Social determinants of obesity: How parents shape the eating behavior and body weight of their children

Dissertation

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Acknowledgements

Abstract

Parents are key players in the development of children's eating habits. As nutritional gatekeepers, they plan and prepare the food and design their children's eating environment. Despite this crucial role, most research on parental influences has concentrated on feeding practices and thus has overlooked the role of many other potent parental influences. The research reported herein was undertaken to advance the current literature on social influences on obesity by identifying and specifying how parents as nutritional gatekeepers influence dietary intake and weight status in children. More specifically, three different types of parental influences were examined: (1) family meals, (2) health literacy skills of nutritional gatekeepers, and (3) the role of nutritional gatekeeping in food insecurity. Section 2 consists of two manuscripts and deals with quantitative and qualitative aspects of family meals. The first manuscript is a meta-analysis showing that the frequency of family meals is significantly associated with better diet quality and lower BMI in children. The second manuscript is a meta-analysis that identifies the following mealtime practices that are positively associated with children's nutritional health: TV off during meals, higher food quality, parental modeling, positive atmosphere, longer meal duration, and children's involvement in meal preparation. Section 3 consists of two manuscripts that deal with the role of parental health literacy skills in their children's body weight. The first study suggests that lower parental numeracy is a potential risk factor for underweight as well as overweight in children; the second study shows that parental sugar underestimation is associated with a higher risk of the child being overweight. Section 4 consists of one manuscript: In a commentary, we suggest that the missing link between food insecurity and obesity in children can be explained by nutritional gatekeeping buffering against the effect of nutrition poverty. Each section elaborates on implications for future research and practice that aim at targeting parents in early obesity prevention.

1 Introduction

The worldwide growing obesity rate is the public health challenge of our time. Since 1980, the prevalence of obesity has more than doubled and new data suggest a continuing increase in obesity in all Organisation for Economic Co-operation and Development (OECD) countries (OECD, 2017). Europe has the second highest prevalence of overweight and obesity, behind the Americas. The proportion of people with overweight (including obesity) in the European region ranges from 30% to 70%. In Germany overweight affects 64% of the people (World Health Organization [WHO], 2015). A high body mass index (BMI, i.e., weight [kg]/height [m^2]) is associated with an increased risk of many serious health conditions, including cardiovascular diseases, type 2 diabetes, cancer, hypertension, and back pain as well as reduced well-being and quality of life (Guh, 2009; Kolotkin, Crosby, & Williams, 2001; Kopelman, 2007; WHO, 2015).

This dissertation lays emphasis on obesity intervention at an early stage for the following reasons. First, the substantial proportion of children who are overweight or obese is of particular concern: One of three 11-year-old children in European Union countries is overweight or obese (WHO, 2017). Second, the consequences of overweight and obesity in children are already significant and include physiological consequences such as a higher risk of developing asthma and diabetes as well as psychological consequences such as disordered eating behavior, low self-esteem, and weight teasing (Serdula et al., 1993; Whitaker et al., 1997). Additionally, childhood obesity is a strong predictor of obesity and related diseases in adulthood: Over 60% of children who are overweight before puberty will become overweight in adulthood (WHO, 2017). Third, obesity, once developed, is difficult to treat. Even after successful weight loss most individuals regain their weight after at least one year (Curioni & Lourenco, 2005). It has been estimated that

the chance of an overweight man attaining normal weight within one year is less than 0.5% (Fildes et al., 2015). Thus, the most effective treatment of obesity is its prevention. Fourth, childhood is a unique window of opportunity in which to counteract the formation of habits that are detrimental to health. Experiences in the first years of life shape the entire course of a person's life. Children who are healthy during their first years of life are more likely to become healthy adults (Rossin-Slater, 2015). This applies particularly to dietary behavior: It is well established from a variety of studies that food habits and preferences are acquired early in life and track into adulthood (Anzman, Rollins, & Birch, 2010).

An enormous amount of research has been done to thwart the global obesity epidemic—with limited success. The great challenge is that there is no single factor that can prevent obesity. Rather, body weight is the result of a complex interplay of individual and environmental factors. Biologically, overweight is the result of energy imbalance. More specifically, individuals gain weight when they consume more calories than they use. This homeostatic process is influenced by genetic predisposition (e.g., via metabolic rate and appetite regulation) and by two key behavioral determinants: physical activity and eating behavior (Hill, Wyatt, & Peters, 2012). These processes are in turn influenced by several intraindividual variables (e.g., self-efficacy and motivation) and environmental influences such as the physical environment (e.g., bike lanes, or density of fast food restaurants), policy regulations (e.g., taxation of foods high in sugar), or the social environment (e.g., social norms, role modeling or peer pressure).

Definition of diet quality, BMI, and nutritional health.

How and what people eat has a considerable influence on their risk of developing overweight. This dissertation focuses on both eating behavior and diet quality.[1] Eating behavior describes how a person eats. This includes behavioral aspects related to food intake, such as the eating rate (Ohkuma, Hirakawa, Nakamura, Kiyohara, & Ninomiya, 2015), emotional or stress-induced eating (Macht, 2008), and dietary practices (Cartwright et al., 2003), as well as contextual aspects, for example, with whom a person eats (Herman, Roth, & Polivy, 2003) and the occasion for a meal (Kerner, Chou, & Warmind, 2015). The term diet quality refers to what a person eats. Although notions of what constitutes a healthy diet have changed over time, currently the consensus is that a healthy diet should include a wide variety of fruits and vegetables, be high in complex carbohydrate foods such as bread, cereals, and potatoes, moderate in milk, dairy products, meat, and fish, and low in fatty and sugary foods (e.g., U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015; Deutsche Gesellschaft für Ernaehrung [German Nutrition Society], 2017). Fruits and vegetables are high in nutrients and low in energy and are associated with health benefits above and beyond those that are related to obesity (e.g., stroke: He, Nowson, & Mc Gregor, 2006; and heart disease: He, Nowson, Lucas, & MacGregor, 2007). Importantly, though, most children do not meet dietary recommendations. For instance, in a sample of nine European countries, only 23% of children met the WHO-recommended 400 g/day consumption of fruits and vegetables (Lynch et al., 2014).

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[1] Despite being another important predictor of obesity, physical activity lies beyond the scope of this dissertation and will not be discussed.

The BMI is the gold standard anthropometric measurement. BMI has been categorized into normal weight (18.5–24.9), overweight (25–29.5), and obesity (≥ 30). In children, BMI percentiles or BMI *z* scores are calculated based on growth charts of large reference populations (Neuhauser, Schienkiewitz, Schaffrath Rosario, Dortschy, & Kurth, 2013). The BMI is a simple measure, but it also has drawbacks. For instance, it does not distinguish between muscle and fat mass (Rothman, 2008). Still, BMI is most useful on a population level. On the individual level waist circumference, waist-to-hip ratio, and biometric impedance are more reliable measures of body fat and obesity-related health risks (Duren et al., 2008).

Nutritional health is an umbrella term for indicators of health related to nutrition. This can include disordered eating behavior (e.g., unhealthy dieting) and eating disorders (e.g., anorexia nervosa). However, the manuscripts included in this dissertation report on two nutritional health outcomes: diet quality and BMI. Thus, in this dissertation, the term nutritional health refers only to these two indicators. In what follows I briefly review theories and models aiming at predicting nutritional health at the individual and social level.

Individual-level predictors of health behavior

Traditionally, (health) psychological research on obesity and dietary behavior has focused on individual-level factors, such as beliefs, motivation, rational considerations of pros and cons, self-efficacy, and self-control (Sleddens et al., 2015). These factors have been studied intensively. Cognitive models of behavior change such as the Health Belief Model (HBM; Rosenstock, 1966), the Theory of Planned Behavior (TPB; Ajzen & Madden, 1986), and the Health Action Process Approach (HAPA; Schwarzer, 2008) integrate several individual-level factors to predict health behavior. A large majority of current obesity prevention and intervention

programs are based on these models. Likewise, individual factors, such as patients' motivation, self-regulation, and control strategies, are prioritized by current obesity treatment guidelines for general practitioners (e.g., evidence-based guidelines of the German Adiposity Society (Berg et al., 2014). Cognitive models are important in understanding how to improve health and have been shown to explain some amount of variance in dietary behavior (Sleddens et al., 2015). However, one weakness of these models is that they concentrate on variables within the individual level and largely ignore factors of the social environment. Some of the models include measures of perceived social norms or normative beliefs in an effort to address social influences, but these variables reflect the individual's cognition about the social environment, rather than factors that operate *within* a social context, such as role modeling or other interpersonal dynamics.

Social-level predictors of health behavior

The widespread conceptualization of eating as an individual food choice does not go far enough. Eating habits are not established in isolation but are closely linked to the social environment. This applies particularly to children who rarely make autonomous food choices. Most of the time children eat in a social context where family members, peers, teachers, or other caretakers shape their eating behavior and diet. It has been shown that social influences on eating such as role modeling, social norms, and social facilitation are profound and can override hunger, dietary status, and health goals (Cruwys, Bevelander, & Hermans, 2015; Prinsen, de Ridder, & de Vet, 2013). Thus, the social environment is an important agent in the food choices people make and a promising target for obesity prevention programs. Yet most health psychology research has put a strong emphasis on individual factors. As a consequence, most

obesity intervention programs still neglect social influences. Ignoring the role of the social environment has another important drawback: Obesity is often seen as a personal disorder, leading to stigmatization not only by the public but also among health care professionals (Phelan et al., 2015). Stigmatization negatively affects psychological well-being and educational achievement and is in turn a risk factor for further weight gain (Puhl & Brownell, 2001). There is now growing recognition by public health organizations of the environment's role in individuals' dietary decisions. In 2014, the WHO declared obesity a "predominantly social and environmental disease" (WHO, 2014), and since then several conceptual frameworks of social influences on health have been developed. Berkman, Glass, Brissette, and Seeman (2000) developed a conceptual framework of how social networks influence health. They assumed a cascading causal process between different levels of social influence, including social structural factors (e.g., cultural norms, policy regulations), characteristics of the social network (e.g., density and intimacy), psychosocial mechanisms (e.g., social support), and different intraindividual pathways (e.g. self-efficacy or eating), that impact health. Another class of social-level frameworks have received increasing attention: ecological models. The central proposition of these models is that it takes the combination of *both* individual-level factors and environmental-level factors to achieve long-term behavior change (Glanz, Rimer, & Viswanath, 2008). Ecological models are behavior specific and incorporate various levels of influence, similar to the model of Berkman and colleagues. Figure 1a illustrates an ecological model of childhood obesity. This model distinguishes between three levels of influence: the individual level (child characteristics), the microsocial environment (family and parenting characteristics), and the macrosocial environment (community and societal characteristics).

Influences of the macrosocial environment

How has the whole population become overweight so quickly? The rapid increase in obesity rates can be observed worldwide, across different socioeconomic groups, and is linked to urbanization in developed countries (James, 2008). It is thus reasonable to presume that the modern, obesity-promoting food environment represents a major drive behind the rise in obesity. Research, mostly from the public health area, has begun to focus on environmental influences. Particularly the affordability and accessibility of energy-dense and unhealthy food has been studied intensively. For example, it has been shown that the number of fast food outlets predicts the obesity prevalence in a particular area (Burgoine, Forouhi, Griffin, Wareham, & Monsivais, 2014). Also, low social capital, defined as low trust, reciprocity, and cooperation among members of a social network, has been associated with a higher risk of obesity (Holtgrave & Crosby, 2006). Social capital may influence obesity via improved information exchange between members of a social network, greater access to health services, and a greater sense of security and belonging (Kawachi, Kennedy, Lochner, & Prothrow-Stith, 1997).

Influences of the microsocial environment

Dietary behavior is also strongly influenced by the close social network. For children, the family represents the core social environment. Findings suggest that interventions in existing social groups such as families are more efficient than focusing on children alone (Golan & Crow, 2004). About two-thirds of children's daily calories stem from food prepared at home (Poti & Popkin, 2011). Parents are important agents in this microcosmos. From the moment of birth, children learn to associate food intake with the presence of their parents. Bottle- or breastfeeding is part of a social interaction necessary for parent–child bonding and the healthy development of

the child (Jansen, de Weerth, & Riksen-Walraven, 2008). Parents, grandparents, and other primary caretakers (henceforth parents) are their children's nutritional gatekeepers (Wansink, 2006). They purchase, plan, and prepare the food for their children and create environments that may either promote healthy eating and body weight or foster unhealthy eating and overweight (Savage, Fisher, & Birch, 2007). All this highlights that a focus on parental influences is essential for successful early obesity prevention.

It is surprising that parents' role as nutritional gatekeepers is still often overlooked. Most research on parental influences on eating and BMI has concentrated on feeding practices. Feeding practices are strategies parents use to promote or discourage eating in children (Birch et al., 2001). The Child Feeding Questionnaire (Birch et al., 2001) is the gold-standard measurement of feeding practices. It distinguishes between restrictive feeding (e.g. keeping sweets out of the child's reach), pressure to eat (e.g. child must eat all the food on the plate) as well as monitoring child's food intake (e.g. keep track of the high-fat foods the child eats). Importantly though, parental influences can come in several ways. Parents not only determine what children eat but also make choices about key determinants of children's eating experiences. They directly and indirectly influence how, with whom, when, and where children eat, which in turn has an important impact on children's nutritional health. Parents serve as role models (Hebestreit et al., 2017); they design the child's meal environment (Hammons & Fiese, 2001) and determine the accessibility of healthy foods at home (Vereecken, Haerens, De Bourdeaudhuij, & Maes, 2010). Systematic research on these influences is largely missing. Similarly, little is known about the role of parents' health-related cognitive skills for their children's weight status. Basic cognitive skills such as numeracy as well as specific health literacy skills such as food label comprehension or sugar estimation skills influence parents' food

choices, which in turn affect their children's food environment. These skills, often referred to as health literacy skills, have been frequently investigated in the adult context. However, their role in children's health has been largely overlooked.

Unlike individual-level models such as the Health Belief Model or the Health Action Process Approach, there is no integrative social-level model for health behavior. The value of ecological models lies in the recognition of individual behavior being embedded in a social context. However, the weakness of such multilevel frameworks is that they do not specify the variables or underlying processes and thus do not make clear and testable assumptions.

Goal and organization of this dissertation

This dissertation is intended to advance the current literature on social influences on obesity by identifying and specifying how parents as nutritional gatekeepers influence dietary intake and weight status in children (see Figure 1b). Three themed sections deal with three different kinds of parental influences. In Section 2, the role of a powerful learning environment—namely, family meals—is illuminated. This part consists of two manuscripts. Manuscript 1 is a meta-analysis examining the association between the *quantity* of family meals and children's risk for overweight and diet quality (i.e., nutritional health). Manuscript 2, also a meta-analysis, investigates *qualitative* aspects of family meals, that is, family mealtime practices and their associations with nutritional health. Section 3 explores how the health literacy skills of nutritional gatekeepers are crucial for dietary decision making and their role in children's weight status. The first study (Manuscript 3) investigates numerical abilities of nutritional gatekeepers and the second study (Manuscript 4) examines sugar estimation skills. Section 4 includes a

commentary (Manuscript 5) on how nutritional gatekeeping can protect against food insecurity and the associated risk of developing obesity.
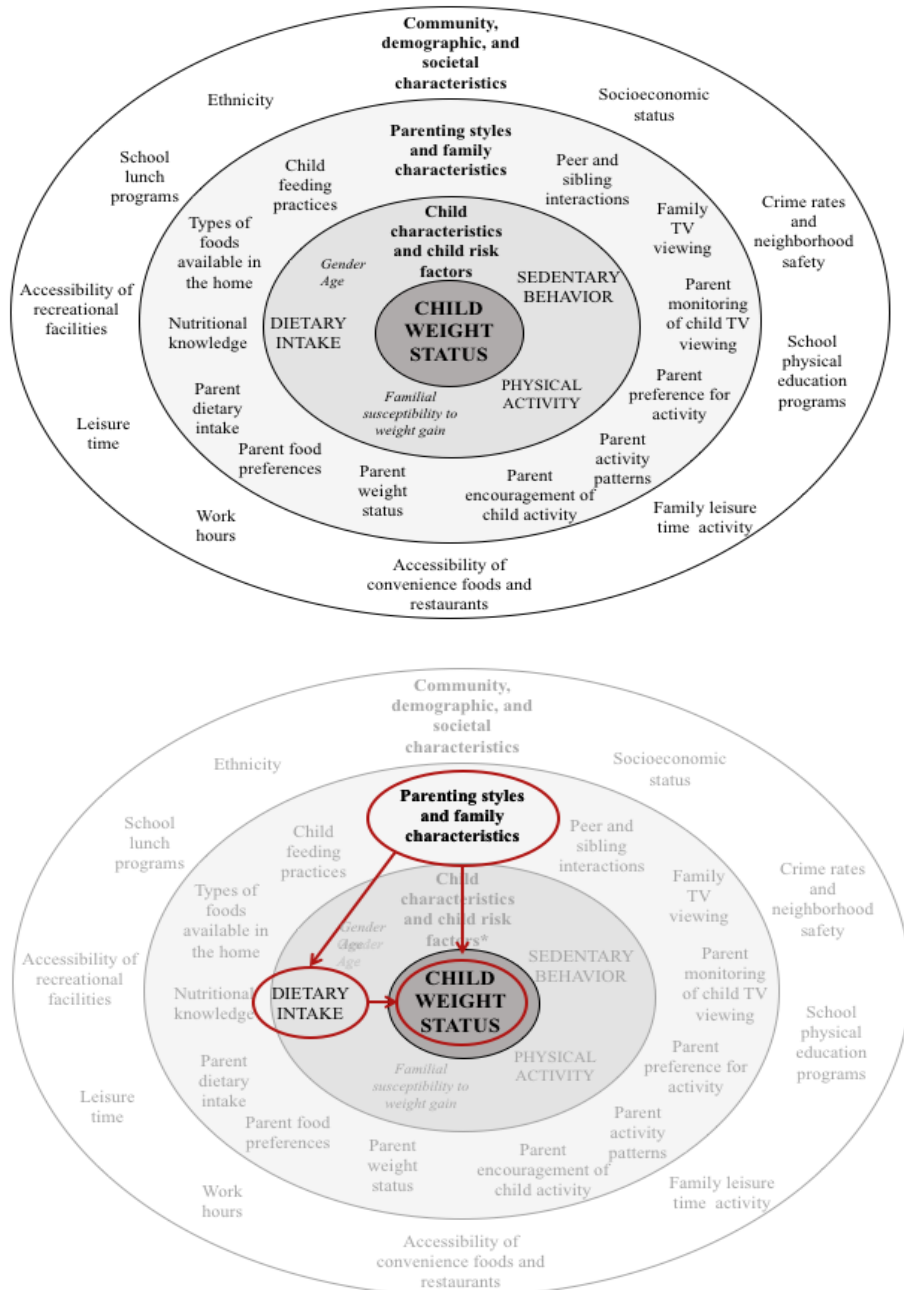
Figure 1. (a) Ecological model of childhood obesity adapted from Davison and Birch (2001). (b) Highlighting variables and respective relationships investigated in this dissertation.

2 Family meals and children's nutritional health

Family meals can be called the *cradle of eating behavior*. By the age of 10 years, a child has already eaten around 10,000 meals—and many of them in the family context. Family meals provide a powerful learning environment: During shared meals, parents have the opportunity to influence the amount and type of food eaten by the children, model healthy eating behavior, and educate children about food preparation and nutrition.

Over the last decade, there has been growing interest in and scientific attention directed toward family meals. A literature search in Web of Science revealed a strongly increasing number of publication on family meals. Between 1970 and 1995 the average number of publications was 5–7 per year; between 2010 and 2015, that number rose to about 45 per year (see Figure 2).

Figure 2. Number of publications on family meals in Web of Science between 1970 and 2015.

