NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch (up to 8 sentences):

Amy Bentley is an Associate Professor in the Department of Nutrition, Food Studies and Public Health at New York University. An historian with interests in the social, historical, and cultural contexts of food, she is the author of *Eating for Victory: Food Rationing and the Politics of Domesticity* (University of Illinois, 1998), and editor of *A Culture History of Food in the Modern Era* (Berg, 2011). Her current book project*, Inventing Baby Food: Taste, Nutrition, and the Transformation of Food in the United States*, is forthcoming (2014) from the University of California Press. She also serves as editor of *Food, Culture and Society: An International Journal of Multidisciplinary Research*.

Abstract (up to 500 words)

My presentation examines how the creation and industrialization of baby food in the twentieth century played a central role in shaping American food practices. The consumption of food is an extraordinarily social activity laden with complex and shifting layers of meaning. Not only what we eat, but how and why we eat, tell us much about society, history, cultural change, and humans' views of themselves. What, when, and how we choose to feed infants and toddlers—the notion of "baby food" as opposed to "adult food," whether these foods are nourishing and satisfying, as well as their appearance, texture, aroma and taste—reveals how mass production, consumption, and advertising, as well as current scientific understanding of nutrition and health have shaped our thinking about infancy and corresponding parenting philosophies and practices. For example, in the space of just over a half-century, from the late-nineteenth to mid-twentieth centuries, normal feeding patterns of infants in the United States changed from near-exclusive consumption of breast milk, whether by mother or by wet nurse, and an introduction to solids later in the infant's first year, to bottle-feeding and the introduction of solids at 6 weeks postpartum. The interrelated changes from late to early introduction of solids, as well as from breast to bottle, over the course of a handful of decades were products of social and economic components of the late-nineteenth and early-twentieth centuries: industrialization, mass production and advertising of the food supply, changing consumption patterns, the discovery and promotion of vitamins, evolving notions of the body and health, the promotion of science as the ultimate authority, and the medicalization of childbirth and infancy.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

I think an historical perspective that highlights the shifting nature of advice and practice provides perspective on contemporary practices. While researchers and advice givers do their best to provide the most accurate information, an historical perspective reminds us that we are always embedded in our current cultural and historical moment.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

Not really my area.

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

Not really my area.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Amy Bentley, 2014. *Inventing Baby Food: Taste, Nutrition, and the Transformation of Food in the United States*, University of California Press.

Amy Bentley, 2006. Booming Baby Food: Infant Food and Feeding in Post-World War II America, *Michigan Historical Review* 32(2): 63-88.

Amy Bentley, 2001. Inventing Baby Food: Gerber and the Discourse of Infancy in the United States, in *Food Nations: Selling Taste in Consumer Societies,* eds., Warren Belasco and Phillip Scranton, *Routledge*, pp. 92-112.

Publications from others that are most applicable to the meeting (2-3 papers):

Charlotte Biltekoff, 2013. *Eating Right in America: The Politics of Food and Health*, Duke University Press.

Suzanne Barston, 2012. *Bottled Up: How the Way We Feed Babies Has Come to Define Motherhood, and Why It Shouldn't*, University of California Press.

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Brief Biosketch (up to 8 sentences):

Dr. Bentley received her M.A. and Ph.D. degrees in Medical Anthropology from the University of Connecticut. From 1985-98, she was a faculty member in International Health at the Bloomberg School of Public Health, The Johns Hopkins University. Since 1998, she has been a faculty member at the University of North Carolina, where she has held several leadership roles, and since 2002 has been the Associate Dean for Global Health. Dr. Bentley's research focuses on the nutrition of women and infants, infant and young child feeding, behavioral research on sexually transmitted diseases, HIV, and community-based interventions for nutrition and health. She has expertise in qualitative research methods and the application of these for program development and evaluation. Dr. Bentley directed a National Institutes of Child Health and Human Development (NICHD)/National Institutes of Health (NIH) 5- year, longitudinal observational study to examine risk factors for the development of pediatric obesity in North Carolina. She also has served as Principal Investigator for two NICHD/NIH community-based interventions to improve child growth and development, one in Andhra Pradesh, India (concluded) and the other in North Carolina (ongoing). In 2005, she became a Paul G. Rogers Ambassador for Global Health, and in 2012, was named the Carla Smith Chamblee Distinguished Professor of Global Nutrition.

Abstract (up to 500 words)

Infant feeding is a complex behavior influenced by environmental and social contexts. Much research demonstrates that both *what* and *how* infants are fed affects short-term growth and long-term risk for overweight. Maternal beliefs about infant feeding are of interest as they may underlie actual feeding behaviors shown to influence infant dietary intake and growth. However, a linear view is far too simplistic. Several disciplines, including anthropology, health behavior, and developmental psychology, embed maternal beliefs in multidimensional systems containing chronological and bidirectional components. Our work in the area of early life obesity prevention contains several exemplars of the complexities of maternal beliefs and the influence that they have on infant feeding practices, dietary intake and growth. We have documented that mothers who perceive their infants to be fussier are more likely to introduce complementary foods, predominately cereal in the bottle, before the age of four months. Mothers that perceive their infants to be fussier are also more likely to feed in front of the television, a practice that could minimize responsiveness to infant feeding cues. We also have developed and validated the Infant Feeding Styles Questionnaire (IFSQ) to measure five feeding styles: responsive, laissez-faire, pressuring/controlling, restrictive/controlling, and indulgent. Using the IFSQ, we have documented several cross-sectional and longitudinal associations between maternal feeding styles and maternal feeding practices, as well as infant dietary intake and growth/size. Using mixed methods

research, we also have explored how mothers define “normal” infant growth and infant overweight. Our quantitative and qualitative findings document that mothers’ perceptions of infant size change with infant age, are sensitive to the size of other infants in the community, and are associated with concerns over health and appetite. These findings highlight the importance of maternal beliefs in early life obesity prevention efforts, and also their complexity. Our work has been conducted primarily among low-income African-American women and infants. More research is needed to understand how maternal perception of infant temperament and maternal infant feeding styles relate to infant dietary intake and growth in other racial and ethnic groups. Another big question is whether feeding styles are modifiable, as very few interventions have incorporated maternal feeding styles, particularly those targeting infants and toddlers. More research also is needed on maternal perception of infant growth; how it is conceptualized in other racial and ethnic groups and whether perception influences feeding behaviors. To be done well, this requires mixed methods (surveys, in-depth interviews, observations), which are time-consuming, but necessary when exploring complex belief systems. We also raise a concern over the continued emphasis on *maternal* beliefs and behaviors. Given the rise in maternal employment over the last several decades, more infants are now cared for by non-maternal caregivers while the mother is working. Indeed, our work shows that relatives and licensed child care providers are substantially involved in the day-to-day feeding of infants and toddlers. Such caregivers should be included in observational and intervention research aimed at early life prevention of obesity.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Thompson AL, Adair LS, Bentley ME, 2013. Pressuring and restrictive feeding styles influence infant feeding and size among a low-income African-American sample. *Obesity* 21: 562-571.

Thompson AL, Bentley ME, 2012. The critical period of infant feeding for the development of early disparities in obesity. *Soc Sci Med* 1-9.

Wasser H, Bentley M, Borja J, Goldman BD, Thompson A, Slining M, Adair L, 2011. Infants perceived as “fussy” are more likely to receive complementary foods before 4 months. *Pediatrics* 127: 229-237.

Publications from others that are most applicable to the meeting (2-3 papers):

Harkness S, Super CM, 1994. The developmental niche: a theoretical framework for analyzing the household production of health. *Soc Sci Med* 38: 217-226.

Monterrosa EC, Pelto GH, Frongillo, EA, Rasussen KM, 2012. Constructing maternal knowledge frameworks. How mothers conceptualize complementary feeding. *Appetite* 59: 377-384.

Savage JS, Fisher JO, Birch LL, 2007. Parental influence on eating behavior: conception to adolescence. *J Law Med Ethics* 35: 22-34.

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch:

Leann L. Birch, Ph.D., is a Distinguished Professor of Human Development and Nutritional Sciences and Director of the Center for Childhood Obesity Research at The Pennsylvania State University. She also holds an appointment in the University's Department of Pediatrics. Dr. Birch's research interests include the developing controls of food intake during infancy, childhood, and adolescence; the development of disordered eating; and risk and protective factors for childhood obesity. Her current research focuses on preventing obesity during infancy. She is internationally recognized for her work in this area and is the author of more than 200 publications. She has received the E. V. McCollum Award and the Lederle Award in Human Nutrition from the American Society for Nutrition. Recently, she chaired the Institute of Medicine (IOM) Committee on Obesity Prevention Policies for Young Children and was a member of IOM Committee on Childhood Obesity Prevention. Dr. Birch received her Ph.D. in Psychology from the University of Michigan.

Abstract:

Although it is often assumed that influence in the parent-child relationship flows from parent to child, bidirectional influence characterizes these interactions. In fact, responsive parenting is defined as responding to the child in ways that are contingent, prompt, and developmentally appropriate, and underscores the importance of influence of the child on parenting behavior. There is evidence that responsive parenting fosters positive cognitive, socio-emotional development in children, and there is some evidence emerging on the impact of responsive parenting on early obesity risk and other health outcomes.

We are in an initial phase of development of interventions to prevent obesity early in life, still trying to determine what should be included in our interventions. There has been a focus on factors causing rapid growth or excessive weight gain in infancy, given that excessive weight gain is a predictor of subsequent obesity. However, the majority of the evidence on this point comes from observational cohort studies or epidemiological data, which can only provide evidence for *associations* between, for example, parenting/feeding practices and infant growth or weight status outcomes. While these associations might reflect the influence of aspects of parenting/feeding on child weight gain, the inherent bi-directionality in parent-child relations also makes reverse causality particularly plausible, and studies using causal modeling have provided some support for reverse causality. Before conducting RCTs, we need evidence about causal relations, not just associations. Evidence obtained using experimental designs is necessary to establish that these associations reflect, at least in part, parenting/feeding effects on child outcomes. In addition, experimental designs also can allow testing whether child or

family characteristics moderate effects parenting/feeding behavior. As mentioned above, there are also statistical approaches, such as including causal modeling, which can give us insight into the direction of influence when randomized experiments are not possible.

This presentation briefly describes the rationale for a pilot intervention we conducted, using a design based on evidence from previous research, including randomized experiments, and present evidence that this approach has led to some success. However, our approach was not based on a systematic evaluation of potential intervention components, but rather on the evidence from research conducted in my laboratory over a 30 year period—clearly not a systematic or efficient way to test candidates for inclusion in an intervention. This research relies heavily on experimental designs, and while not intended to inform the design of early interventions, it was conducted for a related purpose: to understand factors affecting the development of ingestive behavior during the first years of life. There are still many questions to be answered to inform the design of effective, affordable, and sustainable interventions to prevent obesity during early life. Many of these questions will be best addressed by using randomized experimental designs, especially as we move beyond identifying what should be in these inventions to building interventions that are sustainable, affordable and effective in real world settings (see L. Collins presentation for a "roadmap" of how to navigate this process).

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

Our findings from a pilot intervention showing that teaching parenting skills can positively impact parenting self-efficacy and the development of infants' feeding, sleeping, and weight status (see readings below for reference).

What are the 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

What are the most potent factors causing excessive weight gain and obesity risk in the first 2 years of life?

How can these factors, once identified, be combined into effective, affordable, sustainable interventions for early prevention of obesity? How are effects moderated by factors, including race, ethnicity, education, family history?

Are these effects moderated by individual characteristics (infant temperament), race, ethnicity, and poverty?

What are the best approaches to intervening to affect the behavior of parents and caregivers?

What are the obstacles to answering the big questions and what creative ideas for advancing research on obesity prevention during infancy and early childhood?

The experimental evidence is limited regarding the effects of various aspects feeding practices (including what, how much, and when feeding occurs) on intake, growth, and weight status. Although there is no shortage of guidance on feeding infants and toddlers, little of it is evidence-based. As indicated above, more experimental research on this topic is needed prior to conducting Randomized Controlled Trials (RCTs). In terms of creative ideas, Dr. Linda Collins will discuss her research on optimizing interventions.

Publications from your own work that are most applicable to the meeting:

Paul, I.M., Savage, J.S., Anzman, S.L., Beiler, J. S., Marini, M.E., Stokes, J.L., and Birch, L.L., 2011. Preventing obesity during infancy: A pilot study. *Obesity* 19: 353-361. doi: 10.1038/oby.2010.182

Ventura, A.K., Birch, L.L., 2008. Does parenting affect children's eating and weight status? *International Journal of Behavioral Nutrition and Physical Activity* 5: 15 doi:10.1186/1479-5868-5-15.

Publications from others that are most applicable to the meeting

Harshaw, C.W., 2008. Alimentary epigenetics: A Developmental psychobiological systems view of the perception of hunger, thirst, and satiety. *Developmental Review* 28: 541-569.

Gahagan, S., 2012. The development of eating behavior—biology and context. *Journal of Developmental and Behavioral Pediatrics* 33: 262-271.

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Brief Biosketch (up to 8 sentences):

Maureen Black is the John A. Scholl MD and Mary Louise Scholl MD Endowed Professor in the Department of Pediatrics and the Department of Epidemiology and Public Health at the University of Maryland School of Medicine and founder/director of the Growth and Nutrition Clinic, an interdisciplinary clinic for children with growth and feeding problems. She is an adjunct professor in the Center for Human Nutrition, The Johns Hopkins Bloomberg School of Public Health, and in the Department of Psychology at the University of Maryland Baltimore County. Dr. Black is a pediatric psychologist with a longstanding interest in nutrition and child development. In Maryland, she specializes in recovery from growth faltering and in multi-level obesity prevention, through collaborations with Women, Infants and Children (WIC), schools, and childcare centers. In developing countries, she specializes in intervention research that integrates micronutrients and early learning interventions.

Abstract (up to 500 words)

Toddler Obesity Prevention

Background and Objectives: The Toddler Overweight Prevention Study (TOPS), a randomized controlled trial based on developmental-social learning theory, evaluates changes in dietary intake, physical activity (PA), mealtime behavior, and body composition. We implemented an attention control design with two interventions: (1) maternal diet and physical activity and (2) parenting.

Methods: A total of 274 mothers and toddlers were recruited from WIC clinics and enrolled in the 12-month trial. Baseline measures included dietary intake, physical activity (PA), mealtime observation, and anthropometry. Families were randomized into: (1) MOM TOPS (healthy maternal diet and physical activity), (2) TOT TOPS (parenting through responsivity and behavioral strategies rather than food), or (3) SAFE TOPS (toddler safety—attention control). All mother-toddler groups received healthy snacks: 4 group sessions with goal setting; 3 individual sessions with individual goals; and final group session. Follow-up #1 followed the intervention (6 months post-recruitment) and follow-up #2 was 12 months post-recruitment.

