alternatively, if WIC is successful at targeting and enrolling highest-risk women and children, any differences in outcomes between WIC participants and non-participants are likely to be understated due to pre-existing differences in risk. Thus, a key challenge for evaluations of WIC effectiveness is to control for observed differences between WIC participants and non-participants, and findings from studies of WIC effectiveness need to be interpreted within the context of the potential for selection bias.[2]

Research Context

Through the provision of program benefits and services—supplemental nutritious foods, nutrition education and health and social-service referrals—the WIC program is expected to improve the nutritional status of low-income pregnant, postpartum and lactating women, infants and children. For pregnant, postpartum and lactating women, WIC is expected to improve diets, improve pregnancy outcomes and lactation performance and lead to recommended use of health care. For infants and children, WIC is expected to improve diets, lead to recommended use of health care, reduce the prevalence of iron deficiency anemia and improve physical, emotional and cognitive development.

Key Research Questions

Key research questions include the following: (1) Does WIC participation lead to better diets for women, infants and children? (2) Is prenatal WIC participation associated with improved birth outcomes and use of prenatal care? (3) Is WIC participation associated with better iron status of infants and children and reduced iron deficiency anemia? (4) Do infant and child WIC participants comply with recommended use of preventive health care? and (5) Does WIC participation affect children’s physical growth and emotional and cognitive development? Given available data

sources and ongoing surveys, some of these research questions are easier to answer than others. Specifically, information on dietary outcomes and use of health care is available from surveys of low-income women and can be used to address research questions related to dietary status and use of health care. Data from the standard U.S. birth certificate files can be used to analyze the relationship between prenatal WIC participation and birth outcomes. Surveillance data collected by the U.S. Centers for Disease Control and Prevention are useful for assessing trends in iron deficiency anemia and WIC participation. However, because of the long-term nature and expense of collecting data on children's growth and development, only limited information is available on the relationship between WIC participation and physical growth and emotional and cognitive development of children.

Research Results

Numerous studies document positive effects of WIC participation on birth outcomes, although variation in the magnitude of these effects exists due to differences in methodological approaches. By far the most common birth outcome examined in the literature is newborn birthweight, and most studies find a significant effect of prenatal WIC participation on birthweight.[3-7] In a synthesis of 17 major studies, the U.S. General Accounting Office concluded that providing WIC benefits and services to low-income pregnant women significantly reduced the percentage of infants born at very low and at low birthweight.[8] In addition, other reviews of the WIC evaluations conclude that WIC has a positive effect on newborn birthweight.[9,10]

One of the most important, though dated, WIC evaluations is the National WIC Evaluation conducted by David Rush and his colleagues.[11] In this evaluation, longitudinal data on prenatal WIC participants were compared with data on non-WIC registrants at prenatal care clinics. The findings were: a significant increase in the number of women seeking prenatal care early in pregnancy and a significant drop in the proportion of women with too few prenatal care visits; increased intakes of protein, iron, calcium and vitamin C (four of the five targeted WIC nutrients); a decrease in the rate of pre-term delivery; increased head circumference of infants; reduced incidence of fetal death of appreciable but not significant magnitude; increased birthweight with better WIC program quality; and greatest dietary benefits among women at highest risk of poor perinatal outcomes.

In addition to birthweight, other perinatal outcomes examined in previous studies include the timing and quantity of prenatal care, health-care costs at and around birth, and infant and

neonatal mortality. Several studies found that prenatal WIC participants were more likely than non-participants to initiate prenatal care earlier and to receive adequate levels of prenatal care and less likely to receive no care or care in the third trimester.[6,12] The WIC-Medicaid study, which estimated the effects of prenatal WIC participation on health-care costs (Medicaid costs) after birth, found that the estimated savings in Medicaid costs within 60 days after birth per dollar spent on the prenatal WIC benefits ranged from $1.77 to $3.13 across the five U.S. states included in the study.[6] Prenatal WIC participation was also associated with reductions in infant and neonatal mortality, increased gestational age, and a lower incidence of pre-term births among Medicaid newborns.