Family meals are changing as family structures, modern technologies, and eating habits change. Eating take-out and prepared food is an increasing trend, as are the increase in number of dual-earner families and children's extracurricular activities (Adams et al., 2015; Breaugh & Frye, 2008; Smith, Ng, & Popkin, 2013). Therefore, it i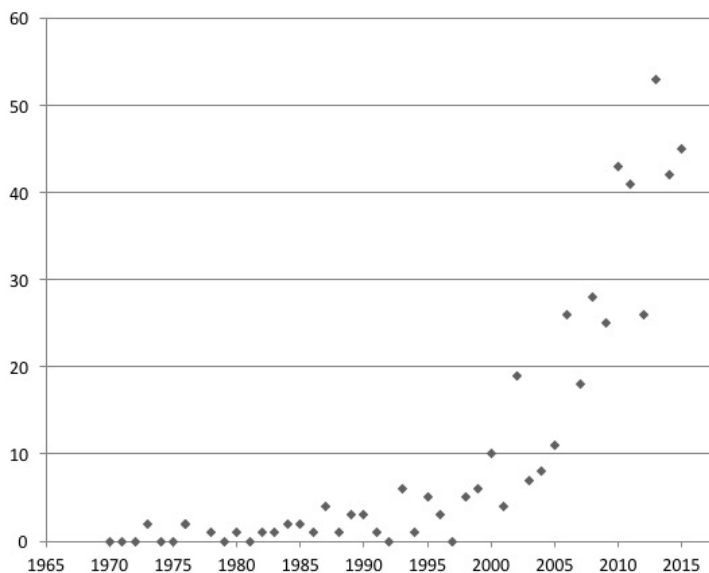s often proclaimed that family meals are disappearing. For example, in an essay published in the *New York Times* the author noted that modern Americans "eat breakfast in their cars, lunch at their desks and chicken from a bucket" (Scrivani, 2005). Yet evidence about the decline of family meals over time is mixed. For example, data suggest that the number of family meals in the United States remained relatively stable between 1999 and 2011 (National Center for Addiction and Substance Use [CASA], 2011). Another study found a decline in family meals in families of low socioeconomic status (SES), but an increase in families of high SES (Neumark-Sztainer, Wall, Fulkerson, & Larson, 2013). Today's families still regularly gather around the table to share a meal. For example, 58% of U.S. adolescents have on average five family dinners per week (CASA, 2011).

To sum up, family meals provide an opportunity for parents to promote children's healthy eating habits. Despite changes in dietary patterns and family structure, for most families shared meals are still an important part of their daily routine, making family meals an ideal entry point for early obesity prevention. It is important to understand whether and how family meals impact children's diet quality and body weight.

2.1 Manuscript 1

Dallacker, M., Hertwig, R., & Mata, J. (2017). *Family meals and nutritional health in children across different ages and countries: A meta-analysis.* Manuscript submitted for publication.

This manuscript is a meta-analysis investigating the relationship between the frequency of family meals and children's nutritional health. What is known about the nutritional health benefits of family meals, and how strong are the effects? Research on the relationship between family meal frequency (henceforth meal frequency) and nutritional health have revealed mixed findings. Some studies analyzing BMI as outcome found a significant relationship with meal frequency (Fulkerson, Neumark-Sztainer, Hannan, & Story, 2008), whereas others did not (Lee et al., 2014). The results with regard to diet quality (e.g., fruit, vegetable, and soft drink consumption) are less contradictory but still differ in effect sizes (e.g., Fink, Racine, Mueffelmann, Dean, & Herman-Smith, 2014; Lillico, Hammond, Manske, & Murnaghan, 2014; Videon & Manning, 2003) and a few studies even failed to find a significant effect (e.g., Sweetman, McGowan, Croker, & Cooke, 2011). What can explain the variation in effect sizes?

Studies on family meals have differed with regard to the demographic characteristics of the target population and the way they operationalized family meals. One example is SES. Families with lower SES tend to have fewer shared meals (Neumark-Sztainer et al., 2013). Thus, it could well be that differences in the health effects of family meals can be traced at least partly to socioeconomic differences. Accordingly, effect sizes in family meal studies may depend on whether the study controlled for SES. Other demographic variables potentially causing differences in effect sizes are the country where the study was conducted and the age of the child. Additionally, studies have differed with respect to who must be present at the table for the

meal to count as a family meal, ranging from "at least one parent" to "the whole family." Further, variability exists regarding the investigated meal type with most studies investigating dinners or just "meals" and others investigating breakfast and lunch. Differences in how family meals are defined and operationalized may account for differences in effect sizes.

In 2011, Hammons and Fiese conducted an early meta-analysis of 17 studies on meal frequency and children's nutritional health. They found that regular family meals were significantly associated with lower risk of overweight and better diet quality in children. Because of the small number of studies, Hammons and Fiese were not able to investigate whether sociodemographic and methodological differences impact the relationship between meal frequency and nutritional health. Taking advantage of the recent increase in studies on family meals, my colleagues and I conducted a meta-analysis to fill this gap. The goal was to identify and quantify nutritional health benefits of family meals. First, we analyzed the relationship between meal frequency and children's BMI, healthy diet, and unhealthy diet as well as overall diet quality. Second, we investigated if positive health outcomes are moderated by (1) age of the target population (children vs. adolescents); (2) the country where the study was conducted (United States, Australia/New Zealand, and countries in South America, Europe, and Asia); (3) whether studies controlled for SES; (4) meal type (breakfast, lunch, dinner, unspecified meal); (5) the definition of family meals with regard to who must be present at the table (at least one parent, some family member, whole family, unspecified family).

The systematic literature search and screening process identified 57 studies eligible for the meta-analysis. In separate meta-analyses, we found a significant association between meal frequency and children's BMI ($r = -.05$), overall diet quality ($r = .13$), healthy diet ($r = .10$), and unhealthy diet ($r = -.04$). The relationships between meal frequency and nutritional health

outcomes were not moderated by age, country of origin, number of family members present at the table, or meal type. Controlling for SES was a significant moderator in studies investigating BMI as outcome (value of the *QM* test of moderators = 4.3, $p < .05$). More specifically, studies that controlled for SES revealed smaller effect sizes ($r = -.03$) compared to studies that did not control for SES ($r = -.06$). Notably, the overall effect size of studies controlling for SES was still significant.

The findings suggest that family meals may have the potential to positively influence children's diet quality and protect against overweight. What can explain this finding? The nutritional explanation would be that family meals consist of more home-cooked, fresh, and healthier foods relative to meals eaten alone. Or it could be that social-level factors, such as role modeling, emotional support, and information exchange, explain the beneficial role of family meals, because they operate only when the child eats in company. The results indicate that the beneficial health outcomes applied across different countries, for younger and older children, for breakfast as well as dinner, and for meals together with the whole family as well as with one parent, and they did not substantially differ across different socioeconomic groups.

Notably, the effect sizes were small, indicating that the mere frequency of family meals may have only a limited effect on children's nutritional health. This raises the question: What is it about family meals that makes them protective for children? What are mealtime practices that foster healthy eating in children? We aimed to answer these questions with a second systematic review and meta-analysis.

2.2 Manuscript 2

Dallacker, M., Hertwig, R., & Mata, J. (2017). *More than just food: A meta-analysis of family mealtime practices and children's nutritional health.* Manuscript submitted for publication.

This manuscript is a meta-analysis of family mealtime practices and children's nutritional health. After the results of the first meta-analysis showed a relationship between the quantity of family meals and better nutritional health in children, my colleagues and I sought to answer the question of what qualitative aspects of family meals make them healthy. There is considerable research on how eating in the company of others can influence food consumption. In their review, Herman and colleagues (2003) identified social facilitation, social modeling, and impression management as mechanisms that could explain how the presence others impacts eating behavior. The authors proposed that people restrict their food intake when they believe that others are evaluating or observing them and tend to eat more when eating in large groups. Some of these mechanisms may also operate in the family context. For example, in laboratory studies, it has been shown that children eat less unhealthy food when they are told that they are being observed by their mother (Klesges, Stein, Eck, Isbell, & Klesges, 1991). However, most of the studies on social influences on eating were conducted in laboratory settings where adults, mostly strangers, ate together. Family relationships and in particular parent–child relationships are characterized by emotional connectedness and power asymmetry (Kuczynski, 2003). Therefore, it is likely that other mechanisms operate within the family meal context, alone or in addition. There has been no systematic research on how eating together with the family shapes eating behavior. This systematic review and meta-analysis had three goals: first, to identify protective family mealtime practices, that is, social, environmental, and behavioral attributes of

family meals, with the potential to shape children's eating behavior; second, to quantify the strength of the association between each identified family mealtime practice and nutritional health in children; and third, to investigate age of the children as well as SES as potential moderators.

With a systematic literature search, we identified six frequently investigated mealtime practices from 43 studies: watching television during shared meals, the quality of the food served at meals, the mealtime atmosphere, parental role modeling during meals, the involvement of children in meal preparation, and the meal duration. The strength of the association between each mealtime practice and nutritional health in children and adolescents was analyzed by separate meta-analyses. Results revealed a positive association between nutritional health and: turning the TV off during meals ($r = .08$), higher food quality ($r = .11$), parental modeling ($r = .11$), positive mealtime atmosphere ($r = .12$), and longer meal duration ($r = .20$). Children's involvement in meal preparation was significantly associated with better diet quality ($r = .08$) but not with BMI ($r = -.06$). On a descriptive level, effect sizes for children were higher compared to adolescents. However, the effect of the moderator was not significant. Likewise, SES did not moderate the associations between the mealtime practices and nutritional health.

The findings shed light on what makes family meals healthy for children. The effect sizes are small, but larger compared to the effect sizes of the meta-analysis on meal frequency. This indicates that the quality of family meals may be more important than the mere quantity. It is important to bear in mind that the meta-analysis was based on observational studies, precluding firm causal conclusions. Importantly though, well-investigated mechanisms in the context of eating behavior could explain how the different practices promote healthy eating. For example, one identified mealtime practice is turning the TV off. Experimental studies demonstrated that

participants who were distracted by the TV consumed more food compared to a control group (Bellisle, Dalix, & Slama, 2004). The mere-exposure effect potentially explains why serving healthy foods at family meals can improve nutritional health. The repeated experience of eating (for example) new vegetables has been found to increase liking and acceptance of these foods (Birch, 1989). The effect of a positive mealtime atmosphere can be explained by a reduced likelihood of emotional eating. Emotional or stress-induced eating is the increased intake of (energy-dense, unhealthy) food in order to compensate for negative feelings (Singh, 2014). Social learning can explain the effect of the involvement of the child in meal preparation. By extending their behavioral repertoire and nutritional knowledge, children can experience self-agency and a greater sense of self-efficacy (Chu et al., 2013). The positive effects of the involvement of children in meal preparation can also be explained by the IKEA effect, which proposes that people value objects more when they have created them themselves (Dohle, Rail, & Siegrist, 2014). Helping to prepare, for example, vegetables could thus increase liking and intake of these foods (Van der Horst, Ferrage, & Rytz, 2014). We also found that a longer meal duration was related to better nutritional health. One explanation is that longer meals indicate slower eating rates. Eating at a slower rate may lead to fewer calories consumed before satiety starts (Berkowitz et al., 2010). Further, experimental studies demonstrated greater intermeal satiety and less (unhealthy) snacking between meals when participants ate at a slower rate (Andrade, Kresge, Teixeira, Baptista, & Melanson, 2012).

2.3 Interim summary: Practical implications and future research

In two meta-analyses, we explored the beneficial role of family meals for children's nutritional health. The first meta-analysis showed that regular family meals may improve overall

diet quality, support the consumption of healthy foods, decrease the consumption of unhealthy foods, and reduce the risk of developing overweight. The positive effect of family meals applied across different countries and socioeconomic groups, for children and adolescents alike, for breakfast and dinner and in meals with only one parent as well as the whole family. The effect sizes were small, suggesting that the quantity of family meals alone may have had only a limited effect on the children's diet quality and weight status. In a second meta-analysis, we investigated qualitative aspects of family meals. This was the first study to systematically summarize and quantify family mealtime practices and their effects on children's nutritional health. We identified the following potentially protective mealtime practices: turning the TV off, higher food quality, parental modeling, positive mealtime atmosphere, involvement of children in meal preparation, and longer meal duration.

Practical implications

The home environment is an important agent in the formation of healthy eating habits in children. Our results suggest that family meals may be a promising entry point for early obesity prevention. To date, several obesity interventions exist that have advocated the promotion of family meals (e.g., DeBar et al., 2012; Haines et al., 2013) but they do not integrate family mealtime practices into the intervention. One exception is the randomized control intervention by Fulkerson and colleagues (2015), in which parents are educated about how they should eat together with their children. Despite early promising results, such as the reduction of weight gain in the intervention group, the multicomponent intervention program precludes drawing conclusion about the effectiveness of single mealtime practices.

If the results of our meta-analyses are confirmed by randomized control trials, the six evidence-based family mealtime practices should be systematically communicated to parents. There are several reasons why such an intervention would be a promising approach. First, most people are not aware of social influences on eating behavior. When asked about the reasons for their eating behavior, they list hunger, satiety, or palatability of food, but rarely the behavior of other people (Roth, Herman, Polivy, & Pliner, 2001). Second, the evidence-based mealtime practices are nonintrusive, low in cost, simple, easily communicated, and can become part of the family's routines. Third, it is widely accepted that families should eat together more often. Our findings suggest that the mere frequency alone is not as important as the quality of family meals and provide more detail on how families should eat together. Additionally, they indicate some flexibility in when (breakfast or dinner) and with whom (one or both parents) the meal could take place. This could relieve pressure on dual-earner families or single parents, who often lack time and resources to have a proper dinner together with the whole family on a daily basis.

A communication campaign alone may not be enough to change family eating habits. For long-term behavior change it is important to also provide the necessary resources (Johnson et al., 2010). Other environmental or behavioral interventions, such as cooking classes and improving the availability of healthy foods, are likely to enhance the success of a family meal intervention particularly in low SES areas (Dwyer, Oh, Patrick, & Hennessy, 2015).

Future research

It is time to start providing evidence for causal pathways. To the best of my knowledge, only one study so far has experimentally manipulated a family mealtime practice. Fiese, Jones, and Jarick (2015) introduced a distracting noise while families ate together and found that in the

distraction group, children ate more unhealthy foods and parents engaged in more negative communication patterns relative to a control group. More research is needed to systematically investigate family mealtime practices in randomized control trials and appropriately designed longitudinal studies. This would shed light on potential mechanisms underlying mealtime practices. As pointed out earlier, family meals are in flux. There is an increasing trend of working mothers, but still, around 90% of nutritional gatekeepers are mothers (Statistisches Bundesamt, 2013). Having regular family meals that follow the six mealtime practices is a challenge, particularly for single parents and dual-earner families. It is not our intention to send women back to the kitchen. Rather, our results suggest another fruitful area of future research: Mealtime practices in other contexts. Early promising results suggest that similar mealtime practices may operate in the school context. One study showed that teachers role modeling the consumption of healthy foods increased the probability of children eating that food (Hendy & Raudenbush, 2000). Several innovative projects exist, such as community kitchens where families share meal-preparation responsibilities, school lunches in small groups of students and teacher, or companies offering a children's menu in order to support family meals in workplace cafeterias. Further work is required to evaluate these programs; however, they suggest creative ways of promoting social meals and healthy eating habits in children.

3 The role of parents' health literacy skills in their children's BMI

Broad cognitive skills such as reading and math skills, and specific health-related skills such as nutrition label comprehension have an impact on the ability to use and understand health related information (Yin et al., 2009). These skills can be summarized under the term health literacy. Although these skills have been frequently investigated in the context of adults, what role parents' health literacy plays in their children's health and body weight has been largely overlooked. The role of parents' health literacy skills in their children's weight status is addressed in this part.

There are several definitions of health literacy. One recent definition described health literacy as "knowledge, motivation and competencies to access, understand, appraise, and apply health information in order to make judgments and make decisions in everyday life concerning healthcare, disease prevention and health promotion, to maintain or improve quality of life during the life course" (Sorensen et al., 2012). It is important to consider that health literacy is not a single variable but an umbrella term for a large set of skills. These include *basic cognitive skills*, such as reading ability and numeracy, and *specific health-related skills*, such as diabetes-related numeracy (Huizinga, Niswender, et al., 2008) or nutrition label literacy (Patel et al., 2011). There is a well-established link between low health literacy and poorer health, including diabetes, unhealthy dietary patterns, and obesity (e.g., Sudore et al., 2006; Wolf, Gazmararian, & Baker, 2005; Zoellner et al., 2011), even after adjustment for sociodemographic variables (Dewalt, Berkman, Sheridan, Lohr, & Pignone, 2004). Several studies suggested that people with low literacy may have impaired abilities to read prescriptions, navigate through the health system, and understand medical instructions and health information, as well as less disease-specific knowledge, which in turn leads to a higher risk of developing overweight (Dewalt et al.,

2004). For example, low health literacy has been associated with impaired nutrition label comprehension (Diamond, 2007; Rothman et al., 2006), trust in nutrition information sources (Zoellner, Connell, Bounds, Crook, & Yadrick, 2009), and dietary self-management (e.g., glycemic control; Cavanaugh et al., 2009). Moreover, research has demonstrated that motivational as well as volitional processes are likely to be influenced by literacy skills (Lipkus & Peters, 2009; von Wagner et al., 2009). For example, in patients with diabetes, a relationship was found between low numerical abilities and lower perceived self-efficacy, and fewer self-management behaviors. Similarly, Guntzviller, King, Jensen, and Davis (2017) found that reading comprehension and numeracy moderated the association between self-efficacy and healthy eating. Most of the research in this area has concentrated on adults. If adults with low literacy have difficulties managing their own health, it is likely that parents with low literacy also have difficulties managing their children's health. Only a few studies have examined the role of parental health literacy skills in children's dietary behavior and risk for overweight (DeWalt & Hink, 2009). For instance, one study showed that high numerical abilities in parents predicted better diabetes outcomes in children (Pulgaron et al., 2014). Another study demonstrated a link between low nutritional literacy in adults and obesity in children (Chari, Warsh, Ketterer, Hossain, & Sharif, 2014).

The following two studies fill a gap in the literature by investigating the role of parents' health literacy skills in their children's body weight. The first study investigated the role of a broader health literacy skill—parental numeracy. The second study investigated a specific health literacy skill, namely, the ability to estimate the amount of sugar in foods and beverages.

3.1 Manuscript 3

Numeracy is one component of health literacy and is defined as the ability to use and comprehend numbers in daily life. Numerical abilities in adults have been shown to be associated with impaired food label comprehension (Rothman et al., 2006), reduced portion size estimation skills (Huizinga et al., 2009) and a higher BMI (Huizinga, Beech, Cavanaugh, Elasy, & Rothman, 2008). It remains largely unexplored how numerical abilities of one person affect the body weight of another person from his or her close social network. This study investigated two subjects that have not been investigated in previous research: First, we explored whether parental numeracy is associated with children's weight status. Malnutrition can lead to both, over- and underweight. Thus, we hypothesized that lower parental numeracy would be associated with under- and overweight in children. Second, we examined potential mechanisms underlying the link between numeracy and BMI. More specifically, we investigated weight-related information processes that depend on numerical abilities. These are the comprehension of nutrition labels (necessary for judging the healthiness of food; Temple & Fraser, 2014), portion size estimation skills (important for following dietary recommendations; Pourshahidi, Kerr, McCaffrey, & Livingstone, 2014) and growth chart comprehension. Growth charts display the weight and height status of the child and are used by pediatricians to explain to parents if their child's BMI lies within the normal range. We hypothesized that weight-related numerical

information-processing skills (i.e., nutrition label comprehension, portion size estimation skills, and comprehension of growth charts) would mediate the link between numeracy and BMI.

To address these questions, we conducted a cross-sectional survey including 320 parent–child pairs. Numeracy and the weight-related information-processing skills of the family's nutritional gatekeeper were examined with computer-based tasks. Body weight of both the parent and the child was measured; height was self-reported.

The results showed that, adjusted for education, low numeracy was significantly associated with a higher ($\beta = -.299, p < .001$) as well as a lower ($\beta = -.126, p = .048$) BMI in children. Lower parental numeracy was also significantly associated with poorer nutrition label comprehension ($\beta = .26, p < .001$), poorer portion-size estimation skills ($\beta = -.08, p = .023$), and inferior growth-chart comprehension ($\beta = .33, p < .001$). However, these weight-related information processes did not mediate the relationship between numeracy and BMI.

This study is the first to show that low parental numeracy skills are a potential risk factor for under- and overweight in children. Further, our findings suggest that numerical abilities are important for certain weight-related information processes, such as portion-size estimation and comprehension of food labels and growth charts. According to our results these skills alone cannot account for the association between numeracy and BMI. One potential explanation is that not one or a few but several cognitive and behavioral skills together account for the numeracy–BMI link. Additional underlying mechanism may include the perception of obesity-related risks, keeping track of the child's eating- and activity-related behaviors (e.g., counting TV hours and calories), and a lower susceptibility to nonnumerical information such as taste and images on food packages (Peters, 2012).

3.2 Manuscript 4

Dallacker, M., Hertwig, R., & Mata, J. (2017). *Parents' considerable underestimation of sugar and their child's risk of overweight.* Manuscript submitted for publication.

In Manuscript 3, we investigated numeracy—a general cognitive ability that can influence children's BMI in several ways. In this study, we investigated a specific health literacy skill, namely, parent's ability to estimate the amount of sugar in foods and beverages.