PA was measured by 7-day ankle accelerometry (average time/day in moderate/vigorous physical activity). Diet was analyzed by the United States Department of Agriculture (USDA)'s Automated Multi-Pass Method. Mealtime observation was videoed and coded using the Emotional Availability Scales. Weight and height were measured and converted to age and gender-specific z-scores using the Center for Disease Control (CDC) references. Data were analyzed using longitudinal mixed modeling and generalized estimating equations, based on intent-to-treat.

Results: At baseline 11% of toddlers and 51% of mothers were obese. 70% were Black, 2% Hispanic, and 22% White. Diet: At follow-up #1, MOM TOPS and TOP TOPS groups had significant improvements in fruit intake over SAFE TOPS (0.49 and 0.93 servings, p = 0.014, 0.014). PA: At follow-up #1, MOM TOPS and TOT TOPS increased in mean PA over SAFE TOPS (14.7 and 14.6 minutes, p = 0.025 and p = 0.025); at follow-up #2, MOM TOPS increased significantly over SAFE TOPS (23.0 minutes, p = 0.002), with marginal improvement of TOT TOPS (11.9 minutes, p = 0.100).

Mealtime behavior: At follow-up #1, TOT TOPS had significantly more improvement than MOM TOPS in 5 of 6 categories of Emotional Availability Scales. At follow-up #2, TOT TOPS showed significantly more improvement in parent non-hostility than MOM TOPS; other comparisons were non-significant. Rates of toddler obesity remained at 11% during the 2 follow-ups with no differences across groups.

Discussion and Conclusion: Both maternal-behavior-focused and parenting interventions were effective in improving toddler fruit intake and PA, suggesting the effectiveness of modeling and parenting skills. The parenting intervention led to improvements in responsivity during feeding, in contrast to the maternal intervention, suggesting that the mother-child feeding relationship can be altered by interventions that focus on parenting, rather than on maternal dietary intake and PA. A relatively brief intervention built on developmental-social learning theory was effective in changing proximal obesity-related behaviors of diet, PA, and mother-toddler mealtime responsivity. Although the absence of increase in rates of toddler obesity is encouraging, the fading of the effects over time and the lack of group differences on weight change and weight status suggest the need for increased focus on sustainability.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

1. Not only do mothers not recognize when their toddlers are heavy, they prefer them to be heavy (Hager et al., 2012).
2. Both WIC and SNAP prevent food insecurity. There is no evidence that either is associated with toddler obesity (Black, 2012; Frank, 2013).
3. Helping mothers of underweight toddlers adopt routines and structure around meals, and be more responsive and respective of their toddler's hunger and satiety cues leads to better weight gain.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

1. Poor dietary practices and lack of cooking skills among low income mothers.
2. Competing pressures (work, other children, etc .) interfere with participation in ongoing intervention groups—need innovative intervention strategies.

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

1. Cheap junk food with easy access.

2. Limited attention to healthy diet in daycare.
3. Poor support for breastfeeding among employers and community.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Hurley K.M., Pepper M.R., Candelaria M., Wang Y, Caulfield L.E., Latta L., Hager E.R., Black M.M., 2013. Systematic development and validation of a theory-based questionnaire to assess toddler feeding. *Journal of Nutrition*.

Hager ER, Candelaria M, Latta L, Hurley KM, Wang Y, Caulfield LE, Black MM, 2012. Maternal perception of toddler body size and satisfaction differ by toddler weight status. *Archives of Pediatric and Adolescent Medicine* 166: 417-422.

Black MM, Quigg AM, Cook J, Casey PH, Cutts DB, Chilton M, Meyers A, Ettinger de Cuba S, Heeren T, Coleman S, Rose-Jacobs R, Frank DA, 2012. WIC participation protects children from health risks associated with dual stressors of household food insecurity and caregiver depressive symptoms. *Archives of Pediatric and Adolescent Medicine* 166: 444-451.

Frank D, Ettinger de Cuba S, Sandal M, Black MM, 2013. SNAP cuts will harm children in the USA. *The Lancet* 382 (9899): 1155-1156.

Publications from others that are most applicable to the meeting (2-3 papers):

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Brief Biosketch (up to 8 sentences):

Dr. Bonuck is a Professor in the Department of Family and Social Medicine at the Albert Einstein College of Medicine. Her research interests include infant and toddler feeding intervention studies, as well as the epidemiology and effects of pediatric sleep problems. Regarding infant feeding, she was the PI of 2 National Institutes of Health (NIH)-funded breastfeeding promotion intervention studies of nearly 1,000 low-income women. This routine, primary care based intervention nearly tripled the rate of high-intensity/exclusive breastfeeding. Regarding toddler feeding, Dr. Bonuck was the PI of a recently completed Women, Infants and Children (WIC)-based randomized controlled trial of a bottle-weaning intervention, aimed at reducing bottle use and associated risk factors for overweight. Her research on pediatric sleep problems, which are also a risk factor for obesity in young children, is published in leading pediatric and sleep journals.

Abstract (up to 500 words)

Bottle-feeding in early life is a modifiable risk factor for overweight. In the first year of life, high bottle-feeding intensity interferes with an infant's ability to self-regulate intake. Professional groups recommend weaning from the bottle at 12-15 months of age. In the second year of life, toddlers continue to consume a high proportion of their calories as liquids via bottles and "sippy cups"— ~50% at 1 year of age, and ~35% at 2 years, in one study of urban nutrition clinics. In cross-sectional and prospective data, prolonged bottle use is associated with overweight given the ease of consuming excess liquids (most often milk), or adding calories (i.e., solids or sweeteners) to the bottle.

This presentation will review the prevalence of prolonged bottle use, its association with diet and overweight, and results of interventions designed to reduce bottle use (primarily aimed at reducing early childhood caries). There will be a focus on the Feeding Young Children's Study (FYCS, final results in press). This WIC-based randomized controlled trial of a bottle-weaning intervention enrolled 300 children, aged 12 months old, who drank > 2 bottles per day. Study outcomes were bottle use, overweight, and dietary intake. FYCS obtained 24 hour dietary recall data, inclusive of beverage container type (e.g., bottle or sippy cup), quarterly, through 24 months of age.

At one year follow-up, the FYCS intervention group had reduced use of any bottles (OR = 0.23, 95% CI = 0.08-0.61), calories from milk bottles (OR = 0.36, 95% CI = 0.18-0.74) and total calories (β = -1.15, p = 0.043), but did not differ from controls in risk of overweight status i.e., $\geq$ 85th percentile weight-for-length (OR = 1.02, 95% CI= 0.5-2.0). The intervention group's decreased bottle usage at 15 and 18 months was paralleled by increased "sippy cup" usage. Forty percent (40%) of bottles and 20% of sippy

cups contained added solids or sweeteners. These bottles and sippy cups with added sweeteners had three times the added sugar and 23% more calories than those without additives.

Thus, this brief intervention, during WIC routine care, reduced early childhood risk factors for overweight–bottle use and energy intake—but not risk of overweight. The intervention group's increased use of sippy cups may have attenuated an intervention effect upon risk of overweight. Given the continued prominence of liquids between 12 and 24 months of age, parents should be counseled about excess intake from bottles and sippy cups.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

1. Parents of low-income toddlers were highly receptive to WIC-based nutritional messages about bottle use, a potential vehicle for excess caloric intake.
2. Including more direct guidance about drinking containers (i.e., sippy cups), could have a significant impact on the toddler diet.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

1. In practice, what guidance (if any) do parents receive about the role of drinking containers and their contents in the toddler diets?
2. What is the impact of drinking containers upon the toddler diet in the general population?

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

1. Studies of dietary intake in toddlers do not specify vessel type. For example, National Health and Nutrition Examination Survey (NHANES) and FITS do not capture data on how, if at all, vessel type impacts overall diet in 12–23 month olds.
2. Depending upon the results of such research, the pediatric and nutritional communities might need to formulate guidance on this topic.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Bonuck KA, Huang V, Fletcher J, 2010. Inappropriate bottle use: an early risk for overweight? Literature review and pilot data for a bottle-weaning trial. *Matern Child Nutr* 6(1): 38-52.

Bonuck K, Ben Avraham S, Lo Y, Kahn R, Hyden C, 2013 (accepted). Bottle-weaning intervention to reduce risk of toddler overweight: randomized controlled trial. *Journal of Pediatrics* (in press).

Publications from others that are most applicable to the meeting (2-3 papers):

Maguire JL, Birken CS, Jacobson S, et al,. 2010. Office-based intervention to reduce bottle use among toddlers: TARGet Kids! Pragmatic, randomized trial. *Pediatrics* 126(2): e343-350.

Gooze RA, Anderson SE, Whitaker RC, 2011. Prolonged bottle use and obesity at 5.5 years of age in US children. *The Journal of Pediatrics* 159(3): 431-436.

Kimbro RT, Brooks-Gunn J, McLanahan S, 2007. Racial and ethnic differentials in overweight and obesity among 3-year-old children. *Am J Public Health* 97(2): 298-305.

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Brief Biosketch (up to 8 sentences):

Dr. Butte is an internationally recognized expert in childhood obesity. Her current research focuses on environmental and genetic factors contributing to obesity in Hispanic children, and the development of community-centered childhood weight management programs. In her past research, complex, longitudinal studies were conducted to define energy requirements of infants, children and adolescents, as well as pregnant and lactating women. Throughout her studies, she has employed state-of-the-art methodology to measure energy expenditure, body composition and physical activity. She has co-authored 190 peer-reviewed journal articles and book chapters. Dr. Butte has served as a consultant for U.S. government and international agencies (IOM, NIH, USDA, NCHS, FAO, WHO, USAID, IAEA).

Abstract (up to 500 words)

Measurement of Body Composition in Infants and Young Children

Implicit in the prevention of *obesity* in infancy and early childhood is our ability to measure *obesity,* which is defined as having an excessive amount of *body fat*. In order to define excessive *body fat*, normative body composition data of healthy infants and children are needed. Unique to infants and young children are developmental maturational changes that invalidate many of the assumptions and constants used in body composition methodologies.

In this presentation, we will review the most commonly used two-compartment model that divides the body into fat free mass (FFM) and fat mass (FM), as well as multicompartment models that incorporate specific elemental, molecular, cellular or anatomical compartments. Several *in vivo* body composition methods are available for measuring FFM and FM compartments in infants and young children, but they require age-and sex-specific conversion factors. We will discuss the theory and application of the following methods in infants and young children.

- Isotope Dilution:
  - Total body water (TBW) using deuterium or oxygen-18
  - Extracellular water (ECW) using bromide
  - Intracellular water (ICW) by difference
- Bioelectrical impedance (BIA) or bioelectrical impedance spectroscopy (BIS):
  - TBW, FFM

Air-displacement plethysmography (ADP):
    Body density and volume
Dual-energy X-ray absorptiometry (DXA):
    Lean tissue mass, FM, bone mineral content (BMC)
Whole Body Counting:
    Total body potassium (TBK)
Magnetic resonance imaging (MRI):
    Whole body FM

The composition of the human body undergoes dramatic maturational changes during the first 2 years of life. The classic body composition reference by Fomon et al. (1982) described the changes in water, protein, minerals, and fat from birth to 10 years. This multicompartment model was constructed from limited measurements of TBW, TBK, and total body calcium published by different laboratories. Butte et al. (2000) published an updated body composition reference based on normative data of 76 healthy children followed prospectively for the first 2 years of life. A multicompartment model based on measurements of TBW, TBK and BMC was used to estimate FFM and FM at 0.5, 3, 6, 9, 12, 18, and 24 mo of age. TBW was determined by deuterium dilution, TBK by whole body counting, and BMC by dual energy x-ray absorptiometry. These normative body composition data can be used to assess normal growth and obesity status of pediatric populations during the first 2 years of life.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

Our research has provided a reference for body composition of healthy infants and toddlers during the first two years of life. Our work also has quantified the energy imbalance underlying the development of childhood obesity, and evaluated genetic and environmental factors contributing to susceptibility to childhood obesity.

Butte NF, Christiansen E, Sorensen TI, 2007. Energy imbalance underlying the development of childhood obesity. *Obesity* 15(12): 3056-66.

Butte NF, Cai G, Cole SA, Wilson TA, Fisher JO, Zakeri IF, Ellis KJ, Comuzzie AG, 2007. Metabolic and behavioral predictors of weight gain in Hispanic children: the Viva la Familia Study. *Am J Clin Nutr* 85(6): 1478-85.

Cai G, Cole SA, Haack K, Butte NF, Comuzzie AG, 2007. Bivariate linkage confirms genetic contribution to fetal origins of childhood growth and cardiovascular disease risk in Hispanic children. *Hum Genet* 121(6): 737-44.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

In the area of *in vivo* body composition, there is a need for contemporary longitudinal data from birth to 5 years of age from ethnically diverse populations in the United States.

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

Research funding should invest in longitudinal studies during pregnancy and early childhood.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Butte NF, Hopkinson JM, Wong WW, Smith EO, Ellis KJ, 2000. Body composition during the first two years of life: an updated reference. *Pediatr Res* 47: 578-585.

Butte NF, Ellis KJ, Wong WW, Hopkinson JM, Smith EO, 2003. Composition of gestational weight gain impacts maternal fat retention and infant birth weight. *Am J Obstet Gynecol* 189: 1423-1432.

Butte NF, Wong WW, Hopkinson JM, Smith EO, Ellis KJ, 2000. Infant feeding mode affects early growth and body composition. *Pediatrics* 106: 1355-1366.

Publications from others that are most applicable to the meeting (2-3 papers):

Ellis KJ, 2000. Human body composition: *In vivo* methods. *Physiological Reviews* 80: 649-673.

Gale C, Logan KM, Santhakumaran S, Parkinson JRC, Hyde MJ, Modi N, 2012. Effect of breastfeeding compared with formula feeding on infant body composition: a systematic review and meta-analysis. *Am J Clin Nutr* 95: 656-69.

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch (up to 8 sentences):

Linda M. Collins, Ph.D., is Director of The Methodology Center, an interdisciplinary research center devoted to the advancement and dissemination of quantitative methods for applications in the behavioral sciences. Dr. Collins's research interests center on engineering-inspired methods for improving behavioral interventions. She is particularly interested in the Multiphase Optimization Strategy (MOST), a methodological framework for optimizing and evaluating behavioral interventions. Her peer-review publications have appeared in a wide range of outlets, including methodological journals such as *Clinical Trials*, substance use journals such as *Nicotine and Tobacco Research*, behavioral health journals such as *Annals of Behavioral Medicine*, and engineering journals such as *IEEE Transactions on Control Systems Technology*. She has co-edited several books and special issues of journals, and co-authored a book on latent class analysis. Her research has been funded by the National Institute on Drug Abuse, the National Science Foundation, the National Cancer Institute, and the National Institute of Diabetes and Digestive and Kidney Diseases.