In contrast to the large body of literature examining the effects of prenatal WIC participation, fewer studies focus on the effects of WIC participation by infants and children. Nevertheless, several studies report generally positive effects of WIC participation. Of particular importance is the evidence suggesting that WIC participation is associated with increases in mean haemoglobin or hematocrit levels and reductions in childhood anemia.[13] Data from the Pediatric Nutrition Surveillance System indicate that the prevalence of anemia among low-income children decreased during the 1980s, a finding largely attributed to improvements in childhood iron nutrition status and to positive effects of public-health programs, especially supplemental foods offered through the WIC program.[14]

Most studies examining the effect of WIC on growth have used measures of children's weight and height. An early evaluation by Edozien and his colleagues[3] used data from a nationally representative sample of over 6,000 infants and children ages zero to three years in 1973-76 and compared outcomes of clinical examinations for infants and children who had participated in WIC for six months with clinical data on newly enrolled infants and children. Their results indicated that WIC had a statistically significant impact on children's growth in weight and height. However, since low weight and height are used as criteria for WIC eligibility, the increase in weight and height after WIC participation may be due to regression to the mean.

Results from the National WIC Evaluation showed that WIC had no significant impact on weight but had a positive effect on weight for height for infants and children who had participated either prenatally or within three months after birth.[11] In addition, intakes of iron, vitamin C, thiamin, niacin, and vitamin B_6 were higher for WIC children than for non-participants.

A crucial feature of these evaluations of the effects of WIC participation by infants and children is that they are based on data that are very old, and significant changes have since occurred in the WIC program. In addition, evaluating the effects of WIC participation on the physical growth and development of children is problematic; impacts of WIC may not be evident until several years after a child has enrolled in WIC, and longitudinal studies of children participating in WIC are difficult to design and expensive to conduct.

Finally, some studies examine the impact of WIC participation on utilization of health care services. Data from the National WIC Evaluation showed that children receiving WIC benefits were significantly more likely to have a regular source of health care than non-WIC children, and that WIC participation was associated with immunizations for some subgroups of infants and children.[11] A recent study conducted using administrative data from the state of North Carolina found that low-income children participating in the WIC program are higher users of all types of health-care services than low-income non-participants.[15] Compared with income-eligible WIC non-participants, child WIC participants use more preventive-care services, more dental health services, and more emergency room and inpatient care. Moreover, children in WIC are more likely to be diagnosed and treated with common childhood illnesses — otitis media, gastroenteritis, upper and lower respiratory infections, asthma and other childhood illnesses. These results suggest that low-income children enrolled in WIC are linked to the health-care system and are much more likely to be receiving preventive and curative care.

Conclusions

Overall, research on the effectiveness of the WIC program suggests positive effects of the WIC program on intakes of most of the target nutrients for both women and children, improved pregnancy outcomes, savings in health-care costs associated with labour and delivery and increased use of health-care services. Less is known about the effects of WIC participation on the growth and development of infants and children, partly because well-designed studies are difficult and expensive to design and conduct. However, pediatric nutrition surveillance data indicate a strong positive effect of WIC on the incidence of anemia among low-income infants and children, a result that is likely to have a positive effect on long-term growth and cognitive development.

Implications

Although a large body of literature suggests beneficial effects of the WIC program, nearly all of this literature uses a study design that compares a group of WIC participants with a similar group of non-participants. However, because WIC participants are a self-selected group, it is not clear whether estimated program effects are due to the WIC program or to underlying and unobservable differences between participants and non-participants. In a context of designing and implementing a new program that would provide services to improve the nutrition of pregnant women and children, it would be very important and useful to implement the program in pilot sites where a random-assignment evaluation could be conducted. Random assignment designs provide the most rigorous and scientifically defensible estimate of program impacts, and are best used to evaluate new programs or program expansions that need to be evaluated before being undertaken on a larger scale.