High sugar intake has been suggested as one contributor to the current obesity epidemic. Therefore, the WHO recommends that the average consumption of free sugar should not exceed 10% of the daily energy intake. For an average adult, this is equal to approximately 16 sugar cubes (53 grams). In fact, in the United States as in many other countries, the consumption of added sugar lies above this threshold. Children in European countries consume around twice as much sugar as recommended (Svensson et al., 2014). Consequently, many countries are currently working on policy interventions aiming at reducing sugar consumption. These include laws to regulate the advertisement of sugary food (Tripicchio et al., 2016), banning the sale of sodas in schools (Terry-McElrath, O'Malley, & Johnston, 2012), and taxing sugar-sweetened beverages (Wise, 2016). Another promising approach is to boost parent's food-related decision competencies. Adequate nutritional knowledge is often seen as a prerequisite for making healthy dietary decisions (Gase, Robles, Barragan, & Kuo, 2014). For example, providing caloric information on sugar-sweetened beverages has been shown to lead to attitude change concerning these beverages (Jordan, Piotrowski, Bleakley, & Mallya, 2012) and reduced purchases (Bleich, Herring, Flagg, & Gary-Webb, 2012). It is likely that knowledge of the sugar content will influence the attitude and consuming behavior of parents in a similar way. In that context, it is

important to better understand how much parents intuitively know about the sugar content in common foods and beverages. We conducted a survey to examine to what extent parents under- and overestimate sugar. Further, we tested the hypothesis that parents' sugar underestimation is significantly associated with a higher risk of overweight in children. We included 305 parent–child pairs in our study. To be included in the study, the parent had to be the family's nutritional gatekeeper. On a computer-based task they were asked to estimate the sugar content (expressed in sugar cubes) of the following six foods and beverages: one glass of orange juice, one glass of Coca-Cola, one yogurt, one granola bar, one frozen pizza, one single-serving package of ketchup. Afterward, body weight and height of the child and the parent were measured. Results revealed that most parents underestimated the sugar content of most foods and beverages. For instance, more than 80% of parents underestimated the sugar content of orange juice and yogurt by on average 7 sugar cubes. More than half of the parents underestimated the amount of sugar in pizza and Coca-Cola and 25–30% of the parents underestimated the sugar in ketchup and the granola bar. After adjustment for parental BMI and education, sugar underestimation was significantly associated with a two-fold increased risk of the child being overweight or obese (odds ratio = 2.01, 95% confidence interval [1.04, 3.91], p = .039). Additionally, we found a small dose–response relationship between the degree of underestimation and children's z-BMI (β = −.110; p = .026).

This is the first study to show that parents tend to underestimate the sugar content of common foods and beverages, in particular those wearing a "health halo" (i.e., yogurt and orange juice). Further, our result suggest that sugar underestimation is a potential risk factor for overweight in children—above and beyond the effect of education. One explanation for this association is that parents who underestimate the sugar content may (unknowingly) give their

children more foods and beverages high in sugar, even if they aim to reduce the sugar intake in their children.

3.3 Interim summary: Practical implications and future research

In contrast to the two manuscripts on family meals, studies included in this section dealt with less obvious, indirect ways parents shape the body weight of their children. I summarized two studies, each examining a component of parents' health literacy and its association with body weight in children. Both studies provide new insights into how nutritional gatekeepers may influence children's risk for overweight. The first study showed that numerical abilities of parents are significantly associated with over- and underweight in children. The second study showed that sugar underestimation is significantly related to a higher risk of the child being overweight. Both relationship exists above and beyond the effect of education.

Practical implications

The prevalence of individuals with low health literacy skills is very high. In Europe, it is estimated that almost one in two adults has insufficient or problematic health literacy skills (Sorensen et al., 2015). Thus, health literacy has received increasing attention on the health agendas of many countries. Many interventions have been developed, implemented, and evaluated. Several studies have shown that relatively simple strategies can improve the comprehension of health-relevant information. These strategies include giving numerical information in tables instead of text, adding icons to numerical information, adding video material to verbal narratives, using color-coded numerical information, and presenting risks in absolute instead of relative values (see Sheridan et al., 2011, for a systematic review).

Importantly, these interventions target the environment instead of the individual and have shown to improve decision making not only in people with low health literacy, but also in people with high literacy (Sheridan et al., 2011).

In contrast to the practical implications suggested in the context of family meals, implications derived from this section put emphasis on changes in the environment. The first study implies that parents with limited numerical skills have more problems interpreting food labels, understanding growth charts, and estimating portion sizes. Easily understandable and transparent information may help low-numeracy parents follow dietary recommendations and make healthy dietary decisions for their children. For example, color-coded graphs may help parents interpret growth charts (e.g., green = normal range, orange = pre-overweight/underweight; red = overweight/underweight). Simple tools such as cups indicating appropriate portion sizes of, for example, juice per day could be one way to overcome difficulties in portion-size estimation (Huizinga, Pont et al., 2008). Also, transparent and easy-to-comprehend information on food packages may help low-numeracy parents grasp the nutritional value of food products.

In a second study, we showed that most parents underestimate the amount of sugar, particularly in products that are generally perceived as healthy. How can nutritional gatekeepers be empowered? Several studies suggest that a large majority of consumers (a) do not use nutrition labels and (b) have difficulties interpreting them (Roberto et al., 2012; Soederberg Miller & Cassady, 2015; Sonnenberg et al., 2013). Even if parents are aware of the daily recommended amount of sugar for children and even if they are motivated to reduce their child's sugar consumption, they still need to have an intuitive knowledge about how much sugar different foods contain. Nutrition labels that make the sugar content more prominent could be

one way to overcome sugar misestimation. For example, a traffic light system indicating that the level of sugar is high (red), medium (yellow), or low (green) has been shown to improve the identification of healthy foods and drinks. These labels seem to be particularly important in the real shopping environment where consumers are often under time pressure and supermarkets are packed with food products competing for their attention (see Hawley et al., 2013, for a systematic review).

The comprehension of health-related information can be seen as an important prerequisite for behavior change. Of course, knowledge alone is not enough to change behavior. The suggested interventions are not a stand-alone strategy but should be combined with other environmental or behavioral interventions. Tobacco control measures are a striking example. The rates of smokers were only significantly reduced after individual-level interventions were combined with changes in the environment, including warning labels, taxation, and regulations (Brownell & Warner, 2009).

Future research

The most important limitation of both studies is that they have a cross-sectional design. Intervention studies using a randomized control and prospective longitudinal designs are needed to shed light on the causal mechanisms underlying the identified links between parental health literacy and children's BMI. Intervention studies with low-numeracy parents could examine whether implementation of the above-discussed tools leads to healthier food choices and positive changes in the home food environment. Additionally, it would be interesting to assess the effects of more salient sugar labeling on parents' food and beverage decisions. Another research question that could be asked is whether improved sugar knowledge would lead to changes in

parents' control of their own and their child's sugar intake. For example, educating parents about the sugar content of yogurt may lead to changes in their own eating habits as well as in restrictions of their child's yogurt intake. Another area of future research is the extent to which numerical skills influence other behavioral determinants of obesity, such as physical activity and sedentary behavior of the child. In addition to nutritional recommendations, parents must understand and keep track of activity recommendations including how many hours per day children should watch TV, play video games, use their smartphones, and be physically active. New technologies such as fitness trackers and smart phone apps offer new tools for interventions targeting parents with low as well as high health literacy skills.

4 Nutritional gatekeeping and food insecurity in children

4.1 Manuscript 5

Mata, J., Dallacker, M., & Hertwig, R. (2017). Social nature of eating could explain missing link between food insecurity and childhood obesity. [Open peer commentary on Nettle, Andrews, & Bateson, Food insecurity as a driver of obesity in humans: The insurance hypothesis]. *Behavioral Brian Science*, e105. doi:10.1017/S0140525X16000947

The following commentary refers to an article about the link of food insecurity and obesity and illustrates how recognizing social factors may offer new answers and insights into determinants of childhood obesity. Food insecurity is defined as a state where access to food is limited or uncertain primarily due to the lack of financial resources (Pinstrup-Andersen, 2009). In the United States about 13% of households are food insecure (Coleman-Jensen, Rabbitt,

Gregory, & Singh, 2016). Food insecurity is a rising problem not only in the United States but also in European countries. In Germany, it is estimated that approximately 7% of the population experiences at least sporadic food insecurity (Pfeiffer, Ritter, & Oestreicher, 2015). In the main article to which this commentary is appended (Nettle, Andrews, & Bateson, 2017), the authors suggested food insecurity as one driver of obesity. They argued that according to the insurance hypothesis, storing fat has the function of buffering against periods of food shortage. Consequently, experiencing food insecurity may lead to more fat storage relative to food security. The authors supported their hypothesis by thoroughly reviewing models from behavioral ecology and findings from animal studies. Finally, they conducted a meta-analysis summarizing epidemiological studies on food insecurity and obesity. The meta-analysis revealed a relationship between food insecurity and a higher risk of obesity. Interestingly, they could not find such a link in children. In our commentary, we suggested that the social nature of eating could account for the missing link. Children may not be affected by food insecurity because parents as nutritional gatekeepers protect them from nutrition poverty. For example, studies suggested that mothers reduce their food intake to guarantee that their child has enough food (McIntyre et al., 2003; Piperata, Schmeer, Hadley, & Ritchie-Ewing, 2013). Additionally, other *institutional* nutritional gatekeepers may counteract the effect of food insecurity. The United States and other countries offer welfare assistance and institutionalized programs, such as school breakfast and lunch programs, to counteract the effect of nutrition poverty in children. Consequently, despite living in a food-insecure household, children, in contrast to adults, may not experience food insecurity. In their review, Nettle et al. (2017) acknowledged the multifactorial nature of obesity. Despite their careful review of different models, they did not

recognize social influences. This commentary points out that comprehensive models in the area of dietary behavior and obesity will benefit from integrating a social perspective.

5 General discussion and conclusion

Unlike individual-level models, there are no integrative social-level models on health behavior. The goal of this dissertation was to identify and specify how parents as nutritional gatekeepers influence dietary intake and weight status in children. In three themed sections, I examined different parental influences on children's nutritional health. The two meta-analyses of Section 2 deal with family meals. The first study identified and quantified nutritional health benefits of regular family meals. The second study was the first to systematically summarize family meal time practices that are associated with better nutritional health in children. The findings add significant value to the existing family meal literature and suggest new ideas for future research and intervention: First, our results suggest that simply prescribing more family meals may not have the desired effects on nutritional health. Rather, how families eat together seems to be important. Second, our results imply there is some flexibility in when and with whom family meals can take place to see a benefit. We found positive effects for family meals with at least one parent as well as with the whole family and for breakfast as well as dinner. Third, we went beyond the mere frequency argument and conducted the first systematic review on qualitative aspects of family meals. We identified six evidence-based mealtime practices that are a promising and meaningful starting point for future research, in particular, randomized control trials investigating casual effects and underlying mechanisms of the identified mealtime practices. Communicating the mealtime practices to parents could be a simple, low-cost

intervention. Importantly, these interventions should come with resources and logistical support for parents to make these changes, such as cooking classes and subsidies for healthy foods.

Section 3 sheds light on the role of parental health literacy skills for their children's weight status. Study 3 was the first to identify low numerical abilities as a potential risk factor for underweight and overweight in children. Study 4 was the first to show a link between parental sugar underestimation and overweight in children. The findings imply that improving children's nutrition is a matter not just of behavioral change in parents but also of environmental changes. Simple and transparent presentation of health information could be one way to promote healthy food choices in nutritional gatekeepers and consequently prevent obesity in childhood and later life. Section 4 gives an illustrative example of how research and theoretical models on obesity could benefit from integrating a social perspective. More specifically, in a commentary, we suggested that the missing link between food insecurity and obesity in children can be explained by a nutritional gatekeeper buffering against the effect of nutrition poverty.

The manuscripts included in this dissertation suggest that parents as nutritional gatekeepers play a crucial role in the development of healthy eating habits and body weight in children. At the same time, targeting the parents alone may have only limited success. Children in our modern society have multiple nutritional gatekeepers. Accordingly, changes not only within the family but also outside the home environment are necessary to prevent obesity. Preschools, schools, and community programs can support social meals and healthy eating habits in children. Literacy-sensitive health information such as simple and transparent nutrition labeling is another way to empower nutritional gatekeepers.

This dissertation is one step toward a better understanding of how parents shape the eating behavior and body weight in children. The results advance the scientific understanding of

social influences on eating behavior and body weight in children and suggest new ideas for future research and interventions. Social influences alone cannot explain the obesity epidemic, but the findings of this dissertation highlight that they represent a significant component of a pluralistic explanation.

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7 Appendix

Zusammenfassung

Soziale Determinanten von Adipositas: Wie Eltern das Essverhalten und Körpergewicht

ihrer Kinder beeinflussen

Essen findet meist in Gesellschaft statt. Verschiedene Studien konnten zeigen, dass soziale Faktoren einen entscheidenden Einfluss auf das Essverhalten von Personen haben. Dies gilt insbesondere für Kinder, die Essensentscheidungen nur selten selbstständig treffen. Eltern haben einen maßgeblichen Einfluss darauf, was, wie viel und wie ihre Kinder essen. Sie werden daher auch als Nutritional Gatekeeper (dt.: Ernährungstürsteher) bezeichnet. Ziel dieser Dissertation ist es, elterliche Einflussfaktoren auf das Ernährungsverhalten und das Gewicht ihrer Kinder zu identifizieren und zu spezifizieren. Es werden im Schwerpunkt drei mögliche Einflüsse untersucht: (1) Familienmahlzeiten, (2) die kognitiven Gesundheitskompetenzen von Eltern und (3) die Rolle der Nutritional Gatekeeper bei Nahrungsunsicherheit und Adipositas.

Der erste Teil der Dissertation besteht aus zwei Studien, die sich mit Familienmahlzeiten beschäftigen. Familienmahlzeiten können ein enormes Lernpotential für Kinder haben. Einerseits können Kinder wiederholt mit gesundem Essen in Kontakt kommen. Andererseits können sie viel über Ernährung im Allgemeinen und die Zubereitung von Essen lernen. Die erste Studie in diesem Teil der Dissertation ist eine Metaanalyse, die untersucht, welche ernährungsrelevanten Gesundheitsvorteile regelmäßige Familienmahlzeiten für Kinder haben können. Insgesamt flossen die Ergebnisse von 57 Studien und 203.706 Probanden in die Analysen ein. Die Ergebnisse zeigen, dass häufige Familienmahlzeiten signifikant mit (1) einem geringeren BMI, (2) mehr gesunder Ernährung, (3) weniger ungesunder Ernährung, und (4) einer besseren Gesamternährungsqualität bei Kindern zusammenhängt. Moderatoranalysen ergaben, dass die Stärke der Zusammenhänge

nicht abhängig war vom Alter der Kinder, dem Herkunftsland, der Art der Mahlzeit (Frühstück/Mittag/Abendessen) und von den Personen, die mit am Tisch sitzen (ein Elternteil/Teile der Familie/ganze Familie). Für Studien, die den BMI untersucht haben, zeigt sich, dass das Kontrollieren für sozioökonomischen Status den Zusammenhang zwischen häufigen Mahlzeiten und geringerem BMI signifikant reduzierte. Zusammenfassend zeigen die Ergebnisse, dass regelmäßige Familienmahlzeiten das Potential haben könnten, eine gesunde Ernährungsweise von Kindern zu fördern und Übergewicht vorzubeugen. Allerdings suggerieren die sehr kleinen Effektstärken, dass Familienmahlzeiten per se nicht zwangsläufig gesund sein müssen. Das führte zu der Frage: Was macht Familienmahlzeiten gesund? Diese Frage haben wir mit einer weiteren Metaanalyse untersucht. Ziel war die Identifikation von Mahlzeitpraktiken, die mit einer besseren Ernährung und einem geringeren Übergewichtsrisiko von Kindern zusammenhängen. Die Ergebnisse zeigen, dass die folgenden Mahlzeitpraktiken signifikant mit einer besseren ernährungsbedingten Gesundheit von Kindern zusammenhängen: (1) Kein Fernsehen während der Familienmahlzeiten, (2) gesunde Lebensmittel, (3) das Rollenvorbild der Eltern während der Familienmahlzeit, (4) eine positive Atmosphäre am Essenstisch, (5) eine längere zeitliche Dauer der Mahlzeit und (6) die Einbeziehung der Kinder in die Zubereitung der Mahlzeit. Es zeigt sich, dass die Einbeziehung der Kinder in die Essenzubereitung zwar mit einer gesünderen Ernährung zusammenhängt, aber gleichzeitig auch mit einem höheren BMI. Die Kommunikation der Ergebnisse beider Metaanalysen an Ärzte, Gesundheitsexperten und an Familien könnte eine effektive Maßnahme zur frühen Übergewichtsprävention bei Kindern darstellen. Zukünftige Forschung sollte die verschiedenen Mahlzeitpraktiken mit Hilfe von randomisierten, kontrollierten Studien untersuchen. Die wachsende Zahl an Doppelverdienerfamilien und die Zunahme an Freizeitverpflichtungen bei Kindern verdeutlichen ein weiteres wichtiges zukünftiges

Forschungsfeld: Die Untersuchung der Übertragbarkeit der Mahlzeitpraktiken in andere Kontexte, wie etwa Schulen und Kindergärten.

Der zweite Teil der Dissertation besteht aus zwei Studien und beschäftigt sich mit dem Einfluss der Gesundheitskompetenzen von Eltern auf das Gewicht ihrer Kinder. Diese kognitiven Fähigkeiten sind für ernährungsrelevante Entscheidungen essentiell, werden allerdings häufig als Determinanten von Übergewicht bei Kindern vernachlässigt. Die erste Studie zeigt, dass niedrige numerische Fähigkeiten von Eltern sowohl signifikant mit Übergewicht als auch mit Untergewicht von Kindern zusammenhängen. In einer weiteren Studie wurde die Fähigkeit von Eltern untersucht, Zuckermengen in Lebensmitteln einzuschätzen. Die Ergebnisse zeigen, dass der Zuckergehalt in vielen Lebensmitteln von einem Großteil der Eltern maßgeblich unterschätzt wurde. Knapp 90% der Eltern haben den Zuckergehalt eines handelsüblichen Fruchtjoghurts um durchschnittlich sieben Zuckerwürfel unterschätzt. Die Ergebnisse belegen, dass elterliche Zuckerunterschätzung mit einer doppelt so hohen Wahrscheinlichkeit von Übergewicht bei ihren Kindern einhergeht. Beide Studien deuten darauf hin, dass sowohl sehr allgemeine elterliche kognitive Kompetenzen, wie numerische Fähigkeiten, als auch spezifische elterliche Kompetenzen, wie das Zuckereinschätzen, eine wichtige Rolle bei der Entstehung von Übergewicht bei Kindern spielen können. Im Gegensatz zu den praktischen Implikationen der Familienmahlzeitstudien, setzen die Implikationen der Studien zu Gesundheitskompetenzen bei der Umwelt an. Eine einfache und transparente Darstellung von gesundheitsrelevanten Informationen, wie beispielsweise eine Ernährungsampel, könnte Eltern helfen, gesunde Essensentscheidungen für sich und ihre Kinder zu treffen.

Der dritte Teil der Dissertation beschäftigt sich mit dem Zusammenhang von Ernährungsunsicherheit und Übergewicht. Ein kürzlich erschienener Review-Artikel konnte

zeigen, dass es bei Erwachsenen einen Zusammenhang zwischen Ernährungsunsicherheit und Übergewicht gibt. Die Autoren erklären den Zusammenhang damit, dass bei einem Gefühl von Ernährungsunsicherheit eher Fettreserven angelegt werden, um sich vor Zeiten von Nahrungsknappheit zu schützen. Dieser Zusammenhang konnte bei Kindern allerdings nicht nachgewiesen werden. In einem Kommentar schlagen wir vor, dass sich der fehlende Zusammenhang durch soziale Faktoren - das heißt die Rolle der Eltern als Nutritional Gatekeeper - erklären lässt. Eltern und auch Schulprogramme können Kinder vor dem Gefühl der Nahrungsunsicherheit schützen und würden somit den Effekt der Unsicherheit auf das Körpergewicht abfedern. Es wird deutlich, dass soziale Einflussfaktoren auf Adipositas in der Forschung häufig noch zu wenig Beachtung finden und das Modelle zur Erklärung von Gesundheitsverhalten von der Einbeziehung von sozialen Faktoren profitieren können.

Die Ergebnisse der Dissertation liefern wichtige neue Erkenntnisse darüber, wie Eltern das Essverhalten und das Übergewichtsrisiko ihrer Kinder beeinflussen. Aus den Ergebnissen lassen sich Präventionsmöglichkeiten ableiten, die innerhalb und außerhalb des Familiensettings ansetzen. Zukünftige Forschung sollte die in dieser Dissertation identifizierten elterlichen Einflüsse, wie Mahlzeitpraktiken und elterliche Gesundheitskompetenzen, mit randomisierten kontrollierten Studien untersuchen.

Curriculum Vitae

For reasons of data protection, the curriculum vitae is not included in the online version.

Curriculum Vitae

For reasons of data protection, the curriculum vitae is not included in the online version.