Abstract (up to 500 words)

Raising the Bar: Engineering Optimized Behavioral Interventions for Increased Public Health Impact

Behavioral interventions are typically developed and evaluated using a treatment package approach. In this approach the intervention is assembled a priori and evaluated by means of a randomized controlled trial (RCT). Using this approach, the intervention is a "black box" because it is unknown which components of the intervention are working and which are not. In this talk, I will review an alternative approach called the Multiphase Optimization Strategy (MOST). MOST is an engineering-inspired framework for developing, optimizing, and evaluating behavioral interventions. MOST includes the RCT for intervention evaluation, but also includes other steps before the RCT. These steps are aimed at empirically assessing the performance of individual intervention components, and at intervention optimization using criteria chosen by the behavioral scientist. The goal may be to develop an intervention made up entirely of active components; to develop a cost-effective intervention; to achieve a specified level of effectiveness; to arrive at the briefest intervention that achieves a minimum level of effectiveness; or any other reasonable goal. Once the optimization criterion has been met, it establishes a bar that can then be incrementally raised as research progresses and further improvements are made. The MOST framework relies heavily on resource management by strategic choice of highly efficient experimental designs. I propose that MOST offers several benefits, including more rapid long-run improvement of behavioral interventions, without requiring a dramatic increase in intervention research resources.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

Using principles and methods drawn from statistics, engineering, and computer science, it is possible to engineer behavioral interventions to meet specific criteria for effectiveness, efficiency, economy, or scalability.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

What needs to be done to produce effective behavioral interventions that will be readily scalable from the beginning and sustainable over the long run?

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

1. We are not developing a coherent and cumulative base of knowledge in intervention science.
2. We are not making the best use of research resources such as experimental subjects and money.
3. Instead of being reluctant to deviate from "business as usual" in intervention development and evaluation, it would be great if intervention scientists working on obesity prevention would consider different approaches that have the potential to move the field forward.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Collins, L.M., Baker, T.B., Mermelstein, R.J., Piper, M.E., Jorenby, D.E., Smith, S.S., Schlam, T.R., Cook, J.W., and Fiore, M.C., 2011. The Multiphase Optimization Strategy for engineering effective tobacco use interventions. *Annals of Behavioral Medicine* 41: 208-226. PMCID: PMC3053423

Collins, L.M., Dziak, J.R., & Li, R., 2009. Design of experiments with multiple independent variables: A resource management perspective on complete and reduced factorial designs. *Psychological Methods* 14: 202-224. PMCID: PMC2796056

Publications from others that are most applicable to the meeting (2-3 papers):

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch (up to 8 sentences):

I began my career as a pediatrician on the Navajo reservation in 1984 when obesity was an emerging disease in that setting. Having seen the outbreak unfold and become endemic, I have dedicated my research and scholarly work to improving understanding of determinants and consequences of obesity in health disparity settings. Simultaneously, my clinical work as a developmental-behavioral pediatrician has focused on infancy and early childhood, including regulatory disorders, feeding problems and development in high-risk newborns. Currently, my research includes: a 22-year follow up of the long-term effects of preventing iron deficiency anemia during infancy; a longitudinal study of complex biological and psychosocial risks for obesity and cardiovascular disease markers with a focus on early life risks; and an innovative study of preventing obesity beginning during pregnancy and the first post-partum year. I also am involved as a co-investigator in several intervention studies, providing expertise in childhood obesity, health disparities, and the role of cultural differences on children's health. As a medical provider, I have worked in underserved communities for most of my career, including Latino, Native American, and African-American communities. I have expertise in assisting parents and children to make behavioral changes for improved health including for problems of obesity, nutritional disorders and breastfeeding. I am Division Chief of Academic General Pediatrics, Child Development &Community Health at the University of California, San Diego.

Abstract (up to 500 words)

The goal of this talk is to provide an overview of how neurodevelopmental competence evolves over the first 24 months of life. Key developmental milestones during infancy and early childhood are presented across 5 developmental domains: gross motor, fine motor, language, cognitive, and socio-emotional. The variability in acquisition of developmental milestones will be highlighted. In addition, the standards for valid and reliable developmental assessment are presented. Possible mechanisms that could relate infant and toddler development to risk for obesity will be proposed. Finally, we will consider how disruptions in acquisition of these milestones might affect obesity risk.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

1. Infant response to maternal encouragement to eat is related to weight at 12 months, 5 years and 10 years.

2. The duration of breastfeeding during the first year of life may improve satiety responsiveness even into adolescence.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

1. Understanding the role of socioemotional development on infant feeding, physical activity and sleep behaviors
2. Understanding how variation in gross motor development affects energy balance

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

1. Research on early obesity prevention will need to be informed by multiple disciplines including child development, nutrition, physical activity, and metabolism.
2. Biological and environmental determinants of energy regulation in infancy and early childhood are expected to interact through complex mechanisms.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Nader P, Huang TK, Gahagan S, Kumanyika S, Hammond RA, Christoffel K, 2012. Next Steps in obesity prevention: Altering early life systems to support healthy parents, infants and toddlers. *Childhood Obesity* 8(3): 195-204. PMID: 22799545.

Gahagan S, 2012. Development of eating behavior: biology and context. *J Dev Behav Pediatr* 33(3): 261-71. PMID:22472944

Reyes M, Hoyos V, Martinez S, Lozoff B, Castillo M, Burrows R, Blanco E, Gahagan S, 2013 (accepted). Satiety responsiveness and eating behavior among Chilean adolescents and the role of breastfeeding. *Int J Obesity*

Publications from others that are most applicable to the meeting (2-3 papers):

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch (up to 8 sentences)

Matthew W. Gillman, M.D., S.M., is Professor in the Department of Population Medicine (DPM) at Harvard Medical School/Harvard Pilgrim Health Care Institute, and in the Department of Nutrition at Harvard School of Public Health. At the DPM, Dr. Gillman directs the Obesity Prevention Program, whose goal is to lessen obesity-related morbidity and mortality through epidemiologic, health services, and intervention research. His major research interests are in early life prevention of childhood and adult diseases, particularly obesity, diabetes, and cardiovascular disease. He is PI of Project Viva, a National Institutes of Health (NIH)-funded cohort study of pregnant women and children that has identified and quantified many pre- and peri-natal risk factors for obesity and its consequences, asthma and allergies, and cognition and behavior. He has served as Co-Principal Investigator of the Coordinating Center of the U.S. National Children's Study. He is a member of the National Heart Lung and Blood Institute (NHLBI) Pediatric Cardiovascular Risk Reduction Initiative Expert Panel, the Institute of Medicine Committee to Reexamine Pregnancy Weight Guidelines, the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) Clinical Obesity Research Panel, and the Council of the Society for Developmental Origins of Health and Disease. He is Co-Editor of *Maternal Obesity*, published by Cambridge University Press. Dr. Gillman received the A. Clifford Barger Excellence in Mentoring Award from Harvard Medical School and the Faculty Mentoring Award from Harvard School of Public Health. He is also the recipient of the 2012 Greg Alexander Award for Advancing Public Health Knowledge through Epidemiology and Applied Research.

Abstract (up to 500 words)

Several factors during infancy are emerging as determinants of later obesity. One is the perinatal hormonal milieu. Rapid weight gain in early infancy predicts later obesity and cardio-metabolic consequences. In Project Viva, *lower* leptin levels in cord blood at delivery predicted faster weight-for-length gain in the first 6 months of life and higher adiposity at 3 and 7 years of age. In contrast, *higher* leptin levels at age 3 years predicted faster BMI gain from 3 to 7 years. These findings suggest that leptin resistance develops before the age of 3 years and are consistent with animal studies showing a critical period of perinatal leptin exposure.

Our bodies contain ten times as many micro-organisms as our native cells; most of these are bacteria in the distal gut. The type, number, and diversity of gut microbiota during infancy are associated with weight gain, at least in rodents. In vaginal deliveries, the infant gut is colonized via transit through the birth canal. In cesarean section, however, the gut is colonized with skin-derived and other non-vaginal bacteria. These differences could be one reason why children born by C-section are at elevated risk of developing obesity.

Epigenetic pathways may be of particular importance for explaining how developmental factors give rise to obesity. DNA methylation, the best known and most studied of epigenetic changes, is largely erased around the time of conception, and orderly re-methylation drives organ and tissue differentiation. Recent data suggest that epigenetic changes in cord blood and tissue are related to growth and adiposity.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

Identifying and quantifying developmental determinants of obesity singly and in combination, including behaviors such as maternal smoking, antenatal depression, gestational diabetes and weight gain, hormonal influences, epigenetic markers, and infant sleep, diet, and rapid weight gain.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

To what extent are these factors causal and modifiable? What are the individual and systems-level levers to effect most change in trajectories leading to obesity and its consequences? How can we reduce disparities in childhood obesity in the United States and abroad?

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

Study designs and analyses are often lacking because of confounding factors, loss to follow-up, small samples, and less-than-perfect measurement. Computational systems science is one approach to unpacking the complexity of obesity etiology and implementation of interventions.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Taveras EM, Gillman MW, Kleinman KP, Rich-Edwards JW, Rifas-Shiman SL, 2013. Reducing racial/ethnic disparities in childhood obesity: the role of early life risk factors. *JAMA Pediatr* 167(8): 731-8.

Boeke CE, Mantzoros CS, Hughes MD, L Rifas-Shiman S, Villamor E, Zera CA, Gillman MW, 2013. Differential associations of leptin with adiposity across early childhood. *Obesity* 21(7): 1430-7.

Wen X, Gillman MW, Rifas-Shiman SL, Sherry B, Kleinman K, Taveras EM, 2012. Decreasing prevalence of obesity among young children in Massachusetts from 2004 to 2008. *Pediatrics* 129(5): 823-31.

Publications from others that are most applicable to the meeting (2-3 papers):

Li HT, Zhou YB, Liu JM, 2013. The impact of cesarean section on offspring overweight and obesity: A systematic review and meta-analysis. *Int J Obes* 37(7): 893-9.

Godfrey KM, Sheppard A, Gluckman PD, Lillycrop KA, Burdge GC, McLean C, Rodford J, Slater-Jefferies JL, Garratt E, Crozier SR, Emerald BS, Gale CR, Inskip HM, Cooper C, Hanson MA, 2011. Epigenetic gene promoter methylation at birth is associated with child's later adiposity. *Diabetes* 60(5): 1528-34.

Ridaura VK, Faith JJ, Rey FE, Cheng J, Duncan AE, Kau AL, Griffin NW, Lombard V, Henrissat B, Bain JR, Muehlbauer MJ, Ilkayeva O, Semenkovich CF, Funai K, Hayashi DK, Lyle BJ, Martini MC, Ursell LK, Clemente JC, Van Treuren W, Walters WA, Knight R, Newgard CB, Heath AC, Gordon JI, 2013. Gut microbiota from twins discordant for obesity modulate metabolism in mice. *Science* 341(6150): 1241214.

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

Name: Matthew W. Gillman, M.D., S.M.
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Director, Obesity Prevention Program
Professor, Department of Population Medicine
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Professor, Department of Nutrition
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Brief Biosketch (up to 8 sentences)

Matthew W. Gillman, M.D., S.M., is Professor in the Department of Population Medicine (DPM) at Harvard Medical School/Harvard Pilgrim Health Care Institute, and in the Department of Nutrition at Harvard School of Public Health. At the DPM, Dr. Gillman directs the Obesity Prevention Program, whose goal is to lessen obesity-related morbidity and mortality through epidemiologic, health services, and intervention research. His major research interests are in early life prevention of childhood and adult diseases, particularly obesity, diabetes, and cardiovascular disease. He is PI of Project Viva, a National Institutes of Health (NIH)-funded cohort study of pregnant women and children that has identified and quantified many pre- and peri-natal risk factors for obesity and its consequences, asthma and allergies, and cognition and behavior. He has served as Co-Principal Investigator of the Coordinating Center of the U.S. National Children's Study. He is a member of the National Heart Lung and Blood Institute (NHLBI) Pediatric Cardiovascular Risk Reduction Initiative Expert Panel, the Institute of Medicine Committee to Reexamine Pregnancy Weight Guidelines, the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) Clinical Obesity Research Panel, and the Council of the Society for Developmental Origins of Health and Disease. He is Co-Editor of *Maternal Obesity*, published by Cambridge University Press. Dr. Gillman received the A. Clifford Barger Excellence in Mentoring Award from Harvard Medical School and the Faculty Mentoring Award from Harvard School of Public Health. He is also the recipient of the 2012 Greg Alexander Award for Advancing Public Health Knowledge through Epidemiology and Applied Research.

Abstract (up to 500 words)

The turn of the millenium began with high hopes that increasing breastfeeding rates would be a major solution to the obesity epidemic. Early evidence demonstrated associations of initiation, longer duration and exclusivity with lower obesity rates later in life. However, concerns about confounding factors were always present. More recent studies take advantage of innovative designs, such as sibling pairs, different confounding structures in different cultures, and cluster randomized controlled trials. Now the collective evidence suggests that although breastfeeding may exert a modest protective effect on childhood and adolescent obesity, it no longer appears to be a major determinant.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

Identifying and quantifying developmental determinants of obesity singly and in combination, including behaviors such as maternal smoking, antenatal depression, gestational diabetes and weight gain, hormonal influences, epigenetic markers, and infant sleep, diet, and rapid weight gain.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

To what extent are these factors causal and modifiable? What are the individual and systems-level levers to effect most change in trajectories leading to obesity and its consequences? How can we reduce disparities in childhood obesity in the United States and abroad?

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

Study designs and analyses are often lacking because of confounding factors, loss to follow-up, small samples, and less-than-perfect measurement. Computational systems science is one approach to unpacking the complexity of obesity etiology and implementation of interventions.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Gillman MW, 2011. Commentary: breastfeeding and obesity—the 2011 Scorecard. *Int J Epidemiol* 40(3): 681-4. doi: 10.1093/ije/dyr085.

Martin RM, Patel R, Kramer MS, Guthrie L, Vilchuck K, Bogdanovich N, Sergeichick N, Gusina N, Foo Y, Palmer T, Rifas-Shiman SL, Gillman MW, Smith GD, Oken E, 2013. Effects of promoting longer-term and exclusive breastfeeding on adiposity and insulin-like growth factor-I at age 11.5 years: a randomized trial. *JAMA* 309(10): 1005-13.

Huh SY, Rifas-Shiman SL, Taveras EM, Oken E, Gillman MW, 2011. Timing of solid food introduction and risk of obesity in preschool-aged children. *Pediatrics* 127(3): e544-51.

Publications from others that are most applicable to the meeting (2-3 papers):

Koletzko B, von Kries R, Monasterolo RC, Subías JE, Scaglioni S, Giovannini M, Beyer J, Demmelmair H, Anton B, Gruszfeld D, Dobrzanska A, Sengier A, Langhendries JP, Cachera MF, Grote V; European Childhood Obesity Trial Study Group, 2009. Infant feeding and later obesity risk. *Adv Exp Med Biol* 646: 15-29.

