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Early Infant Feeding Influences and Weight of Children

Elizabeth Reifsnider[1] and Elnora Mendias[2]
[1]College of Nursing and Health Innovation, Arizona State University
[2]School of Nursing, University of Texas Medical Branch, Galveston
USA

1. Introduction

Childhood obesity has become a major health concern in nearly every country in the world. In the United States, the number of overweight children aged 2 to 5 years has more than doubled in the past 30 years. Overweight and obesity, already epidemic among the world's adults and children in both developed and developing countries, is escalating. While 61% of U.S. adults and almost 12% of U.S. children were overweight in 2001, a decade later, over two thirds of U.S. adults and almost one-third of U.S. children and adolescents were overweight or obese (Satcher, 2011). A 2010 estimate by the World Health Organization (WHO, n.d.[a]) indicated 42 million overweight children under five years of age worldwide, with 35 million living in developing countries. However, 2010 estimates provided by the International Association for the Study of Obesity International Obesity Taskforce (IASO/IOTF, n.d.) indicated one billion overweight (and another nearly half billion obese) adults internationally, with even higher estimates if adjusted for Asian-specific obesity measures. Moreover, the IASO International Obesity Taskforce's 2010 estimated 200 million obese or overweight school-aged children (IASO/IOTF, n.d.[b]).

Global trends toward childhood overweight or obesity have been attributed to two major factors: 1) increasing intake of energy-dense foods, high in sugars and fats and nutrient-poor (low in beneficial nutrients, such as minerals, vitamins, and healthy micronutrients); and 2) increasingly sedentary lifestyles, with low physical activity (Corvalan et al., 2009; Satcher, 2011; WHO, n.d.[b],). However, though primarily associated with unhealthy nutrition and limited physical activity, WHO (n.d.[b]) suggests that increased childhood obesity rates are related to child behaviors and numerous economic or social changes, as well as environmental, educational, urban planning, agricultural, transportation, and food policies. Polhamus et al. (2009) reported that data from 1998−2008 Pediatric Nutrition Surveillance System indicate prevalence of overweight/obese preschool children as 14.7%, and this prevalence is higher among Hispanic preschoolers (18.5%). Infant and toddler stages are a time of transition from dependent feeding to independent feeding. During early life, weight trajectories and food preferences predict trends and preferences throughout life (Allen & Myers, 2008). Early childhood is a crucial stage for monitoring growth and BMI and the most opportune time to prevent obesity in children by promoting healthy dietary and physical activity behaviors (Hawkins & Law, 2006a; He, 2008; Story et al., 2002). Many

factors contribute to the alarming rates of childhood obesity. Childhood obesity has a strong hereditary tendency (American Academy of Pediatrics [AAP], 2003; Barsh et al., 2000); however, there is evidence that a child's size (height, weight, and BMI) is influenced by factors in the family's environment. Many researchers have examined the relationship between childhood obesity and individual and family risk factors (Hawkins & Law, 2006b), such as parental BMI (Burke et al., 2001; Wardle et al., 2001), childhood television use (Adachi-Mejia et al., 2007; Dennison et al., 2002; Faith et al., 2001), and diet (Dennison et al., 1997; Welsh et al., 2005).

Sturm (2002) is among the many researchers who have noted that obesity has the same association with chronic health conditions as does 20 years of aging, and the cost of obesity exceeds the costs of smoking and drinking for national health care use. According to a study of costs attributed to adult overweight (BMI 25–29.9) and obesity (BMI > 30), these expenses accounted for 9.1% of the total U.S. medical expenditures in 1998 and reached $92.6 billion in 2002 dollars. In 2008 dollars, these costs totaled about $147 billion (Finkelstein et al., 2003, 2009). Some investigators predict that adolescent obesity may result in up to 1.5 million life-years lost, with total costs of $294 billion if lost productivity is counted along with medical costs (Inge & Xanthakos, 2010; Lightwood et al., 2009). Being overweight or obese carries considerable consequences. Substantial research has linked child obesity/overweight to increased risks for serious health outcomes, which include adverse physical, psychological/behavioral, or social consequences (AAP, 2005; Levi et al., 2011; Monasta, Batty, Cattaneo, et al., 2010; Monasta, Batty, Macaluso et al., 2010). Overweight or obese children tend to remain overweight or obese as they become adults, and these children also tend to develop illnesses, such as cardiovascular diseases, hypertension, or diabetes, at younger ages (Horta et al., 2007; WHO, n.d.[a],). Barker (1990) has been credited with first relating infant birth weight with adult illness such as hypertension, cardiovascular disease, and diabetes. Since then a number of studies, some of which are reviewed below, have examined relationships between obesity and these or other illnesses.

Recent studies have indicated that obesity has negative outcomes on very young children and contributes to health problems as obese children age. Investigators found that 3-year-old children who were very obese at < 2 years had multiple markers of inflammation associated with numerous chronic diseases (Skinner et al., 2010). Rising BMIs in childhood are also associated with increased risk for coronary heart disease in adulthood. Obese children have higher rates of asthma (Al-Shawwa et al., 2007; Rodriguez-Artalejo et al., 2002), hepatic steatosis (fatty degeneration of the liver; Dietz, 1998), sleep apnea (Kaditis et al., 2008), and type 2 diabetes (Must & Anderson , 2003). Risks of developing diabetes by the late teens can be predicted as early as age six based on blood pressure, BMI, fasting glucose, insulin and lipid values (Morrison et al., 2008, 2010). Most researchers now realize that by the time a child is 5, the prime years for prevention of obesity have passed. By this age, many children and families are set in patterns of eating and activity that are difficult to modify. Infancy and early childhood are now viewed as the prime ages for preventing obesity (Birch & Ventura, 2009; McCormick et al., 2010; Taveras et al., 2010).

Several systematic reviews have examined the relative contributions of a host of factors that contribute to childhood obesity. Hawkins and Law (2006b) reported on 59 studies (out of 1,923 originally identified) that met the inclusion criteria of accurate body-size measures and including children between the ages of six months and five years. Their review was organized as an ecological model with concentric circles expanding outwards to represent

the spheres of influence on the development of child obesity. They identified the levels of child characteristics (infant feeding, weaning, bottle use, diet, snack foods, physical activity and sedentary behavior, amount of screen time and use); family characteristics (parental factors, maternal pre-pregnancy weight, maternal smoking during pregnancy, maternal employment, social disadvantage); community-level factors (neighborhood, day care); and policy implications (dietary intake, opportunities for physical activity). These factors were largely reiterated in a systematic review by Monasta, Batty, Macaluso et al. (2010), who conducted a systematic review of 22 systematic reviews but in a different arrangement of factors. Monasta's et al. systematic review reported strong evidence from the constellation of reviews for the following factors as contributors to child obesity: genetics, maternal factors (including gestational diabetes and smoking), infant birth weight; size; and rate of growth; infant feeding, sleep duration, abuse/neglect and other negative social experiences, physical activity and sedentary behavior, and society and the built environment. A recent systematic review of interventions to prevent obesity in children birth to age five examined 18 studies and reported that few showed any evidence of effectiveness regardless of the location or components of the study. The authors concluded by stating that prevention of obesity and early intervention at its earliest sign is the most effective means to combat child obesity, as interventions later in childhood are not very effective (Hesketh & Campbell, 2010).

Whincup et al. (2008) conducted a systematic review examining the relationship between birth weight and type II diabetes in adults. The authors reported an inverse relationship between birth weight and risk for Type II diabetes (pooled OR, adjusted for age and gender: 0.75; 95% Confidence interval (CI): 0.70-0.81). Harder et al. (2009) conducted a systematic review and meta-analysis of studies examining relationships between diabetes and birth weight or weight gain during an infant's first year of life. The authors reported a significant association between higher birth weight (e.g., >4,000 grams) and increased risks for subsequent later development of Type I diabetes (OR: 1.17; 95% (CI): 1.09- 1.26). Harder et al. (2009) also noted studies supported a relationship between rapid weight gain in early life and later Type II diabetes development, though a meta-analysis was not possible due to differences in studies' time measurements and parameters for weight gain.

Recently, Monasta, Batty, Cattaneo, et al. (2010) conducted a systematic review of 22 published systematic reviews examining determinants of overweight/obesity in children in early life (e.g., conception to 5 years). Monasta, Batty, Cattaneo, et al. (2010) concluded that breastfeeding may be protective against later overweight/obesity and identified multiple factors that may affect risks for obesity. The researchers noted difficulty extricating "the complex web of associations and of reciprocal influences of all these factors" (Monasta, Batty, Cattaneo, et al., 2010, p. 703) and called for early-life intervention studies to substantiate protective and risk factors.

Hurley et al. (2011) conducted a systematic review of child obesity and responsive feeding (caregiver recognition and response to a child's hunger or satiety cues) in high-income countries. The majority of studies reviewed (24/31) reported significance between child BMI z-scores and nonresponsive feeding (e.g., caregiver lack of recognition of or response to child hunger/satiety cues; Hurley at al., 2011). This could be an interesting area to explore in breastfed children, where babies are much more "in charge" of their breast milk intake.

Along with birth weight and parental body size, infant feeding is recognized as one of the most influential biological and environmental factors that affect weight gain during infancy (Griffiths et al., 2009). Parental feeding practices have a strong impact on children's food

availability (Keller et al., 2006), eating behaviors, and weight (Birch & Fisher, 1998, 2000). Parental involvement in feeding is essential for children to grow, and parental knowledge, parenting style, modeling of food choices, and eating environment all have a strong impact on an infant's and child's weight (Campbell et al., 2008). Johnson and Birch (1994), for example, reported that parental over-control of child eating was associated with poorer eating regulation by the child and increased BMI. Helping parents acquire health-promoting parenting techniques is thus a key component in addressing the growing epidemic of childhood obesity in infants and toddlers (Anderson & Whitaker, 2010; Olstad & McCargar, 2009), yet systematic reviews have recognized that opportunities for prevention of obesity are plentiful but poorly recognized (Monasta, Batty, Macaluso et al., 2010) by health care providers and parents.