List of Publications

* References marked with an asterisk indicate studies included in the dissertation

***Dallacker, M.,** Hertwig, R., & Mata, J. (2017). *Association between family meal frequency and children's nutritional health.* Manuscript under review.

***Dallacker, M.,** Hertwig, R., & Mata, J. (2017). *Parents' considerable underestimation of sugar and their child's risk of overweigh*. Manuscript under review.

***Dallacker, M.** Hertwig, R., & Mata, J. (2017). *More than just food: A meta-analysis of family mealtime practices and children's nutritional health*. Manuscript under review.

Mata, J., **Dallacker, M**., Vogel, T., & Hertwig, R. (in press). *The Role of Attitudes in Diet, Eating, and Body Weight.* In D. Albarracín & B. T. Johnson (Eds) Handbook of Attitudes. London: Routledge (Taylor and Francis Group)

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Conference Presentations

Dallacker, M., Hertwig, R., & Mata, J. (August 2017). Longer meal duration increases healthy eating in children. An experimental study. Talk presented at the 31th Conference of the European Health Psychology Society, Padua, Italy

Dallacker, M., Hertwig, R., & Mata, J. (August 2017). Longer meal duration increases healthy eating in children. An experimental study. Talk presented at the 13th conference of the German Health Psychology Society, Siegen, Germany

Dallacker, M., Hertwig, R., & Mata, J. (April 2017). More than just food: A meta-analysis of family mealtime practices. Talk presented at the 38th Annual Meeting of the Society of Behavioral Medicine, San Diego, USA (Abstract awarded as meritorious student abstract)

Dallacker, M. Hertwig, R., & Mata, J. (September, 2016). More than just food: A meta-analysis of family mealtime practices. Talk presented at the 50th Conference of the German Society for Psychology

Dallacker, M. Hertwig, R., & Mata, J. (August, 2016). A meta-analysis of family mealtime practices associated with children's nutritional health. Poster presentation at the 30th Conference of the European Health Psychology Society, Aberdeen, Scotland (Poster award for outstanding poster presentation)

Dallacker, M. Hertwig, R., & Mata, J. (June, 2016). More than just food: A meta-analysis of family mealtime practices. Poster Presentation at the 15th Conference of the International Society of Behavioral Nutrition and Physical Activity, Cape Town, South Africa

Dallacker, M., Hertwig, R., Peters, E., & Mata, J. (August, 2015). Lower parental numeracy is associated with children being under- and overweight. Poster presentation at the 12th Conference of the German Health Psychology, Graz, Austria

Dallacker, M., Hertwig, R., Peters, E., & Mata, J. (August, 2015). Lower parental numeracy is associated with children being under- and overweight. Talk presented at the 29th Conference of the European Health Psychology Society, Limassol, Cypres

Erklärung

Hiermit versichere ich, dass ich die vorgelegte Arbeit selbstständig verfasst habe. Andere als die angegebenen Hilfsmittel habe ich nicht verwendet. Die Arbeit ist in keinem früheren Promotionsverfahren angenommen oder abgelehnt worden.

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Berlin, den 24.08.2017   Unterschrift (Mattea Dallacker)

Manuscript 1

Dallacker, M., Hertwig, R., & Mata, J. (2017). *Association between family meal frequency and children's nutritional health.* Manuscript under review.

Family meal frequency and nutritional health in children across ages and countries:
A meta-analysis

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Conflict of interest statement

The authors report no conflicts of interest.

Abstract

Findings on the relationship between family meal frequency and children's nutritional health are inconsistent. The reasons for the mixed results are largely unexplored. This systematic review and meta-analysis of 57 studies (203,706 participants) examines (a) the relationship between family meal frequency and different nutritional health outcomes and (b) potential explanations for the inconsistent findings, namely, sociodemographic and mealtime characteristics. Separate meta-analyses revealed significant associations between higher family meal frequency and better overall diet quality ($r = .13$), more healthy diet ($r = .10$), less unhealthy diet ($r = -.04$), and lower body mass index, BMI ($r =. -.05$). Child's age, country, number of family members present, and meal type (i.e. breakfast, lunch or dinner) did not moderate the relationship of meal frequency with BMI, healthy diet, or unhealthy diet. Socioeconomic status (SES) only moderated the relationship with BMI. The findings suggest that family meals have the potential to positively influence children's nutritional health—in both younger and older children, across countries and socioeconomic groups, and whether meals are taken with the whole family or just one parent. The small effect sizes, however, suggest that other factors beyond family meal frequency are also in operation. More research on the causal mechanisms behind the nutritional health benefits of family meals is needed.

Introduction

Childhood obesity is a serious health condition with short- and long-term risks to both psychological and physical health (e.g., low self-esteem; higher risk of developing asthma, diabetes and cardiovascular disease at a young age). Childhood obesity also strongly predicts obesity in adulthood (1-3). Obesity rates are high and rising around the globe, with serious consequences for people's quality of life and even life expectancy. For example, in the U.S., it is anticipated that the current generation of children may—as a result of the obesity epidemic—be the first with a lower average life expectancy than their parents (4).

The home food environment as a gateway for early obesity prevention

Current weight loss interventions have limited, if any, success (5). Consequently, researchers have begun to focus on *preventing* weight gain. The childhood years represent a unique window of opportunity to preempt the formation of detrimental health habits, including those conducive to overweight and obesity. But which prevention approaches are effective during this critical formative period? One promising preventive pathway is the promotion of healthy eating habits. Developing such competences is crucial in today's obesogenic food environment. Indeed, the obesity epidemic is increasingly understood as a consequence of a food environment that promotes excessive energy intake through relatively inexpensive, calorie-dense and nutrient-poor foods, available in large portion sizes everywhere at any time (6). Accordingly, the World Health Organization (WHO) has declared obesity to be a "predominantly social and environmental disease" (7). Adults make their daily food choices in this obesogenic food environment. Children, however, especially in early childhood, do not generally interact with this

food environment autonomously. Rather, their nutritional gatekeepers—parents, grandparents and other caretakers—shape their nutritional ecosystem (8-10).

About two-thirds of children's daily calories stem from food prepared at home (11). Therefore, the home food environment offers a key opportunity for obesity prevention in children. What measures can be taken to improve this food environment? One entry point for interventions is the family meal. Assuming that children eat three meals a day, the large majority of them in the family context, family meals offer the opportunity to expose children to healthy foods. Moreover, communal meals present a learning opportunity: children can learn about nutrition and parents can model healthy eating. Family meals thus constitute a social setting with the potential to shape children's eating routines and behaviors from an early stage. As a naturally occurring gateway for early obesity prevention, the family meal has recently become a buzzing focus of scientific attention: According to the *Web of Science*, the average number of publications on family meals increased from some 5–8 per year between 1970 and 1995 to, on average, 45 publications per year between 2010 and 2015.

Definitions of nutritional health

In this meta-analysis, we consider four nutritional health outcomes: body mass index (BMI), healthy diet, unhealthy diet and overall diet quality. *BMI* relates body weight to height and is often employed to describe whether a person is underweight, normal weight, overweight or obese. However, BMI is only an approximate indicator of health. For example, it does not differentiate between fat and muscle mass. In some circumstances, obesity does not increase mortality (e.g. in old age; 12) and even has survival benefits (e.g. after surgery; 13). *Healthy diet* is often operationalized as the number of portions of fruit and vegetables consumed per day.

Consuming five or more portions per day has been associated with reduced risk of cancer and cardiovascular disease (14). *Unhealthy diet* is generally operationalized in terms of consumption of sugar-sweetened beverages, fast food, or unhealthy sweet or salty snacks. Such eating patterns are associated with a higher intake of sugar, fat and energy and consequently with a greater risk of developing diabetes, high blood pressure, coronary heart disease and obesity (15-17). Some studies do not differentiate between healthy and unhealthy diet, but report *overall diet quality*. One gold standard measure is the Healthy Eating Index (HEI), which assesses compliance with dietary guidelines on, for example, consumption of fruits, whole grains, fatty acids and sodium (18).

Nutritional health benefits of family meals

Findings on the relationship between the frequency of family meals (henceforth "meal frequency") and overweight and obesity are mixed. Some studies have found that regular family meals are associated with a lower risk of overweight and obesity (e.g. 19, 20); others found no link (e.g. 21, 22). Frequent family meals have been found to be associated with several positive dietary outcomes, including higher average fruit and vegetable intake (e.g. 23), lower fast food and soft drink consumption (e.g. 24, 25), and better overall diet quality (e.g. 26). However, effect sizes differ, and a few studies failed to find significant links (e.g. 27 for fruits and vegetables; 28 for soft drinks). In sum, the data on the nutritional health benefits of family meal frequency are mixed. In this article, we investigate whether and to what extent these heterogeneous findings are a consequence of sociodemographic and methodological differences between studies.

The role of sociodemographic and mealtime characteristics

Studies on family meal frequency differ in the properties of the populations targeted, including socioeconomic status (SES), children's age, and country. Further, there is not yet a standard definition of what exactly constitutes a *family meal*. These factors may impair reliable measurement and thus contribute to inconsistent findings. In the following, we summarize previous findings on the role of sociodemographic and methodological factors in family meal studies and suggest how they may affect the links observed between meal frequency and nutritional health.

SES. Family meals are most frequent in children with high SES. At the same time, higher SES predicts healthier diet and body weight (29). But to what extent does higher SES explain the positive link between family meals and nutritional health? If SES is a significant driver of the link between meal frequency and nutritional health, lower effect sizes should be observed in studies controlling for SES.

Age. As children grow up, they become more independent from their family and the influence of peers increases (30). If family meals have a smaller influence on the nutritional health of adolescents, studies investigating children should, ceteris paribus, report larger effect sizes than studies with samples of adolescents.

Country. The large majority of family meal studies stem from the U.S., followed by European countries, South America, Australia, New Zealand and Asian countries. Meta-analytic techniques afford the opportunity to investigate the effect of cultural differences on family meals.

Meal type. Another source of heterogeneity between family meal studies may be differences in the meal types considered. Whereas most studies have investigated either "family

dinner" or simply "family meals", some have looked specifically at "family breakfast" or "family lunch".

Family members at the table. Studies differ with regard to who must be present at the table for a meal to be considered a "family meal". Definitions range from "at least one parent" to "the whole family". One study with a sample of 160 parent–child pairs investigated variations in group size (i.e. who was present at the table) and found small differences in weight outcomes. More specifically, measures asking about "sitting and eating together" revealed stronger effects than measures that addressed either sitting together *or* eating together. No differences were found in dietary outcomes (31).

The present investigation

To the best of our knowledge, only one previous meta-analysis has examined the relationship between family meal frequency and children's nutritional health (32). It found that regular family meals were associated with better nutritional health in children. However, due to the small number of studies analyzed ($k = 17$), the authors were not able to investigate potential reasons for the heterogeneity in results across studies. The present meta-analysis aims to fill this gap. Taking advantage of the surge in studies on family meals published over the last decade it investigates potential sources of heterogeneity and scrutinizes potential moderators of the relationship between family meal frequency and children's nutritional outcomes. Unless these moderating factors are properly understood, it will be difficult to harness the potential of family meals in obesity-prevention interventions.

This meta-analysis has the following objectives:

(1) to identify and quantify the nutritional health benefits of family meals; these benefits are measured in terms of the child's BMI, healthy diet, unhealthy diet and overall diet quality;

(2) to determine the impact of demographic characteristics (age, gender, SES, country) and mealtime characteristics (meal type, family members present at the table) on the health benefits of family meals.

Method

Literature Search and Study Selection

The search strategy and keywords were developed in collaboration with a professional librarian. The literature search consisted of the following three steps: First, we conducted systematic literature searches in *Web of Science* (search terms: ["family meal" OR "mealtime*" OR "shared meal" OR "dinner"] AND ["BMI" OR "body mass index" OR "overweight" OR "obesity" OR "food intake" OR "eat*" OR "diet" OR "nutrition"], refined by topic "child*" OR "adolescent*" OR "young adult*"); *PubMed* (Medical Subject Headings (MeSH) (search terms: ["diet" OR "feeding behavior"] AND "family", filter: "preschool child", "child", "adolescent"), and in *PsycInfo* (search terms: ["body mass index" (Thesaurus) OR "body weight" OR "obesity" OR "overweight" OR "diets" OR "eating behavior" (Thesaurus) OR "food" (Thesaurus) OR "food preferences" OR "nutrition"(Thesaurus)] AND ["mealtimes" (Thesaurus) OR "meal*" OR "dinner" OR "lunch"]). The search terms used differ between databases because we used both

free and controlled vocabulary (i.e. MeSH terms in Pubmed; Thesaurus terms in PsycInfo). The

literature search was conducted in January 2017. It covered both published and unpublished

studies (e.g. conference abstracts, dissertations) in English or German. Second, we performed

forward searches. Using *Web of Science*, we systematically searched for studies that cited key

studies identified in the literature search. Third, we conducted backward searches, that is, we

manually examined the reference lists of reviews on family meals.

These searches identified a total of 3,906 articles (see Figure 1 for a PRISMA flow chart

illustrating the study selection process). Inclusion/exclusion of the first 500 studies was

determined independently by the first author and a second trained rater. Because the agreement

rate (94%) was high (33), the remaining studies were screened by only one rater each. The

eligibility criteria for inclusion in the meta-analysis were as follows: (a) a measure of family

meal frequency; (b) at least one indicator of nutritional health; and (c) a statistical association

between family meal frequency and nutritional health. Measures of nutritional health considered

were (a) BMI, (b) healthy diet, (c) unhealthy diet and (d) overall diet quality. Studies were

excluded if (a) children were not the target population; (b) the study examined children with

feeding problems (e.g. children with autism) or with diseases that require a special diet (e.g.

children with cystic fibrosis or diabetes); and (c) the study reported insufficient statistics to

calculate an effect size. The screening process yielded 57 studies (20-24, 26-28, 31, 34-81).

Coding of Studies

In accordance with existing guidelines (82), we extracted the following information from

each study:

- Source characteristics: author, year of publication

- Sample characteristics: sample size, ethnic composition, age

- Measure characteristics: outcome type (BMI, healthy diet, unhealthy diet, overall diet quality)

- Design characteristics: longitudinal, cross-sectional

- Study quality: external validity (subpopulation, sampling procedures); construct validity (measurement characteristics, including reliability and validity)

- Moderators: age group, country, SES, family members present, meal type

Table 1 summarizes selected study characteristics relevant for the meta-analysis.

Data Synthesis

Calculation of effect sizes

The primary studies reported multiple levels of variables and statistics. For each study, we calculated the correlation coefficient r as an effect size quantifying the association between family meal frequency and children's nutritional health. We chose r as the effect size because both the frequency of family meals and the frequency of food consumption are naturally continuous. Consequently, most studies measured meal frequency and nutritional health on a continuous scale and many reported correlation coefficients. Additionally, r is easy to interpret and can be extracted from several statistical parameters. Where statistics from group comparisons were reported (e.g. means, t values, odds ratios or frequencies), Cohen's d was calculated and converted to r (82, 83). Where only standardized regression coefficients were available, we used those (84, 85). Correlation coefficients were transformed to a z score metric using Fisher's z-transformation. In all analyses, we used r-to-z transformed values. For figures including funnel and forest plots, the pooled effect sizes were back-transformed to r values.

Meta-analyses: Estimating effect sizes for nutritional health outcomes

We applied random-effects models, because we expected systematic heterogeneity between studies due to differences in study samples, measurements and quality. Random-effects models do not assume one true effect size but a distribution of effect sizes. The pooled effect size represents an estimate of the mean of this distribution. Heterogeneity was quantified by the I^2 statistic, specifying the degree of systematic variation between studies (86): An I^2 value of 0 means that variation in effect sizes between studies results from random error; values above 0 indicate the proportion of systematic between-study variation.

To investigate the associations between family meal frequency and nutritional health, we analyzed the following nutritional health outcomes in separate meta-analyses: (a) children's BMI (reported or measured), (b) healthy diet (consumption of healthy foods, e.g. fruit and vegetable intake), (c) unhealthy diet (consumption of unhealthy foods, e.g. intake of sugar-sweetened beverages, fast food, sweet and salty snacks), (d) overall diet quality (dietary index combining healthy and unhealthy diet, e.g. the Healthy Eating Index (HEI) as a measure of compliance to the Dietary Guidelines for Americans). We performed separate meta-analyses for each of our four outcome types because, first, they represent qualitatively different aspects of nutritional health, and the strength of their association with meal frequency may thus differ. Second, we observed large nonrandom variability, not only across but also within outcome categories. To control for differences between outcome categories, we explored the effect of demographic and meal characteristics within outcome categories.

Combining subgroups and outcomes

Some studies reported statistics for multiple subgroups (e.g. separate results for boys and girls, or for younger and older children). In these cases, we computed separate effect sizes for each subgroup as well as a pooled effect size across subgroups (83). Other studies reported several nonindependent outcomes (e.g. separate results for fruit and vegetable consumption). In order to adjust for dependencies in effect sizes, we calculated a pooled effect size, but took the correlation between the outcomes into account. We applied the same procedure to studies reporting different outcomes but sharing the same data and, consequently, the same sample.

Moderator analyses

Within each meta-analysis of more than 10 studies, we investigated the following sociodemographic and mealtime characteristics as potential moderators: (a) age (children < 11 years/adolescents $\geq$ 11 years); (b) SES (controlled/not controlled; note that the group of studies controlled for SES includes both studies that adjusted their effect sizes for indicators of SES and studies where the target population was homogenous with respect to SES): (c) country (North America/Europe/South America/Asia/Australia or New Zealand); (d) type of meal (breakfast/lunch/dinner/unspecified); (e) family members present at the table (all or most family members/one parent or some family members/unspecified). In order to examine differences in the strength of meal frequency effects and variability between effect sizes, we first calculated separate effect sizes and the heterogeneity index I^2 for each category of the potential moderator. In a second step, we tested for moderator effects using QM test of moderators with $c - 1$ degrees of freedom, where c is the number of categories in the moderator variable.

Publication bias

We used funnel plots and trim and fill methods to investigate the likelihood of publication bias due to the file drawer problem (studies with null findings are less likely to be published and included in meta-analyses). Funnel plots depict effect sizes and the corresponding standard errors. An asymmetric funnel plot indicates a higher probability of publication bias. Funnel plot asymmetry was tested using Egger's linear regression method. Trim and fill methods add missing studies until the funnel plot shows a symmetric distribution. Next, we computed an adjusted pooled effect size, taking into account effect sizes added by the trim and fill method (87).

Results

Meta-analyses

Across all studies, having frequent family meals was significantly associated with a lower BMI ($r = -.05$, 95% CI [$-.06,-.03$]), a more healthy diet ($r = .10$, 95% CI [.09, .12]), a less unhealthy diet ($r = -.04$, 95% CI [$-.07, -.03$]) and better overall diet quality ($r = .13$, 95% CI [.06, .20]). We found large heterogeneity across studies, indicated by high I^2 values (see Table 2 for statistical details, and Figures 2–5 for forest plots).

Moderator analyses

Demographic characteristics

We tested whether the demographic characteristics of age, country and SES moderated the effect of family meal frequency on BMI, healthy diet or unhealthy diet. Moderator effects for

age and country were not significant for any of the outcomes (see *QM* statistics in Table 3). SES was a significant moderator only in studies investigating BMI as the outcome. Subgroup analyses revealed larger effect sizes of family meal frequency on BMI in studies not controlling for SES than in studies controlling for SES.

Mealtime characteristics

We next examined the number of family members present at the table and meal type as potential moderators. No significant moderator effects were observed (see Table 3).

Publication bias

The funnel plot for overall diet quality showed a roughly symmetrical distribution. The plots for BMI, healthy diet and unhealthy diet were slightly skewed to the right. Egger's tests for funnel plot asymmetry were significant for BMI ($p = 0.001$) and healthy diet ($p = 0.046$), but not for unhealthy diet ($p = 0.103$). Trim and fill analyses imputed five hypothetically missing studies for BMI, four studies for healthy diet and three studies for unhealthy diet (see Figures 6a–6d). Importantly, though, the adjusted effect sizes remained the same or were only slightly lower, but still significant (BMI: $r = -0.042$; 95% CI[−.06, −.03]; healthy diet: $r = 0.10$; 95% CI[.08, .12]; unhealthy diet: $r = -0.037$; 95% CI[−.06, −.02]; overall diet quality: $r = 0.16$; 95% CI [.09, .23]).

Discussion

Our meta-analyses found evidence of small and significant associations between family meal frequency and children's nutritional health. The associations for healthy diet and overall diet quality were stronger than those for BMI and unhealthy diet. Our results for a sample of 57 studies are in line with the findings of Hammons and Fiese (2011; $k = 17$ studies), who also

found small associations between frequent family meals and lower risk for overweight, more healthy diet and less unhealthy diet. Our findings make an important contribution to the research and policy discussion on family meals, as they show that the beneficial effects of family meals are robust against potential moderators such as country, age, constellation of family members present at the table and type of meal. None of these variables moderated the link between family meal frequency and nutritional health outcomes. SES was a significant moderator only in studies investigating BMI: When studies controlled for SES, the negative association of family meal frequency with BMI was smaller compared to studies that did not control for SES.