Weng SF, Redsell SA, Swift JA, Yang M, Glazebrook CP, 2012. Systematic review and meta-analyses of risk factors for childhood overweight identifiable during infancy. *Arch Dis Child* 97(12): 1019-26.

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch (up to 8 sentences):

Laurence Grummer-Strawn is the Chief of the Nutrition Branch at the U.S. Centers for Disease Control and Prevention (CDC). Having earned his Ph.D. from Princeton University, he has worked at the CDC for over 22 years in the areas of Reproductive Health and Nutrition. He is an epidemiologist who has published over 150 scientific publications. He is recognized internationally for his work on vitamin and mineral deficiencies, breastfeeding policy, and development of both the CDC and the WHO Growth Charts. Dr. Grummer-Strawn served as scientific editor of the Surgeon General's Call to Action on Breastfeeding. He chairs the Federal Interagency Breastfeeding Workgroup, the National Fruit and Vegetable Alliance, and the Iodine Global Network. He also serves on the Executive Management Team of the Flour Fortification Initiative. As Branch Chief, he is responsible for national breastfeeding support efforts, fruit and vegetable promotion, and international micronutrient deficiency programs.

Abstract (up to 500 words):

Measurement of Weight and Linear Growth in Infants and Young Children

In April 2006, the World Health Organization (WHO) released new international growth charts for children aged 0–59 months. Similar to the 2000 CDC growth charts, these charts describe weight for age, length (or stature) for age, weight for length (or stature), and body mass index for age. Whereas the WHO charts are growth standards, describing the growth of healthy children in optimal conditions, the CDC charts are a growth reference, describing how certain children grew in a particular place and time.

CDC recommends that clinicians in the United States use the 2006 WHO international growth charts, rather than the CDC growth charts, for children aged < 24 months, whereas the CDC growth charts should continue to be used for the assessment of growth in persons aged 2–19 years. The recommendation to use the 2006 WHO international growth charts for children aged < 24 months is based on several considerations, including the recognition that breastfeeding is the recommended standard for infant feeding. In the WHO charts, the healthy breastfed infant is intended to be the standard against which all other infants are compared; 100% of the reference population of infants were breastfed for 12 months and were predominantly breastfed for at least 4 months. When using the WHO growth charts to screen for possible abnormal or unhealthy growth, use of the 2.3rd and 97.7th percentiles (or ± 2 standard deviations) are recommended, rather than the 5th and 95th percentiles. Clinicians should be aware that fewer U.S. children will be identified as underweight using the WHO charts, slower growth among breastfed infants during ages 3–18 months is normal, and gaining weight more rapidly than is indicated on the WHO charts might signal early signs of overweight.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

The WHO Growth Charts demonstrate the slower growth of breastfed infants compared to formula-fed infants after the first 3 months of life. Longer durations of breastfeeding as well as slower infant growth have been associated with reduced risk of childhood obesity. However, the biological mechanisms for these associations are not well understood.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

1. What are the causal mechanisms by which infant feeding and growth are associated with later incidence of obesity? Specifically, what are the roles of dietary intake patterns, satiety regulation, and early fat deposition?

2. Would BMI-for-age be an appropriate indicator of relative weight gain in infants?

3. What interventions would be appropriate for infants who are identified as growing too quickly on the growth charts, to reduce their risk of later obesity without creating nutritional deficiencies or feeding problems?

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

Randomization at the individual level is likely to be unethical for many of the behaviors that are of interest. Group randomized interventions to improve dietary intake in infancy with longitudinal follow-up would be recommended to see if recommended dietary patterns are effective in preventing later obesity or in treating the early detection of high BMI.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Grummer-Strawn LM, Reinold C, Krebs NF, 2010. Use of World Health Organization and CDC Growth Charts for Children Aged 0–59 Months in the United States, *MMWR* 59: RR–9.

Grummer-Strawn LM, Mei Z, 2004. Does breastfeeding protect against pediatric overweight? Analysis of longitudinal data from the CDC Pediatric Nutrition Surveillance System, *Pediatrics* 113: e81.

Mei Z, Grummer-Strawn LM, Scanlon KS, 2003. Does overweight in infancy persist through the preschool years? An analysis of CDC Pediatric Nutrition Surveillance System data. *Social and Preventive Medicine* 48: 161-7.

Publications from others that are most applicable to the meeting (2-3 papers):

Garza C, de Onis M, 2004. Rationale for developing a new international growth reference, *Food Nutr Bull* 25(Suppl 1): S5-12.

Monteiro POA, Victora CG, 2005. Rapid growth in infancy and childhood and obesity in later life—a systematic review. *Obesity Reviews* 6(2): 143–154.

Adair LS, Fall CH, Osmond C, Stein AD, Martorell R, Ramirez-Zea M, Sachdev HS, Dahly DL, Bas I, Norris SA, Micklesfield L, Hallal P, Victora CG, COHORTS group, 2013. Associations of linear growth and relative weight gain during early life with adult health and human capital in countries of low and middle income: findings from five birth cohort studies. *Lancet* 382(9891): 525-34.

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch (up to 8 sentences):

In my position as Professor of Pediatrics, I am Head of the Section of Nutrition in the Department of Pediatrics and Medical Director of Clinical Nutrition at Children's Hospital of Colorado. I investigate nutritional requirements and growth of infants and young children, in both the United States and international settings. Current research investigates the influence of maternal phenotype (lean vs. obese) on bioactive components of human milk, effects of complementary food choices on infant growth and body composition, effects of dietary exposures on infants' microbiome, and potential for pre-conceptional interventions to improve fetal growth in low-resource international settings and to reduce obesity risk in offspring in the United States. My clinical work includes consultations for growth faltering and nutritional deficiencies in infants and toddlers, and an integrated, multidisciplinary pediatric program for weight management.

Abstract (up to 500 words)

Complementary Feeding: Influence of When, What & How

The period of complementary feeding (CF) represents the largest component of the "1000 Days Critical Window," and includes several transitions: advancing from a single, liquid food to a mixed, complex diet; developing physically from essentially complete dependency on adult care providers to acquiring motor skills that allow self-feeding; and progressively interacting with environmental, biological, and social-emotional factors that foster development of temperament and autonomy. Furthermore, all of this development is profoundly influenced by the intrauterine environment and maternal and paternal influences. This period is thus critically important for identification of biologically driven and modifiable determinants of overweight and eventual obesity. The evidence for a relationship between timing of introduction of CF and infant obesity risk is conflicting, with some studies failing to detect a relationship, and others reporting relationships with a variety of obesity outcomes. Infant feeding mode may be a key variable to explain this variation, as two large cohort studies have reported that early introduction of CF was associated with increased odds of obesity at 3 years only among formula fed infants, and increased infant weight gain only among infants who were breastfed < 20 weeks. With respect to what is fed, the distinction between breastfed and formula fed infants is particularly important for risks associated with CF. Following the introduction of CF, the caloric contribution of human milk (HM)/formula can dramatically differ between breastfed and formula fed infants/toddlers. The breastfed infant exhibits fairly tight self-regulation of energy intake, decreasing consumption of HM in response to caloric intake from CF, even when breastfeeding frequency is maintained. The mechanisms whereby appetite and satiety may be less well regulated in the formula fed infant are unclear, but likely include a combination

of absence of biological feedback that reduces supply, exclusive bottle feeding, lack of exposure to bioactive components in HM that regulate appetite and satiety, and varied satiety responses to different CF (high vs. low-calorie and liquids vs. semi-solids). High protein intake has been associated with excessive weight gain and adiposity, but this relationship has been observed only with dairy protein and in formula fed infants. High fat intake via CF has not been associated with excessive weight gain, and a substantial number of infants have fat intakes below the recommended range. Regarding how infants are fed, inappropriate feeding behaviors, including both restrictive and indulgent/overly permissive parenting styles, have been associated with poor self-regulation of energy intake and with increased infant adiposity and overweight. Feeding interactions are also bi-directional. Care providers' feeding behaviors are influenced by infant temperament, developmental progression and nutritional status, including micronutrient deficiencies that influence appetite, attention span, and social-emotional state.

Future research ideally will examine the complex interactions of environmental, behavioral, nutritional and biological factors that affect health outcomes specific to the complementary feeding period as well as risk profiles at later stages of the life cycle.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

- Linear growth faltering (stunting) is associated with relatively excessive weight gain, both in developing and developed countries.

- Maternal weight and metabolic status affects human milk composition and may explain rapid "risky" early post-natal weight gain.

- Differences in complementary feeding patterns result in strikingly different macro- and micronutrient intakes, which may have very distinct effects on growth.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

- Compared to weight gain in early postnatal life, what is the additional, potentially modifiable impact of weight and adiposity gain in older infants and toddlers?

- What is the impact of maternal phenotype on early postnatal growth and what are the modifiable determinants?

- To what extent do dietary patterns (including macronutrient distributions) during the complementary feeding period alter risk established in the early postnatal period?

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

- The paucity of intervention studies and the tendency to compartmentalize a complex continuum of risk factors.

- The general reluctance to intervene with early infant feeding, and specifically with excessive weight gain.

- Absence of interventions targeting the highest risk groups.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Berngard SC, Berngard JB, Krebs NF, Garcés A, Miller LV, Westcott JE, Wright LL, Kindem M, Hambidge KM, 2013 (in press). Newborn length predicts early infant linear growth failure and disproportionately high weight gain in a low-income population. *Early Human Development.*

Haemer M, Ranade D, Baron A, Krebs NF, 2012. A clinical model of obesity treatment is more effective in preschoolers and Spanish speaking families. *Obesity* 21: 1004-1012.

Young B, Johnson SL, Krebs NF, 2012. Biological determinants linking infant weight gain and child obesity: current knowledge and future directions. *Adv Nutr* 3(5): 675-686.

Publications from others that are most applicable to the meeting (2-3 papers):

Stunkard, A.J., et al., 1999. Energy intake, not energy output, is a determinant of body size in infants. *The American Journal of Clinical Nutrition* 69(3): 524-30.

Siega-Riz, A.M., et al., 2010. Food consumption patterns of infants and toddlers: Where are we now? *Journal of the American Dietetic Association* 110(12 Suppl): S38-51.

Koletzko B, et al., 2009. Lower protein in infant formula is associated with lower weight up to age 2: a randomized clinical trial. *Am J Clin Nutr* 89: 1836-45.

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch (up to 8 sentences):

I am an Associate Professor in the Department of Pediatrics (Medical School) and Department of Environmental Health Sciences (School of Public Health), as well as at the Center for Human Growth and Development, at the University of Michigan. I completed medical school and pediatric residency at the University of Michigan and a fellowship in Developmental and Behavioral Pediatrics at Boston University. I have been on faculty at the University of Michigan since 2003. I am a developmental and behavioral pediatrician. Clinically, I evaluate young children with developmental delays and behavioral challenges. I spend most of my time conducting research on childhood obesity, eating behavior, stress eating in young children, and parenting related to food and eating. My research is currently funded by NIDDK, NICHD and the American Heart Association.

Abstract (up to 500 words)

I will be providing one of the final talks of the meeting, in which I will address the practical challenges faced in recruiting and retaining children younger than 24 months and their families into studies of childhood obesity. A large proportion of families with children in this age range are low-income, which introduces unique challenges. I will address data regarding parents' general reluctance to enroll their children in research studies. Additional challenges to conducting this work in this age group include parents' attitudes towards the cause of obesity in general, as well the cause specific to children, and their feelings about their own feeding and parenting.

My own research focuses on the question of whether links between obesity, psychosocial stress, biological markers of stress (e.g. cortisol or alpha amylase), and stress eating are detectable in children as young as age 21 months. I also am interested in "what the child brings to the table" with regard to eating behavior. While much work has focused on maternal feeding practices altering children's eating behavior (and theoretically disrupting their presumably "innately" well-regulated hunger and satiety cues), less work has focused on whether some children (particularly those predisposed to become obese) have a less well-regulated ability to respond to hunger and satiety accurately. If there is a subgroup of children who, from early infancy, are less able to accurately read hunger and satiety cues, this suggests the need to identify: (1) the biological predictors of this behavior; (2) whether and what type of parenting around feeding is best suited to altering the eating and weight trajectories of these children; (3) when differences in eating behaviors (i.e. willingness to work for food, attention bias for food, the soothing quality of food, satiety responsiveness) first emerge differentially within subgroups of infants.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

Patterns of cortisol reflective of chronic stress exposure are associated with higher body mass index in children as young as age 3 years.

Although self-regulatory capacity (the ability to inhibit an impulse and delay gratification) appears to be important to obesity prevention, preliminary data suggest that appetitive drive may be a particularly important feature of children's eating behavior that needs to be acknowledged and addressed in very early childhood.

Low-income parents of young children generally have a high sense of parenting self-efficacy, believe that they are feeding their children better than they were fed growing up, and believe that when children are overweight, it is because their parents "do not care." This has substantial implications for how interventions are framed.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

What are the determinants of and markers of appetitive drive in children younger than age 24 months? For infants with high appetitive drive, what are the most appropriate feeding strategies?

How do links between psychosocial stress, its physiology, eating behavior, and obesity first manifest in children younger than age 24 months?

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

There is a need for more accurate measures of maternal feeding behaviors among infants that go beyond maternal self-report.

There is a need for a more detailed understanding of infant eating behavior, maternal feeding behavior, and dietary intake between ages 6 and 18 months.

There is a need for practical yet accurate measures of body fat among children in this age range that can be used on a large scale "in the field."

A large, multisite observational cohort collecting a host of different measures focused on biological and behavioral correlates of eating behavior, activity, and obesity in children from birth to 24 months would provide the necessary power to advance the science.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Lumeng JC, Ozbeki TN, Appugliese DP, Kaciroti N, Corwyn RF, Bradley RH, 2012. Observed assertive and intrusive maternal feeding behaviors increase child adiposity. *American Journal of Clinical Nutrition* 95(3):640-7. Epub 2012 Jan 25. PMCID: PMC3278242.

Kalinowski A, Krause K, Berdejo C, Harrell K, Rosenblum K, Lumeng JC, 2002. Beliefs about the role of parenting in feeding and childhood obesity among mothers of lower socioeconomic status. *Journal of Nutrition Education and Behavior* 44 (5) 432-7. PMCID: PMC3189434.

Frazier B, Gelman S, Russell J, Lumeng JC, 2011. I'll have what she's having: The impact of model characteristics on children's food choices. *Developmental Science* 1-12. DOI: 10.1111/j.1467-7687.2011.01106.x. PMCID: PMC3261590.