This chapter will review the current research on gestational programming of growth, maternal factors, and early infant feeding and the subsequent impact on the development of overweight, obesity, or both. As the earliest infant feeding is milk based, the review will discuss the research on breastfeeding as to whether the evidence shows a clear link between breastfeeding and obesity and present issues concerning maternal obesity and breastfeeding. The problems of early and rapid weight gain will be discussed. We will also discuss the factors associated with the development of overweight/obesity among a specific population, namely low-income Hispanic children in the southwest United States, as that is the first author's field of expertise. Recommendations for health care providers, researchers, and parents on ways to prevent the development of overweight/obesity among infants and young children will be presented for clinicians.

2. Programming of growth

Although the focus of this chapter is not on fetal growth and development, it is necessary to briefly review the contributions of fetal nutrition on infant growth and development. The fetal environment can set in motion developmental changes in metabolism to promote the survival of a fetus and neonate, so that his/her postnatal life will be enhanced. The developmental origins of disease, or developmental programming as it is also known, were popularized by the work of Barker and colleagues two decades ago (Barker et al., 1989, 1990; Hales et al., 1991). They proposed that developmental changes in key tissues and organ systems at critical periods of fetal growth can influence the long-term risk of metabolic and cardiovascular diseases (Warner & Ozanne, 2010). Fetal malnutrition from poor maternal diet or impaired placental blood flow can "program" the fetus to spare the development of the nervous system to the detriment of the endocrine system, for example. The poorly fed fetus results in a small for gestational age (SGA) or low birth weight (LBW) infant. If these infants are born into a poor nutritional environment, they are equipped through fetal development to grow appropriately for the available food and to survive through abdominal storage of fat. If however, the SGA or LBW infants have been born into an abundant nutritional environment, they rapidly gain weight (experience catch-up growth) and have been shown in numerous epidemiological studies to be at higher risk for hypertension, cardiovascular disease, insulin resistance and type 2 diabetes, renal disease, skeletal muscle alterations, and increased fat storage (Warner & Ozanne). A recent systematic review of 22 studies examining 40,000 deaths among 400,000 people reported that for deaths from all causes, there was a 6% lower risk per kg higher birth weight for men and women (adjusted HR = 0.94; 95% CI: 0.92-0.97, Risnes et al., 2009). The association was stronger for deaths from cardiovascular diseases (HR =0.88; 95% CI: 0.85-0.91).

The hazard ratio was increased for men and cancer mortality but not significant for women. These results from a strong systematic review show that birth weight is an indicator of in utero developmental processes that influence long-term health. However, the available data do not allow us to determine whether sociocultural factors, genetic factors, the intrauterine environment or life course exposures are more influential in explaining the observed associations. The type of nutritional support for appropriate catch-up growth that will allow a SGA or LBW infant to thrive without becoming at risk for later metabolic disease is still unknown.

While maternal undernutrition has received the most attention for its contribution to metabolic programming for infants and children, maternal overnutrition is now recognized for its role in creating detrimental health outcomes. Infants who are born large for gestational age (LGA) are also at risk for developing metabolic and cardiovascular diseases similar to infants born SGA and exposed to plentiful postnatal nutrition (Warner & Ozanne, 2010). Infants born to mothers who have gestational diabetes often are LGA and at risk for adult disease, due to the higher glucose maternal blood levels they are exposed to during gestation. In fact, researchers now believe that a U-shaped curve of risk exists for both ends of the birthweight spectrum, as SGA and LGA infants are both at risk for developing metabolic disorders later in life (Curhan, Chertow et al. 1996; Curhan, Willett, et al. 1996). Overfeeding and accelerated postnatal (catch up) growth appears to be the trigger that establishes the trajectory for at-risk status for SGA infants (Eriksson et al., 1999; Cheung et al., 2000) while the link between accelerated postnatal growth and metabolic disease for the LGA infants has not been as clearly identified (Cottrell & Ozanne, 2008).

Maternal smoking is a factor other than maternal diet that can influence a fetus's growth and impact the infant's risk of becoming overweight or obese. Maternal smoking during the first trimester and through the entire pregnancy has been associated with childhood obesity at age 5 (Toschke et al., 2003a), with more than twice the odds (OR 2.22; 95% CI: 1.33-3.69) for obesity at 5 years of age for maternal smoking in the first trimester and nearly twice (OR 1.70; 95% CI: 0.1.02-2.87) for smoking throughout pregnancy. Mizutani et al. (2007) reported that maternal smoking habits were associated with overweight in the 5-year-old children (OR 2.15; 95% CI: 1.12-4.11) among children of Japanese mothers who smoked during pregnancy. Mangrio et al. (2010) found that smoking worked synergistically with maternal obesity in that the odds for obesity were greater when the mothers were obese and smoked (OR 3.12; 95% CI: 1.13-8.63), while smoking did not appear to increase child obesity if the mother was not obese.

The reasons for the association of smoking and obesity are not well understood. Smoking can reduce blood flow to the placenta, which in turn can promote development of SGA or LBW. Magee et al. (2004) found that LBW was 58% more common among smokers than among non-smokers, and LBW can lead to accelerated postnatal growth, which itself can lead to obesity (Institute of Medicine [IOM], 2011). It has been demonstrated in animal models that maternal under-nutrition leads to LBW offspring who have altered leptin levels, hyperphagia, and increased weight gain (Plagemann & Harder, 2009). Smoking in pregnancy is implicated in appetite control and impulse control among offspring (Montgomery et al., 2005). Toschke et al. (2003b) described self-reported appetite among adults who were 42 years old and had been followed from birth. The proportion with poor appetite increased with levels of maternal smoking during pregnancy: from 4.5% with maternal non-smoking to 7.7% with maternal heavy smoking. BMI or levels of obesity among the adults were not reported. Montgomery et al. (2005) reported that compared with

non-smoking mothers, the adjusted odds ratios (95% confidence intervals) for bulimia in offspring were 0.74 (0.25-2.21) for those who gave up before pregnancy, 3.04 (1.16-7.95) for giving up smoking during pregnancy and 2.64 (1.47-4.74) for smoking throughout pregnancy. Smoking during pregnancy was not associated with anorexia nervosa in offspring. Neither BMI nor variation between childhood and adult BMI explain the association. If the association of smoking during pregnancy with bulimia in offspring is causal, then it may operate through compromised central nervous system development and its influence on impulse or appetite control. The increased risk associated with mothers who gave up smoking during pregnancy emphasizes the importance of smoking cessation prior to conception.

The Millennium Cohort Study (a longitudinal study of 11,653 preschool children) Child Health Group reported significant factors that impacted rapid weight gain at age three included parental weight status (maternal and paternal), pre-pregnancy maternal obesity, and maternal smoking; they were highly significant in predicting high BMI at age three (Griffiths et al., 2010) The BMI at age three was also a risk factor for subsequent excessive weight gain. However, how smoking may also affect the activity levels, appetite, or metabolism of the infants is currently unknown but may be through neurobehavioral changes in the developing neural system of the fetus.

Moran and Phillip (2003) reviewed studies of leptin, a hormone involved in human food intake and energy expenditure and nutritional balance, which is produced primarily by fat cells and elevated in obesity. They concluded a growing body of evidence linked leptin and diabetic pathophysiology. Some researchers have suggested that increased obesity rates are related to earlier puberty onset (precocious puberty), as both trends occurred over a similar time period. A review by Kaplowitz (2008) reported linkages between higher BMIs and earlier onset of puberty, especially in girls, identifying leptin as the key connection between body fat and early puberty.

Maternal prenatal behaviors such as diet and rest also contribute to infant obesity. The odds of obesity among children whose mothers did not eat breakfast was 1.78 (95% CI: 1.14-2.77), but if the mothers had a long sleep duration during pregnancy, the odds of obesity were 0.37 (95% CI: 0.15-0.88), showing a protective effect of maternal rest (Mizutani et al., 2007). Poor maternal diet among women who are normal or underweight at conception contributes to LGA and LBW infants (Fall, 2009; Scholl, 2008), and the link between maternal intake, LBW infants, and later development of metabolic disease in adults was the basis for the theory of metabolic programming, discussed earlier. Maternal rest and sleep has not been as well established as a contributor to LBW, but was linked to LBW by Abeysena et al. (2010) who studied paid employment, sleep, and levels of psychosocial stress, and found that standing more than 2.5 hours per day and sleeping less than 8 hours at night were significantly associated with LBW, while levels of psychosocial stress were not.

3. Early infant feeding

Although the link between infant feeding and overweight/obesity is established for preschoolers and younger school-aged children, not all studies have established a link between infant feeding and overweight/obesity at later age. Michels et al. (2007) examined the relation between infant feeding and the development of overweight/obesity throughout the life course. They utilized the Nurses' Health Study II, a prospective cohort of 116,678 female nurses. The mothers of the nurses in the study were contacted and queried about the

type of feeding given to the nurse subject when she was an infant. The mothers reported if they had breast-fed and if so, for how long, and if the subject was bottle-fed, the type of milk used in the bottle. Breastfeeding, regardless of its duration, did not influence the adult BMI of the nurse subjects, and there was also a lack of relationship between breastfeeding and the recalled weight of the nurse subjects at age 18. Although the feeding was reported as exclusively breast-fed or not, the type of associated food (liquid or solid) that was provided if the infant was not exclusively breast-fed was not addressed.