The findings suggest that family meals in general may have potential to improve children's diet quality and protect against weight gain. In what follows, we discuss qualitative aspects of family meals, that is, nutritional and social factors that could explain the link between family meal frequency and nutritional health.

How family meals may improve diet quality and protect against obesity

Our meta-analytic findings suggest that family meals may improve overall diet quality, promote consumption of healthy foods (i.e. fruit and vegetables) and decrease consumption of unhealthy foods (i.e. soft drinks, fast foods, unhealthy snacks). One explanation for this finding is nutritional: family meals expose children to more healthy foods (88). The number of family dinners is negatively correlated with the number of ready-made dinners (89, 90), whereas meals eaten alone or with friends are more likely to include fast food or ready-made food (91). Social factors may also explain the link between the social institution and social activity of family meals and nutritional health. Shared meals with the family offer a recurrent and rich learning

environment. Parental feedings styles, such as role modeling or encouragement, can positively influence children's dietary behavior (e.g. 92, 93).

Why did smaller effect sizes emerge for unhealthy diet than for healthy diet? One potential explanation is that parental feeding styles and serving healthful foods influence children's fruit and vegetable consumption *directly* within the meal situation. Unhealthy diet, in contrast, is affected only indirectly: It is not the family meal per se, but its replacing of less healthy alternative eating habits, such as snacking or eating ready-prepared meals alone, that reduces consumption of unhealthy foods. Still, fast food or soft drinks may also be served during family meals (e.g. Neumark-Sztainer and colleagues, 89, found that one fifth of families in their sample reported consuming soft drinks and fast food regularly during shared meals).

We found a small but significant association between family meal frequency and BMI, suggesting that regular family meals may offer some protection against obesity. One possible explanation is that the link between family meals and BMI results from an increase in healthy diet and a decrease in less unhealthy diet. Another is that these results are due to social factors. For instance, family meals provide an opportunity for information exchange and emotional support, and may improve the interpersonal dynamics within the family (94, 95); all of these factors may increase the likelihood of children learning healthy eating habits and becoming resilient to unhealthy habits (e.g. regulating unpleasant emotions through food consumption).

Moderator analyses

SES. Children with lower SES are more likely to experience poorer health including obesity (96). With respect to BMI, we found lower effect sizes in studies controlling for SES than in studies not controlling for SES. This observation indicates that the positive effect of

family meals can be partly attributed to differences in SES. However, the pooled effect size for studies controlling for SES was still significant, suggesting that the link between family meal frequency and nutritional health exists above and beyond differences in SES.

Age. Our findings suggest that family meals are equally beneficial independent of the children's age. This result is somewhat unexpected; past studies have shown that family influence decreases as children grow older and participate in fewer family meals in adolescence (97). Importantly though, our findings point towards the possibility that it might not be the mere frequency of family meals that matters, but their quality.

Country. On a descriptive level, we found small differences in pooled effect sizes between countries; however these differences were not significant. It is important to bear in mind that few studies have been conducted outside the U.S., meaning that the numbers of studies in the other moderator subcategories are small. Nevertheless, our moderator analyses suggest that the link between family meal frequency and nutritional health does not differ substantially between countries.

Meal type. We found no significant differences in effect sizes across meal types, suggesting that family meals are beneficial no matter whether families eat breakfast, lunch or dinner together. Again, these results should be interpreted with caution because the majority of studies examined family dinner or did not specify the meal type. Only a few studies investigated family breakfast and lunch (not surprisingly, because in many countries, children's school schedules prohibit them from having lunch at home).

Family members present at the table. Effect sizes did not differ across different definitions of a "family meal" for any of the outcome measures. These findings suggest that

meals with just one parent may be as beneficial for children's nutritional health as meals with the whole family.

Limitations

The effect sizes identified in this meta-analysis are small. One explanation could be the considerable variation in how families practice daily routines such as family meals. As reviewed earlier, nutritional and social factors, such as serving healthy foods and parental feeding styles, could explain the link between family meal frequency and children's nutritional health. At the same time, these findings indicate that merely eating together as a family is not a panacea for children's nutritional health. Eating fast food at family meals, parental role modeling of unhealthy eating behavior, or watching television during meals could have adverse effects on children's nutritional health (98-100). The complexity of the nutritional health outcomes investigated may also account for the weak associations. BMI and dietary behavior are complex constructs influenced by a number of factors.

We found large heterogeneity in results across all nutritional health outcomes. The main reason is likely to be that studies differ in how they define and measure both family meal frequency and nutritional health outcomes. Where possible, we used moderator analyses to investigate potential sources of heterogeneity (i.e. differences in meal type and family members present). Although including moderators resulted in a reduction of heterogeneity in most subgroups (e.g. an I^2 index of 7% in studies investigating family dinners with BMI as the outcome), no single moderator was able to explain a large part of heterogeneity between studies. This might be due to the large variation in family meal measures implemented across studies. For example, some studies used the average number of family meals per week, others dichotomized

the frequency using median split, and some compared extreme poles, such as having family meals every day vs. once a week. The same applies to the food consumption scales and BMI measures.

Finally, the studies summarized in this meta-analysis are observational, meaning that we cannot draw causal conclusions. To our best knowledge, no randomized control studies have examined the effect of family meal frequency on nutritional health outcomes. Therefore, we cannot rule out the possibility that third variables may have driven the results. For example, better family functioning is a predictor of better health in children and is also associated with more frequent family meals (101). Regular family meals might thus be a manifestation of better family functioning. Importantly, however, the frequency of family meals would seem easier to modify than family functioning and thus offers a more feasible mechanism for promoting nutritional health in children.

Implications and future directions

Our findings suggest that family meals may be beneficial for children's nutritional health across a broad range of study and sample characteristics. However, the relationships found in observational studies are weak and should be interpreted with caution. It may be that the mere frequency of family meals has limited effects on children's nutritional health. Healthcare professionals are therefore well advised to be cautious in simply prescribing more family meals. They should also emphasize the nutritional and social factors operating during family meals that may improve children's nutritional health, such as serving healthy foods, role modeling, and removing (digital) media distractions. An experimental study by Fiese and colleagues (102) investigated the effects of a noisy distraction on family meal time dynamics and found increased

unhealthy eating in children and negative communication patterns in adults. More experimental research is needed to investigate such less obvious qualities of family mealtimes and to identify potential mechanisms underlying the link between meal frequency and children's nutritional health.

Our moderator analyses did not find significant differences between countries. This is an important result because it suggests that findings stemming predominately from one country can inform research and policy in other countries as well. Likewise, we did not observe substantial differences between different types and definitions of family meals. Thus, *when* families eat together does not seem to matter much—an important message for families with busy schedules.

Finally, our results raise the possibility that other communal meals (e.g. at kindergarten or school) may also shape children's nutritional habits. These contexts also warrant more research attention. Relatedly, the growing attention to family meals coincides with an increasing number of mothers entering the workforce, making the provision of regular family meals more of a challenge. Interventions should take into account the lifestyle of modern families. Factors such as work/life stress, poor cooking skills, or busy family schedules can also make it difficult to put healthy family meals on the table every day (103, 104). There is already evidence suggesting that "family-style meals" at school could have beneficial effects on children's nutritional health. For example, Hendy & Raudenbush (105) showed that teachers' role modeling of novel food consumption increased the likelihood of children consuming these foods in the future.

Conclusion

Our findings indicate that family meals offer a gateway to positively influencing children's nutritional health. Importantly, our findings of small effect sizes suggest that other

factors beyond mere frequency are also in operation. In light of the growing interest among scientists, public health officials and the general public in how family meal practices can impact children's nutritional health, the next frontier for the research community is to design and implement randomized control trials. This approach will help to reveal the mechanisms that make family meals more or less healthy and that can potentially be harnessed in future obesity-prevention interventions.
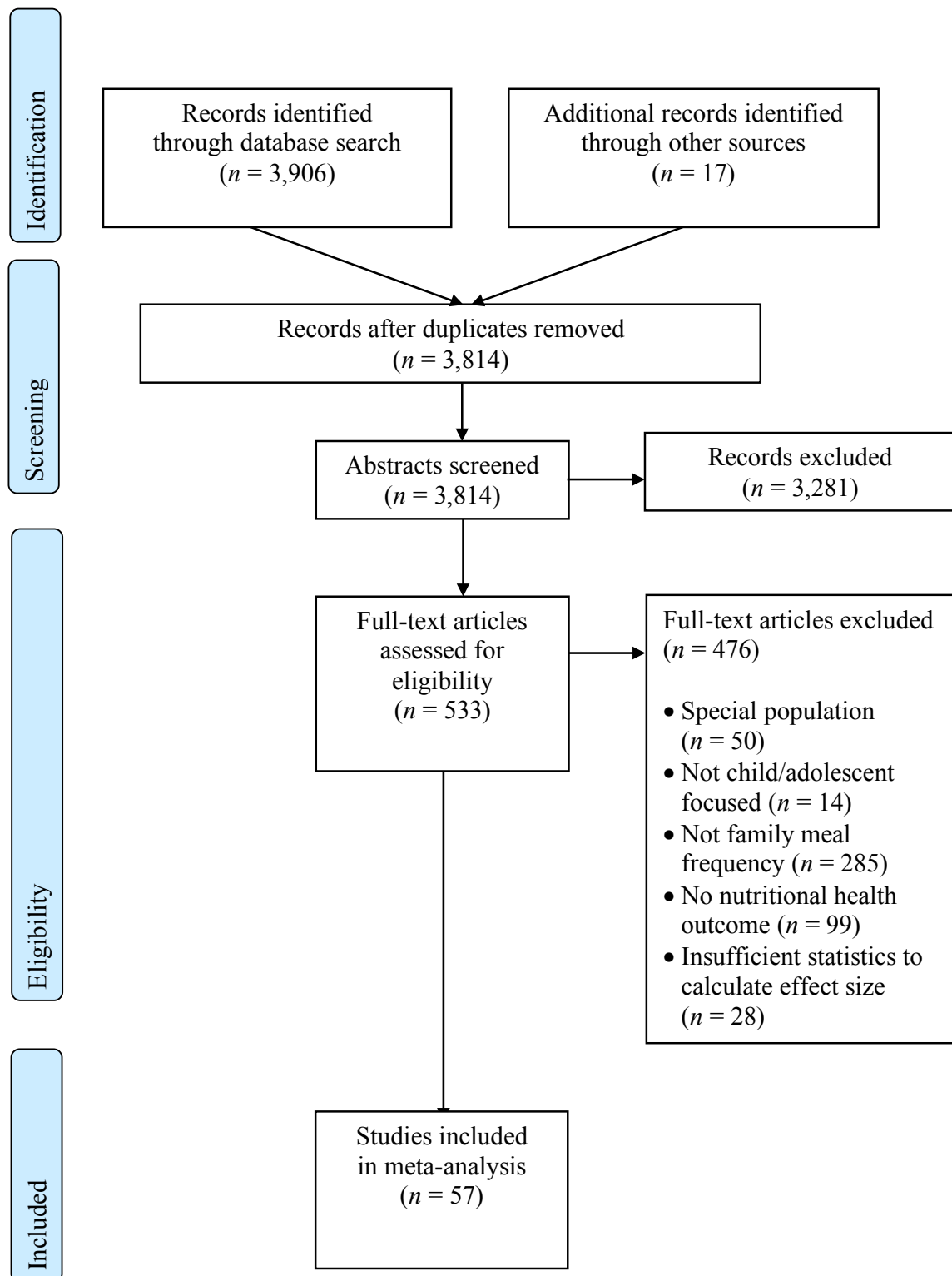
Figure 1. PRISMA flow chart showing the study selection process.

Table 1

Selected characteristics of studies included in the meta-analysis

First Author	Year	Country	Outcome	N	Age	SES	Meal type	Family members
Andaya	2011	US	H, U	794	children	yes	B, L, D	unsp.
Appelhans	2014	US	H, U	103	children	yes	unsp.	most/all
Ayala	2007	US	U	167	adolescents	yes	B, L, D	unsp.
Bauer	2011	US	BMI, H, U	253	adolescents	yes	unsp.	unsp.
Befort	2006	US	H	228	adolescents	no	unsp.	unsp.
BeLue	2009	US	B	35184	adolescents	no	unsp.	most/all
Berge	2014	US	BMI, H, U	2682	adolescents	yes	unsp.	most/all
Chan	2011	US	B	141	adolescents	no	unsp.	most/all
Christian	2013	England	H	1516	children	yes	D	unsp.
Crombie	2009	Scotland	O	300	children	yes	unsp.	unsp.
Cutler	2011	US	H, U	4746	adolescents	yes	unsp.	most/all
de Wit	2015	Europe[a]	H, U	2764	adolescents	no	B, D	most/all
Fink	2014	US	H, U	1992	adolescents	yes	unsp.	unsp.
Fulkerson	2008	US	BMI	2516	adolescents	yes	unsp.	most/all
Fulkerson	2009	US	BMI, H, U	139	adolescents	yes	D	most/all
Gable	2007	US	BMI	8000	children	yes	B, D	unsp.
Gillman	2000	US	H, U	16202	adolescents	no	D	unsp.
Goldman	2012	US	H	229	children	yes	unsp.	unsp.
Granner	2011	US	H	736	adolescents	no	D	unsp.
Horning	2016	US	BMI, H, U, O	160	children	no	D	most/all
Jaballas	2011	US	B	339	children	no	unsp.	one/some
Koszewski	2011	US	H	108	children	yes	B, L, D	unsp.
Larson, MacLehose	2013	US	H, U	2507	adolescents	yes	B	most/all
Larson, Wall	2013	US	BMI	2793	adolescents	yes	unsp.	most/all
Larson	2016	US	H, O	827	adolescents	no	B	most/all
Laurson	2008	US	BMI	268	adolescents	no	D	unsp.
Lee	2014	Korea	BMI	3435	children	no	D	unsp.
Leech	2014	Australia	H, U	155	adolescents	no	D	one/some
Lehto	2011	Finland	BMI	604	children	no	D	unsp.
Lillico	2014	Canada	BMI	3341	adolescents	no	unsp.	one/some
Liu	2014	US	BMI	1000	children	no	D	one/some
Mamun	2005	Australia	BMI, U	3757	adolescents	no	unsp.	unsp.
Moon	2014	Korea	H	2588	children	no	B, unsp.	one/some
Ness	2012	US	BMI	5342	adolescents	no	unsp.	most/all

Ntalla	2016	Greece	BMI	1929	adolescents	yes	unsp.	unsp.
Peters	2013	Australia	H	269	children	no	D	unsp.
Price	2009	US	BMI	4688	adolescents	no	D	unsp.
Prior	2013	UK	H, U	76	adolescents	no	unsp.	unsp.
Pyper	2016	Canada	H	3206	children	yes	unsp.	unsp.
Ranjit	2015	US	O, H, U	2502	adolescents	no	unsp.	unsp.
Reed	2013	US	BMI	43	adolescents	yes	B, D	unsp.
Roos	2001	Finland	H	65059	adolescents	no	D	unsp.
Roos	2014	Europe	BMI	2586	adolescents	yes	B, D	one/some
Santiago-T.	2014	US	O	187	adolescents	yes	unsp.	unsp.
Sen	2006	US	BMI	2524	adolescents	yes	D	unsp.
Serrano	2014	Puerto Rico	BMI, O	112	adolescents	no	unsp.	unsp.
Skafida	2013	Scotland	O	2190	children	no	unsp.	most/all
Spurrier	2008	Australia	U	280	children	no	unsp.	one/some
Sweetman	2011	UK	H	434	children	yes	unsp.	one/some
Taveras	2005	US	BMI	3088	adolescents	yes	D	unsp.
Utter	2008	New Zealand	H, U	3119	adolescents	yes	D	most/all
V.Lippevelde	2012	Europe[b]	BMI	6374	adolescents	yes	B	one/some
Verzeletti	2010	Europe[c]	H	14407	adolescents	yes	D	one/some
Videon	2003	US	H	18177	adolescents	yes	unsp.	one/some
Woodruff	2009	Canada	BMI, U	3025	adolescents	no	D	one/some
Woodruff	2010	Canada	O	985	adolescents	no	D	one/some
Wyse	2011	Australia	H	396	children	no	D	unsp.

N = sample size on which effect size calculations were based; BMI = body mass index; H = healthy eating; U = unhealthy eating; O = overall diet quality; B = breakfast; L = lunch, D = dinner; unsp.= unspecified; most/all = most or all family members; one/some = one parent or some family members.
[a]Netherlands, Poland, Portugal, Poland and UK
[b]Belgium, Greece, Hungary, Netherlands, Norway, Slovenia, Spain and Switzerland
[c] Belgium and Italy

Table 2

Results of meta-analyses on the effects of family meal frequency by outcome type

Outcome	r	[95% CI]	k	I^2
BMI	−.05**	[−.06, −.03]	25	78%
Healthy diet	.10**	[.09, .12]	27	87%
Unhealthy diet	−.04**	[−.07, −.03]	19	78%
Overall diet quality	.13*	[.06, .20]	9	85%

Note. Results from random-effects models. r = correlation coefficient; CI = confidence interval; k = number of samples; I^2 = heterogeneity index.

Author, Year	r [95% CI]

Chan, 2011 — −0.23 [−0.38, −0.06]
Serrano, 2014 — −0.19 [−0.36, 0.00]
Horning, 2016 — −0.15 [−0.30, 0.00]
Reed, 2013 — −0.15 [−0.43, 0.15]
Bauer, 2011 — −0.14 [−0.26, −0.02]
Ntalla (II), 2016 — −0.11 [−0.18, −0.05]
Fulkerson, 2008 — −0.11 [−0.14, −0.07]
Ntalla (I), 2016 — −0.10 [−0.16, −0.04]
Larson, 2013a, Larson, 2013b, Berge, 2014 — −0.09 [−0.12, −0.05]
Ness, 2012 — −0.06 [−0.09, −0.03]
Jaballas, 2011 — −0.06 [−0.16, 0.05]
Liu, 2014 — −0.05 [−0.12, 0.01]
Price 2009; Sen, 2006 — −0.05 [−0.08, −0.02]
Taveras, 2005 — −0.04 [−0.08, −0.01]
Fulkerson, 2009 — −0.04 [−0.21, 0.12]
Laurson, 2008 — −0.04 [−0.16, 0.08]
Van Lippevelde, 2012 — −0.04 [−0.06, −0.01]
Roos, 2014 — −0.04 [−0.06, −0.02]
Lillico, 2014 — −0.03 [−0.04, −0.02]
Woodruff, 2009 — −0.02 [−0.06, 0.01]
Gable, 2007 — −0.02 [−0.04, 0.00]
BeLue , 2009 — −0.01 [−0.02, 0.00]
Lee, 2014 — −0.00 [−0.04, 0.03]
Lehto, 2011 — −0.00 [−0.08, 0.08]
Mamun, 2005 — 0.01 [−0.02, 0.04]

Weighted mean correlation — −0.05 [−0.06, −0.03]

−0.5   −0.25   0   0.2

lower BMI   higher BMI

Figure 2. Forest plot showing the distribution of effect sizes for BMI.

Author, Year		r [95% CI]
Larson, 2016		−0.00 [−0.07, 0.06]
Sweetman, 2011		0.01 [−0.09, 0.11]
Wyse, 2011		0.03 [−0.07, 0.13]
Goldman, 2012		0.05 [−0.08, 0.18]
Cutler, 2011		0.06 [0.03, 0.08]
Roos, 2001		0.06 [0.05, 0.07]
Verzeletti, 2010		0.07 [0.05, 0.08]
Moon, 2014		0.07 [0.04, 0.10]
Andaya, 2011		0.09 [0.04, 0.13]
Utter, 2008		0.09 [0.06, 0.13]
Gillman, 2000		0.09 [0.08, 0.11]
Videon, 2003		0.10 [0.08, 0.11]
Befort, 2006		0.12 [0.00, 0.22]
Berge, 2014; Larson, 2013a		0.12 [0.09, 0.15]
Fink, 2014		0.12 [0.07, 0.17]
Granner, 2011		0.13 [0.06, 0.20]
Pyper, 2016		0.14 [0.11, 0.17]
Bauer, 2011		0.14 [0.02, 0.26]
Ranjit, 2015		0.16 [0.12, 0.19]
Koszewski, 2011		0.16 [0.03, 0.28]
Christian, 2013		0.16 [0.11, 0.21]
de Wit, 2015		0.16 [0.12, 0.20]
Fulkerson, 2009		0.18 [0.01, 0.34]
Horning, 2016		0.20 [0.05, 0.35]
Peters, 2013		0.21 [0.09, 0.32]
Prior, 2013		0.23 [−0.01, 0.44]
Appelhans, 2014		0.29 [0.12, 0.43]
Weighted mean correlation		0.10 [0.09, 0.12]

−0.25   0   0.25   0.5

less healthy diet   more healthy diet

Figure 3. Forest plot showing the distribution of effect sizes for healthy diet.