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Helping Children Develop Healthy Eating Habits

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Introduction

The first year of life is characterized by rapid developmental changes related to eating. As infants gain truncal control, they progress from sucking liquids in a supine or semi- reclined position to eating solid foods in a seated position. Oral motor skills progress from a basic suck-swallow mechanism with breast milk or formula to a chew-swallow mechanism with semi-solids, progressing to complex textures.[1,2] As infants gain fine motor control, they progress from being fed exclusively by others to at least partial self-feeding. Their diet extends from breast milk or formula, through purees and specially prepared foods, to the family diet. By the end of the first year of life, children can sit independently, can chew and swallow a range of textures, are learning to feed themselves and are making the transition to the family diet and meal patterns.

As children transition to the family diet, recommendations address not only food, but also the eating context. A variety of healthy foods promote diet quality, along with early and sustained food acceptance. Data gathered on infants and young children 6 to 23 months of age across 11 countries have demonstrated a positive association between dietary variety and nutritional status.[3] Exposure to fruits and vegetables in infancy and toddlerhood have been associated with acceptance of these foods at later ages.[4-6]

Children’s eating patterns and food preferences are established early in life. When children refuse nutritious foods such as fruits or vegetables, mealtimes can become stressful or confrontational, and children may be denied both the nutrients they require and healthy, responsive interactions with caregivers. Caregivers who are inexperienced or stressed, and those who have poor eating habits themselves, may be most in need of assistance to facilitate healthy, nutritious mealtime behaviour with their children.

Subject

Problems associated with eating occur in 25% to 45% of all children, particularly when children are acquiring new skills and are challenged with new foods or mealtime expectations.[7] For example, infancy and toddlerhood are characterized by bids for autonomy and independence as children strive to do things themselves. When these characteristics are applied to eating behaviours, children may be neophobic (hesitant to try new foods) and insist on a limited repertoire of foods,[8] leading them to be described as picky eaters.

Most eating problems are temporary and easily resolved with little or no intervention. However, eating problems that persist can undermine children's growth, development, and relationships with their caregivers, leading to long-term health and developmental problems.[9] Children with persistent eating problems whose caregivers do not seek professional advice until the problems become severe, may be at risk for growth or behaviour problems.

Problems

Eating patterns have developmental, family and environmental influences. As children become developmentally able to make the transition to family foods, their internal regulatory cues for hunger and satiety may be overridden by familial and cultural patterns. At the family level, children of caregivers who model healthy food intakes are likely to consume more fruits and vegetables than children of caregiver who do not, whereas children of caregivers who model less healthy, snack food intakes are likely to establish patterns of eating behaviours and food preferences that include excess amounts of fat and sugar.[10] At the environmental level, children's frequent exposure to fast-food and other restaurants has led to increased consumption of high-fat foods, such as french fries, rather than more nutritious options, such as fruit and vegetables.[11] In addition, caregivers may not realize that many commercial products marketed for children, such as sweetened drinks, may satisfy hunger or thirst, but provide minimal nutritional benefits.[12]

National surveys have reported excessive caloric intakes during toddlerhood,[13,14] and many children continue to consume alarmingly low quantities of fruit and vegetables and essential micronutrients.[15] By elementary school, many children receive over half their beverage intake from sweetened drinks,[16] a pattern that undoubtedly begins during the toddler and preschool years. These poor nutritional patterns (high fat, sugar and refined carbohydrates; sweetened drinks; and limited fruit and vegetables) increase the likelihood of micronutrient deficiencies (e.g., Iron Deficiency Anemia) and excess weight gain in young children.[17]

Research Context

Eating is often studied through observational studies or caregiver reports of mealtime behaviour. Some investigators rely on clinical samples of children with growth or eating problems, while others recruit normative children.

Key Research Questions

Key questions include the progression of eating behaviours from infancy through toddlerhood, methods children use to signal hunger and satiety, and why some children (the so-called “picky” eaters) have selective food preferences. Key questions for caregivers and families are how to promote healthy eating behaviours in young children, how to encourage children to eat healthy food, and how to avoid problems in feeding and growth.

Recent Research Results

Attachment and eating

Healthy eating behaviour begins in infancy, as infants and their caregivers establish a partnership in which they recognize and interpret both verbal and non-verbal communication signals from one another. This reciprocal process forms a basis for the emotional bonding or attachment between infants and caregivers that is essential to healthy social functioning.[18] If there is a disruption in the communication between children and caregivers, characterized by inconsistent, non-responsive interactions, the attachment bond may not be secure, and eating may become an occasion for unproductive, upsetting battles over food.