The type of formula fed to infants is also studied for its relation to later obesity risk. Breast milk has lower protein content than does formula that is based on cow's milk (Alexy et al., 1999) and formula fed infants have been found to have higher postprandial insulin than breast-fed infants, which enhances growth and stimulates adipocyte activity (Lucas et al., 1981) and results in earlier adiposity rebound and higher childhood BMI (Scaglioni et al., 2000). This is known as the early protein hypothesis (Koletzko et al., 2009) and was tested in the European Childhood Obesity Trial. Infants whose mothers chose to formula feed were randomly assigned to infant formula with higher protein content or lower protein content (Grote et al., 2010). Infants whose mothers chose to breast-fed were also followed as the standard growth group to which the growth of the formula fed infants was compared. All three groups of infants were followed for 2 years for growth. Significant differences in weight and weight-for-length emerged by 6 months in the 2 groups of formula fed infants and remained stable, with the higher protein-fed infants having a .20 higher z-score for growth than the lower protein-fed infants (Grote et al.). There was no difference in length at 2 years of age. Compared to the breast-fed group, the lower protein formula-fed infants had similar growth, while the higher protein infants had significantly higher weight and weight-for-length z-scores at 2 years of age. The researchers note that the lower-protein-formula group still had a higher intake of protein than did the breast-fed infants, and that the difference in protein content between the higher-protein-formula infants and the breast-fed infants would produce a 13% higher risk for later obesity.

3.1 Rapid growth

The growth rate of infants in the first six months of life has been suggested as an early indicator of risk status for becoming overweight/obese or as a cause of later obesity. A population-based study in the Netherlands (Generation R Study) examined the development and health of 1,232 infants. Their mothers consented during pregnancy, and the growth of the infants was examined from fetal life until six months of age. Body composition was ascertained through skinfold thickness. The investigators found that infants who had the greatest increase in weight from birth to six months of age had the highest percentage of body fat, regardless of their BMI, and concluded that rapid postnatal weight gain represents the early onset of adiposity (Holzhauer et al., 2009). Rapid weight gain during infancy of Chilean SGA children was associated with insulin resistance which preceded the weight gain, although the overall body weight was similar to children who had been born at normal weight (Mericq et al., 2005).

Several systematic reviews have been conducted on the issue of rapid weight gain, rapid growth, or both in infancy and the later development of overweight/obesity. Monteiro and Victora (2005) conducted a systematic review of 15 articles on rapid early growth and its association with obesity in later life. They reported that 13 of the studies found strong associations between rapid early growth and the occurrence of overweight, obesity, and

increased adiposity in spite of the ages at which the children were measured for follow-up of early growth. In their systematic review, Baird et al. (2005) reported on 24 studies out of 27,949 references originally identified. All studies were observational in design. The studies were remarkably consistent, in that they found that infants who were defined as obese in infancy were more likely to be obese in childhood, adolescence, or adulthood. Rapid growth was especially predictive, with odds ratios of 1.06 to 5.70 for rapid early growth and later obesity. They did not find an association between the timing of the rapid growth; any periods of rapid growth in the first or second year led to later obesity. Ong and Loos (2006) conducted a systematic review of 21 articles reporting on weight gain during infancy and risk for obesity in later life. They defined rapid infant weight gain as >0.67 SD in weight, as this SD represents the change from one centile line on the standard infant growth charts (e.g., 2nd, 10th, 25th, 50th, 75th, 90th, 98th centiles). All examined studies showed evidence of a positive association of infant weight gain that crosses percentiles upwards and a subsequent risk of obesity. They found that weight gain very early in life is a critical time for later obesity risk and that increasing weight gain from 1 to 2 years of age presents a 60% increased risk of obesity. They also reported that the effects of rapid early weight gain are similar in normal birth weight infants and LBW infants, demonstrating that rapid weight gain and catch-up growth are both important contributors to obesity development.

Owen et al. (2005) conducted a systematic review of published studies examining influences of types of initial infant feeding (breast vs. formula) on later development of obesity. Breastfeeding was associated with lower obesity risk, compared with formula feeding (OR: 0.87; 95% CI: 0.85, 0.89); this effect was stronger in smaller studies (<500 participants) but also apparent in larger studies (Owen et al., 2005). In another study, Owen et al. (2006) conducted a systematic review of published research examining relationships between initial infant feeding (breast vs. formula) and type 2 diabetes and glucose and insulin concentrations. Breastfeeding was associated with lower risks for type 2 diabetes in later life, compared to formula (OR: 0.61; 95% CI: 0.44, 0.85: p = 0.003, Owen et al., 2006).

3.2 Breastfeeding

There are many conflicting research studies about the effects of breastfeeding on later childhood obesity. Many studies acknowledge that breastfeeding is beneficial in reducing morbidity and mortality from gastrointestinal and respiratory infections, necrotizing enterocolitis in preterm infants, sudden infant death syndrome, and results in reduced atopic eczema, and higher IQ and academic performance (Kramer, 2010). However, the studies that also examine the risk for obesity have had conflicting results. This is partially due to the high level of confounding inherent in examination of the effects of breastfeeding on infant outcomes, as it is not possible to randomly assign infant feeding methods to mothers and infants. The choice to breast-feed is highly associated with education, income level, culture, influence of family and friends, and these variables are also associated with risk for adult obesity. This brief review of the conflicting studies will present the research that supports the effect of breastfeeding on lower risk for obesity initially and then present the studies that indicate that breastfeeding is not protective against later obesity risk.

3.2.1 Breastfeeding trends

Numerous international and national health organizations and professional groups have supported and continue to support breastfeeding as the optimal infant nutrition, for a

variety of psychological, development, nutrition, immunological, environmental, and economic reasons ([AAP], 2005). WHO for many years has endorsed exclusive breastfeeding (e.g., the infant receiving only breast milk, though vitamins, medicine, and minerals may also be received) from birth to six months of age in both developed and developing countries (Kramer & Kakuma, 2002) or longer. UNICEF (n.d.) also has promoted exclusive breastfeeding for the first six months of life, with continued breastfeeding for two or more years, as well as responsive, appropriate complementary food added at six months of age.

Despite this support and endorsement, global breastfeeding rates, especially for exclusive breastfeeding, are still less than optimal. U.S. breastfeeding rates have increased recently, with infants reported as ever breastfed rising from 60% to 77% of infants born (1993-94 vs. 2005-2006; McDowell et al., 2008). Moreover, U.S. breastfeeding rates remained significantly affected by race/ethnicity (80% for Mexican American, 79% for non-Hispanic white, and 65% for non-Hispanic black infants), family income (74% for higher income v 57% lower income infants), and maternal age (43% for women less than 20 years old v 65% of mothers 20-29 and 75% of mothers 30 or older; McDowell et al.). While recent data indicated that about three-fourths of U.S. infants were ever breastfed (Centers for Disease Control and Prevention [CDC], 2010), rates for exclusive breastfeeding for six months (e.g., only breast milk, with no other liquids or foods) were much lower at 13.3% (Levi et al., 2011). Moreover, only 35% of infants in the 94 countries monitored by WHO or 65% of global infant population) are exclusively breastfed for the first 4 months of life (WHO, 2006).

3.2.2 Breastfeeding and child health

Although multiple factors have been examined for their relationship to overweight/obesity (Lamb et al., 2010), a large body of evidence has established linkages between breastfeeding and breastfeeding mothers' and children's health outcomes (Metzger & McDade, 2010). Breastfeeding benefits for the infant are thought to be both short term, such as protection from infection and morbidity (Horta et al., 2007; UNICEF, n.d.), and longer term (Horta et al.). A stunning amount of research has examined breastfeeding and child health outcomes. A comprehensive summary of breastfeeding is beyond the scope of this chapter.

Breast milk has long been viewed as the ideal infant food (AAP, 2005; Kramer, 2010; McDowell et al., 2008). Nevertheless, past debate focused on weighing exclusive breastfeeding benefits and concerns that exclusive breastfeeding might be insufficient to meet infants' energy and micronutrient needs after four months of age (Kramer & Kakuma, 2002). Kramer and Kakuma conducted a systematic review of studies that compared maternal or child health outcomes for exclusive breastfeeding > six months of age vs. exclusive breastfeeding between three to four months as well as complementary liquids or foods through six months of age or longer. The authors concluded that evidence failed to support increased risks in infants exclusively breastfed for six months in developed or developing countries.

Druet and Ong (2008) examined the early childhood predictors of adult body composition, and support the view that breastfeeding has a protective effect against later obesity. They believe that the effect may be due to the slower weight gain that breastfed infants maintain compared to formula fed infants and reduced protein intake. The WHO has identified breastfeeding as the normal feeding for infants and the growth of breastfed infants as the norm to which the growth of formula fed infants should be compared. The WHO 2006

Growth Standards are based on the growth of breastfed infants worldwide whose mothers were provided with lactation support for exclusive or predominant breastfeeding (de Onis et al., 2004).

3.2.3 Breastfeeding reduces childhood obesity

Breast milk contains many biologically active substances, some of whom have functions as yet unknown. The composition of milk varies throughout the feeding, throughout the day, and from day to day. Leptin, a hormone released by adipocytes to regulate energy balance by decreasing food intake and increasing energy expenditure, is present in breast milk (Palou & Picó, 2009). It allows for the body to maintain fat stores within a certain range but appears to lose its effect with weight gain, in that most obese individuals are resistant to leptin (Ahima & Flier, 2000). The effect of leptin on breastfed infants may regulate their feeding, although this remains unknown. Palou and Picó examined the effects of leptin provided to suckling rats and found that these rats as adults were more resistant to age-related weight increases and less likely to gain weight when provided with a high-fat diet. They conclude that leptin plays a critical role in assisting with the development of brain regions that regulate body weight.