Author, Year		r [95% CI]
Leech, 2014		−0.17 [−0.32, −0.01]
Spurrier, 2008		−0.16 [−0.27, −0.04]
Appelhans, 2014		−0.16 [−0.32, 0.01]
Fink, 2014		−0.13 [−0.21, −0.05]
Fulkerson, 2009		−0.12 [−0.26, 0.03]
Horning, 2016		−0.08 [−0.21, 0.05]
Woodruff, 2009		−0.08 [−0.11, −0.05]
Lillico, 2014		−0.07 [−0.09, −0.05]
Ayala, 2007		−0.06 [−0.19, 0.07]
Gillman, 2000		−0.06 [−0.07, −0.04]
Ranjit, 2015		−0.05 [−0.09, −0.01]
Cutler, 2011		−0.03 [−0.06, −0.01]
Mamun, 2005		−0.03 [−0.05, 0.00]
Andaya, 2011		−0.02 [−0.06, 0.03]
Utter, 2008		−0.01 [−0.04, 0.02]
Berge, 2014; Larson, 2013a		0.02 [−0.02, 0.05]
de Wit, 2015		0.02 [−0.02, 0.06]
Prior, 2013		0.04 [−0.20, 0.28]
Bauer, 2011		0.04 [−0.09, 0.16]
Weighted mean correlation		−0.04 [−0.07, −0.02]

−0.35   −0.2   0   0.3

less unhealthy diet   more unhealthy diet

Figure 4. Forest plot showing the distribution of effect sizes for unhealthy diet.

Author, Year	r [95% CI]
Larson, 2016	0.00 [−0.07, 0.07]
Santiago−Torres, 2014	0.01 [−0.14, 0.15]
Serrano, 2014	0.03 [−0.16, 0.21]
Skafida, 2013	0.09 [0.05, 0.14]
Woodruff, 2010	0.14 [0.08, 0.20]
Leech, 2014	0.14 [−0.02, 0.29]
Ranjit, 2015	0.18 [0.14, 0.22]
Horning, 2016	0.20 [0.05, 0.35]
Crombie, 2009	0.33 [0.23, 0.43]
Weighted mean correlation	0.13 [0.06, 0.20]

lower overall diet quality   higher overall diet quality

Figure 5. Forest plot showing the distribution of effect sizes for overall diet quality.

Table 3

Results of moderator analyses with subgroups

Outcome	Moderator	Subgroups of moderator	r	[95% CI]	k	I^2	QM
BMI	Age	Child	−.02*	[−.04, −.01]	6	0%	1.63
		Adolescent	−.05**	[−.07, −.04]	19	82%	
	Country	Europe	−.05**	[−.09, −.02]	5	67%	7.94
		South America	−.19	[−.37, −.01]	1		
		North America	−.05**	[−.07, −.03]	17	76%	
		Asia	−.03	[−.04, −.03]	1		
		Australia or New Zealand	−.01	[−.02, −.04]	1		
	SES	Not controlled for SES	−.06**	[−.09, −.04]	11	72%	4.30*
		Controlled for SES	−.03**	[−.05, −.01]	13	66%	
	Family members	One parent, some members	−.03**	[−.04, −.02]	4	0%	0.44
		All or most members	−.06**	[−.09, −.03]	10	84%	
		Unspecified	−.05**	[−.09, −.03]	12	71%	
	Meal type	Breakfast	−.07	[−.16, .00]	3	96%	1.47
		Dinner	−.04**	[−.05, −.02]	10	7%	
		Meal (unspecified)	−.06*	[−.09, −.03]	14	89%	
Healthy diet	Age	Child	.11**	[.08, .15]	12	64%	0.61
		Adolescent	.10**	[.08, .12]	15	91%	
	Country	Europe	.10**	[.05, .15]	6	95%	0.88
		North America	.11**	[.09, .13]	17	76%	
		Asia	.07**	[.04, .10]	1		
		Australia or New Zealand	.10*	[.02, .19]	3	70%	
	SES	Controlled for SES	.11**	[.09, .13]	14	66%	0.23
		Not controlled for SES	.10**	[.07, .13]	13	93%	
	Family members	One parent, some members	.08**	[.06, .10]	3	72%	0.80
		All or most members	.11**	[.06, .17]	8	88%	
		Unspecified	.11**	[.09, .14]	16	79%	
	Meal type	Breakfast	.10**	[.03, .16]	5	82%	0.70
		Lunch	.12	[−.02, .26]	2	53%	
		Dinner	.09**	[.07, .12]	12	83%	
		Meal (unspecified)	.11**	[.09, .14]	14	77%	
Unhealthy diet	Age	Child	−.09*	[−.17, −.01]	4	54%	0.89
		Adolescent	−.04**	[−.06, −.02]	15	81%	
	Country	Europe	.02	[−.02, .02]	2	0%	3.60
		North America	−.05**	[−.07, −.03]	13	75%	
		Australia or New Zealand	−.07	[.14, −.01]	4	87%	
	SES	Controlled for SES	−.03	[−.06, .00]	9	66%	0.01
		Not controlled for SES	−.03**	[−.08, −.03]	10	80%	
	Family members	One parent, some members	−.08**	[−.09, −.06]	3	2%	9.3
		All or most members	−.02	[−.05, .01]	8	65%	
		Unspecified	−.05**	[−.06, −.03]	8	33%	
	Meal type	Breakfast	−.01	[−.06,−.06]	2	60%	4.91
		Lunch	.04	[.03, .11]	1		
		Dinner	−.06**	[−.09, −.03]	7	63%	
		Meal (unspecified)	−.04*	[−.07, −.01]	12	78%	

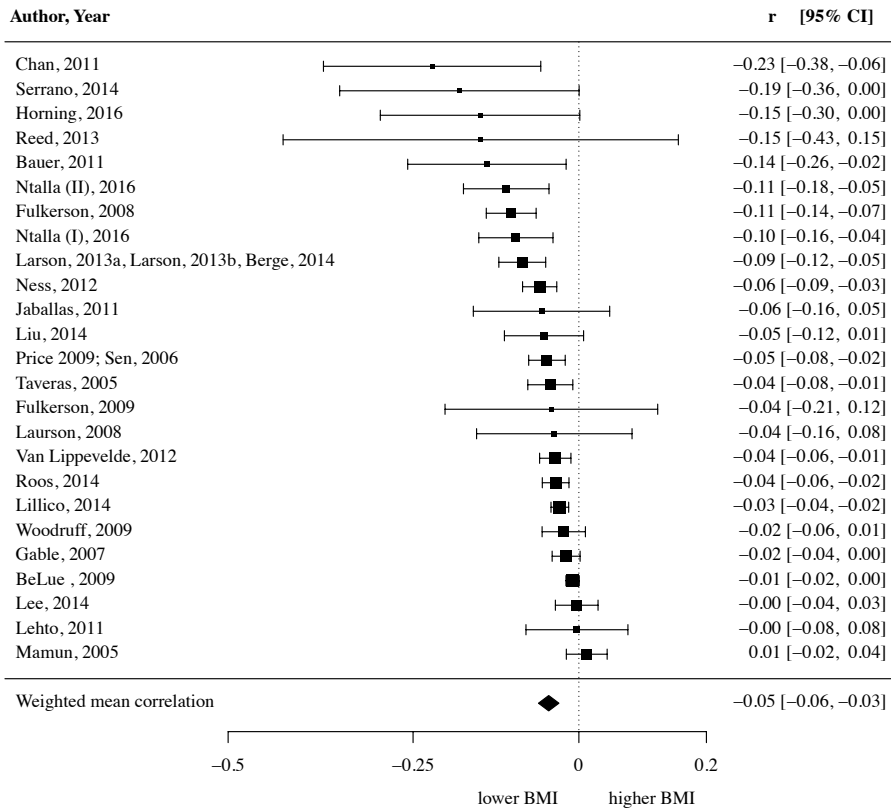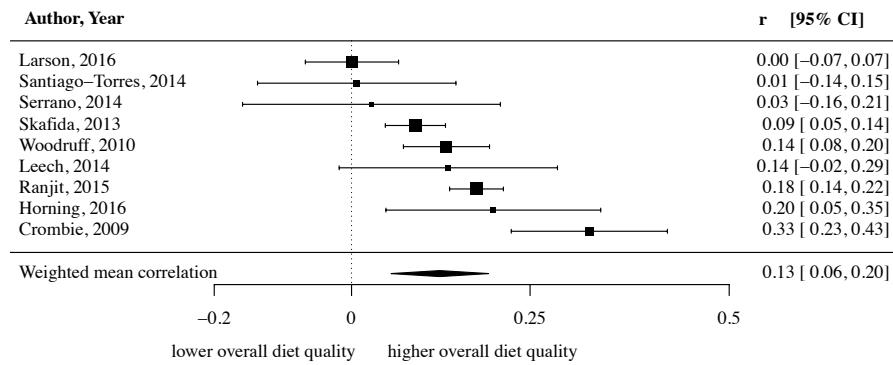*Note.* Results from mixed effects models. r = correlation coefficient; CI = confidence interval, k = number of samples; I^2 = heterogeneity index; QM = QM test of moderators with c − 1 degrees of freedom, where c is the number of categories in the moderator variable.
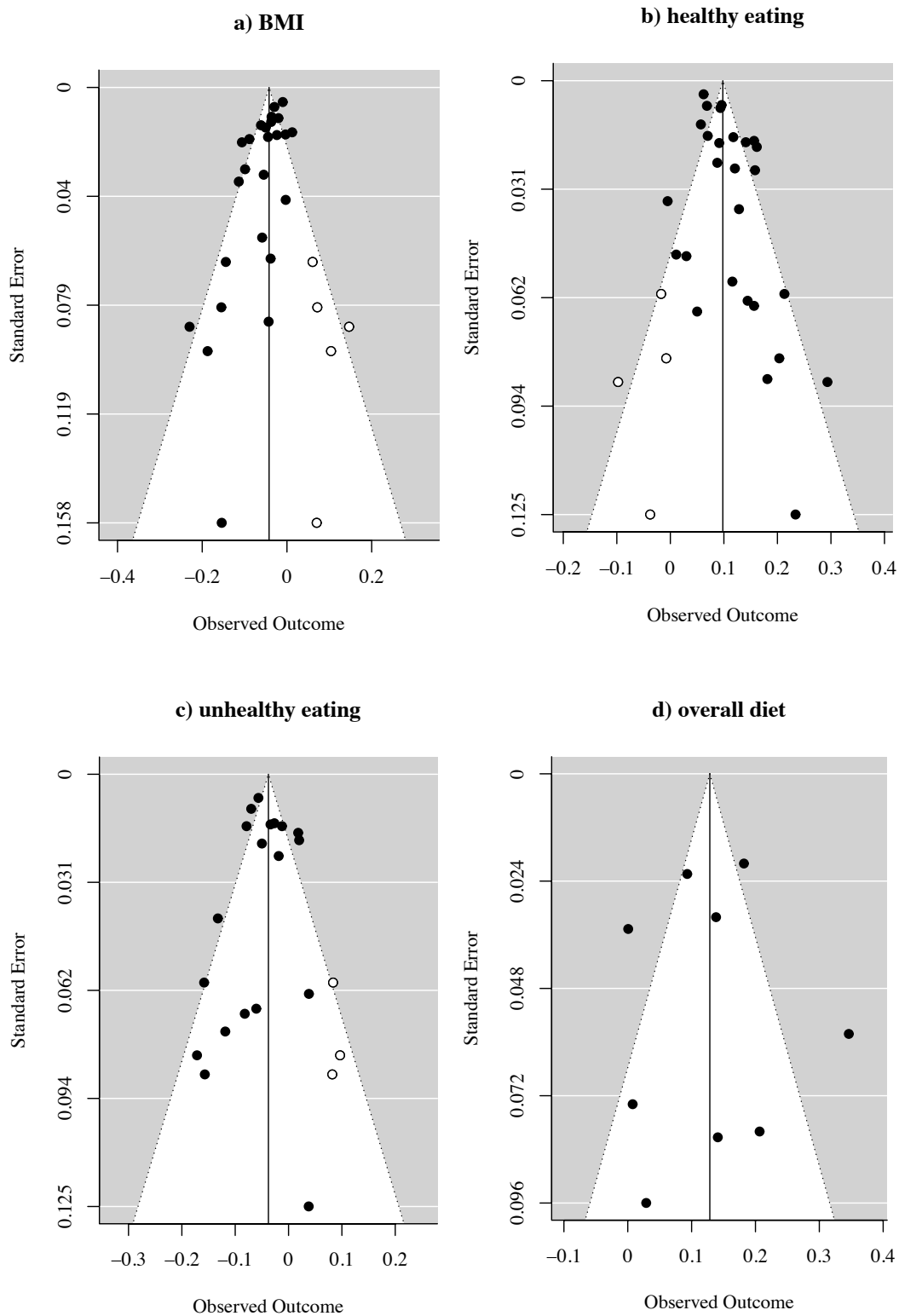* p <.05, ** p<.01.

Figure 6. Funnel plots with trimmed and filled effect sizes for (a) BMI, (b) healthy eating, (c) unhealthy eating, (d) overall diet.

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Manuscript 2

Dallacker, M. Hertwig, R., & Mata, J. (2017). *More than just food: A meta-analysis of family mealtime practices and children's nutritional health*. Manuscript under review.

More Than Just Food:

A Meta-Analysis of Family Mealtime Practices and Children's Nutritional Health

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Abstract

Figuratively speaking, family meals are the cradle of eating behavior: by the age of 10, a child has eaten about 10,000 meals, most of them in a family setting. A higher frequency of family meals is known to be associated with better diet quality and lower body mass index (BMI) in children. But what aspects of family meals make them healthy for children? This meta-analysis systematically summarizes studies on social, environmental, and behavioral attributes of family meals that have the potential to positively influence children's nutritional health. Six frequently investigated family mealtime practices were identified (from 43 studies with 40,569 participants reporting 57 effect sizes). In separate meta-analyses, positive associations consistently emerged between the following practices and children's nutritional health: TV off during meals ($r = .08$), higher food quality ($r = .11$), parental modeling ($r = .11$), positive atmosphere ($r = .12$), and longer meal duration ($r = .20$). Children's involvement in meal preparation was associated with better diet quality ($r = .08$), but also with higher BMI ($r = -.06$). Mechanisms potentially underlying these effects are proposed, building on the Herman, Roth, and Polivy (2003) model of how the presence of others shapes eating behaviors. The generalizability of the identified mealtime practices is discussed, as are potential practical implications.

Keywords: children, body mass index, diet quality, family meals, meta-analysis

More Than Just Food:

A Meta-Analysis of Family Mealtime Practices and Children's Nutritional Health

Overweight and obesity are a global phenomenon. In the Americas and Europe, for example, rates of overweight and obesity have been climbing for decades; overweight rates now approach 60% and obesity rates up to 27% (NCD Risk Factor Collaboration [NCD-RisC], 2016; World Health Organization [WHO], 2015). Obesity is associated with serious health consequences, such as diabetes, coronary heart disease, and cancer (WHO, 2015), as well as with reduced psychological wellbeing and quality of life (Guh et al., 2009; Kolotkin, Crosby, & Williams, 2002). The increasing prevalence of overweight and obesity is not confined to adults. For example, about 17% of U.S. children and adolescents are obese and a further 15% are overweight (Ogden, Carroll, Kit, & Flegal, 2014). Childhood overweight and obesity are not only associated with impaired physiological and psychological health but strongly predict overweight in adulthood (Daniels, 2009; Guo & Chumlea, 1999; Weiss & Caprio, 2005).

Various factors contribute directly or indirectly to obesity and overweight. Genetic factors (e.g., preference for fatty food and a fast eating rate, Rolls, Morris, & Roe, 2002), psychological factors (e.g., learning history, Birch & Anzman-Frasca, 2011; or stress, Epel, Lapidus, McEwen, & Brownell, 2001), and environmental factors (e.g., abundance of calorie-dense food, J. O. Hill, Wyatt, & Peters, 2005) impact weight-related behaviors such as energy intake and physical activity. To date, no single factor has been identified that can explain—or has the potential to stop—the global rise in obesity. It is therefore important to consider a number of possible levers to fight obesity, knowing that each one can have a meaningful, albeit not necessarily large, effect on obesity and its reduction.

Most people eat in in the company of others most of the time (Herman, Roth, & Polivy, 2003). This applies particularly to children.[1] Considerable research demonstrates that social influences at mealtimes are profound and can override hunger and satiety, making the social environment an important and promising candidate for the modification of eating behaviors (e.g., Cruwys, Beyelander, & Hermans, 2015; Herman et al., 2003, for reviews). In our meta-analytic investigation, we therefore focus on the relationship between children's social environment and their nutritional health. Specifically, we examine the extent to which a social institution in the life of a family—shared meals (henceforth *family meals*)—impacts children's diet quality and body weight. For children, the family—in particular, parents and other primary caregivers (e.g., grandparents; Coall & Hertwig, 2010; Patrick & Nicklas, 2005)—is the core social environment. The social institution of "family meals" is currently in flux, with less home-prepared food being eaten, a high ratio of meals being eaten out, and inexpensive take-away food being widely available—while numbers of dual-earner families, all-day schools, and children's extracurricular activities increase (Adams et al., 2015; Breaugh & Frye, 2008; Chen, Moser, & Nayga, 2015; Nielsen, Siega-Riz, & Popkin, 2002; Smith, Ng, & Popkin, 2013). Yet evidence of a decline in family meals is mixed, with some studies reporting a decrease in certain subgroups (e.g., youth from low socioeconomic backgrounds; Neumark-Sztainer, Wall, Fulkerson, & Larson, 2013) and others not finding any differences (National Center on Addiction and Substance Abuse, 2011). U.S. families still have on average 5.1 family meals/dinners per week (Saad, 2013), and each such meal represents a potential learning opportunity. It is therefore important to understand the role that family meals can play in the prevention of childhood overweight and obesity.

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[1] For reasons of simplicity, we generally refer to all minors as "children," without distinguishing between children and adolescents.

Family Meals as the "Cradle" of Eating Behavior

Parents are their children's nutritional gatekeepers. According to one estimate, they control about 72% of what and how much their family members eat (e.g., Wansink, 2006). They determine the variety (or lack thereof) in their children's food; they guide and, through their own behavior, model the amount and quality of food their children consume (Birch & Davison, 2001; Gibson et al., 2012; Savage, Fisher, & Birch, 2007). Parents thus shape the development of children's eating habits and food preferences. Acquired early in life, these are important drivers of children's present and future body weight. Assuming that children eat three meals a day, by the age of 10, they will already have experienced 10,000 meals, many in the family context. Figuratively speaking, family meals thus represent the "cradle" of eating behavior.

Researchers have recently begun to investigate the substantial potential of family meals to shape eating behavior (Fiese & Schwartz, 2008), with associations being found between the frequency of family meals and nutritional health (Hammons & Fiese, 2011). Specifically, numerous studies on family meals have focused on two indicators of nutritional health: weight status and diet quality. Weight status in children is commonly measured by the age-standardized body mass index (z-BMI or BMI percentiles), either as a continuous BMI score or by using cut-off points. Cut-off criteria for overweight differ slightly across studies, with most studies defining a BMI > 85th percentile as overweight. Diet quality typically reflects how well food intake meets dietary guidelines and recommendations—that is, to what extent the diet is composed of healthy (e.g., fruits and vegetables) and less healthy (e.g., sweets or soft drinks) foods.

What is known about the relationship between frequency of family meals and nutritional health? A number of studies have found shared meal frequency to be positively associated with

consumption of fruit and vegetables and negatively associated with consumption of fast food,

unhealthy snacks, and soft drinks (Feldman, Eisenberg, Neumark-Sztainer, & Story, 2007;

Fulkerson, Kubik, Story, Lytle, & Arcan, 2009). In addition, the frequency of family meals co-

occurs with a lower risk of overweight in children and adolescents (Chan & Sobal, 2011; Tovar

et al., 2013), though these effects are relatively small and somewhat inconsistent. The effects of

family meals on nutritional health appear to be more pronounced in younger children than in

adolescents, potentially because younger children are more dependent on their families, whereas

adolescents have a busier social life and are more engaged in out-of-home leisure activities

(Berge, Wall, et al., 2014; Fulkerson, Larson, Horning, & Neumark-Sztainer, 2014; Neumark-

Sztainer, Hannan, Story, Croll, & Perry, 2003). Longitudinal evidence is scarce and mixed: Two

longitudinal studies have found a higher frequency of family meals during adolescence to be

associated with a lower risk of overweight and obesity in early adulthood (Berge et al., 2015;

Sen, 2006). Another found it to predict a lower risk of overweight in the present but not in the

future (Taveras et al., 2005).