Infants who do not provide clear signals to their caregivers or do not respond to their caregivers’ efforts to help them establish predictable routines of eating, sleeping and playing are at risk for regulatory problems that may include eating.[9] Infants who are premature or ill may be less responsive than healthy full-term infants and less able to communicate hunger or satiety. Caregivers who do not recognize their infants’ satiety cues may overfeed them, causing infants to associate feelings of satiety with frustration and conflict.

The caregiver-child context of feeding

Variability in the caregiver-child feeding context is related to children’s eating behaviour and growth.[19] The dimensions of parental structure and nurturance, which incorporate parents’

perceptions of their child's behaviour, have been applied to the feeding context (Figure 1).[20,21,22] Responsive feeding reflects a reciprocal pattern in which caregivers provide guidance and developmentally appropriate responses to their child's signals of hunger and satiety. Unresponsive feeding is marked by a lack of reciprocity between the caregiver and child, often characterized by the caregiver taking excessive control of the feeding context (forcing/pressuring or restricting food intake), the child controlling the feeding context (e.g., demanding a limited repertoire of food, indulgent feeding), or the caregiver ignoring the child's signals or failing to establish mealtime routines (uninvolved feeding).[23,24]

Figure 1. The Caregiver-Child Feeding Context: Patterns of Parenting and Feeding

	NURTURANCE	
	HIGH	LOW
HIGH	AUTHORITATIVE • Involved • Nurturing • Structured **Responsive**	AUTHORITARIAN • Forceful • Restrictive • Structured **Controlling**
LOW	INDULGENT • Involved • Nurturing • Unstructured **Indulgent**	UNINVOLVED • Unengaged • Insensitive • Unstructured **Uninvolved**

A controlling feeding style, high in structure and low in nurturance, represents caregivers who use forceful or restrictive strategies to control mealtimes. Controlling feeding is embedded in an overall authoritarian pattern of parenting and may include over-stimulating behaviours, such as speaking loudly, forcing foods or otherwise overpowering the child.[27] Controlling caregivers may override their child's internal regulatory cues for hunger and satiety.[28] The innate capacity that infants have to self-regulate their energy intake declines during early childhood in response to family and cultural patterns.[29] A responsive feeding style, high in nurturance and structure, a derivative of authoritative parenting, represents caregivers who form a relationship with their child that involves clear demands and mutual interpretation of signals and bids for mealtime

interaction. Responsive feeding is characterized by interactions that are prompt, contingent on the child's behaviour and developmentally appropriate with an easy give-and-take.[22,25,26]

An indulgent feeding style, high in nurturance and low in structure, is embedded in an overall indulgent style of parenting, and occurs when caregivers allow children to make decisions around meals, such as when and what they will eat.[23] Without parental guidelines, children are likely to be attracted to high salt/high sugar foods, rather than to a more balanced variety including vegetables.[23] Thus, an indulgent feeding style may be problematic, given infants' genetic predispositions to prefer sweet and salty tastes.[30] Children of caregivers who display an indulgent feeding style are often heavier than children of caregivers who use non-indulgent feeding styles.[24]

An uninvolved feeding style, low in both nurturance and structure, often represents caregivers who have limited knowledge and involvement in their child's mealtime behaviour.[23] Uninvolved child feeding styles may be characterized by little or no active physical help or verbalization during feeding, lack of reciprocity between the caregiver and child, a negative feeding environment and a lack of feeding structure or routine. Uninvolved feeders often ignore both child feeding recommendations and their toddler's cues of hunger and satiety and may be unaware of what or when their toddler is eating. Egeland and Sroufe[31] found that children of uninvolved or psychologically unavailable caregivers were more likely to be anxiously attached when compared with children of available caregivers. An uninvolved feeding style is embedded in an overall uninvolved style of parenting.[23]

Several recent systematic reviews report associations between parental feeding control and infant and early child weight gain and/or weight status.[24,32,33] Controlling feeding has been associated with increased weight gain (e.g., children of caregivers who use restrictive feeding practices tend to overeat)[34] and to decreased weight gain (e.g., children who are pressured to eat more, do not).[35] However, the cross-sectional design of most studies, along with a tendency to rely exclusively on caregiver behaviour, rather than consider the reciprocal nature of feeding interactions, has hindered the understanding of caregiver-child feeding interactions. A recent randomized controlled trial among infants in Australia found that providing anticipatory guidance regarding infant feeding behaviour led to healthier weight gain and higher rates of self-reported responsive feeding behaviour.[36] Additional trials are needed to better understand strategies to promote healthy feeding interactions and healthy growth.