Publications from others that are most applicable to the meeting (2-3 papers):

Mennella JA, Griffin C, Beauchamp GK, 2004. Flavor programming during infancy. *Pediatrics* 113:840-845. PMC1351274

Shutts K, Kinzler KD, DeJesus JM, 2013. Understanding infants' and children's social learning about foods: Previous research and new prospects. *Developmental Psychology* 49 (3): 419-425.

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch (up to 8 sentences):

Dr. Julie A. Mennella obtained her Ph.D. from the Department of Behavioral Sciences at The University of Chicago in Chicago, IL. She subsequently did postdoctoral work on the transfer of volatiles from maternal diet to human milk at the Monell Chemical Senses Center in Philadelphia, PA. She joined the faculty there in 1990 where she is now a Member. Her major research interests include sensitive periods in flavor learning and growth during breastfeeding and formula feeding; the role of genetics and culture on taste sensitivity and preferences; and the effects of alcohol and tobacco use during lactation on various aspects of women's health, lactational performance and mother-child interaction. Dr. Mennella is the recipient of grants from the National Institute of Deafness and Other Communication Disorders and the Eunice Kennedy Shriver National Institute of Child Health and Human Development at the National Institutes of Health, and she is the author or co-author of research papers which have appeared in publications such as *The New England Journal of Medicine*, *Pediatrics, Journal of Clinical Therapeutics and Pharmacology, American Journal of Clinical Nutrition* and *Proceedings of the National Academy of Sciences.*

Abstract (up to 500 words)

Health initiatives address childhood obesity in part by encouraging good nutrition early in life. In this talk, I will highlight the basic science that revealed children naturally prefer higher levels of sweet and salty tastes and reject lower levels of bitter tastes than do adults. Thus, their basic biology does not predispose them to favor the recommended low-sugar, low-sodium, vegetable-rich diets and makes them especially vulnerable to our current food environment of foods high in salt and refined sugars. If this is the bad news, the good news is that sensory experiences, beginning early in life, can shape preferences. Mothers eating diets rich in healthy foods can get children off to a good start since flavors are transmitted from the maternal diet to amniotic fluid and mother's milk, and experience with such flavors leads to great acceptance of those foods. In contrast, infants fed formula learn to prefer its unique flavor profile and may have more difficulty initially accepting flavors of fruits and vegetables not found in formula. Once weaned, regardless of early feeding mode, infants can learn through repeated exposure and dietary variety. Finally, more recent evidence revealed, like flavor learning, not all formulas are alike in terms of the dynamics of feeding (e.g., satiation, growth) and that such differences may be related to compositional differences among the formulas. In summary, early life experiences with healthy tastes and flavors may go a long way toward promoting healthy eating and growth, which could have a significant impact in addressing the many chronic illnesses associated with poor food choice.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

- There are age-related changes in functional plasticity, or sensitive periods, for flavor learning.

- Arrays of dietary flavors are transmitted from the maternal diet to both amniotic fluid and mother's milk. Because infants become familiar with and learn to accept the flavors of foods they experience through their mothers' amniotic fluid and breast milk, mothers can get their infants off to a good start by eating a diet rich in healthy foods, both while they are pregnant and lactating and then repeatedly offer a variety of these foods at weaning. These early experiences influence flavor preferences of children that may affect food choices and therefore health in later life.

- Formula-fed infants are <u>not</u> a homogeneous group in terms of both growth and flavor learning. Because infants fed cow milk formula exhibit faster growth trajectories than those fed extensively hydrolyzed protein formula (ePHF)—the latter of which exhibit growth trajectories similar to those of breastfed infants—it may no longer be appropriate to group all formula-fed infants together when evaluating the effect of early diet composition on growth and health outcomes and with respect to certain health outcomes such as obesity.

- Children live in different sensory worlds than adults, naturally preferring higher levels of sugars and salt than do adults. Thus, they are vulnerable to the current food environment, which differs from the diet of our past, when salt and sugars were once rare and expensive commodities.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

- Are there are optimum periods during development when experience with flavors promotes greater liking and enjoyment?

- While supporting breastfeeding initiation and duration are key, the majority of U.S. infants are also exposed to infant formula. Today's infant formulas differ substantially in macronutrient composition and presence/absence of pre- and pro-biotics. These compositional differences can affect energy balance and growth. Research is needed to determine the effect of infant diet composition on (1) energy intake, (2) energy expenditure, and (3) the gut microbiome, to better understand their interrelationships to early growth and obesity risk. Since infants who feed one type of formula (cow milk formula) exhibit more rapid growth than those who feed extensively hydrolyzed formulas or those who breast feed. What are the mechanisms underlying such growth differences? Is the composition of milk affecting satiety? How do babies signal satiety during breast and bottle feeding? How does it change with developmental age and how is it affected by caregivers' behaviors? Such knowledge is significant because more than half of American infants receive infant formula while in hospital (either exclusively or as a supplement to breast milk), and this percentage increases steadily to more than 60% by 4 months of age.

- Many illnesses of modern society are, in part, the consequence of poor food choices.

- Although foods high in salt (NaCl) and refined sugars contribute to poor health, people of all ages consume them in excessive amounts, in part because these foods have powerful hedonic appeal, especially for children. Understanding the basic biology that drives the hedonic dimension of sweet and salty taste during childhood is needed to develop effective strategies to improve their diets.

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

- We can't focus on feeding infants and children separately from their caregivers. Mothers feed their children the foods that they like and enjoy. Research is needed to: (1) improve dietary habits of women during pregnancy and postpartum; (2) understand how infants learn to like foods; (3) understand processes of satiation and satiety during infancy and its impact/stability during development; (4) understand how mothers recognize and interpret their infant's satiation and satiety cues.

- As new infant formulas are developed, a common goal of premarket growth and safety trials is to demonstrate a rate of weight gain on the new formula that is comparable to that of breast-fed infants or a currently marketed infant formula over the first 4 months of life, both to assure the formula is suitable during early infancy (a period of rapid growth) and because nutrient intake during this time period is mainly attributed to infant formula rather than confounders such as early introduction of solid foods. Many studies do not follow the infants into the second 6 months of life, which the time in which formula fed infants tend to gain more weight than breastfed infants. Further, in many large-scale observation studies, formula-fed infants are often categorized into one large group, and little research has examined how infant formulas of different composition affect growth or why growth for some formula-fed infants, but not all, differs substantially from the gold standard of breast-feeding.

- Evaluating past research on formula-fed infants is confounded by changing formulations of infant formulas and the differences in composition of the current types (cow milk based, soy, partial hydrolysates, extensively hydrolyzed) on the market? There is very little research on contemporary infant formulas and how compositional differences impact energy balance and growth.

- There exists little research on the impact of feeding both breast milk and formula (mixed feeding) on later food choice and development.

- Complying with recommendations to reduce added sugars and salt in children's diets likely faces a biological challenge during periods of growth, emphasizing the need for research and evidenced-based strategies to improve children's diets.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Mennella JA, Griffin C, Beauchamp GK, 2004. Flavor programming during infancy. *Pediatrics* 113: 840-845. PMC1351274

Mennella JA, Lukasewycz LD, Castor SL, Beauchamp GK, 2011. The timing and duration of a sensitive period in human flavor learning. *American Journal of Clinical Nutrition* 93: 1019-1024.

Trabulsi JC, Mennella JA, 2012. Diet, sensitive periods in flavor learning, and growth. *International Review of Psychiatry* 24: 219-30.

Publications from others that are most applicable to the meeting (2-3 papers):

Birch LL, Anzman-Frasca S, Paul IM, 2012. Starting early: obesity prevention during infancy. *Nestle Nutr Inst Workshop Ser.* 73: 81-94. doi: 10.1159/000341300.

Rzehak P, Sausenthaler S, Koletzko S, Reinhardt D, von Berg A, Krämer U, Berdel D, Bollrath C, Grübl A, Bauer CP, Wichmann HE, Heinrich, J, 2009. Short- and long-term effects of feeding hydrolyzed protein infant formulas on growth at < or = 6 y of age: Results from the German Infant Nutritional Intervention Study. *American Journal of Clinical Nutrition* 89: 1846-1856.

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch (up to 8 sentences):

Mary Jo Messito is Clinical Associate Professor of Pediatrics and Associate Director of the General Academic Pediatric fellowship at NYU School of Medicine. Her area of research is obesity prevention in early childhood. She is PI on a USDA–funded 5-year Randomized Controlled trial (RCT) of a primary care based child obesity prevention program beginning during pregnancy called *Starting Early*. She has studied parent feeding styles in infancy and their association with obesity, and developed interventions to prevent obesity in early childhood including *Benufit Baby,* a primary care-based child obesity prevention intervention for the families of newborns, which was the pilot trial of the currently running Starting Early program. She has also worked with Public Health Solutions, the largest provider of WIC services in New York City to develop their healthy feeding video for WIC clients: *It's Never Too Early: Feeding Your Baby Well.* As a consultant and clinician leader on *Greenlight,* an NIH funded multi-site RCT of a low–literacy obesity prevention tool for pediatricians, she developed intervention content and assisted in provider training in communication and use of the tools with families. She has been an educator and primary care pediatrician for low socioeconomic status (SES) immigrant and Hispanic children at Bellevue Hospital Center (BHC) for more than 20 years and has served as director of the *BeNuFit* pediatric obesity treatment and prevention program for the last 10 years. The obesity program treats patients referred from primary care for medical weight management and is collaborating with a bariatric surgeon to develop a weight loss surgery program for adolescents at BHC.

Abstract (up to 500 words)

Background:
The high prevalence of obesity in young children, and disparities found among low SES and Hispanic groups suggests the need for preventive interventions beginning early in life. Parent feeding styles, practices and lifestyle behaviors like sleep and screen time, operate on the child from infancy and are established by age 2 years. These modifiable behaviors are critical mediators of the disparities in obesity risk. To address this, we have developed an innovative individual and group counseling preventive intervention called *Starting Early* (*SE*). The SE intervention integrates evidence-based strategies to reduce obesity risk in prenatal and pediatric primary care. We are implementing SE with a USDA-funded large scale randomized controlled trial (RCT), which will enable us to study intervention impact, relative importance of prenatal and postnatal intervention, and better understand the trajectories and mechanisms of early child obesity.

Objectives:
To determine impact of SE in low SES Hispanic families on:

1) parent feeding styles, practices and lifestyle behaviors
2) growth trajectories and obesity

To use the SE cohort to better understand:

1) the relative importance of prenatal and postnatal intervention components
2) factors related to trajectories and mechanisms of early child obesity

Design/Methods:
RCT comparing *SE* to standard care for 500 women. Enrollment in third trimester from prenatal clinic in an urban hospital and community clinic. *SE* delivered in three modalities: (1) individual nutrition counseling and nutrition and parenting support groups coordinated with prenatal and well child visits and the peri-partum hospital stay, (2) nutrition video developed for NYC WIC clients, (3) low-literacy handouts to reinforce group messages. Mother infant dyads followed from 3rd trimester of pregnancy through child age 3 years. Assessment of feeding styles, diet content, lifestyle behaviors and maternal and child weight lengths/heights and blood pressure at baseline (prenatal), 3, 10, 19, 24 and 36 months. Videotaped feeding interactions and movement analysis obtained at 9, 13, and 24 months.

Results:
N = 254 women enrolled, 238 randomized: 118 control, 120 intervention. Baseline: 35% obese pre-pregnancy, 40% first child, 23% U.S. born, 31% low education, 87% WIC, 36% SNAP, 34% food insecure, 35% depressive symptoms. Mean daily servings fruit = 1 (1.1), vegetables =1.8 (.8), sweetened beverage 9 oz (9.2). Mean 2.8(2) h TV time daily, and 50% with no daily physical activity. No baseline difference between intervention and control groups. 206 babies born, 53% male. 117 3–month assessments complete. 21% exclusively breastmilk, 27% exclusive formula, 52% combination. 72% watched TV, 75% TV in room where child sleeps, mean TV time 0.5 h(1.8), 21% no daily tummy time, mean restrictive feeding style score: 3.8 (1.2)

Conclusions:
Many low-income Hispanic pregnant women report unhealthy dietary and lifestyle practices and multiple social stresses. At 3 months, infants are exposed to obesity promoting practices, such as restrictive feeding style, formula or combination feeding, and media exposure. *SE* represents a unique opportunity to leverage primary care as a population scaleable platform for universal engagement of at-risk families to prevent obesity at a critical stage early in the life course.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

<u>1. Assessment of the impact of a preventive intervention based in primary health care</u>: Pregnancy and infancy are critical periods for development of the feeding, diet and lifestyle behaviors that cause obesity and the metabolic processes that sustain it. The most exciting potential findings from our research would be the ability of our intervention to impact child weight trajectory and reduce child obesity. Improvement in diet and lifestyle behaviors, such as increased fruit and vegetable consumption, physical activity and better sleep patterns, as a result of the intervention, would also be important and exciting findings leading to improved health, even if the rate of obesity is not reduced.

2. Assessment of the relative impact of preventive intervention during the prenatal period compared to the infant/toddler period: The longitudinal nature of our study would allow us to evaluate the relative contribution of the 3 different temporal components of the program (pre-natal counseling, peripartum breastfeeding support and infancy nutrition/ parenting support) to effect change in both healthy weight and behaviors.

3. Better understanding of obesity prevention for low SES Hispanic families: We have enrolled a low SES Hispanic cohort that is being followed from the third trimester of pregnancy through infancy and early childhood— a period of particular vulnerability for the onset of obesity. This is a group at highest risk for early child obesity that has not been extensively studied in early life.

4. Better understanding of the mechanisms and trajectories of early childhood obesity in low SES Hispanic families: Growth trajectories will be plotted with detailed feeding style, diet content and lifestyle behaviors collected prospectively. This will allow the relative contribution of these factors to infant growth and obesity to be assessed. It will also allow better understanding of direction of causality for many factors potentially contributing to early child obesity; e.g. is maternal restricting feeding style caused by excess infant weight gain and hunger or the converse?

5. Better understanding of barriers to healthy feeding and lifestyles among low SES Hispanic families: Many authors have reported on the disparities in obesity and related feeding and lifestyle behaviors for poor and minority children. Consistent with this literature, our preliminary studies in low SES Hispanic families have found that disparities in weight do not begin at birth. But the feeding and lifestyle behaviors linked to excess infancy weight gain, such as controlling feeding style, combination breast and formula feeding, food insecurity and maternal depression operate on the infant from the first days of life. Understanding why poor families are less likely to adhere to the feeding and life style behaviors leading to optimal infant growth, is a key outcome of our study. Our intervention, a counseling and support program linked to primary care and grounded in social learning theory is particularly suited to address these disparities.