Hammons and Fiese (2011) have conducted a meta-analysis on the relationship between

frequency of family meals and children's nutritional health. They found that a frequency of three

or more family meals per week was associated with a decrease in the odds of overweight (OR =

1.12; corresponding to $r = 0.03$) and unhealthy eating (OR = 1.20; corresponding to $r = 0.05$) and

an increase in the odds of healthy eating (OR = 1.24; corresponding to $r = 0.06$). Two

conclusions can be drawn from these results: First, family meals have the potential to positively

affect children's diet quality and BMI. Second, the impact of family meals per se on children's

nutritional health appears to be quite small. Yet the size of this impact may depend on which

family mealtime practices are implemented. This raises the question of *how* others shape

children's eating behavior during family meals.

How Could Family Meals Foster Nutritional Health?

Herman and colleagues (2003) have proposed three potential mechanisms to explain how

the presence of others can shape food intake: inhibitory norms, social facilitation, and role

modeling. First, the presence and behavior of others can trigger inhibitory norms that can curb a

person's food intake. For instance, in a dating context, women are likely to eat less because

excessive eating is thought to appear less feminine and attractive (Pliner & Chaiken, 1990).

Second, social facilitation may lead a person to eat more in the presence of others than when

alone. Third, the eating behavior of others may provide a model for the quantity or quality of

food consumed. Of these mechanisms, only role modeling has been explicitly examined in the

family context: A handful of studies have shown that children's nutritional health is better if their

parents 'model' healthy eating—for instance, by consuming vegetables during family meals

(Draxten, Fulkerson, Friend, Flattum, & Schow, 2014). It seems likely that inhibitory norms and

social facilitation also operate in the context of family meals. For example, one study found that

children who were told that their eating behavior was being observed by their mothers chose

healthier snacks and consumed less unhealthy food than did their peers in a control group

(Klesges, Stein, Eck, Isbell, & Klesges, 1991), and nutritional gatekeepers establish food and

eating norms by being the architects of the family food environment (Cruwys et al., 2015).

Although the three mechanisms proposed by Herman et al. (2003) are likely to generalize

across many social contexts involving food, family meals differ from meals with peers in several

respects: (1) Parent–child relationships involve a power asymmetry: parents know more, define

norms, monitor behavior and, if necessary, enforce norms (Kuczynski, 2003; Maccoby, 2000). A

weaker power asymmetry, evidenced by a lower perceived hierarchy within a family, has been

reported to be associated with higher BMI in children (Hasenboehler, Munsch, Meyer, Kappler,

& Voegele, 2009). (2) The attachment and parenting style influences eating and diet quality

(Kremers, Brug, de Vries, & Engels, 2003). (3) Parents are nutritional gatekeepers, determining

the quality and quantity of food consumed by their children (Wansink, 2006). Additional

mechanisms beyond those proposed by Herman et al. (2003) may thus underlie how the presence

of others shapes eating behavior in the family-meal context.

What could these mechanisms be? Studies have investigated how various characteristics

of family meals relate to nutritional health in children. One is the atmosphere at the family table.

When families enjoy eating together, children are less likely to be overweight (e.g., Berge,

Rowley, et al., 2014; Moens, Braet, & Soetens, 2007). Some studies have found that children's

nutritional health is better when the TV is turned off during family meals (e.g., Roos et al., 2014)

but others have found no such effect (Wansink & van Kleef, 2014). Parental feeding styles are

strategies influencing the amount and type of food consumed by children and adolescents, such

as limiting the availability of unhealthy foods and/or rewarding the consumption of healthy

foods. Parental feeding styles have been widely investigated across many contexts and found to

impact children's diet but not necessarily their BMI (e.g., Brown, Ogden, Voegele, & Gibson,

2008).

One conclusion from this brief review of individual studies is that the findings are

relatively mixed. Narrative reviews have summarized these and other studies' findings on how

various social, environmental, and behavioral attributes of family meals are associated with

children's diet and body weight and identified several mealtime practices potentially associated

with better nutritional health in children (Fulkerson et al., 2014; Martin-Biggers et al., 2014; Patrick & Nicklas, 2005; Rockett, 2007; Skeer & Ballard, 2013; Woodruff & Hanning, 2008). A systematic and quantitative analysis could—as a next step—help to advance the understanding of how characteristics of family meals relate to children's nutritional health for several reasons. First, most existing reviews do not systematically review the literature, and they differ in the definitions of family mealtime practices used. Second, they do not quantify and analyze effect sizes. Third, they do not explicitly focus on family meals but cover a variety of family variables, such as aspects of the home food environment and demographic and sociocultural factors (e.g., Pearson, Biddle, & Gorely, 2009), with family meals not being clearly distinguished from other types of meals (e.g., children watching TV while eating alone or with the family). Fourth, no randomized controlled studies on mechanisms potentially underlying the relation between family meals and children's diet quality or body weight are currently available. A systematic review of family mealtime practices could offer valuable pointers on such mechanisms.

Research Questions

This meta-analysis addresses *potentially protective family mealtime practices*. We define these practices as social, environmental, and behavioral attributes of family meals that have the potential to boost children's diet quality and facilitate a healthy body weight.
We pursued two main research questions:

(1) Which family mealtime practices have been investigated to date in the context of children's nutritional health?

(2) How strong is the association between family mealtime practices and children's nutritional health? We explored potential moderators of the observed effect sizes, such as age

(children vs. adolescents), nutritional health (BMI vs. diet quality), and socioeconomic status (SES; controlled vs. not controlled for SES).

Method

This meta-analysis complies with the Meta-Analysis Reporting Standards (MARS; APA Publications Communications Board Working Group on Journal Article Reporting Standards, 2008) and, specifically, its recommendations to specify the search strategy, provide details on how primary studies were classified and coded, assess the quality of the primary studies, use appropriate methods to combine data, test for publication bias and heterogeneity, consider alternative explanations for observed results, and provide guidelines for future research.

Search Strategy

A three-step search strategy was developed with the assistance of a research librarian: First, we conducted a systematic literature search in *Web of Science* (search terms: ("family meal" OR "mealtime*" OR "shared meal" OR "dinner") AND ("BMI" OR "body mass index" OR "overweight" OR "obesity" OR "food intake" OR "eat*" OR "diet" OR "nutrition") [Refined by topic "child*" OR "adolescent*" OR "young adults]); *PubMed* (Medical Subject Headings (MeSH): ("Diet" OR "feeding behavior") AND "family" [Filter: "preschool child," "child," "adolescent"]) and in *PsycInfo* (search terms: ("body mass index" OR "body weight" OR "obesity" OR "overweight" OR "diets" OR "eating behavior" OR "food" OR "food preferences" OR "nutrition") AND ("mealtimes" (Thesaurus) OR "meal*" OR "dinner" OR "lunch")). Note that because we used both free and controlled vocabulary (i.e., MeSH terms in Pubmed; Thesaurus in PsycInfo), the exact search terms used differed between databases. We included published and unpublished studies (e.g., dissertations, conference abstracts) written in

English or German, without any restrictions on the year of publication. The literature search was concluded in January 2016. Second, we performed forward searches on relevant studies found in the literature search, using Web of Science to identify later articles that cited them. Third, we conducted backward searches on literature reviews, that is, we reviewed their reference lists. Throughout, we used key terms that cast a wide net to identify studies that did not necessarily include mealtime practices in their title or abstract. This procedure is likely to have increased the probability of including studies with non-significant results.

Screening for Eligibility

Studies had to meet three criteria to be eligible for inclusion in the meta-analysis: They had to report (i) at least one family mealtime practice, (ii) one indicator of nutritional health that was child- or adolescent-focused, (iii) one bivariate statistical association between the relevant mealtime practice and indicators of nutritional health. Studies were excluded if they focused on a specific population that had feeding problems or required a special diet (e.g., people with learning difficulties, autism, diabetes, or cystic fibrosis). Manifestly irrelevant studies (e.g., focusing on animals, older adults, the school setting, breastfeeding, or eating disorders) were excluded after screening of the title or abstract. For all other studies, the full text was screened to determine eligibility. A PRISMA flow diagram (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009) of the screening process is given in Figure 1.

The first author and an independent rater initially screened 300 studies against the above criteria. Because the agreement rate (Cooper, Hedges, & Valentine, 2009) proved to be very high (95%), the remaining 3,147 studies were screened and categorized by only one rater.

Categorization of Mealtime Practices

To document which mealtime practices have been investigated thus far in the context of nutritional health, we produced a table summarizing all mealtime practices identified in the literature search. In total, 18 mealtime practices were identified. There is no objective criterion determining how many studies are needed to conduct a meta-analysis. We decided to further investigate mealtime practices investigated in at least five studies.

Coding of Studies

Studies were coded according to established guidelines (Card, 2011). The following information was coded for each study:

- Sample characteristics: demographic features (ethnic composition, age), sample size.

- Measurement characteristics: source of information (child, parent report, observer), type and description of measure used (nutritional health and mealtime practice).

- Design characteristics: cross-sectional versus longitudinal.

- Source characteristics: author, year of study, publication type.

- Study quality: external validity (e.g., random sampling procedures, specific subpopulations), construct validity (reliability of measures, relevant measurement characteristics).

Outcome Variable Nutritional Health

Nutritional health is an indicator of health that goes beyond the exclusive focus on body weight. Two qualitatively different components of nutritional health are examined: children's BMI and diet quality. Effect sizes for both indicators are reported separately as well as combined. BMI is an indirect measure of body fat and obesity, both of which are linked to serious health conditions such as asthma, diabetes and a higher risk of obesity in adulthood

(Daniels, 2009, Guo and Chumlea, 1999; Weiss and Caprio, 2005). Importantly, focusing on BMI alone has several drawbacks. First, BMI is only an approximate measure of obesity and body fat (e.g., Rothman, 2008). For example, BMI does not distinguish between muscle and fat mass, and consequently, many body builders would be considered overweight based on their BMI. Second, BMI is only one of several risk factors for chronic degenerative diseases and can be compensated by lifestyle. For example, the risk of coronary heart disease for sedentary women with a healthy waist is similar to that of overweight women who are physically active (Li et al., 2006). Last, emphasizing BMI as intervention target has ethical consequences and can lead to body shame, stigmatization, and dysfunctional eating behaviors in those who are or feel that they are placed outside of standard norms (Bacon and Aphramor, 2011). For these reasons, we analyzed diet quality as an indicator of nutritional health in addition to BMI. A better diet quality, such as higher fruit and vegetable intake, is associated with several health benefits including lower risk of diabetes, heart diseases and stroke – often above and beyond body weight (He, Nowson, & Mc Gregor, 2006; He et al., 2007; Muraki et al., 2013).

Effect Size

We chose the correlation coefficient r as an effect size of the association between mealtime practice and nutritional health for several reasons: many of the studies reported r values; r values can be computed from a wide range of statistics; most measures were continuous (or artificially dichotomized); and r is an easily interpretable effect size. The results were coded such that a positive effect size indicates that the mealtime practice in question is positively associated with better nutritional health (if necessary, the direction of the r-value was reversed). If available, unadjusted r-values were used. If r-values were not available but standardized regression coefficients were, we used those (Becker & Wu, 2007; Bowman, 2012; Peterson &

Brown, 2005). If statistics other than *r* were reported, such as *t*-test or odds ratios, we converted them into *r*-values (Borenstein, Hedges, Higgins, & Rothstein, 2009; Card, 2011). If a study did not report sufficient statistics to calculate an *r*-value, we contacted the authors up to two times. Seven of the 15 authors contacted responded to these queries.

Artifact Corrections

Dichotomizing a continuous variable attenuates its association with other variables (Card, 2011). Because some of the primary studies included in the meta-analysis may be affected by this artifact, *r* was corrected whenever continuous variables were dichotomized (e.g., BMI was measured, but the analysis was based on the BMI categories "normal" vs. "overweight"; for details, see Hunter & Schmidt, 2004, p. 36).

Data Synthesis: Estimating Overall Effect Sizes for Mealtime Practices

To investigate our second research question, the strength of the association between family mealtime practices and nutritional health in children, we conducted a separate meta-analysis for each mealtime practice identified. Furthermore, *r*-values were transformed using variance-stabilizing Fisher's *z* transformation (Borenstein et al., 2009), and all analyses used the *r*-to-*z* transformed values. For forest plots and tables, pooled effect sizes were back-transformed to *r*-values.

A random effects size approach was used to calculate a pooled effect size with 95% confidence intervals. Random effects models do not assume a single effect size but a distribution of population effect sizes; consequently, they consider systematic variance between studies (Borenstein et al., 2009). We used random effects models because the primary studies differed in how they examined specific mealtime practices and nutritional health (see Results). Within each

practice, we calculated a pooled effect size for BMI, for diet quality, and for nutritional health (i.e., for both measures combined).

Heterogeneity

We calculated Q tests to assess the null hypothesis of homogeneity among effect sizes. A nonsignificant Q test would indicate that between-study variance stems from random rather than systematic differences. Heterogeneity was quantified with I^2 statistics indicating the degree of systematic variance between studies (Huedo-Medina, Sanchez-Meca, Marin-Martinez, & Botella, 2006): An I^2 value of 0 would mean that between-study variance results from random error; values above 0 would indicate the proportion of systematic between-study variance.

Moderator Analyses

In addition to estimating the overall effect size, we conducted moderator analyses to identify conditions under which mealtime practices have particularly strong effects and to shed light on the sources of heterogeneity. Outcome type (BMI vs. diet quality), age of target population (children vs. adolescents), and SES (controlled vs. not controlled for SES) were examined as potential moderators. Moderator analyses were conducted only for mealtime practices investigated in more than 10 studies (Borenstein et al., 2009).

Publication Bias

We used funnel plots to investigate the possibility that studies finding nonsignificant results were less likely to be published. Funnel plots are scatterplots of effect sizes in primary studies and their standard errors; asymmetric funnel plots may indicate publication bias (Light, Singer, & Willet, 1994). We used Egger's linear regression method to test for funnel plot asymmetry. Additionally, we used the "trim and fill" method to impute suspected missing studies

until the studies were symmetrically distributed around the pooled effect size; we then computed

an adjusted effect size (Duval & Tweedie, 2000).

Multiple Effect Sizes From Single Studies

Some of the studies reported data from two or more independent subgroups (e.g., girls

and boys; low and high SES). We treated each subgroup as a separate study and computed a

pooled effect size for each. Some of the studies reported multiple results for the same sample

(e.g., BMI and diet quality). Others shared the same sample, but reported on different outcomes.

In these cases, we computed a pooled effect size but took the correlation among the outcomes

into account (Borenstein et al., 2009). When investigating outcome type (BMI vs. diet quality) as

a moderator, if a study reported both, we calculated separate effect sizes. All analyses were

implemented using the *metafor* package in the statistical software *R* (version 3.1.1; Viechtbauer,

2010).

<div align="center">Results</div>

Research Question 1: Which family mealtime practices have been investigated in the

context of children's nutritional health?

Our keyword search yielded 4,052 potentially relevant articles. Thirteen further articles

were identified through forward and backward search. After duplicates were removed, our pool

comprised 3,447 articles. Of these, 118 examined the association between one or more mealtime

practice(s) and at least one indicator of nutritional health (see Methods section for inclusion and

exclusion criteria). Thirteen articles were excluded because they did not provide sufficient data

to compute effect sizes, and 32 articles were excluded because there were too few primary

studies to investigate the respective mealtime practice within a meta-analytic framework. This

resulted in a total of 73 studies being selected for further analyses. Of those, 37 investigated feeding styles as reviewed in Table 1; these studies were not included in the quantitative analysis unless they also researched relevant mealtime practices. This resulted in a total of 43 studies being included in the meta-analysis (Table S2 in the Supplementary Material lists the excluded studies with reasons for their exclusion).

Mealtime Practices Identified for Analysis

The literature search identified six mealtime practices for analysis, with 57 relevant effect sizes being reported in 43 studies.

TV off refers to the practice of turning the TV off during family meals. Studies examining this practice ($k = 14$) asked participants how often they watched TV during shared meals.

Food quality refers to the nutritional quality of family meals. Studies examining this practice ($k = 11$) asked how often the family ate vegetables, home-cooked meals, fast food take-aways, or at fast food restaurants.

Parental modeling refers to parental eating behavior that provides a model for the quantity or quality of food consumed. The relevant studies ($k = 12$) measured this practice directly by asking parents if they modeled healthy food consumption at mealtimes (e.g., eating vegetables) or indirectly by asking parents if they ate the same food as their children during family meals.

Atmosphere refers to the mood during shared meals. Some studies used parental self-reports of how enjoyable family mealtimes are; others assessed atmosphere using expert ratings of videotaped family meals ($k = 9$).

Children's involvement refers to children's participation in family meal preparation. The relevant studies ($k = 6$) asked how involved a child was in this activity.

Duration of meals refers to how long family meals last. The relevant studies ($k = 5$) assessed duration by measuring the average length of videotaped family meals or by asking if mealtimes were a rush.

Another important mealtime practice was identified in the literature but not ultimately included in the analyses. *Feeding styles* are parental strategies influencing the amount and type of food consumed by their children. The relevant studies differed substantially in how they defined and measured feeding styles. For instance, a controlling feeding style was measured using questionnaires assessing concepts as diverse as authoritarian feeding styles, pressure to eat, and restriction, or more general concepts, such as obligations or good manners. In addition, in some cases, studies that measured the same behaviors classified them as indicators of different styles (e.g., some studies classified the behavior of encouraging children to eat as a controlling feeding style; others, as an indicator of a supporting or authoritative feeding style). Given such heterogeneous definitions and assessments, it is not clear how the results of a meta-analysis could be interpreted. Instead, Table 1 provides an overview of the different feeding styles examined and frequency counts of studies reporting an association with nutritional health.[2]

The two other key concepts in our literature analysis were family meals and nutritional health:

Family meals. Some studies assessed main meals in general; others separately assessed dinner, lunch, or breakfast.

Nutritional health. The primary studies analyzed the first indicator of nutritional health—children's BMI—either as a continuous or a categorical (normal weight, overweight, obesity)

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[2] We only included studies that examined feeding styles in the context of family meals. Studies analyzing snacking behavior and the control of the general home environment (e.g., studies using the child feeding questionnaire [CFQ; Birch et al., 2001]) were not included.

measure. The second indicator of nutritional health, diet quality, was measured by food frequency questionnaires assessing the intake of healthy and unhealthy foods either on a continuous scale (e.g., amount of fruit, vegetables, fast food, chips, sweets, and soda consumed per day) or by assessing specific categories (e.g., whether a child eats five or more portions of fruit and vegetables per day).

Study Characteristics

Table 2 summarizes the characteristics of the studies included in the six separate meta-analyses by mealtime practice (for more details, see Tables S1 in the Supplementary Materials). In total, 43 studies with a total of 40,569 participants (range: 40–4,072) were analyzed. Of these, 34 studies examined one mealtime practice, five studies examined two of the mealtime practices included in our meta-analyses, three studies examined three mealtime practices, and one study examined four mealtime practices. Twenty-five studies focused on children (2–10 years) and 18 on adolescents (11–18 years). Eleven studies were published between 2000 and 2009 and 32 between 2010 and 2016. None of the studies published before 2000 fulfilled the inclusion criteria. Samples stemmed from diverse countries, with the majority coming from the United States ($k = 27$). Most studies were cross-sectional; only three had a longitudinal design. Twenty-one studies examined diet quality as indicator for nutritional health, 17 studies examined BMI, and five studies reported both. For 33 studies we were able to use unadjusted r-values in the analyses; for 10 studies we had to use r-values adjusted for covariates. Finally, 14 studies controlled for indicators of SES. More specifically, eight studies adjusted effect sizes for proxies of SES, such as education and income, and six studies eliminated the influence of SES by

investigating samples that were homogenous with respect to low SES; the other 29 studies investigated heterogeneous samples and did not control for indicators of SES.

Research Question 2: How strong is the association between family mealtime practices and children's nutritional health?

In this section, we report pooled effect sizes, heterogeneity analyses, moderator analyses, and publication bias statistics for each mealtime practice. Figure 2 shows the corresponding forest plots, Figure 3 the funnel plots, and Figure 4 the distribution of effect sizes across all mealtime practices separately for adolescents and children.

TV Off

Fourteen studies with 13,140 participants examined the association between watching TV during family meals and children's nutritional health. The random effect size model revealed a significant pooled effect size ($r = .08$, 95% CI [0.04–0.12]; see Figure 2 for a forest plot). The statistical test of heterogeneity indicated significant heterogeneity ($Q = 24.85$, $p < 0.001$), with an I^2 index of 70.06%.