Since so many of the confounding variables that accompany infant feeding choices cannot be controlled through random assignment, researchers have attempted to control these variables through intra-family studies of feeding choices and through large scale, nationally representative cohort studies. An interesting study, conducted by Metzger and McDade (2010), examined breastfeeding effects on obesity prevention, using a sibling difference model. The children of women who chose different feeding methods for their infants (formula feeding or breastfeeding) were studied as part of the Panel Study of Income Dynamics (PSID), a longitudinal examination of representative families in the United States on child development. Children who were not breastfed had lower birth weights and were more likely to be preterm; their mothers were more likely to be teens at the time of birth and their income lower. There were 118 children who differed by feeding method within families and they were much more similar to each other than the overall comparisons of formula fed or breastfed children. The breastfed children, when compared to their formula fed siblings, were 0.4 SD thinner, which amounts to 14 pounds for a 14 year old boy, and the breastfed children were less likely to be at the upper end of the BMI distribution (Metzer & McDade).

The growth velocities of 2 cohorts of infants in Germany were examined (Rzehak et al., 2009) as part of the GINI and LISA birth cohort studies. Infant feeding method was noted, along with many socioeconomic variables and was studied in 7,643 infants. The investigators found that the velocity of weight gain was lower for exclusively breastfed infants than formula fed infants, and the larger difference between velocities was between 3 and 6 months. The velocity of length gain did not differ between infants with different feeding methods. For each time period, exclusively breastfed infants had lower velocity of monthly weight-for-length (BMI) gain than did formula fed or mixed (formula- and breast milk–fed) infants.

The growth of 10,533 children from birth to age 3 was examined as part of the Millennium Cohort Study in the United Kingdom in which parental confounding factors were adjusted in the analyses (Griffiths et al., 2009). The researchers noted that infants who received no breast milk gained weight most rapidly and infants who were breastfed for fewer than 4

months gained weight more quickly than those who were breastfed longer than 4 months. These differences in weight gain were significantly associated with BMI z-score at age 3, although there was no significant difference in height z-score. The researchers also reported that early introduction of solid foods was not associated with greater BMI at age 3 in contrast to earlier research. The researchers from both the U.S. cohort study (PSID), the U.K. cohort study, and the German cohort studies conclude that their finding are consistent with the early programming hypothesis that breast milk and breastfeeding have biological and physiological effects on brain development that impact on the risk for later weight gain and development of obesity. The mechanisms that foster the effects remain to be determined but may also be due to infant self-regulation of hunger and satiety.

Kramer was credited with first proposing that breastfeeding provides a protective effect against childhood obesity (Arenz et al., 2004; Horta et al., 2007). In 1981, Kramer conducted an epidemiological case-control study including 639 children 12-18 years of age attending a clinic at which obesity was a frequent reason for care and 533 high school students of similar age, where lower rates of obesity were deemed likely. In the study, participants were first classified as non-obese, overweight, and obese based on anthropomorphic measurements (height, weight, and subscapular and triceps skinfold thickness), then demographic, family history, and feeding history were obtained by phone interviews with participants' mothers. The school participants' obesity prevalence rate was lower than that of clinic participants (11.3% vs. 20.3%), and school participants' breastfeeding rates were higher (36.2% vs. 21.6%). Kramer (1981) concluded that breastfeeding significantly reduced subsequent obesity through adolescence, with a slight increase with duration greater than two months. There was little additional benefit from delaying solid food introduction, and findings remained significantly protective after controlling for several confounders, including race, socioeconomic status, and birth order

Harder et al. (2005) completed a meta-analysis of studies examining breastfeeding duration and risk for later overweight. Breastfeeding duration was significantly negatively associated with risk for overweight in later life (regression coefficient: 0.94, 95% CI 0.89, 0.98). Categorical analysis of five breastfeeding duration categories (<1 month, 1-3 months, 4-6 months, 7-9 months, and >9 months) confirmed a dose-response association between duration and risk of later overweight, beginning at one month and plateauing at nine months. Each month of breastfeeding was associated with a 4% decrease in risk for later overweight (OR=0.86, 95%CI: 0.50, 0.91).

3.2.4 Breastfeeding has no impact on childhood obesity

In contrast to mechanistic and cohort studies that conclude that breastfeeding is protective against childhood obesity, some researchers have found no effect of type of infant feeding on obesity using samples from different cohort studies than described above. Kramer et al. (2009) recently published the effects of their large randomized intervention trial of a breast-feeding promotion intervention in Belarus. The PROBIT (Promotion of Breastfeeding Intervention Trial) design randomized lactation support interventions by hospital and was conducted in Belarus from June 1996 to December 1997 with a sample size of 16,491 infants. The exclusive breastfeeding rate at 3 months of age among infants born at the intervention hospitals was 43% compared to 6.4% among infants born at control hospitals. The mothers in the study were not significantly different by group. At age 6 there were no significant differences between the children in the intervention group and the children in the control

group for height, BMI, waist circumference or skinfold thickness. The children in the intervention group had significantly improved cognitive ability (higher IQ and academic performance) at age 6 and reduced atopic eczema in infancy (Kramer et al., 2009, 2010). Though the intervention was effective in producing exclusive breastfeeding at 3 months of age (43.3 % v. 6.4%, P <0.001) and higher rates of breastfeeding throughout infancy, they observed no significant intervention effects of their breast-feeding promotion intervention on measures of height, blood pressure, BMI, or adiposity. However, one critique of this study is that it appeared not to have originally been designed to examine overweight/obesity outcomes (Monasta, Batty, Macaluso, et al., 2010).The children who were breastfed were not compared to the children who were bottle-fed regardless of their group membership and so this was not a true comparison of the effect of breastfeeding on obesity; rather it was a test of the effectiveness of hospital-based lactation support on increasing rates of breastfeeding. The PROBIT study provides information for policy changes on lactation support as it demonstrated that lactation support can increase breastfeeding rates among postpartum hospitalized mothers.

A sample of 2,291 Kuwaiti 3 to 6 year old children were examined for height and weight and were taken from the larger Kuwait Nutrition Surveillance System (Al-Qaoud & Prakash, 2009). The children's early feeding histories were obtained by questionnaire and were categorized by breastfed or never breastfed, and duration of breastfeeding. The investigators found no significant differences between the children who were breastfed regardless of duration and children who were not breastfed after adjusting for confounding variables such as time of introduction of solid foods, mother's socio-economic status, and child's birth weight and gestational age. The majority of the infants were breastfed for fewer than 4 months. The investigators note that Kuwait has undergone a nutrition transition that has resulted in increased high-fat food consumption and a more sedentary lifestyle and that these environmental impacts may also affect infants' and young children's size and growth.

The Copenhagen Perinatal Cohort, consisting of 9,125 individuals, was begun in 1959. Information on the infants' feeding history was collected when they were 1 year old and rates of breastfeeding were high, with only 9% of infants not receiving breast milk during 1st week of life. Data on the timing of solid food introduction and the type of solid foods were also measured at age 1. The participants' BMIs were measured longitudinally throughout their lives, and the relationship between early infant feeding and BMI was examined at age 42 (Schack-Nielsen et al., 2010). A longer duration of breastfeeding was associated with a lower BMI at age 1, but no effect was seen at older childhood or in adulthood. A later introduction of solid food was associated with a lower BMI at age 42 but no effect was seen at earlier ages. The authors conclude that early introduction of solid food is related to adult obesity, and adult obesity is not related to breastfeeding in infancy. It is possible that a longer duration of breastfeeding is related to a later introduction of solid foods. Mothers who determine that their breastfed infants are satisfied with breast milk and are growing adequately may not introduce solid foods as soon as mothers who perceive that their infants are not getting full with breast milk and want more to eat.

A similar cohort study examined the relationship of early infant feeding and adult BMI among the participants of the Nurses Health Study II, a prospective cohort of 116,678 female registered nurses ages 25-42 in 1989 and residing in the US. In 2001, the mothers of the study participants were asked about the infant feeding their daughters received. The data collected from the mothers included type of feeding (breast or bottle), duration of

breastfeeding and bottle feeding, and use of formula or evaporated milk. The ages of introduction of solid food and cow's milk was also obtained. There were 41% of nurse participants who were breastfed for longer than 1 week and no effect type of infant feeding was found in adulthood for overweight or obesity (Michels et al., 2007). The duration of breastfeeding was also not associated with adult BMI as women who were breastfed for 9 months had the same risk of obesity as did women who were exclusively bottle-fed, although the women who were breastfed had a lower risk of being overweight during early childhood.

Though a number of reviews in this paper have agreed that breastfeeding has a protective effect again later obesity, others have been less conclusive (Monasta, Batty, Cattaneo, et al., 2011). Neutzling et al. (2009) studied relationships between breastfeeding duration, introduction of complementary solid/semi-solid foods before age four months, and overweight/obesity at eleven years of age in adolescents born in Pelotas, Brazil. They reported that the lowest prevalence of overweight or obesity was observed in participants breastfed one-three months, noting that their findings did not indicate consistent relationships between breastfeeding and introduction of complementary food or risks for later obesity. However, they recommended caution in interpreting their findings, due to several limitations, including a very short duration of breastfeeding in their participants.