6. Understanding the potential role for primary health care as a population scalable model for preventive intervention: In addition, our intervention, developed as an "Add-on" to primary care, is a model of individual counseling and support groups utilizing primary care as a platform, without further "crowding" the already full preventive components of those visits for providers. At our institution, providers have already been trained in communication of preventive infant nutrition and use of low literacy education tool. A model in which providers have been optimally trained to deliver preventive counseling, with an additional intensive counseling and support group will allow us to evaluate the effect of the combined intervention in a group at high risk of obesity and its complications. This type of intervention has the potential to be brought to scale as standard of care for such groups, with eventual incorporation into obstetric visits earlier in pregnancy.

7. Better characterization of the interactional nature and stability of infant feeding styles. We will perform coded videotape analysis of feeding interactions at 3 time points of significant transition in infant feeding: 9, 13 and 24 months of age. This will lead to a better understanding of the relationship between both survey measurements of feeding styles and cues and their causal relationship to excess weight gain and obesity. These analyses at multiple time points will allow us to assess the stability of transactional feeding interactions and how they are impacted by our intervention.

8. Better characterization of the nature and quantity of infant activity and the stability of these patterns: We also have leveraged this cohort to do innovative assessments of infant activity by performing coded video tape measurement of gait and movement at three time points of significant transition in infant development: 9, 13 and 24 months of age. This will allow better understanding of the trajectory of infant movement and activity and how they relate to weight gain. In addition, there are few tools to measure infant movement and activity; creation of these detailed analyses will allow comparison to both survey and accelerometer data standards. These sophisticated analyses at multiple time points will also give us exciting information on the stability of patterns of infant movement and activity, and how they are impacted by our intervention.

9. Exploratory analysis of the relationship between environmental toxins and child obesity We are performing measurement of urinary levels of the environmental toxins phthalates at 3 time points in our cohort. This provides the opportunity to explore the relationship between infant diet, exposure to these toxins and the development of child obesity.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

1. Can preventive interventions in primary care improve feeding style, diet content and lifestyle behaviors? Does improvement in these modifiable behaviors impact early infant weight gain and later obesity risk? Understanding the relative importance of these factors and how they interact is also important. For example: does responsive feeding style operate differently on child weight for breast vs. formula or combination feeding?

2. What are the barriers to adopting optimal feeding style, diet content and lifestyle behaviors in low SES and ethnic minority families? Although the vast majority of low SES and minority women and children are seen frequently in primary care, and knowledge of optimal feeding practices such as breastfeeding is widespread, many families do not adhere to them. A better understanding of these barriers is essential to developing effective prevention programs and bringing them up to scale.

3. How are feeding styles, infant hunger and satiety cues, diet content and infant activity best measured, and are they stable over time?

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

One obstacle is the difficulty engaging high risk, low SES and minority families during vulnerable periods in the life-cycle, such as pregnancy and infancy to prevent the establishment of the patterns that cause and sustain obesity. These are also periods in which women, infants and families have frequent contact with health care providers in obstetric and pediatric primary care. A focus on disparities and how to help low SES and minority parents sustain healthy feeding and lifestyle practices is critical. Ideas for advancing research in this area include using primary care in obstetrics and pediatrics as a platform for culturally tailored supportive interventions based in social learning theory.

Other obstacles include the higher financial, time and opportunity costs of the feeding and lifestyle behaviors which promote optimal growth and decrease obesity. Understanding what prevents parent adherence to best feeding practices when knowledge of those practices is clear is another. Another obstacle is the incomplete knowledge of how maternal characteristics during pregnancy, such as

obesity, impaired glucose tolerance and weight gain impact infant body weight set point and obesity risk. Developing an understanding of the importance of these factors and how they relate to early postnatal feeding practices is also key.

Measurement issues?

Validated, easy-to-use measures for large scale assessment of infant hunger, physical activity, and food intake are needed. Measures for parent feeding style and responsiveness need refinements, especially for low SES and minority families. Aside from self-report surveys, good measures don't exist to quantify breast feeding or fruit/vegetable intake. The development of an objective measure, e.g., simple blood test for aspects of healthy diet intake would be helpful. Better measures of infant adiposity would be useful, such as air impedance technology, as well as ready availability of small blood volume assays (e.g. spot filter paper) for metabolic markers such as insulin, leptin, ghrelin, and adiponectin.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Rachel S. Gross, Alan L. Mendelsohn, Arthur H. Fierman, Andrew D. Racine**,** Mary Jo Messito, 2012. Food Insecurity and Obesogenic Maternal Infant Feeding Styles and Practices in Low-Income Families, *Pediatrics* 130(2): 254-261. Gross, Rachel S, Mendelsohn Alan, Fierman Arthur, Messito Mary Jo, 2011. Maternal Controlling Feeding Styles During Early Infancy, *Clinical Pediatrics* 50(12): 1125–1133.

Gross R, Fierman A, Mendelsohn A, Chiasson M, Rosenberg T, Scheinmann R, Messito M, 2010. Maternal Perceptions of Infant Hunger, Satiety and Pressuring Feeding Styles in an Urban Latina WIC Population, *Academic Pediatrics* 10(1): 29-35.

Messito MaryJo, Gorman Allison, Fierman Arthur, Green Cori, Berkule Samantha, Tomopoulos Suzy, Yick Christina, Handler Marci, Dreyer Benard, Gelfand Amy, Mendelsohn Alan, 2009. BeNuFit Baby: 2 Year Results from a Pilot Feasibility Trial of Primary Obesity Prevention for Newborns. Abstract 136-OR *Obesity* 17: S2.

Publications from others that are most applicable to the meeting (2-3 papers):

Philip J. Ciampa, Disha Kumar, Shari L. Barkin, Lee M. Sanders,H. Shonna Yin, Eliana M. Perrin, Russell L. Rothman, 2010. Interventions Aimed at Decreasing Obesity in Children Younger Than 2 Years: A Systematic Review, *Arch Pediatr Adolesc Med.* 164(12): 1098-1104.

Elsie M. Taveras, Matthew W. Gillman, Ken Kleinman, Janet W. Rich-Edwards Sheryl L. Rifas-Shiman, 2010. Racial/Ethnic Differences in Early-Life Risk Factors for Childhood Obesity, *Pediatrics* 125: 686

Sanna Talvia, Hanna Lagstro¨m, Minna Ra¨sa¨nen, Mari Salminen, Leena Ra¨sa¨nen, Pia Salo, Jorma Viikari, Tapani Ro¨nnemaa, Eero Jokinen, Tero Vahlberg, Olli Simell, 2004. A Randomized Intervention Since Infancy to Reduce Intake of Saturated Fat *Calorie (Energy)* and Nutrient Intakes Up to the Age of 10 Years in the Special Turku Coronary Risk Factor Intervention Project, *Arch Pediatr Adolesc Med.* 158: 41-47.

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Dr. Jodi Mindell is the Associate Director of the Sleep Center at The Children's Hospital of Philadelphia and Professor of Psychology at Saint Joseph's University and of Pediatrics at the University of Pennsylvania School of Medicine. Dr. Mindell is an associate editor of the journal *Sleep* and on the editorial board of *Behavioral Sleep Medicine.* She is also the author of *Clinical Guide to Pediatric Sleep: Diagnosis and Management of Sleep Problems*. She has served on the Board of Directors of the National Sleep Foundation and the Sleep Research Society and co-chairs the bi-annual *Pediatric Sleep Medicine* conference.

Abstract (up to 500 words)

Research to date has provided evidence of the relationship between sleep duration and obesity across the majority of age groups, although results are not as clear cut in young children. In one study of infants and toddlers, no associations were found between any adiposity indicators at 3 years of age and parent-reported total sleep duration at 9 months, 18 months, and 3 years. Another longitudinal study found that sleep duration did not predict obesity in children ages 0–7 years, and concluded that "current trials of sleep interventions to prevent or manage obesity in young children may be premature." These same researchers investigated outcomes of an infant sleep intervention at 6 years of age and found no differences in rates of child obesity. However, in contrast, in one pilot trial, an added sleep intervention was found to reduce obesity at 1-year follow-up. These results indicate that it may be not the increases in sleep *per se* that made the difference, but that the likely reduced nighttime feedings associated with nighttime wakings led to differences in obesity post-treatment. A clearer understanding of the relationship between sleep, whether that is sleep duration and/or sleep disturbances, and pediatric obesity is needed, as well the results of ongoing investigations assessing the impact of sleep interventions on obesity outcomes.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

Sleep duration and sleep disturbances appear to be associated with the development of obesity, at least in school-aged children and adults. The data are not as clear cut in young children. However, if sleep disturbances do mediate the relationship in young children, there is a significant body of empirical evidence supporting behavioral interventions for infant and toddler sleep disturbances, thus preventing obesity.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

A clearer understanding of the relationship between sleep and obesity are needed, and whether it is sleep duration *per se* or the nighttime feedings often associated with infant and toddler sleep disturbances that may be contributing to this potential relationship.

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

Publications from your own work that are most applicable to the meeting (2-3 papers):

Mindell, J. A., Johnson, C., Sadeh, A., Telofski, L., Kulkarni, N., and Gunn, E. 2011. Efficacy of an internet-based intervention for infant and toddler sleep disturbances. *Sleep* 34: 451-458.

Mindell, J. A., Sadeh, A., Wiegand, B., How, T. H., and Goh, D., 2010. Cross-cultural differences in infant and toddler sleep, *Sleep Medicine* 11: 274-280.

Mindell, J. A. et al., 2006. Behavioral treatment of bedtime problems and night wakings in young children: AASM Standards of Practice. *Sleep* 29: 1263-1276.

Publications from others that are most applicable to the meeting (2-3 papers):

Paul, I. et al., 2011. Preventing obesity during infancy: A pilot study. *Obesity* 19: 53–361.

Hiscock, H., Scalzo, K., Canterford, L. and Wake, M., 2011. Sleep duration and body mass index in 0–7-year olds, *Arch Dis Child.* 96: 735–739.

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch (up to 8 sentences):

Ken Ong is a Paediatric Endocrinologist and Epidemiologist who leads the "Child Growth and Development" programme at the MRC Epidemiology Unit, University of Cambridge. His research has identified trajectories of childhood growth, weight gain, and pubertal timing as determinants of obesity and related disease, and aims to understand the genetic, epigenetic, and endocrine mechanisms that underlie these links. He works closely with the Unit's other research areas in the aetiology of obesity and type 2 diabetes, and the development and testing of interventions to prevent childhood obesity.

Abstract (up to 500 words)

Many studies consistently report that that the rapidity of weight gain during the first months and years of life is associated with higher risk of obesity in children and adults. In addition to outcomes based on Body Mass Index (BMI), faster infancy weight also is associated with subsequent higher percent body fat, insulin resistance and other metabolic syndrome traits. There is no obvious window of rapid weight gain and there is a continuum in obesity risk with increasing weight gain; infants who gain > +1.33 in weight Z-score have a 3 to 4-fold higher relative risk of childhood obesity than infants with average weight gain. Together with maternal BMI and birth weight, consideration of infancy weight gain allows moderate-high ability to predict childhood obesity.

Rapid infancy weight gain leads to a rapid tempo of childhood growth and development, manifested by higher circulating levels of leptin, IGF-I and adrenal androgens, and earlier pubertal maturation. In turn, a rapid tempo of childhood development is associated with persisting obesity risk in adult life, and higher risks for type 2 diabetes, cardiovascular disease, and mortality. Interestingly, only around half of the increased risk of type 2 diabetes appears to be explained by higher adult BMI; therefore, there may be other mechanisms that directly link earlier pubertal timing to later risks of disease and ageing.

Understanding of the dietary and other modifiable determinants of rapid infancy weight gain underlies the development of early prevention strategies. In western settings, formula milk feeding is associated with rapid infancy weight gain, childhood obesity, and earlier pubertal maturation. Among formula fed infants, higher energy intakes are positively associated with weight gain and childhood BMI. Current strategies under investigation to reduce rapid weight gain in this group include avoidance of excessive calorie intake and use of lower protein content milk formulas.

Finally, this "rapid tempo of growth and development" trajectory is a heritable trait. Common genetic variants associated with adult BMI confer susceptibility to faster weight gain and growth, starting even

in the first months from birth and leading to earlier pubertal maturation. Genetic predisposition does not mean that early weight gain is not modifiable. However, it may be helpful to acknowledge that some infants have greater predisposition to rapid weight gain, and their parents may need greater support to achieve optimal levels of infant nutrition and weight gain.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

1. Rapid infancy weight gain is highly consistently associated with greater childhood and adult obesity risk.
2. Infant calorie intake is positively associated with infant weight gain and childhood BMI.
3. Formula fed infants are a high risk group and their parents express a need for greater understanding and support with infant feeding.
4. Breastfeeding is not always easy. Some infants are rated as having more challenging temperaments. Acknowledgment of this may allow more realistic expectations by parents, and more realistic support by professionals.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

1. How to address and change socio-cultural attitudes to infant weight gain ("bigger is better") and infant behavior (e.g., sleeping through the night).
2. Early recognition of infants at high risk of obesity requires an informed understanding of the early growth phenotypes related to later obesity. For example, there is an assumption that infant weight-for-length should be targeted, whereas evidence shows that rapid length gain often accompanies unhealthy rapid weight gain.
3. Understanding how to promote "healthy catch up" (balancing height and cognition vs. adiposity and metabolic risk) in low-birthweight infants, remains a major challenge.
4. Other predictive biomarkers of future risk would also be helpful, both for possible targeting interventions and for assessing the response to intervention.

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

Wrongful assumptions that observations made in different setting (i.e., those that are more challenging with regard to infant nutrition, infection and growth) apply equally to contemporary western settings. Particular examples are:

1. Overlooking the potential benefits of breastfeeding on obesity due to reliance on trials in settings where breastfeeding protects against infections and promotes heavier infant weight.
2. Identification of long-term health-related infant growth parameters (e.g., growth in length) in populations of poor infant growth and stunting.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Lakshman R, Ogilvie D, Ong K, 2009. Mothers' experiences of bottle-feeding: a systematic review of qualitative and quantitative studies. *Arch Dis Child* 94: 4953-4960.

Elks CE, Loos RJ, Sharp SJ, Langenberg C, Ring SM, Timpson NJ, Ness AR, Davey Smith G, Dunger DB, Wareham NJ, Ong KK, 2010. Genetic markers of adult obesity risk are associated with greater early infancy weight gain and growth. *PLoS Med* 7: e1000284.

Lakshman R, Elks CE, Ong KK, 2012. Childhood obesity. *Circulation* 126: 1770-1779.

Ong KK, Hardy R, Shah I, Kuh D, 2013. Childhood stunting and mortality between 36-64 years: the British 1946 Birth Cohort Study. *J Clin Endocrinol Metab* 98(5): 2070-7.

Publications from others that are most applicable to the meeting (2-3 papers):

Llewellyn CH, van Jaarsveld CH, Plomin R, Fisher A, Wardle J, 2012. Inherited behavioral susceptibility to adiposity in infancy: A multivariate genetic analysis of appetite and weight in the Gemini birth cohort. *Am J Clin Nutr* 95: 633-639.