Food preferences

Children who are raised with caregivers who model healthy eating behaviours, such as a diet rich in fruit and vegetables, establish food preferences that include fruit and vegetables.[4]

Food preferences are also influenced by associated conditions. Children are likely to avoid food that has been associated with unpleasant physical symptoms, such as nausea or pain. They may also avoid food that has been associated with the anxiety or distress that often occurs during meals characterized by arguments and confrontations.

Children also accept or reject food based on qualities of the food, such as taste, texture, smell, temperature or appearance, as well as environmental factors, such as the setting, the presence of others and the anticipated consequences of eating or not eating. For example, consequences of eating may include relief from hunger, participation in a social function or attention from caregivers. Consequences of not eating may include additional time to play, becoming the focus of attention or getting snack food instead of the regular meal.

Increasing familiarity with the taste of a food increases the likelihood of acceptance.[37,38] Caregivers can facilitate the introduction of new foods by pairing the new food with preferred food and presenting the new food repeatedly until it is no longer “new.”

Conclusions

Eating patterns are established early in life in response to internal regulatory cues, caregiver-child interactions, mealtimes routines, foods offered and modeling from family members. Exposing children to fruits and vegetables early in life establishes a pattern of fruit and vegetable preference and consumption throughout life. Research is needed to investigate the individual, interactive and environmental determinants of the caregiver-child feeding context, relationships between responsive/unresponsive feeding and children’s eating behaviour and weight gain and population-specific validated tools to measure responsive/unresponsive feeding.[24]

Early childhood eating behaviours are heavily influenced by caregivers and are learned through early experiences with food and eating. Education and support provided by health professionals (i.e., public health nurses, family physicians and pediatricians) and nutrition programs need to be strengthened to ensure that caregivers have the facilities needed to address issues of eating behaviours during childhood.

Caregivers should eat with children so modelling can occur and mealtimes are viewed as pleasant social occasions. Eating together lets children watch caregivers try new foods and helps children and caregivers communicate hunger and satiety, as well as enjoyment of specific foods.[39]

Caregivers control both the food that is offered and the mealtime atmosphere. Their "job" is to ensure that children are offered healthy food on a predictable schedule in a pleasant setting.[39] By developing mealtime routines, caregivers help children learn to anticipate when they will eat. Children learn that feelings of hunger are soon relieved and there is no need to feel anxious or irritable. Children should not graze or eat throughout the day, so they develop an expectation and an appetite around mealtime.[39]

Mealtimes should be pleasant and family-oriented, with family members eating together and sharing the events of the day. When mealtimes are too brief (less than 10 minutes), children may not have enough time to eat, particularly when they are acquiring self-feeding skills and may eat slowly. Alternatively, sitting for more than 20 or 30 minutes is often difficult for a child and mealtimes may become aversive.

When meals are characterized by distractions from television, family arguments or competing activities, children may have difficulty focusing on eating. Caregivers should separate mealtime from playtime and avoid using toys, games, or television to distract the child during mealtime. Child-oriented equipment, such as highchairs, bibs and small utensils, may facilitate eating and enable children to acquire the skills of self-feeding.