3.2.5 Impact of maternal obesity on breastfeeding

An association between maternal obesity and reduced breastfeeding incidence and duration has been known since 1992 (Rutishauser & Carlin, 1992); subsequently, other researchers have found lower rates of breastfeeding among women who are overweight or obese (Donath & Amir, 2008). The reasons suggested for the association are cultural, physiological, and physical (results of pregnancies and deliveries complicated by obesity). The Third National Health and Nutrition Survey (Li et al., 2002) and the Pediatric Nutrition Surveillance System and the Pregnancy Nutrition Surveillance System (Li et al., 2003), established that obese women were less likely to have ever breast-fed. Two factors, both independently associated with reduced breastfeeding incidence, are higher maternal BMI before pregnancy and higher gestational weight gain. A dose-response was evident from the Longitudinal Study of Australian Children (Donath & Amir), with increasing rates of obesity among women associated with reduced incidence of breastfeeding. The women least likely to breastfeed are obese women with a BMI > 40. Danish women also demonstrated this dose response relationship between increased obesity and a lower incidence of breastfeeding (Baker et al., 2007). Finding this association in societies that are very supportive of breastfeeding (Denmark and Australia) suggests that the association may be due to physiological factors, in addition to psychological or cultural factors.

3.2.6 Physiological factors impacting breastfeeding

Lactogenesis II, the postpartum onset of copious lactation, is also known colloquially as when the milk "comes in" and usually occurs between 48 and 72 hours postpartum. Delayed lactogenesis II occurs when copious milk is not available more than 72 hours after delivery. Delayed lactogenesis II is associated with a high maternal pre-pregnancy BMI, and a delay in copious milk production may predict shorter breastfeeding duration. The negative effects of greater maternal BMI can, however, be overcome if in-depth breastfeeding support is present (Chapman & Perez-Escamilla, 2000).

The discrepancy between normal weight and obese postpartum women in lactogenesis II may be due to several factors. First, lower levels of prolactin in the first 48 hours after delivery are found in obese new mothers (Rasmussen & Kjolhede, 2004). Release of prolactin is reduced in obese women more than in lean women, and it is connected to the numerous hormonal changes that occur postpartum (Rasmussen, 2007). Obese women have reduced prolactin response to an infant's sucking at 2 and 7 days postpartum, and this may reduce the mother's confidence that her milk is sufficient for her child and lead to early cessation of breastfeeding. In addition, obese women have a less steep decline in insulin concentrations from the end of pregnancy to the initiation of lactation, perhaps leading to less glucose available for milk synthesis (Lovelady, 2005). Higher leptin levels, which have been found in obese women postpartum, can inhibit oxytocin's effect on muscle contractions in vitro, leading to an increased incidence of dysfunctional labor and higher cesarean section rates among obese women (Moynihan et al., 2006). Oxytocin is also necessary for the milk ejection reflex, which allows milk to be available to the sucking infant.

An interesting hypothesis related to the interaction of early feeding and life course development may also partially explain why obese women have lower rates of breastfeeding initiation and duration (Rasmussen 2007). Studies in domesticated animals (such as cows, pigs, sheep, and laboratory animals) have shown that a high-energy intake during early development and gestation can lead to reduced growth of the mammary glands and reduced milk yield. This has been extensively studied in dairy cows and has the name of "fat cow syndrome" (Morrow, 1976). However, the ways in which early feeding contributes to development of connective, adipose, and epithelial tissue, all of which constitute human breasts, remains unclear. It is not yet known if breast development in obese women mimics the reduced mammary development that occurs in overfed animals.

3.2.7 Medical/physical factors impacting breastfeeding

Obese women are more likely to have comorbid conditions and to develop certain pregnancy-related diseases such as preeclampsia, gestational hypertension, and gestational diabetes, leading to higher rates of complicated labor, higher rates of cesarean delivery, and more postpartum complications such as hemorrhage (Hadar & Yogev, 2011; Rasmussen & Kjolhede, 2008). Recovery is longer after difficult labors, cesarean deliveries, or both than after spontaneous labors and vaginal deliveries. Women with difficult labors and deliveries experience more infections, pain from incisions, and greater delay in putting the infant to breast (Sebire et al., 2001). Delays in putting the infant to breast can result from the need to attend to the health of the mother after the complicated delivery, pain from incisions, or from separation of the newborn from the mother for observation in the newborn nursery. It is also more difficult to hold an infant in the traditional "Madonna" position (a common breastfeeding position) after a cesarean section because of pain from an abdominal incision. In addition, the mechanical difficulties of latching an infant onto a large breast may require specialized lactation expertise unavailable to the new mother (Jevitt et al., 2007). Kitsantas and Pawloski (2010) found that obesity impacts the initiation and duration of breastfeeding only among mothers who experienced medical complications during pregnancy or labor and delivery complications. They reported that obese women who had no pregnancy, labor, and delivery complications initiated breastfeeding at the same rate as women who were not overweight/obese. Lactation education and assistance can make a difference in breastfeeding initiation and duration among obese women.

3.2.8 Sociocultural factors impacting breastfeeding

Sociocultural factors may exert an indirect effect on lactation, while physiological or medical factors among obese women can have direct effects on lactation. The National Immunization Survey conducted by the Centers for Disease Control and Prevention (CDC, 2007) revealed that rates of exclusive breastfeeding were lowest among infants of mothers who were under 20 years of age, with a high school education or less, unmarried, living in rural areas, and at the federal poverty level or below. In population-based studies, obese women have been found to be more likely to be lower income, with less education, and with higher rates of smoking than women of normal weight (Donath & Emir, 2008; Eriksson et al., 2003). Even as obesity has been found to be an independent risk factor for low rates of breastfeeding (Oddy et al., 2006), the constellation of obesity, low levels of education, rural residence, poverty, smoking, and being unmarried combine to predict a high risk of not breastfeeding. Women with these risk factors will need special lactation education, counseling, and support to overcome the risk of failing to breastfeed.

3.2.9 The impact of breastfeeding on maternal obesity

Breastfeeding can have short- and long-term effects on the weight of postpartum women (Walker et al., 2004). It is important to include these effects in this review because retained weight from each pregnancy is a risk factor for maternal obesity, which perpetuates the cycle of LGA infants. Breast milk contains varying amounts of calories based on the child's age, the mother's diet, and the amount of milk produced by the mother. Calories in milk can range from 53 to 75 kcal/100 ml, also depending on the mother's dietary intake and the timing of the feeding as milk produced later in the feeding is higher in fat (hindmilk). Mothers in developed countries produce breast milk with higher calories than mothers in developing countries (Lauber & Reinhardt, 1979), probably because women in developed countries are better nourished. The mother whose infant consumes a liter of breast milk a day may use 600 kilocalories a day in milk production and in the content of the milk. If the breastfeeding woman does not increase her dietary intake by a corresponding number of calories, postpartum weight loss can result. Araujo et al. (2006) found that in Brazil, postpartum weight retention was lowest in women who breast-fed for 4 to 12 months and highest for mothers who breast-fed for less than 1 month or more than 12 months. In a related study, Gigante et al. (2001) reported that 5 years after the birth of their children, BMI did not significantly differ between women who had breast-fed and those who had not. Brazilian researchers also found that breastfeeding did not have a significant effect on postpartum weight retention in obese women, although it did on women with a normal pre-pregnancy BMI (Kac et al., 2004). It may be necessary to include the maternal pre-pregnancy weight status when examining the effect of breastfeeding on postpartum weight loss.

Studies from the Danish National Birth Cohort have shown that if obese women breastfeed as recommended (exclusively to 6 months, and continuing in addition to solid food to 12 months) postpartum weight retention could be eliminated and BMI could be reduced by 18 months postpartum (Baker et al., 2008). The Stockholm Pregnancy and Weight Development Study provided 15 years of follow-up of women who delivered in 1984-1985. Women with a higher BMI at the 15-year follow-up had a higher pre-pregnancy BMI and more gestational weight gain (Linne et al., 2003); women who remained normal weight had breast-fed longer and more exclusively than women who became overweight across the 15 years of follow-up. In a related study, the long-term impact of lactation on women's health was examined in the

Women's Health Initiative (WHI). Thirty-five years after childbearing, women who had breast-fed for cumulative lifetime duration of 12 months or longer were less likely to have hypertension, diabetes, hyperlipidemia, or cardiovascular disease (Schwarz et al., 2009). In summary, breastfeeding can promote postpartum weight loss depending on breastfeeding intensity (exclusive or supplemental), duration in months, the woman's pre-pregnancy BMI, and the woman's dietary intake. Breastfeeding can thus be beneficial not only for the infant but also for the breastfeeding mother.

3.2.10 Recommendations for promoting breastfeeding among obese women

Given the findings that breastfeeding is beneficial to women's and infants' health, that obese women are at more risk to deliver LGA infants who are at risk to develop cardiovascular disease as adults, and that obese women are less likely to breastfeed, it is important for obstetric care providers to assist obese postpartum women to breastfeed (Reifsnider, 2011). Many clinicians are unaware of the research showing that obese women have lower rates of breastfeeding or of the reasons for the lower rates (Rasmussen et al., 2006). Thus, clinicians need to be aware of the risks of lactation failure in obese women and target these women for additional education and support during pregnancy and after delivery. It may be more difficult for an infant to latch onto the breast of an obese mother, and obese women will benefit from specific counseling on latching on and from breast support with a towel placed under the breast (Jevitt et al., 2006; Rasmussen et al.). Pumping from both breasts using a double-pump system between infant feedings can increase milk production and promote the woman's sense of accomplishment in feeding her infant (Jevitt et al.).