Koletzko B, von Kries R, Closa R, Escribano J, Scaglioni S, Giovannini M, Beyer J, Demmelmair H, Gruszfeld D, Dobrzanska A, Sengier A, Langhendries JP, Rolland Cachera MF, Grote V, European Childhood Obesity Trial Study G, 2009. Lower protein in infant formula is associated with lower weight up to age 2: A randomized clinical trial. *Am J Clin Nutr* 89: 1836-1845.

Victora CG, de Onis M, Hallal PC, Blossner M, Shrimpton R, 2010. Worldwide timing of growth faltering: Revisiting implications for interventions. *Pediatrics* 125: e473-480.

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch (up to 8 sentences):

Ian M. Paul, M.D., M.Sc., is a Professor of Pediatrics and Public Health Sciences and Chief of the Division of Academic General Pediatrics at the Pennsylvania State University College of Medicine. He also is Associate Vice Chair for Research and Director of the Pediatric Clinical Research Office at Penn State Children's Hospital. Dr. Paul is a pediatrician and clinical and health services researcher with principal interests in (a) primary preventive interventions for newborns, infants, and families and (b) clinical therapeutics for children. His research focuses on these two areas with the largest current NIH/NIDDK-funded projects focusing on the prevention of childhood obesity through home-based interventions delivered to parents of infants. He recently completed a federally funded study that evaluated postpartum home visitation delivered by a community-based home health agency as an alternative to office-based care for newborns and their mothers. Dr. Paul is a co-investigator on numerous NIH-funded projects related to co-parenting, infant sleep, prevention of Shaken Baby Syndrome, prevention of adverse pregnancy outcomes and the treatment of asthma, the latter through participation as a co-investigator on the National Heart, Lung and Blood Institute (NHLBI)-funded network, AsthmaNet.
Dr. Paul received his B.A. from Franklin and Marshall College (cum laude) with a major in Chemistry (with honors), received both graduate degrees (M.D. and M.Sc.) from The Penn State College of Medicine, and completed his pediatric residency at Duke University. He and his family reside in Lancaster, PA.

Abstract (up to 500 words)

This presentation will focus on lessons learned from the SLeeping and Intake Methods Taught to Infants and Mothers Early in life (SLIMTIME) study, a pilot study involving 160 newborns and their families aimed at the primary prevention of obesity through interventions delivered during the first year after birth. Following presentation of these lessons learned, the presentation will shift to the ongoing Intervention Nurses Start Infants Growing on Healthy Trajectories (INSIGHT) study, a prospective, randomized, controlled trial evaluating the efficacy of a responsive parenting intervention designed to prevent rapid infant weight gain and childhood obesity among first-born infants, who will be followed from birth to age 3 years and beyond. Topics will include attrition, participant burden, and intervention content, dose, and measures.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

Interventions beginning during infancy, focused on responsive parenting and healthy eating and feeding behaviors, have high potential for the prevention of rapid infant weight gain and early life overweight.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

What is the best, most efficient, and most cost-effective way to deliver early life obesity preventive interventions? In essence, what "dose" is needed, who should deliver it, which families should it be delivered to and where should it be delivered?

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

The biggest obstacle to answering big questions might be the differing root causes of the problem based on income, race/ethnicity, etc., which make finding a universal solution quite difficult.

A further obstacle is the traditional length of funding periods. For early life obesity prevention, it would be ideal to enroll women prior to or at the beginning of pregnancy and follow them and their offspring for several years after birth. This is almost impossible to do in a 4–5 year funding cycle.

An optimal approach would be a multi-center collaborative network of investigators who could develop and plan a study or series of studies that include diverse populations and could test interventions that could be evaluated over many years.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Paul IM, Bartok CJ, Downs DS, Stifter CA, Ventura AK, Birch LL, 2009. Opportunities for the Primary Prevention of Obesity During Infancy. *Adv Pediatr* 56: 107-133.

Paul IM, Savage JS, Anzman SL, Beiler JS, Marini ME, Stokes JL, Birch LL, 2011. Preventing obesity during infancy: A pilot study. *Obesity* 19: 353-361.

Birch LL, Anzman-Frasca S, Paul IM, 2012. Starting Early: Obesity Prevention during Infancy. In *Obesity Treatment and Prevention: New Directions*. Drewnowski A, Rolls BJ (eds). Nestlé Nutritional Institute Workshop Series 73: 81–94.

Publications from others that are most applicable to the meeting (2-3 papers):

Sullivan SA, Birch LL, 1994. Infant dietary experience and acceptance of solid foods. *Pediatrics* 93: 271-7.

Stettler N, Zemel BS, Kumanyika S, Stallings VA, 2002. Infant weight gain and childhood overweight status in a multicenter, cohort study. *Pediatrics* 109: 194-9.

Taveras EM, Rifas-Shiman SL, Oken E, Gunderson EP, Gillman MW, 2008. Short sleep duration in infancy and risk of childhood overweight. *Arch Pediatr Adolesc Med* 162: 305-11.

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch (up to 8 sentences):

Dr. Rothman is an Associate Professor of Internal Medicine and Pediatrics at Vanderbilt, and serves as the Director of the Vanderbilt Center for Health Services Research. He also currently serves as Chief of the Vanderbilt Med/Peds Section, Co-Director of the Vanderbilt Community Engaged Research Core of the Vanderbilt Institute of Clinical and Translational Research (VICTR), and the Associate Director of the NIDDK funded Vanderbilt Center for Diabetes Translational Research. Dr. Rothman's current research focuses on improving care for adult and pediatric patients with diabetes, obesity and other chronic diseases. He has been funded by the National Institutes of Health (NIH) and other sources to examine the role of health communication, literacy and numeracy in diabetes and obesity management and prevention. Dr. Rothman is currently a Principal Investigator on a National Institute of Child Health and Human Development (NICHD)-funded cluster randomized trial, known as the Greenlight Study, that is examining the impact of a health communication/health literacy intervention on early childhood obesity prevention.

Abstract (up to 500 words)

In 2003, Surgeon General Richard Carmona stated that low health literacy was “one of the largest contributors to our nation’s epidemic of overweight and obesity.” This assertion is supported by recent studies which have found that low health literacy or numeracy is associated with poorer caregiver breastfeeding knowledge, incorrect mixing of infant formula, difficulty understanding food labels and portion sizes, and higher Body Mass Index (BMI) in adults and children. Of particular concern is the impact of the obesity epidemic on our youngest children. Approximately one fourth of preschool children are now overweight (BMI ≥ 85%) or obese (BMI ≥ 95%). Rates of obesity in preschool children are highest increases among low income and minority children—the same communities most affected by low health literacy.

To date, many efforts to prevent childhood obesity have had limited efficacy. Efforts need to start early, because children who are overweight by age two are five times as likely to become overweight adolescents, and subsequently at higher risk for obesity-related complications. No published clinical studies have rigorously addressed obesity prevention prior to age 2 with a specific low-literacy and numeracy focus. Addressing caregiver health literacy in early childhood is an innovative strategy to promote healthy nutrition and activity among these families to prevent unhealthy weight gain.

Our current study, known as the Greenlight Study, is a multi-site cluster-randomized trial to assess the efficacy of a low-literacy/numeracy-oriented intervention designed to promote healthy family lifestyles and to prevent early childhood obesity. The intervention is delivered by pediatric resident physicians in primary care settings in under-resourced communities at four academic medical centers. Two centers

(Vanderbilt University and New York University) receive the intervention, while the other two centers (University of Miami and University of North Carolina at Chapel Hill) receive an active control focused on injury prevention.

At each site, a cohort of 150-250 English- or Spanish-speaking caregiver-child dyads were enrolled and are being followed from the child's 2-month well-child visit through the 24-month well-child visit. The intervention includes a low-literacy-oriented "Greenlight" toolkit for pediatric residents to use with families and clear health communication training for the pediatric residents. At control sites, pediatric residents provide "usual care" with respect to lifestyle counseling, but also receive an injury-prevention education program to act as an attention control. The primary hypotheses are that the intervention will improve family dietary and physical activity behaviors and that it will reduce the rate of childhood overweight (BMI ≥ 85%) at age 24 months.

To date, 865 families and over 400 pediatric residents were successfully enrolled into the study, and over 400 families have completed the study. Initial analyses at enrollment reveal high rates of parental feeding and child activity behaviors for their two month old children that may be "obesogenic." Significant relationships between parent health literacy and "obesogenic" behaviors have been identified, suggesting that addressing literacy may be an important target for intervention. Complex racial and ethnic disparities in potentially obesogenic behaviors have also been identified and merit further study.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

Our study is still ongoing and therefore does not yet have results about the impact of our intervention. However, preliminary analyses of our baseline data have revealed important knowlege about the prevalence and complexity of feeding and activity behaviors in the first 0–6 months of life that may contribute to obesity development. Initial analysis have also demonstrated important links between parental literacy and obesity related behaviors—suggesting that addressing literacy related issues may help to address obesity prevention.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

1. How to optimally define overweight/obesity or obesogenic risk factors in children 0–2 years of age?
2. How to optimally measure feeding and activity behaviors for children 0–2 years of age?

3. What are the optimal approaches for improving caregiver behaviors to optimize child feeding and activity behaviors?

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

Additional research in large cohorts of children age 0–2 is needed to further identify risk factors for obesity development in children 0–2, and to develop a better understanding of weight status in children

of this age and its relation to later obesity development. In addition, more research is needed to develop better methods to assess infant feeding and activity behaviors including the use of mobile technology, actigraphs, and other health information technology tools to improve ecological momentary assessment. Finally, studies that explore novel approaches to promote behavior change, including the use of novel health information technology tools is needed.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Ciampa, P, Kumar D, …..Rothman RL, 2010. Interventions aimed at impacting obesity in children under the age of two: A systematic review, *Arch of Pediatrics* 164(12): 1098-104. PMCID: PMC3369272.

Kumar D, Sanders L, Perrin EM, ….. Rothman RL, 2010. Parental understanding of infant health information: Health literacy, numeracy and the parental health literacy activities test (PHLAT), *Academic Pediatrics* 10 (5): 309-16. Epub 2010 Aug 2. PMCID:PMC2933956

Rothman RL, DeWalt D, Malone R, Bryant B, Shintani A, Crigler B, Weinberger MW, Pignone MP, 2004. The influence of patient literacy on the effectiveness of a primary-care based diabetes disease management program. *JAMA* 292: 1711-1716. PMID: 15479936.

Publications from others that are most applicable to the meeting (2-3 papers):

Taveras EM, Gillman MW, Kleinman KP, Rich-Edwards JW, Rifas-Shiman SL, 2013. Reducing racial/ethnic disparities in childhood obesity: the role of early life risk factors. *JAMA Pediatr* 167(8): 731-8. doi: 10.1001/jamapediatrics.2013.85.PMID: 23733179.

Taveras EM, Rifas-Shiman SL, Belfort MB, Kleinman KP, Oken E, Gillman MW, 2009. Weight status in the first 6 months of life and obesity at 3 years of age. *Pediatrics* 123: 1177-83.

Leunissen RWJ, Kerkhof GF, Stijnen T, Hokken-Koelega A, 2009. Timing and tempo of first-year rapid growth in relation to cardiovascular and metabolic risk profile in early adulthood. *JAMA* 301: 2234-42.

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch (up to 8 sentences):

Kristin Shutts is an Assistant Professor in the Psychology Department at the University of Wisconsin-Madison, and an Investigator at the Waisman Center. She received her Ph.D. from Harvard University in 2006, and was a Mind, Brain, and Behavior postdoctoral fellow at Harvard and Children's Hospital-Boston until 2009. Her research focuses on the development of social cognition in infancy and early childhood.

Abstract (up to 500 words)

Modern research in the field of developmental psychology reveals that infants are remarkably engaged and adept social learners. In this talk, I will review the literature on infants' learning from other people's actions, emotions, and testimony, with particular attention to the domain of food and the role that social models play in guiding infants' food selection. In addition to reviewing findings from controlled, laboratory-based research, I will address implications of the findings for intervention efforts.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

Infants are attuned to the preferences and eating behaviors of those around them; seeing positive models may encourage healthy choices.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

How does learning and experience with foods during infancy affect food preferences and eating behaviors later in development?

Why does "picky eating" increase from infancy into toddlerhood and early childhood?

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

Obstacles: Cost of longitudinal research; limited collaborations between developmental psychologists and pediatricians. Ideas: funding that supports and encourages collaborations across disciplines/training/methods.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Shutts, K., Kinzler, K.D., and DeJesus, J., 2013. Understanding infants' and children's social learning about foods: Previous research and new prospects. *Developmental Psychology* 49: 419-425.

Shutts, K., Kinzler, K.D., McKee, C.B., and Spelke, E.S., 2009. Social information guides infants' selection of foods. *Journal of Cognition and Development* 10: 1-17.

Shutts, K., Condry, K., Santos, L.R., and Spelke, E.S., 2009. Core knowledge and its limits: The domain of food. *Cognition* 112: 120-140.

Publications from others that are most applicable to the meeting (2-3 papers):

Mumme, D. L., and Fernald, A., 2003. The infant as onlooker: Learning from emotional reactions observed in a television scenario. *Child Development* 74: 221–237.

Csibra, G., and Gergely, G., 2009. Natural pedagogy. *TICS* 13: 148-153.

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch (up to 8 sentences):

Cynthia Stifter, Ph.D., is Professor of Human Development and Psychology at The Pennsylvania State University. Dr. Stifter's expertise is in temperament with an emphasis on self-regulation and its impact on behavioral adjustment and health. Her research has focused on how the temperament dimensions of approach and withdrawal in infancy interact with physiology, parental responsivity, and self-regulation to predict mental and physical health. She is currently conducting a study relating temperament, self-regulation, and parenting to rapid weight gain in infancy and obesity in childhood. In addition, she is researching the role of positive affect and curiosity in young children's lives. Dr. Stifter has authored numerous publications on infant, toddler, and preschool development including the emergence of emotion self-regulation, the effect of emotion regulation on behavioral control, and the psychobiology of temperament. She has served on several NIH review panels and editorial boards. She is currently an Associate Editor of *Child Development*, and a Fellow of the Association for Psychological Science.