Implications

Implications can be directed to environmental, family and individual levels. At the environmental level, encouraging fast-food and other restaurants to also provide healthy, palatable food options that are appealing to young children may reduce some of the feeding problems that occur when children are repeatedly exposed to high-fat foods, such as french fries, rather than to nutritious options, such as fruit and vegetables. At the family level, guidelines for children's nutrition should include information on their nutritional needs and on strategies to promote healthy eating behaviour, including recognizing children's signals of hunger and satiety and use of appropriate feeding interactions, allocating time for meals, scheduling meals at relatively consistent times, promoting new foods through modelling and avoiding stress and conflict during meals. At the individual level, programs that help children develop healthy eating patterns by eating nutritious

foods and eating to satisfy hunger, rather than to satisfy emotional needs, may prevent subsequent health and developmental problems.[40]

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Nutritional Programs and Policies for Women and Children Commenting: Black, Reifsnider, and Devaney

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Introduction

These three papers highlight clinical, programmatic, and policy issues relevant to the provision of services promoting optimal health and nutrition in women and children. The first paper, by Black,[1] highlights issues related to the promotion of optimal feeding behaviours in young children with the goal or preventing malnutrition (undernutrition or overnutrition) and the development of healthy eating habits over a lifetime. The second paper, by Reifsnider,[2] characterizes macro-level trends and inter-generational influences on maternal and child health and nutrition, and advocates a life-course approach for programs in this area. The third paper, by Devaney,[3] describes the design of the largest nutrition program for women and children in the United States, and current knowledge with respect to its effectiveness in improving outcomes. Although markedly different in emphasis and style, the papers pinpoint several critical points as presented for discussion below.

Subject

The papers provide a case for integrative maternal and child programs as well as a broadening of such programs and policies towards a life-course approach. Despite numerous achievements in programs and policies, women and children are still some of the most vulnerable members of society, and the need for special provisions will likely remain for many years to come. Several important lessons have been learned from major programmatic experience. First, there is a need to provide continuity of care in maternal and child health and nutrition as the two are inextricably linked; this means providing integrated approaches to care for the pregnant woman, the baby, the lactating mother, the growing child, and the inter-conceptional woman. Second, what happens in early life can make a lifetime of difference, be it in relation to maternal undernutrition (which can lead to impaired fetal growth and subsequent incidences of diabetes and cardiovascular disease in adulthood), or to how early feeding experiences, appetite regulation, and dietary patterns affect

the development of health eating habits and adult health, and are passed on to the next generation. Third, unless we take a comprehensive and integrative approach to program evaluation, programs to support and improve maternal and child nutrition and health will be underestimated and underfunded.

Problems

With this context in mind, the papers highlight the need for consistent and comprehensive research in this area. The paper by Black examines how feeding behaviours affect both dietary intake and health problems, but provides few references. Clearly, this shortcoming underscores the emerging nature of the field and the need for active research to describe the public health consequences associated with our failure (to date) in considering such issues within child nutrition programs and the keys to change in this area that will promote healthy eating and lifestyle behaviours in the youngest members of society. However, while programs should focus on children, they should not discount the integral role that mothers play, nor should they forget that improvements to dietary patterns and health behaviours of women can be transferred beyond immediate program beneficiaries. Such links are not well established, however, and underscore a second important context for research in program evaluation. The illustration in the paper by Devaney regarding the complexities of creative program evaluation makes a case for the development of better methods and more funding for the appropriate evaluation of complex and comprehensive programs such as the Women, Infants and Children (WIC) program in the United States.

Research Context

It is clear from these papers that the context is ripe for further research in this area. There is an urgent need for research on the development of healthy eating patterns and on the familial and environmental influences on this development, including cultural and transgenerational factors. There is also a related need to identify and evaluate culturally appropriate and acceptable interventions to promote healthy dietary and lifestyle behaviours, and to develop programs and policies around successful approaches.

Key research questions

Key questions for research include the following:

1. What are the key personal, familial, environmental and societal factors that negatively affect the dietary patterns and nutritional well-being of women and children?
2. What are the most effective means by which to promote healthy eating patterns and nutrition in children and families?
3. How can we build, sustain, and comprehensively evaluate complex “life-course” or integrative maternal and child health and nutrition programs?
4. How can we scale-up models which are successful as pilot or small-scale nutrition programs?
5. How can we provide a better “voice” to policy makers on the successes of effective nutrition programs?