Encourage skin-to-skin contact and put newborn to breast as soon after birth as possible
Limit maternal-newborn separation, encourage mother-baby in same room
Carefully observe latch-on and correct any incorrect placement of infant's jaw and assist with latch-on until mother is competent
Encourage frequent sucking and ad lib newborn feeding at breast
Demonstrate variety of nursing positions to relieve pressure on nipples
Assist mothers with flat or inverted nipples to use shields to allow for nipple protrusion
Support large breasts with towel placed under breast
Teach mothers how to use breast pump and encourage pumping between feedings to increase milk supply
Teach mothers how to wake a "sleepy baby" and encourage the neonate to nurse
Teach mothers how to recognize neonate swallowing of breast milk
Teach mothers to recognize signs of adequate infant intake (to 5-6 stools per day and first appearance of yellow stool by Day 6)   to reassure her that her milk is sufficient for her infant. This can promote breastfeeding duration and exclusivity (Shrago et al., 2006).
Refer to lactation specialist if needed

Table 1. Clinical Lactation Support for Obese Breastfeeding Mothers

4. Timing of weaning/introduction of solid foods

The age at which an infant is introduced to foods other than breast milk or formula has been examined as one factor influencing the risk for obesity. The American Heart Association (AHA) has released dietary recommendations for children and adolescents, and the recommendations have been endorsed by the American Academy of Pediatrics (AHA, 2006). The recommendations recognize that the period from weaning (introduction of solid foods) to consumption of a mature diet, occurring from 4 to 6 months to 2 years of age, represents a major developmental time point for children, but there has been very little research on the best methods to achieve optimal nutrition during this transition. Transition to solid foods and sources of nutrients other than breast milk or formula should begin at 4 to 6 months of age to ensure sufficient nutrition in the diet, but the best methods for accomplishing this task are essentially unknown. A recent examination of the timing of solid food introduction and obesity at three years of age was reported by Huh et al. (2011). The children were in a prospective cohort study from birth and the primary outcome was obesity at age three. The exposure to solid foods at < 4 months, 4-5 months, or ≥ 6 months was examined along with the type of feeding (breast-fed or formula fed). Infants who were breast-fed for less than four months were categorized in the formula-fed group. Among breast-fed infants, 9% were obese at three years of age, and the timing of solid food introduction was not associated with obesity. Among formula-fed children, introduction of solid foods before four months was associated with a six times higher increase in the odds ratio for obesity (OR 6.3; 95% CI: 2.30-6.90). Only 8% of breast-fed infants were introduced to solid foods before four months, compared with 33% of formula fed infants. Introduction of solid foods between four and six months did not increase the odds for obesity at age 3.

These finding are similar to those reported almost two decades ago by researchers with the DARLING study, who found that solid foods displaced milk intake in breast-fed infants but not in formula fed infants, who consumed the same amount of formula while adding solid foods as well (Heinig et al., 1993). A prospective cohort followed from birth in the United Kingdom found that energy intake at four months was higher in formula fed or mixed feeing (formula and breast milk) infants who were fed solid foods earlier (some starting at 1-2 months). The higher energy intake at four months predicted greater weight gain from birth to age 1, age 2, and age 3, and resulted in larger BMI at age 3. No effect of early feeding on BMI at age 3 was found in breast-fed infants. In the formula and mixed-feeding group, each 100 kcal increase in energy intake at age four months was associated with increased risk of obesity at age three (OR 1.46; 95% CI:1.20-1.78) and at five years of age as well (OR 1.25; 95% CI: 1.00-1.55). The authors noted that the larger energy intake and the increased weight gain from year to year contributed to the risk of obesity at age three (Ong et al., 2006). A prospective cohort study from Australia enrolled 620 pregnant women and followed their children until they were 10 years old, when their BMI was assessed (Seach et al., 2010). The duration of breastfeeding (whether exclusive or mixed) was not associated with BMI, but the age of solid food introduction and parental smoking were both significantly associated with higher BMIs. Healthy-weight children started solid foods on average at 20.5 weeks of age, while the obese children started solid foods at 18.7 weeks of age. The prevalence of obesity in the group that started solids before 20 weeds was 34.7%, while it was 19.4% among the children who started solid foods at 24 weeks or later. The researchers did not find any interaction effects with duration of breastfeeding and introduction of solid foods, as opposed to the findings of Huh et al., discussed earlier.

However, they recommend that solid foods not be introduced until the infant is six months of age to provide the strongest protection against obesity, both as an infant and as a child.

Adiposity rebound is the time when the fatness of children accelerates and usually occurs between the ages of 4 to 6. Children's growth rate slows after age 1 and the children become thinner, but with the advent of the adiposity rebound, the fatness and the weight increase. Children who become obese have an earlier rebound (approximately age 3) than those who do not (ages 4 to 6). The Raine prospective cohort study followed 1,330 children from birth to adolescence and collected detailed infant feeding data during their first year. The investigators conducted repeated anthropometric measurements (Chivers et al., 2010) and found that at 14 years of age, BMI was consistently higher for the group breast-fed less than four months. Adiposity rebound occurred on average at age 5.3 years for the normal weight group, age 3.8 for the overweight group, and age 2.6 for the obese group. Adiposity rebound was earlier and the BMI at the nadir was earlier for the group that was breast-fed less than four months. The impact of other feeding (besides formula) on the adiposity rebound or later obesity was not reported in this study, while the authors concluded that the early introduction of formula is associated with accelerated growth and later obesity.

In a retrospective study in Brazil of 566 children, investigators collected data on infant feeding from their parents along with types of feeding and dates of weaning (Simon et al., 2008). The children were between the ages of two and six, with the older children being significantly heavier than the younger children. The duration of exclusive breastfeeding was found to be protective of being obese as a preschooler as infants who were exclusively breast-fed for six months having nearly half the odds of being obese (OR .57; 95% CI: 0.38-0.86). In addition, the duration of breastfeeding also contributed to the reduction of obesity, as being breast-fed until 24 months results in OR of 0.13; 95% CI: 0.05-0.37) for obesity. There were no significant differences between rates of obesity and the timing or the type of solid foods given to the infants. The foods the infants were given included tea, fruit, non-maternal milk, cold cuts, sugar, meat, and eggs.

An interesting examination of how infants consume their food revealed that infants who were breast-fed less than 20% of milk feedings (included pumped breast milk and formula) were two times more likely to have excess weight between 6 to 12 months, and infants who often emptied their bottles were 70% more likely to have excess weight (Li et al., 2010). Maternal encouragement to finish the bottle was not significantly associated with excess weight; only the infants' own initiated bottle-emptying behavior predicted later obesity. Nursing from the breast was not associated with excess weight. The authors recommend that mothers be taught to recognize satiety in infants and provide less formula in bottles to reduce the amount of intake at each bottle feeding. Parenting education is also needed to recognize signs of infant temperament and use other soothing techniques besides providing a bottle of formula or juice. Wasser et al. (2011) found that among mothers and infants in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC program), infants were introduced to solids and juice by the first and second months. The most common sources of nutrition other than formula were juice and cereal in formula bottles. Mothers who perceived that their children were "fussy" were twice as likely to be fed solid food before six months. The formula fed infants who received solid or juice consumed approximately 100 kcal more than infants who consumed only formula. This amount mirrors the amount of extra kcal reported by Ong et al. in the U.K. (see above). Clearly, parenting education is needed to promote delaying introduction of solids and juice until six

months, to provide appropriate amounts of formula, and to use techniques other than bottle feeding when a child is fussing or crying.

5. First author's research with obesity and low-income Hispanic families in the southwest United States

The toddler stage is a time of transition from dependent feeding to independent feeding. During this early time in life, food preferences develop, and often they predict preferences throughout life (Allen & Myers, 2006). Not only is this a crucial stage for monitoring growth and BMI, it is the most opportune time to prevent obesity in children by promoting healthy nutrition and increased physical activity behaviors (He, 2006; Story et al., 2002). The majority of intervention studies on pediatric obesity have been conducted with white, middle-class samples (Ward-Begnoche et al., 2009), thus providing scant knowledge for intervening with low-income, Hispanic populations. Hispanics of Mexican American origin are at an increased risk for obesity, particularly among those in the lower socioeconomic level (Fisher-Hoch et al., 2010). Treviño et al. (2008) found rates of obesity of 33% among low-income, school-aged Hispanic children in rural south Texas. McCormick et al. (2010) have documented that 16% of infants in their practice in Galveston, Texas are obese, as measured by weight for length calculations. More Hispanic infants were obese than were children of other ethnicities with no significant differences in sex or financial status. Only 14% of the obese infants and 23% of the obese 24 month olds were diagnosed as obese by their primary care provider, demonstrating that obesity may not be acknowledged by parents or health care providers. The first author's work has focused on the causes and elimination of these health disparities in growth.

The ecological model of growth (EMG; Reifsnider & Ritsema, 2008) has been used as the framework for all the first author's studies and directs the choice of conceptual and operational variables to measure. The EMG is a heuristic model that explains the levels of a child's environment that contribute to a child's growth (Reifsnider, 1995; Reifsnider et al., 2005). The EMG is a combination of Human Ecology (Bronfenbrenner, 1979) and epidemiology and illustrates influences at the host (child) and agent (food) levels as they interact in the environment (microsystem and mesosystem). The host variables are those that are characteristics of the child, such as a child's anthropometric measurements, a child's diet, and level of activity or inactivity. The agent is viewed as the proximate cause of the problem, in this case, nutrition that is not balanced with the child's needs. The ecological environment is conceived as a set of connected structures, each influencing the other structures within the set. The microsystem is the immediate setting containing the parent and child. In the studies reviewed below, the family, the family's home situation, other children in the family, and the interaction between parent and child are all considered characteristics of the microsystem.