Abstract (up to 500 words)

The evidence is clear that childhood obesity is a serious public health issue. Given the urgency of preventing further increases in this health problem, it is critical that researchers study the early origins of obesity and overweight in childhood. Infancy is an important developmental period to examine the possible precursors of childhood obesity due to the rapid growth and the developmental plasticity observed during this age period. One area of inquiry that may inform how it is that some children become obese is the characteristics of the infant and how they influence interactions with the environment, particularly parents. Temperament, or individual differences in reactivity (emotional, physiological) and regulation (processes that modulate reactivity), is one such characteristic. Despite its central role in the child's developmental process, research has only just begun to consider temperament as an early precursor of childhood obesity. In this talk, the construct of temperament will be discussed and the studies linking temperament to eating/childhood obesity will be reviewed. Studies examining temperament and childhood obesity typically focus on the reactive aspects. Self-regulation as a temperamental dimension of temperament is largely ignored or misunderstood. Yet, several studies have emerged that illustrate how the inability to regulate one's attention, emotion or behavior contributes to childhood obesity. The impact of temperament on childhood obesity is not direct but likely operates through the parenting environment. One method through which temperament indirectly contributes to childhood obesity is by evoking distinct feeding behaviors from parents that may put them at risk for obesity. In this talk one such developmental transactional pathway will be presented. An important issue to consider in light of the burgeoning new research linking temperament to childhood eating and obesity is how to best measure infant and child temperament. The advantages and disadvantages of assessing temperament via parent reports, a method found in most eating and

childhood obesity studies, will be discussed and alternatives offered. Finally, preliminary data from our laboratory linking temperament, parent feeding styles, and child weight outcomes will be presented.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

My aim in trying to understand childhood obesity grew out of my work in infant and child temperament. I have been interested in the emotional and behavioral adjustment outcomes of children of different temperament types, called behaviorally inhibited and exuberant types. We have shown several interesting findings with regard to parenting strategies that related to the child's ability to regulate emotions and behavior. At the same time I did a study examining parent soothing of infant distress to immunization and found that about 10% of parents used feeding/pacifying as a method for soothing. A more detailed examination showed that they used food to soothe after using other methods suggesting that they resorted to this strategy when all others failed. This led me to question what the outcome might be of parents who use food to soothe and whether infants of certain temperament types may be at more risk for rapid weight gain or childhood obesity as a result. A pilot study confirmed this hypothesis showing that infants rated as highly negative in temperament weighed more if their mothers endorsed using food to soothe than infants rated as low negative.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

1. Are the biological mechanisms underlying temperament also related to risk for childhood obesity?
2. Does training/supporting the development of self-regulation, particularly for children of different temperaments, generally relate to better eating/weight outcomes or is regulation of eating behaviors, specifically, more important?
3. How do we conceptualize and measure parent use of food to soothe or food to change behavior (instrumental feeding)?

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

Measurement of parenting around soothing with food is very difficult to assess outside of asking parents directly.

As self-regulation development may differ depending upon the temperament of the child, any preventative intervention on developing these skills must be more tailored to the different types of temperament.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Stifter, C., Anzman-Frasca, S., Birch, L., and Voegtline, K., 2011. Parent use of food to soothe infant/toddler distress and child weight status: An exploratory study. *Appetite* 57: 693-699.

Anzman-Frasca, S., Stifter, C., Paul, I., & Birch, L. (in press). Negative temperament as a moderator of intervention effects in infancy: Testing a differential susceptibility model. *Prevention Science*.

Cipriano, E. and Stifter, C., 2010. Predicting preschool effortful control from toddler temperament and parenting behavior. *Journal of Applied Developmental Psychology,* 31: 221-230. PMC3693473

Publications from others that are most applicable to the meeting (2-3 papers):

Graziano, P., Calkins, S. and Keane, S., 2010. Toddler self-regulation skills predict risk for pediatric obesity. *International Journal of Obesity* 34: 633-641. PMC2854309

Francis, L. and Susman, E., 2009. Self-regulation and rapid weight gain in children from age 3 to 12 years. *Archive of Pediatric And Adolescent Medicine* 163: 297-302.

McMeekin, S., Jansen, E., Mallan, K., Nicholson, J., Magarey, A., and Daniels, L., 2013. Associations between infant temperament and early feeding practices. A cross-sectional study of Australian mother-infant dyads from the NOURISH randomised controlled trial. *Appetite* 60: 239-245.

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch (up to 8 sentences):

Dr. Taveras is Chief of the Division of General Pediatrics and Director of Pediatric Population Health Management at Massachusetts General Hospital. She is also Associate Professor of Pediatrics and Population Medicine at Harvard Medical School. Dr. Taveras is a board-certified Pediatrician and an obesity researcher. Her main focus of research is understanding determinants of obesity in women and children and developing interventions across the lifecourse to prevent obesity, especially in underserved populations. She served on committees for the Institute of Medicine to develop recommendations for prevention of obesity in early life and for evaluating the progress of national obesity prevention efforts. Her work has been cited by The Robert Wood Johnson Foundation as one of the most influential studies of 2010 and was cited in the White House Task Force Report on Childhood Obesity in May 2010.

Abstract (up to 500 words)

Obesity represents a major threat to public health and results in significant excess burden of chronic diseases, health and societal costs, and adverse quality of life. Although obesity rates in the United States may have plateaued in some population subgroups, overall rates remain high, and racial/ethnic and socioeconomic disparities appear to be increasing. Many factors contribute to the persistence of disparities in obesity, but promising approaches for prevention and reduction of related health disparities are emerging, including cross-sector strategies that support changes at the individual, family, and systems-levels and which begin in the earliest stages of life. Preventing obesity in early life can be achieved by working across the key sectors that interface the most with vulnerable mother-infant pairs and their families, e.g. obstetric and pediatric providers; Women, Infants and Children Program (WIC); Maternal, Infant, and Early Childhood Home Visiting Programs (HV); Early Head Start Programs; and even industry.

This presentation will provide an overview of the prevalence of overweight among children 2 years of age and under, and existing disparities among racial/ethnic minority groups and children living in low resource settings. The presentation also will review the existing systems that interface the most with mother-infant-father triads from conception to 24 months of age and the contexts in which behavior change decision-making is occurring. Such information can assist in the planning of interventions in these periods of life.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

Some of the most exciting findings from the research I am involved in is showing that racial/ethnic differences exist in almost all known risk factors for obesity in early life, and that if we were to intervene in these life periods (pregnancy and obesity), we could substantially reduce the observed disparities among Black and Hispanic children, compared to their White counterparts, that are so striking by the time children are two years of age.

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

More evidence is needed on practical and clinically relevant methods of identifying at-risk children in early childhood. Also, how do we best leverage clinical and community resources to prevent and manage obesity in early life? How can we change our current clinical and community approaches to take more of a lifecourse approach to obesity prevention?

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

Whereas some studies suggest key, evidence-informed behavioral targets for counseling in early life, other evidence is inconsistent or has shown that some behaviors, commonly thought to be protective of obesity, have no long-term protective effects. More research is needed on modifiable risk factors in children under age 2 years.

National and federal funding initiatives with the purpose of preventing childhood obesity must also provide opportunities for interventions to target the prenatal, infancy, and early childhood periods. Many national funding initiatives continue to exclude children under the age of 2 years—a missed opportunity for obesity prevention.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Taveras EM, Gillman MW, Kleinman KP, Rich-Edwards JW, Rifas-Shiman SL, 2013. Reducing racial/ethnic disparities in childhood obesity: the role of early life risk factors. *JAMA Pediatr* 167(8): 731-8. doi: 10.1001/jamapediatrics.2013.85.

Baidal JA, Taveras EM, 2012. Childhood obesity: shifting the focus to early prevention. *Arch Pediatr Adolesc Med* 166(12): 1179-81. doi: 10.1001/2013.jamapediatrics.358.

Dixon B, Peña MM, Taveras EM, 2012. Lifecourse approach to racial/ethnic disparities in childhood obesity. *Adv Nutr* 3(1): 73-82. doi: 10.3945/an.111.000919.

Publications from others that are most applicable to the meeting (2-3 papers):

Nader PR, Huang TT, Gahagan S, Kumanyika S, Hammond RA, Christoffel KK, 2012. Next steps in obesity prevention: altering early life systems to support healthy parents, infants, and toddlers. *Child Obes* 8(3): 195-204. doi: 10.1089/chi.2012.0004.

NIH WORKSHOP ON PREVENTION OF OBESITY IN INFANCY AND EARLY CHILDHOOD

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Brief Biosketch (up to 8 sentences):

Dr. Ulrich is a Professor in the Department of Movement Sciences in the School of Kinesiology at the University of Michigan. He also is the Director of the Center on Physical Activity and Health in Pediatric Disabilities. He is an elected fellow in the National Academy of Kinesiology. Most of his funded research has a focus on designing and testing parent implemented early physical activity interventions to improve health and functioning in infants with developmental disabilities. His current interest is in translating the results of the physical activity interventions for use in infants at risk for rapid weight gain.

Abstract (up to 500 words)

Physical Activity and Sedentary Behavior in Infants and Toddlers

Current obesity prevalence rates indicate that 9.7% of infants are expected to be obese before 24 months of age with 14.8% of Hispanic infants expected to be obese before they turn 2 years of age (Ogden et al., 2012). The majority of overweight infants remain overweight into childhood, and childhood obesity is a strong predictor of obesity in adults (Dattilo et al., 2012; De Kroon et al., 2010; Whitaker et al., 1997). The most robust findings related to very early onset of obesity suggest that this is a complex problem and that rapid weight gain from birth through 6 months of age is a leading determinant (Baird et al., 2005; Dennison et al., 2006; Eid, 1970; Mihrshahi et al., 2011; Monteiro et al., 2005; Ong et al., 2006; Reilly et al., 2005; Stettler et al., 2003; Wells et al., 2005). Prevention of rapid weight gain during infancy should be a major focus of interdisciplinary efforts to combat this global problem of early onset of obesity (Taveras et al., 2009). Decreased physical activity (PA) in childhood is frequently given as a major contributor of childhood risk for obesity (Fox, 2004; Goran, Reynolds, and Lindquist, 1999). Unfortunately, very little is currently known about physical activity (PA) and sedentary behavior in infants, or the most appropriate protocol for its measurement (Cliff, Reilly, and Okely, 2009; Hauck, 2012). In this presentation, we will summarize what is currently known about PA during the first 24 months of age. We also will discuss recent research to help establish the trajectory of PA over the first six months of life with the most dramatic increase occurring during months 1 through 3. During the first 6 months, there appears to be a trend of increased motor skill development among more physically active infants which is not surprising given the view that early spontaneous activity is an important mechanism for the young infant to acquire motor control and coordination in their limbs needed for the onset of locomotion and the development of important systems of the body (Piek, 1995; Thelen, 1985; Ulrich and Ulrich, 1995). In the few studies that have been published on PA during infancy, one consistent finding across these studies is that there does not appear to be a gender difference. Infants who spend the most amount of time each day positioned in an infant positioning device (IPD) compared to those that spent the lowest amount of time in an IPD displayed a higher weight for length percentile at

6 months of age (Hauck, 2012). In promoting increased PA during infancy, the only suggestion by the IOM is to increase supervised tummy time. The lack of research on tummy time makes it impossible to recommend an appropriate dose needed to influence daily PA. In this presentation, we will recommend a model of physical activity exposures, founded on research, that should be considered by families of infants who possess a profile known to place their infant at risk for rapid weight gain. These physical activity exposures can begin from month 1 through months 6 and 12 and be implemented by parents in the home and be combined with other public health prevention efforts. Until we establish what a typical level of physical activity is during infancy, it will be difficult for physicians to identify infants who are meaningfully less active requiring parents to implement home-based physical activity interventions. Based on our longitudinal research projects over the past 20 years involving physical activity interventions in infancy, parents who have not received a physician's diagnosis of an early health concern may lack motivation to intervene.

Questions:

What are the most exciting findings from your research that could inform our understanding of obesity development or intervention during infancy and early childhood?

Our early physical activity interventions that have been employed with infants with Down syndrome and infants with neuromotor delays, improve their functioning (earlier acquisition of locomotor skills) and level of physical activity (Ulrich and Hauck, 2013; Angulo-Barroso et al., 2008; Ulrich et al., 2008; Lloyd and Ulrich, 2006). Improvements in physical activity for the experimental group last well beyond the end of the intervention period suggesting physical activity may be programmable. Early exposures to physical activity during the first year may contribute to early health outcomes. Our physical activity interventions do not appear to have negative effects on growth and development.

The trajectory of physical activity from 1–6 months of life in non-disabled infants measured at the ankle and wrist improves with age (Hauck and Ulrich, 2013). Early motor activity begins as spontaneous movement that helps the young infant acquire control and coordination of their limbs. During the first 6 months, there is a trend of increased motor skill development measured by the Bayley Motor Scale among infants who generate a higher level of physical activity. Being constrained in an infant positioning device appears to only affect those infants at either extreme with high frequency resulting in significantly elevated weight for length percentile at 6 months (Hauck, 2012).

We have established methods in several studies to use with infants wearing accelerometers with good fidelity by parents (Hauck and Ulrich, 2013; Ulrich et al., 2008).

What are 2-3 most pressing questions for your topic area that need to be addressed in order to develop effective approaches for obesity prevention during infancy and early childhood?

Is physical activity programmable during the first year of life by increasing physical activity exposures and will it modulate rapid weight gain? Will parents of infants who are at risk for early rapid weight gain implement physical activity exposures with good fidelity without having physicians diagnose an early health concern?

What are the obstacles to answering the big questions and what are creative ideas for advancing research on obesity prevention during infancy and early childhood?

Currently, we do not have a database available on infants to help us establish what a typical level of physical activity is. Currently, there is no established physical activity cut points for determining how much time an infant spends in sedentary, light, or moderate to vigorous physical activity during a day. Protocols must be established for measuring physical activity in infants and toddlers. Some parents position their infant in a seated device for too many hours that restricts leg movements. Innovation is one critical element of designing early intervention for infants. Another requirement is that interventions must be designed to maximize parent involvement.

Publications from your own work that are most applicable to the meeting (2-3 papers):

Angulo-Barroso, R., Burghardt, A.R., Lloyd, M., and Ulrich, D.A., 2008. Physical activity in infants with Down syndrome receiving a treadmill intervention. *Infant Behavior and Development*, 31: 255-269.

Ulrich DA and Hauck, JL (In Press). Programming Physical Activity in Young Infants At-Risk for Early Onset of Obesity, *Kinesiology Review,* Human Kinetics Publishers, Champaign IL.

Ulrich DA, Lloyd MC, Tiernan C, Looper J, and Angulo-Barroso RM, 2008. Effects of intensity of treadmill training on developmental outcomes and stepping in infants with Down syndrome: A randomized trial. *Physical Therapy* 88: 114-122.

Publications from others that are most applicable to the meeting (2-3 papers):

Rovee, C.K., and Rovee, D.T., 1969. Conjugate reinforcement of infant exploratory behavior. *Journal of Experimental Child Development* 8: 33-39.

Thelen, E., and Ulrich, B.D., 1991. Hidden skills: a dynamic systems analysis of treadmill stepping during the first year. *Monographs of the Society for Research in Child Development* 56 (1, Serial No. 23).

Ulrich, B., 2010. Opportunities for early intervention based on theory, basic neuroscience, and clinical science. *Physical Therapy Journal* 90: 1868-1880.