Conclusions

Maternal and Child Health and Nutrition (MCH/MCN) policy is currently undergoing a comprehensive transformation and rejuvenation. While many have always recognized the need for life-course approaches, recent research on the early origins of adult disease has attracted the attention and support of new partners. The time has come for all parties to work together to systematically build and sustain effective programs that accomplish a traditional agenda in MCH that prevents undernutrition and associated diseases and that will constitute a “new agenda” in preventing chronic disease, including obesity. These papers identify areas in which that work needs to proceed to promote healthy eating and dietary patterns now and for generations to come, focusing on children as well as the family.

Implications for Policy and Services

The life-course approach to maternal and child health has implications for programs and services beyond that provided to children. Integrated programs for women and children are just that — integrated. There are traditional barriers between branches of medicine and other clinical care providers that need to be broken down. Beastfeeding promotion is one case in point: adequate promotion and support of breastfeeding can require the cooperation and commitment amongst multiple medical specialties, including obstetrics, neonatology, pediatrics, and family medicine. A life-course approach requires the melding of short-term and long-term considerations regarding what is best or optimal for the fetus, child, or family. Such an approach would essentially be a marriage between policy makers in MCH and chronic disease. While complex and unwieldy, this marriage will be necessary if we are to accomplish the goal of optimal nutrition and health in

children and families over both the short and long terms.

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Facilitating Improved Nutrition for Pregnant and Lactating Women, and Children 0–5 Years of Age Commenting: Black, Reifsnider, and Devaney

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Introduction

The three papers on this theme provide an excellent overview of several key topics related to improving nutrition among childbearing women and their children. As Reifsnider points out, it is important to take a life cycle approach to this issue, rather than focusing solely on nutrition *during* pregnancy and the postpartum period. Nutrition during childhood and adolescence influence a woman's pre-conceptional nutritional status, which subsequently influences the outcome of pregnancy and the health of her child. Malnutrition is perpetuated across generations via this cycle. For this reason, programs to improve the nutrition of women and children must be comprehensive, targeting all stages of the life cycle. This commentary will focus on some of the issues not covered by the three papers, such as the lack of dietary guidelines specifically designed for pregnant and lactating women and young children, the importance of breastfeeding for both mother and infant, and the emerging crisis accompanying increased rates of child and adult obesity.

Subject

Why are maternal and child nutrition important in the context of early childhood development? There are numerous linkages between adequate prenatal and postnatal nutrition and a child's physical, cognitive, emotional, and motor development. For example, low birthweight resulting from intrauterine malnutrition is a key predictor of developmental delay, among other adverse outcomes.[1] Duration of breastfeeding has been positively associated with a child's cognitive[2] and motor[3,4] development. Maternal nutritional status, such as iron-deficiency anaemia, may affect the degree and quality of child caregiving. Lastly, maternal dietary practices and weight status are strongly related to a child's risk of being overweight,[5] a condition that can have lasting consequences on emotional and physical development.

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Problems

One of the barriers to improving maternal and child nutrition is the lack of consistent, evidence-based dietary guidelines targeted specifically at pregnant and lactating women, infants, and young children. Although nutrition during pregnancy and lactation was the topic of two comprehensive documents published by the U.S. Institute of Medicine,[6,7] and guidelines for maternal nutrition have been developed by various agencies, states, and countries, no critical scientific review or systematic consolidation of these recommendations has taken place. Consequently, there has been a duplication of efforts and inefficient targeting of resources. Efforts are underway to develop dietary guidelines for children, although most agencies have not yet grappled with recommendations for children under 2 years of age (apart from providing advice on breastfeeding). One exception is the Pan American Health Organization (under the aegis of the World Health Organization), which recently issued guiding principles for complementary feeding (6–24 months) of breastfed children.[8]

Research Context

Despite decades of interest in improving maternal and child nutrition, there is relatively little evidence regarding the efficacy (biological impact under ideal conditions) and effectiveness (effect of programs implemented on a large scale) of various strategies and programs. Previous studies have rarely assessed child development as one of the outcomes.