Since first noticing the rising rates of obesity among the WIC population, the first author has worked extensively with low-income, predominately Hispanic families on issues of maternal child nutrition and growth. The samples have been drawn from the population of women and children who qualified for food subsidies from WIC, a program funded by the U.S. Department of Agriculture for families who are at 185% of the federal poverty level or below. The WIC program provides to pregnant and breastfeeding women and children up to the age of five with nutritional needs, specified foods to be purchased using vouchers that include (for pregnant women) milk, cheese, fresh fruits and vegetables, whole wheat breads

(including brown rice and corn tortillas), eggs, peanut butter, breakfast cereals that are low in sugar and high in vitamins and minerals, fruit juice, and for breastfeeding women, tuna and salmon. Infants are provided vouchers for baby fruits and vegetables, cereal, and infant formula. If infants are breast-fed, they can also receive vouchers for infant canned meat. Multiple studies have found that the rates of breastfeeding are lower and the early introduction of cow's milk is higher if pregnant women receive WIC. These differences persist after the women receiving WIC are compared with women in similar socioeconomic situations (Ziol-Guest & Hernandez, 2010). Overall, breastfeeding rates of initiation and duration are lower in low-income women than are the rates in middle- and higher-income women, although the reasons for the lower rates have not been clearly elucidated.

The first author conducted studies on breastfeeding promotion using qualitative methods with Hispanic families who were WIC clients, consisting of pregnant and postpartum women, the mothers of the women receiving WIC, and male partners of the women receiving WIC. The findings revealed that all participants viewed breastfeeding as the healthier choice for the infant, and some perceived it also as a cheaper choice than formula feeding. The women chose breastfeeding without input from their partners. All the respondents felt that breastfeeding in public, with its attendant risk of an exposure of a breast, to be unacceptable. The women believed it was appropriate to breastfeed around their intimate partners and perhaps other female relatives. Other barriers to breastfeeding concerned nipple pain and inconvenience, in that no one could feed an infant other than the mother (Gill et al., 2004). A similar study was conducted with staff at WIC clinics (clerks, educators, nutritionists) who were WIC providers (92% Hispanic) of the subjects described in the previous study. They were asked similar questions and encouraged to share what they had heard about breastfeeding from their WIC clients. The WIC staff reported that their WIC clients did not breastfeed because of work, lack of family support, or misinformation about diet during lactation. They believed that they would encourage a WIC client to breastfeed, and that after delivery, she would be exposed to bottle-feeding in the hospital, and would choose not to breastfeed. They felt that the hospitals could make a better effort with teaching and supporting a new mother to breastfeed (Reifsnider et al., 2003).

These qualitative studies laid the groundwork for intervention studies on supporting breastfeeding among the WIC population, and a study was conducted with 200 low-income pregnant women who were followed for six months after delivery. The intervention group received telephone support and, if indicated by concerns elicited during the phone calls, home visits from lactation educators and lactation consultants. The home visits consisted of observation of breastfeeding, weighing of the infant, and discussion of any other problems the new mothers were having. Often, receiving reassurance that the infant was gaining weight and growing was enough to encourage the women to continue to breastfeed. The control group received regular WIC support, which included WIC peer counseling for breastfeeding if requested by the new mother. The results showed that the intervention group had twice (OR 2.31) the odds of starting breastfeeding, twice (OR 1.84-3.15) the odds of continuing to breastfeed for 6 months, and only half (.50-.54) the tendency to quit at any one time than did the control group (Gill et al., 2007).

The first author and research team also conducted qualitative studies on Hispanic mothers' perceptions of their children's growth, health, and body size (Reifsnider et al., 2000a, 2000b, 2006). These studies revealed that mothers perceived their children's growth as determined by heredity, over which they had little influence. Growth charts that demonstrated their

children's BMI, or pictures of children of differing sizes, were not useful to mothers when considering their children's own sizes. Hispanic mothers relied more heavily on comparing their children's sizes with other children of their acquaintance to determine if they were underweight, normal weight, overweight, or obese. Another method used by mothers to monitor size and growth was the size labels on the children's clothing. Both of these methods have flaws, as individuals tend to have affiliations with others of their similar size (Valente et al., 2009), and clothing sizes vary depending on the type of garment and its maker. The mothers' views of health did not consider a child's size but rather focused on a child's mood, activity level, and appearance. The first author found that Hispanic mothers defined a healthy child as one who has chubby legs and arms with round cheeks, and an unhealthy child as one who is thin. If a child is chubby, happy, active, and appears well-cared for, the child is considered healthy. An unhealthy child is described as thin, unhappy, lacking in energy, and unkempt. When asked directly if an overweight child is a healthy child, the mothers denied this but used descriptions such as "plump, dimples, rolls, round" to describe health in children. A thin child was evidence that the mother was not "doing a good job caring for her child." This theme was corroborated by Sussner et al. (2009), who documented that Hispanic mothers described how providing a lot of food to children is consistent with good parenting. Hispanic mothers and grandmothers traditionally are the primary health caretakers for their families, and altering their views of appropriate child weight may have long-term benefits for the child as well as other siblings and family members.

The first author also conducted descriptive and quantitative studies of low-income Hispanic children who received food assistance through the WIC program. The sample size was 100 children ages 12 to 24 months in each of three conditions (stunted, normal sized, and obese) and their mothers (N = 600), and a cross-sectional design was used. The WIC program in this health district had an average monthly enrollment of 50,000 women and children, and the clinic where the data collection occurred was its largest site. By virtue of qualifying for WIC, all the families were at 185% of federal poverty level or lower. All children had documented residence in the city. To be included in the study, the children had to fit anthropometric criteria for being stunted, normal-sized, or obese. In addition, they had to live with a parent or guardian (no foster children), not have any metabolic or major illnesses or any neurological or developmental delays, and not have an organic cause for stunted growth or obesity. No inclusion or exclusion criteria existed for the children's mothers.

Data were collected from children and their mothers on weight and height (weight for height for children and BMI for mothers), 24-hour diet recall of child's diet from mothers, social and demographic variables from mothers (income, educational level of parents, parental employment, number and relation of people in the household, receipt of food stamps and monthly amount, receipt of free or reduced lunches for any siblings in the family, length of residence in current house, generation of residence in United States, ethnicity, and language spoken at home). Acculturation was measured by the Acculturation Rating Scale for Mexican Americans-II (ARSMA-II; Cuéllar et al., 1995). The variable of parent–child interaction was measured by the Nursing Child Assessment Teaching Scale (NCATS; Barnard et al., 1989). The mother's activity level was measured by the Baecke Questionnaire, which is designed to measure three aspects of an adult's daily activities: work, leisure, and sports (Baecke & Frijters, 1982).

The child-focused agent variables that showed significant differences between the groups were dietary intake, as well as length of time breast-fed and daily ingestion of fluoride. The normal-weight group was breast-fed the longest and the obese group the shortest length of time. The stunted group received fluoride more often than did either of the other two groups. The obese group had significantly higher daily intakes of Mexican rice and Kool-Aid and showed a trend to significance for higher intakes of water and bread, while the normal-weight group had the highest daily intake of American cheese, raw apple with peel, and pancakes and showed a trend to significance for Vitamin C. The stunted group showed a trend to significance for the highest daily intake of vegetables.

Analysis of the food intake indicates that diets featuring dairy protein (American cheese) and fruit (apple with peel and Vitamin C) are a characteristic of the normal-sized group, while diets featuring starches (Mexican rice, breads) and sweetened beverages (Kool-Aid®) are characteristic of the obese group. Dairy consumption has been inversely associated with components of the metabolic syndrome in adults in several studies (Pfeuffer & Schrezenmeir, 2007). Zemel (2005), in a review on the role of dairy foods in weight management, postulated that high-calcium diets reduce fat accumulation and play an important role in maintenance of normal weight and management of overweight. Ariza et al. (2004) found that overweight Hispanic children (ages 5-6 years) were more likely to consume sweetened beverages (including Kool-Aid®) daily. Vegetables are generally low in calories, and the finding that the stunted group ate the most vegetables could indicate their lower caloric intake. The diet differences are only suggestive at this time but do lend support to advising mothers to provide dairy protein and fresh fruit to encourage normal growth and discouraging intake of many servings of starches and sweetened beverages to prevent overweight. In one of the largest studies (*N*=428, children aged 4-5 years) to investigate appetite and activity preferences in children at risk of becoming obese, Wardle et al. (2001) found that children of obese or overweight families had a higher preference for fatty foods in a taste test, lower preference for vegetables, and a more "overeating-type" eating style. In addition, children of overweight or obese families had a stronger affinity for sedentary activities. Similarly, in a longitudinal study of older children, Burke et al. (2001) found that obese or overweight parents had children with higher BMIs.

The differences in the parent variables, regarding size of parents, are consistent with previous findings. The BMI of the parents of the obese children was significantly larger than the BMI of the parents of the normal-sized children. Of note is the finding that the mean BMI for parents in both groups, both mothers and fathers, was in the range considered overweight (BMI >25), and the BMI of the mothers of the obese children was in the obese range (BMI > 30). The finding that the mother's participation in activity during leisure time decreased as the children's BMI increased has not been previously reported. The finding that more leisure-time physical activity is associated with a lower BMI was expected because Mouton et al. (2000) have shown that leisure-time physical activity was inversely associated with obesity among repeated samples of Mexican American adults from family practice clinics in South Texas. Increasing a mother's leisure-time physical activity could be one way to promote normal child size and decrease risk of overweight in children (Fogelholm et al., 1999).

Our finding that as more parents and grandparents are born in the United States the children's BMI increases mirrors the finding of Duerksen et al. (2007), who noted that parental overweight is associated with eating at American restaurants, while child and

parental BMI were lowest in families that ate predominately at Mexican restaurants. However, Ariza et al. (2004) found no association between children's overweight and the mother's score on the acculturation scale in their study of 250 kindergarten children who were primarily Mexican American. The effect of acculturation and generation in the United States on health and weight gain is complex, and it calls for models that examine the patterns of health and disease outcomes for distinct ethnic and cultural subgroups, according to Castro (2007).

The children in the original cross-sectional study were followed for six months while they remained clients of the WIC Program. The differences between the normal-weight and obese groups on dietary intake were grouped into fluids, fat, protein, carbohydrates, and total calories. The differences occurred between the normal-weight and obese groups, across time from time 1 to time 2 (six months apart), and in some cases, resulted in significant group by time interaction effects. There were significant differences between the groups at Time 1 in their water intake and within the normal-weight group across time as they significantly increased their intake of water. These differences also resulted in a significant group-by-time interaction effect. The obese group significantly increased their juice intake across time but did not differ from the normal-weight group in total intake. Both groups significantly decreased their intake of soda across time. Both groups also significantly increased their intake of fat, meat, and protein across time, but the intake did not differ between groups. Both groups significantly increased their intake of bread across time, with the obese group eating significantly more bread and other carbohydrates at Time 1 and Time 2. The obese group consumed more calories than the normal-weight group at Time 2 and also had higher rate of calorie increase than did the normal-weight group. This resulted in a trend to significance for an interaction effect.

The dietary intake of the groups revealed areas of significant differences between the groups in fluid, fat, bread and carbohydrate intake, and total calories, with the obese group consuming more servings. These differences, however, resulted in an alarming increase in calories, with the overweight group consuming a mean of 300 more calories per day by Time 2. Across time, the overweight group increased significantly in water, juice, meat, and protein. Both groups significantly decreased their soda intake across time. Adjustments to dietary intake such as a reduction in fruit juice intake may alter weight at an early age. These dietary changes may reflect the emphasis on the food pyramid when it included breads and carbohydrates as its bottom tier, encouraging consumption of 6-11 servings a day. The increase in fruit juices and the decrease in soda may reflect the impact of nutrition education since all the children were in WIC and their mothers were receiving nutrition education every six months.

The first author found both clinically and statistically significant differences in various aspects of the microsystem such as (home), agent (food), but not in the mesosytem (neighborhood) of normal and obese preschoolers. A variety of factors influence the development of obesity in young children. The greater BMI measures of the obese group at time 1 and time 2 were expected and support the view that the microsystem influences body size. The mothers of the overweight participants had significantly higher BMIs at time 1 and remained higher across the six months of measurement. If children reflect or imitate parental behavior in diet, activity, or both, then it appears that obese children in this study could be destined to follow their mothers. It would thus be important to follow these mothers and children to see whether the trend continues or whether reversals in both occur.

For example, a child may be encouraged to consume more when accompanied by a parent than when eating alone. Those who sit with children tend to influence their intake at meal time. At both time 1 and time 2, more of the overweight children did not eat alone. One feature of the home environment was that mothers of both groups at Time 1 were twice more likely to sit with their children at mealtime than were fathers (p=.00); however, this difference was not significant at Time 2. The obese children more often ate with someone at mealtime (100%) while 93% of the time the normal-weight children (p=.02) had someone sitting with them at mealtime. This suggests that both groups received attention at meals (by mothers most often), even though the obese group received attention more often.

The parent-child interaction scores overall indicated that mothers of the obese group had more positive interactions with their children in all areas except for response to distress. Mothers of normal-weight children responded more to their children's distress than did mothers of obese children. The mothers of both groups significantly increased in their responsiveness to their children. However, in all the subscales except clarity of cues, the mothers of obese children had a greater increase in being responsive to their children than did the mothers of the normal-weight children. We hypothesize that in this sample, the mothers of the obese children viewed feeding their children as an important way to interact with their children and show them affection. Findings from the earlier qualitative studies suggest that Hispanic mothers may view a thin child as an unloved or uncared for child, and the mothers took pride in caring for their children. The mothers of the obese children were more likely to be overweight themselves, and perhaps they associated food with positive emotion and were repeating that pattern with their children. It is important to educate mothers of overweight children to interact with their children in more active ways that do not involve food, such as reading stories, going on walks, and paying attention to their children at other times than mealtimes. This will also help the children learn that there are other positive ways to receive attention and affection than through meals and food.

The studies by the first author, reported above were limited to Mexican American, low-income children participating in a WIC program in a large city. Generalization to other Hispanic populations may be possible, but similarities in acculturation and economic situations must be taken into consideration.

6. Conclusions and recommendations

It is important to recognize that childhood obesity is a complex systems problem that has resulted from environmental changes and biological dispositions. For millennia, parents had to struggle to obtain sufficient food for their children, and a 'plump' child was evidence that the parents were good providers. In times of food scarcity, the children at either end of the growth spectrum would be more likely to survive; those born LBW/SGA as they were prenatally programmed to use nutrients efficiently, and those who were large with extra adipose tissue. Society has now changed from times of food scarcity to the easy provision of calorie–dense food and elimination/reduction of daily activities that could consume calories. Biology and culture have not adapted as rapidly as humans are still programmed to gain weight for survival and large children are a sign of successful parenting in many cultures. We need to create and encourage interventions that integrate multiple levels of influence, and note the intervention effects on social and environmental change as well as behavioral and clinical changes at the individual and family level (Huang & Story, 2010).

Though a number of studies have studied prevention of child obesity, great gaps exist in identifying effective interventions. Three issues related in general to child obesity prevention are worth mentioning as appropriate considerations when conducting studies of obesity prevention. First, a Cochrane Review examined evidence related to intervention effectiveness of obesity prevention in children and found insufficient evidence to prove that any single program could prevent child obesity (Summerbell et al., 2005). On a positive note, Summerbell et al. reported a trend for more recent interventions to include communities. Second, Saunders's (2007) literature review of studies examining prevention of obesity in children less than 5 years of age pointed to overall poor study quality, inconsistencies in research themes and findings, and absence of comprehensive evidence related to intervention effectiveness. Finally, a systematic review of randomized control trials of overweight or obesity prevention interventions for preschool children (<5 years of age) reported that none of the reviewed interventions demonstrated effectiveness (Monasta, Batty, Macaluso, et al., 2010). Reviewers recommended more rigorous examination of interventions and of social/environmental factors affecting lifestyle (Monasta, Batty, Macaluso, et al.).

Although many studies have been conducted on prevention and treatment of pediatric obesity, the prevalence remains high, especially among populations affected by health disparities. Family-based treatment is effective yet time-consuming and requires adherence by parents, while population-based efforts require political will that can be easily diverted to other pressing problems. Epstein and Wrotniak (2010) propose a multi-pronged approach from numerous fields of science to address the epidemic of childhood obesity. They recommend contributions from the fields of molecular genetics, basic behavioral science, educational science, developmental science, decision science, and sociology (social networks). Findings from each of these fields can be integrated into culturally-competent, community-specific interventions. Each culture and community must be considered and the persons affected by the issue of childhood obesity must be included when interventions are created with the community.

The IOM's recent report (2011) recommended 5 areas of focus to reduce childhood obesity. They recommend that all children be screened, monitored, and have their growth tracked from birth to age 5 to detect and treat obesity as soon as the child's growth begins to accelerate. They recommend that children increase physical activity and reduce sedentary behavior, and that parents be helped to find ways to accomplish this. All children should consume a variety of nutritious food and breastfeeding should be supported during infancy. Access to affordable healthy foods is a priority. Parents need to be taught how to recognize children's cues of hunger and satiety. Children's screen time should be monitored and limited to 2 hours a day or fewer, depending on the age of the child. Age appropriate sleep durations are important for healthy growth, and parents can be assisted with creating restful environments for their children. These recommendations are family and community focused and have been supported through clinical trials.

Based on findings briefly reviewed, several recommendations appear relevant for future studies. Among these are:

1. Increase study quality and rigor, with improved design and data analysis;
2. Consider prenatal, infancy, and early childhood periods when examining development and prevention of obesity and obesity consequences (Taveras et al., 2010);

3. Emphasize intervention studies focused on obesity determinants (Monasta, Batty, Macaluso, et al., 2010);
4. Approach child obesity as a social problem, using population-based, multisectoral, culturally appropriate, and multi-disciplary approaches (WHO, n.d.[b]);
5. Use community-based participatory research and other models that view community as active participants in research; and
6. Emphasize bench-to-bedside/community research that links study of complex bio-physiological factors, such as leptin and other adipocyte-produced compounds, to clinical outcomes.

7. References

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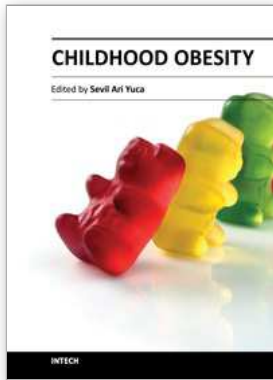
Childhood Obesity

Edited by Dr. Sevil Ari Yuca

This book aims to provide readers with a general as well as an advanced overview of the key trends in childhood obesity. Obesity is an illness that occurs due to a combination of genetic, environmental, psychosocial, metabolic and hormonal factors. The prevalence of obesity has shown a great rise both in adults and children in the last 30 years. It is known that one third of children who are obese in childhood and 80% of adolescents who are obese in their adolescent years continue to be obese later in life. Obesity is an important risk factor in serious illnesses such as heart disease, hyperlipidemia, hyperinsulinemia, hypertension and early atherosclerosis.

How to reference

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