Key Research Questions

The three papers on this theme list several research questions that warrant attention. In the context of early childhood development, other important questions include the following:

1. *What is the relative contribution of pre-conceptional, peri-conceptional, prenatal, and postnatal nutrition to subsequent child growth and development, and which nutrients are most critical at each of these stages?*
   Some outcomes appear to be influenced by a mother's general nutritional status (eg, body mass index), whereas others may be affected by specific micronutrient deficiencies occurring at critical times, such as during organogenesis (the development of organs) or during myelination (the formation of the lipid substance [fat] that surrounds parts of some nerve cells, sometimes used as an index of maturation).

2. *How do we explain observed associations between the duration of breastfeeding and child cognitive and motor development?*
   Are these associations attributable to certain constituents in human milk, such as docosohexanoic acid (a long-chain polyunsaturated fatty acid important for brain development), the act of breastfeeding itself (via the enhancement of the maternal–infant relationship), or residual confounding by attributes of the family environment that have not been adequately measured in most studies?

3. *What is the most cost-effective mix of strategies to improve maternal and child nutrition, including nutrition education or counselling, food subsidies or supplements for low-income women, and micronutrient fortification or supplementation?*
   During pregnancy, it is very difficult to achieve the recommended intakes of certain nutrients (such as iron) without the use of fortified products or vitamin-mineral supplements. On the other hand, most nutritionists believe that focusing on food choices is the best long-term approach for improving nutrition.

Recent Research Results

Significant advances have been made in our understanding of maternal and child nutrition within the past several years. Key findings include the following:

1. *The global reproductive and developmental consequences of micronutrient deficiencies*
   These include impaired cognitive development (linked with deficiencies of iron, iodine, and zinc), impaired immunity (associated with lack of iron, vitamin A, and zinc), adverse reproductive outcomes, and maternal health problems (attributable to deficiencies of iron, iodine, vitamin A, zinc, folate, and calcium), and poor bone status in infants and children (related to low intakes of calcium, other minerals, and vitamin D).[9]

2. *The link between fetal/early postnatal nutrition and chronic health problems in adulthood*
   An avalanche of research papers has provided evidence for the “fetal programming” hypothesis which purports that the nutritional conditions experienced by the fetus and young infant result in permanent metabolic changes that alter the risk of hypertension, obesity, diabetes, heart disease, and mortality in later life.[10,11]

3. *The beneficial effects of breastfeeding for both mother and infant*
   The list of outcomes associated with breastfeeding grows longer each year. It includes enhanced maternal postpartum health (emotional well-being, weight loss, reduced risk of anaemia), lower risk of maternal ovarian and breast cancer, reduced infant morbidity (gastrointestinal illness, severe respiratory illness, ear infections, allergies), lower risk of child obesity, diabetes, cancer and other chronic health problems, and enhanced cognitive and motor development.

4. *The causes and consequences of maternal and child obesity*
   Alarming increases in the prevalence of adult and child obesity have occurred not only in the US[12] and other industrialized countries, but also in developing countries.[13] Maternal obesity has recently been linked to greater risk of complications during pregnancy and delivery and of congenital anomalies in offspring.[9] Child obesity increases the risk of type II diabetes and other adverse health outcomes. Our understanding of the genetics of obesity are is improving, but genetics do not explain the recent trends. The relative contribution of environmental factors, such as sedentary lifestyles and dietary habits, is the subject of intense research.

Conclusions

Improving maternal and child nutrition requires multiple strategies, with interventions aimed at various critical points during the life cycle. Ensuring adequate diets prior to pregnancy, during pregnancy and lactation, and during early childhood (particularly the first two years) is essential. Such interventions have the potential to substantially enhance child development, as well as the general health of women and children. There is a need for interdisciplinary teams of experts in fields such as reproductive health, nutrition and child development to work together to assess the efficacy and effectiveness of various approaches.

Implications for Policy and Services

Policy makers and service providers can take action by making maternal and child nutrition an integral part of comprehensive programs that serve women and children. A recent report by the March of Dimes provides the rationale and a blueprint for how to achieve this goal.[9] In addition, program planners and managers can stimulate further progress by requesting evidence-based dietary guidelines for pregnant and lactating women, and young children, and by advocating for

the research required to increase our understanding of the most critical needs and the interventions most effective in addressing these needs.

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