We conducted independent moderator analyses for outcome type (BMI vs. diet quality), sample age (children vs. adolescents), and SES (controlled vs. not controlled for SES). A larger pooled effect size was found for diet quality ($r = .11$, 95% CI: [.06–0.17]) than for BMI ($r = 0.05$ [95% CI: .00–0.11]). However, the effect of the moderator was not significant ($Q_M = 2.41$; $df = 1$; $p = 0.120$). Likewise, a higher pooled effect size was found for children ($r = .10$, 95% CI [0.04–0.15]) than for adolescents ($r = .07$, 95% CI [.00–0.14]) but age was not a significant moderator either ($Q_M = 0.35$; $df = 1$; $p = 0.554$). The pooled effect size from studies controlling for SES ($r = 0.08$, 95% CI [0.01–0.15]) was similar to that from studies not controlling for SES

($r = 0.09$, 95% CI [0.03–0.15]). Accordingly, SES was not a significant moderator ($Q_M = 0.09$; $df = 1$; $p = 0.768$).

A funnel plot showed a roughly symmetrical distribution of effect sizes by standard error, and Egger's regression test for funnel plot asymmetry was not significant ($p = 0.215$). The trim and fill method did not impute missing studies; see Figure 3a.

Food Quality

Eleven studies with 9,878 participants investigated the association between the quality of family meals and nutritional health. The pooled effect size was significant ($r = .11$, 95% CI [.06–.16]; see Figure 2 for a forest plot). The heterogeneity of effects was significant ($Q = 47.36$, $p < 0.001$; $I^2 = 79.35\%$).

The pooled effect size was higher across studies assessing diet quality ($r = .15$, 95% CI [.06–.23]) than across studies assessing BMI ($r = .10$, 95% CI [.04–.15]). However, the effect of the moderator was not significant ($Q_M = 1.03$; $df = 1$; $p = .310$). The pooled effect size of studies with children ($r = .11$, 95% CI [0.02–.21]) was comparable to that of studies with adolescents ($r = .11$, 95% CI [.05–.18]), and sample age was not a significant moderator ($Q_M = 0.04$; $df = 1$; $p = .847$). Likewise, the pooled effect size of studies controlling for SES ($r = 0.12$, 95% CI [0.03–0.23]) was similar to that of studies not controlling for SES ($r = 0.11$, 95% CI [0.5–0.17]), and SES was not a significant moderator ($Q_M = 0.09$; $df = 1$; $p = 0.765$).

The funnel plot was slightly skewed to the right. Egger's regression test for funnel plot asymmetry was not significant ($p = 0.104$). Trim and fill analysis imputed five studies, resulting in an adjusted estimate of $r = .07$, 95% CI [0.02–0.12]; see Figure 3b. Although lower, the adjusted effect size was still significant; therefore, we do not consider the threat of publication bias to be grave (see Rothstein, Sutton, & Borenstein, 2005).

Parental Modeling

Twelve studies from 11 samples with 7,966 participants investigated the association between parental modeling and nutritional health. We found a significant pooled effect size (r = .11, 95% CI [.07–.15], see Figure 2). The heterogeneity of effects was significant (Q = 42.32, p < 0.001; I^2 = 69.35%).

On a descriptive level, the pooled effect sizes for studies assessing diet quality were higher (r = 0.11 [95% CI: 0.07–0.15]) than for studies assessing BMI (r = 0.04 [95% CI: .01–.07]). The effect of the moderator was significant (Q_M = 5.06; df = 1; p = 0.025). Studies with children revealed a higher pooled effect size (r = .13, 95% CI [0.08–0.17]) than studies with adolescents (r = .06, 95% CI [–.01–.13]). Sample age was not a significant moderator (Q_M = 2.76; df = 1; p = 0.096). The pooled effect size for studies controlling for SES (r = 0.11, 95% CI [0.04–0.17]) was equal to that for studies not controlling for SES (r = 0.11, 95% CI [0.05–0.16]); the moderator analysis was not significant (Q_M = 0.00; df = 1; p = 0.979). Studies used two conceptually different measures of parental role modeling: indirect measurement (asking parents if family members ate the same meal) versus direct measurement (asking parents if they modeled healthy eating). We therefore also investigated direct versus indirect measurements as moderators. The pooled effect size was r = .13, 95% CI [.06–.21] for indirect measurement and r = .10, 95% CI [.05–0.14] for direct measurement; the moderator analysis was not significant (Q_M = 0.58; df = 1; p = 0.441).

The funnel plot was roughly symmetrical and Egger's regression test was not significant (p = 0.899). The trim and fill method added one study, leading to an adjusted effect size of r = 0.10, 95% CI [0.06–0.14]; see Figure 3c.

Atmosphere

Nine studies with 7,763 participants investigated the association between atmosphere and nutritional health. We found a significant pooled effect size ($r = 0.12$, 95% CI [0.06–0.19], see Figure 2). Heterogeneity was significant ($Q = 47.55$ $p < 0.001$; $I^2 = 84.75\%$). Although too low in power to investigate as a moderator, on a descriptive level, studies using observational methods had a higher pooled effect size and lower heterogeneity ($r = .25$, CI [.13–.37], $I^2 = 0\%$) than did studies using parental self-reports of mealtime enjoyment ($r = .10$, 95% CI [.03–.16], $I^2 = 89.60\%$). In other words, heterogeneity seems to be located in studies assessing atmosphere by means of self-report.

The pooled *r* was higher for studies focusing on children ($r = 0.15$, 95% [CI: 0.05–0.25]) and studies examining BMI ($r = .14$, 95% CI [.05–.27]) than for studies focusing on adolescents ($r = 0.09$, 95% CI [−.02–0.20]) and studies examining diet quality ($r = .09$, 95%CI [.02–.16]. Because only one study controlled for SES, we did not calculate effect sizes for subgroups here. Also, because fewer than 10 studies were included in this analysis, we did not test for moderator effects.

Egger's regression test was not significant ($p = 0.17$). The trim and fill method imputed three additional studies, resulting in an adjusted effect size of $r = 0.09$, 95% CI: [0.02–0.16]; see Figure 3d.

Children's Involvement

Six studies with 8,989 participants investigated the association between children's involvement in the preparation of the family meals and their nutritional health. The pooled effect size was not significant ($r = .04$, 95% CI [−.03–.11]; see Figure 2). Heterogeneity was significant

($Q = 35.10$, $p < 0.001$) and the corresponding I^2 index suggested high systematic variance across studies ($I^2 = 87.17\%$).

The pooled effect size for studies examining diet quality was statistically significant ($r = .08$, 95% CI [.04–.11]). Notably, the pooled effect size for studies examining BMI as an outcome was also significant but negative ($r = -.06$, 95% CI [−.11–−.02]), indicating that children's involvement in preparing family meals was associated with higher BMI. The outcome investigated in the primary studies may be a source of heterogeneity: our results showed a considerable difference between the pooled effect sizes for diet quality and BMI and lower heterogeneity for each effect size (BMI: $I^2 = 20.45\%$, diet quality: $I^2 = 49.83\%$). The pooled effect size for studies with children ($r = .07$, 95% CI [−0.03–.17]) was higher than that for studies with adolescents ($r = .01$, 95% CI [−.09–.12]. The pooled effect size for studies controlling for SES was descriptively higher ($r = .10$, 95% CI [−0.05–0.26]) than that for studies not controlling for SES ($r = 0.03$, 95% CI [−0.05–0.11]). Again, we did not conduct a formal moderator analysis because fewer than 10 studies were available. Note that only two studies controlled for SES.

The funnel plot was roughly symmetrical; Egger's regression test was not significant ($p = .973$) and the trim and fill method did not indicate any missing studies; see Figure 3e.

Duration of Meals

Five studies with 2,666 participants investigated the association between duration of meals and nutritional health. The pooled effect size was significant ($r = .20$, 95% CI [.09–.29]; see Figure 2). Heterogeneity was not significant ($Q = 7.12$, $p = .130$), with an I^2 index of 45.60%. Given the low number of studies, we did not investigate pooled effect sizes for subgroups.

The funnel plot was skewed to the right. Egger's regression test for funnel plot asymmetry was significant ($p = 0.008$). Trim and fill analysis imputed three studies, resulting in an adjusted estimate of $r = .12$, 95% CI [0.02–0.23]; see Figure 3f. Although lower, the adjusted effect size was still significant; therefore the impact of meal duration can be considered modest (Rothstein et al., 2005).

Discussion

We conducted a systematic review of the literature on the relationship between family mealtime practices and children's nutritional health. The goal was to reveal potentially protective practices that could explain why frequent family meals foster children's nutritional health (Hammons & Fiese, 2011). We identified six practices, each showing typically small but reliable associations with nutritional health in children. Next, we discuss our findings in relation to the two guiding research questions, theoretical implications (in terms of potential mechanisms), the strengths and limitations of our analysis, and possible practical implications.

Which Family Mealtime Practices Have Been Investigated to Date in the Context of Children's Nutritional Health?

Our systematic search identified family mealtime practices that have thus far been investigated in the context of children's nutritional health. They pertain to the social, environmental, and behavioral attributes of the family meal and thus shed light on what it is about family meals that can make them a lever for improving children's nutritional health. To be included into the analysis, a practice had to be investigated across at least five studies and thus suitable for a meta-analytical approach. We analyzed six practices: TV off, food quality, parental modeling, atmosphere, children's involvement, and duration of meals.

How Strong Is the Association Between Family Mealtime Practices and Children's

Nutritional Health?

The meta-analysis produced five key results. First, each mealtime practice was

significantly associated with better nutritional health in children. Effect sizes were small but

significant, ranging from $r = .08$ (TV off) to $r = .20$ (duration). The only exception was

children's involvement in food preparation, for which the overall effect size ($r = .04$) was not

significant; however, its pooled effect size was significant for studies analyzing diet quality as

the outcome ($r = .08$). Importantly, although small, the effect sizes for all mealtime practices

(except children's involvement) proved larger than the overall effect sizes found in meta-

analyses on the association between the *frequency* of family meals and children's nutritional

health (Hammons & Fiese, 2011). This suggests that specific mealtime practices are stronger

predictors of children's nutritional health than is the frequency of shared meals alone.

Second, there were notable differences between mealtime practices. For illustration, let us

consider watching TV during meals. Nearly all reviews on family determinants of children's

eating behavior and body weight include this behavior, suggesting that many researchers expect

it to be of importance. Indeed, we found not having the TV on during meals to have a beneficial

effect. Importantly, though, the effects of all other significant mealtime practices were larger.

One possible explanation is that food and social interactions are in the foreground during family

meals, and that the TV blends into the background, making it less distracting than when someone

eats alone in front of the TV. Comparative analyses such as ours render it possible to generate

hypotheses about the relative importance of various mealtime practices for children's nutritional

health.

Third, at a descriptive level, we consistently found stronger associations between mealtime practices and nutritional health for children than for adolescents (Figure 4), though only one of these differences—parental modeling—was significant. This result is consistent with previous findings showing that adolescents' eating behavior is more strongly influenced by peers, school, media, or cultural norms than is younger children's (Story, Neumark-Sztainer, & French, 2002).

Fourth, we did not find differences in effect sizes between studies controlling for SES and studies not controlling for SES. This suggests that the associations observed between the mealtime practices and nutritional health do not depend on SES (exception: family mealtime atmosphere, for which not enough studies were available to test the potential moderating role of SES). This conclusion requires further investigation, however, as only 30% of the studies included controlled for SES. Previous studies have found the frequency of family meals to be positively associated with economic resources and years of parental education (Anderson, 2012; Bauer, Neumark-Sztainer, Fulkerson, Hannan, & Story, 2011; Fulkerson, Neumark-Sztainer, & Story, 2006). We cannot rule out the possibility that SES affects the *frequency* of specific mealtime practices. For example, it has been shown that watching TV during dinner is more prevalent in low-SES families (Berry, 2007). Importantly though, our results suggest that the association between TV off and nutritional health exists above and beyond effects of SES, making this mealtime practice relevant for families of all economic backgrounds.

Fifth and finally, we did not find important significant moderators. It is possible that the statistical power to detect moderator effects was insufficient due to the small numbers of studies included. As more studies are conducted in the future, the moderator analysis can be redone.

Mechanisms Potentially Underlying the Effects of Family Meals

Our meta-analysis built on previous work that has suggested mechanisms to explain how the presence of others shapes eating behaviors (e.g., Herman et al., 2003). The mechanism that most naturally applies to the family context is role modeling. Indeed, we found evidence that *parental modeling* of healthy eating is related to children's nutritional health. Unfortunately, our search did not identify enough studies to examine other relevant mechanisms, namely, social facilitation and inhibitory norms. However, our findings suggest that other potential mechanisms, including some that are not social in nature, also operate in the context of family meals. We next turn to those mechanisms.

TV off. Why is it beneficial to turn off the TV during family meals? One potential explanation is that the concurrent activities of watching TV and eating impair the individual's capacity to monitor food intake or attend to satiety cues (Bellisle, Dalix, & Slama, 2004; Blass et al., 2006; Scheibehenne, Todd, & Wansink, 2010; Wansink, Shimizu, Cardello, & Wright, 2012). Another is that eating behavior is influenced by on-screen food advertisements. Up to 90% of foods advertised are high in fat and sugar (Batada, Seitz, Wootan, & Story, 2008). Moreover, children's exposure to TV food advertising is associated with altered snack choices and consumption patterns (Gorn & Goldberg, 1982; Harris, Bargh, & Brownell, 2009). These latter effects may, however, be more likely to operate outside the context of family meals (Higgs & Woodward, 2009). Another possible effect during family mealtimes is that parents distracted by the TV are less able to monitor the amount and quality of food consumed by their children (Fiese, Jones, & Jarick, 2015).

Food quality. Family meals are beneficial to the extent that they are, on average, of higher quality and healthier than other kinds of meals. A high frequency of shared meals can

trigger an important psychological effect, namely, liking. Assuming that family meals tend to be homemade and not processed or ready-made, frequent family meals may involve exposure to healthier foods, such as vegetables and fish. Frequency, in turn, produces familiarity, and familiarity breeds liking. This *mere-exposure effect* (Bornstein & Ludemann, 1989) may be one mechanism that engenders a link between frequent family meals, liking of healthier food, and nutritional health in children, whose food preferences are still highly malleable (Gibson et al., 2012; Hausner, Olsen, & Moller, 2012).

It is not unreasonable to speculate that the societal norm that family meals are homemade has changed: The frequency of out-of-home food consumption is high (e.g., one third of children and adolescents in the United States consume fast food on a given day; Vikraman, Fryar, & Ogden, 2015), and half of the energy that children obtain from fast food is eaten at home (Poti, & Popkin, 2011). Eating fast food, in turn, is associated with higher intake of fat and bigger portions than is eating home-prepared food (Guthrie, Lin, & Frazao, 2002; Lachat et al., 2012). Thus, if family meals tend to be unhealthy (e.g., fast or convenience food), the otherwise protective effect of family meals may be thwarted.

Atmosphere. A positive mealtime atmosphere is related to better nutritional health, whereas a stressful atmosphere has detrimental effects. It is possible that stress-inducing family mealtime environments (e.g., due to parent–offspring arguments) prompt children to regulate their unpleasant emotions by consuming high-energy and fatty foods (Singh, 2014). If this occurs repeatedly, children may learn to comfort themselves with food and to engage in emotional eating (Wildermuth, Mesman, & Ward, 2013). Notably, the pooled effect size for studies examining BMI as an outcome was higher than that for studies examining diet quality. Although the number of studies available was too low to examine the effects of potential moderators, this

result deserves further attention, as for all other mealtime practices the pooled effect size for diet quality was higher than that for BMI. Most of the primary studies examined fruit and vegetable intake as an indicator of diet quality. One explanation for the lower effect sizes reported in studies examining diet quality is that emotional eating does not affect fruit and vegetable consumption but consumption of food high in fat and sugar and, in the long term, children's BMI.

Children's involvement. The present findings indicate that children's involvement in meal preparation is associated with better diet quality but also with higher BMI. One potential mechanism underlying the association with diet quality is social learning. Learners observe and imitate the behavior of others and thus extend their behavioral repertoire (Bandura, 1977). Children involved in the process of preparing meals engage more actively in the acquisition and execution of new behaviors. They thus experience self-agency and participatory decision making in meal preparation. Such experiences can be conducive to greater interest in nutrition (L. Hill, Casswell, Maskill, Jones, & Wyllie, 1998) and a greater sense of self-efficacy for healthy eating (Chu et al., 2013). Interestingly, children's involvement in meal preparation was also associated with higher BMI; because only two primary studies analyzed BMI as an outcome, however, these results must be interpreted with caution. Nevertheless, one explanation is that children who are more interested in food and take more pleasure in eating are more willing to help preparing meals. Indeed, studies have found a lack of interest in food to be more prominent in underweight children, whereas overweight children showed a higher interest in and affinity to food (dos Passos, Gigante, Maciel, & Matijasevich, 2015; Sleddens, Kremers, & Thijs, 2008).

Duration of meals. Longer meals are associated with lower BMI and better diet quality. At first, this association seems counterintuitive. One potential explanation is that people who

take more time eat at a slower rate, permitting a sense of satiety to kick in before they have finished (Andrade, Kresge, Teixeira, Baptista, & Melanson, 2012; Berkowitz et al., 2010). Thus, the longer the meal takes, the fewer calories may be consumed. It is also possible that longer mealtimes result in longer inter-meal satiety, meaning that fewer calories are consumed across the day (Andrade et al., 2012).

In sum, we have suggested several potential mechanisms underlying the effects of family meals beyond those outlined by Herman et al. (2003). These suggestions are, of course, somewhat speculative. To what extent these mechanisms are indeed in operation and how exactly they affect the relation between family meals and nutritional health requires more investigation—and, in particular, randomized control studies. This raises one of the limitations of the presently available set of studies.

Limitations and Future Research

Statistical Power

The relationship between family meal practices and children's health is still a young research field. This explains why two of our six meta-analyses were based on relatively small samples of studies (i.e., meal duration, $k = 5$, $n = 2,666$; children's involvement, $k = 6$, $n = 8,989$). Nevertheless, a meta-analytic synthesis of—even few—studies is a more transparent and informative approach than other methods of synthesis such as narrative reviews (Valentine, Pigott, & Rothstein, 2010). The present meta-analysis thus takes an important first step in systematizing the literature and provides a basis for generating new hypotheses and identifying gaps in the literature.

Dependencies Between Mealtime Practices

Very few of the available studies examined the co-occurrence of two or more family mealtime practices and their relation to children's nutritional health (only nine of the 43 studies in this review examined more than one mealtime practice). However, it is entirely possible that the mealtime practices are not independent of each other. For example, children's involvement in meal preparation may co-occur with higher food quality. Involvement could be an indicator of more homemade foods and thus of higher quality meals and less fast food. Likewise, watching television while eating is associated with a higher eating rate, which, in turn, may lead to shorter durations of family meals. Conversely, parental modeling may lead to longer meal durations. Taking the time and effort to present children with a (potentially unknown) food that the parent enjoys could lead to longer meal durations than simply serving up a child's favorite meal.

Heterogeneity in Methods and Definitions

Variability between studies was high. Beyond the moderators we investigated, there are other potential sources of heterogeneity. For example, there was substantial variability in the definitions and operationalization of family mealtimes, with differences in the target meal (e.g., dinner vs. main meal) and in the family members who had to be present to make it a family meal. There was also variability in how key variables (e.g., overweight) were measured. Although most studies defined overweight as a BMI > 85th percentile, some used BMI > 95th percentile (Anderson & Whitaker, 2010; Fulkerson et al., 2009) and some employed self-reported instead of measured BMI (Roos et al., 2014). Unfortunately, because of the limited number of studies and the large variability in many variables, we could not analyze to what extent many of these differences mattered. However, let us emphasize that the pattern of effects is also important when it comes to evaluating the presence of heterogeneity (e.g., Higgins, Thompson, Deeks, &

Altman, 2003). Nearly all studies in our meta-analysis reported positive associations between the variables of interest. Thus, the average positive effect sizes are not the result of aggregation across a mixed set of effects but reflect a consistent pattern across studies.

Confounding Variables, Causality, and Unintended Consequences

Although the present results suggest that individual mealtime practices are related to the likelihood of a healthier diet and healthier body weight in children, all studies considered were observational. The variables of interest were not experimentally manipulated. Therefore, we cannot rule out the possibility of confounding variables and alternative explanations. The next logical step would be to subject the family mealtime practices identified to randomized control trials in order to examine how causally relevant they are for nutritional health.

As our results are correlational, it is possible that simply prescribing more family meals or recommending different family mealtime practices will not have the desired effects. Such prescriptions can have unintended consequences. For example, happier couples have been found to have more sex (Blanchflower & Oswald, 2004). However, advising couples with a more conflicted relationship to have more sex made conflicts worse (Loewenstein, Krishnamurti, Kopsic, & McDonald, 2015). By the same token, it is possible that recommending more family meals or qualitatively different mealtime practices will have detrimental effects in some families. For instance, it is conceivable that advising families with conflictual parent–parent or parent– children relationships to have more or longer family meals will induce more stress, impair the atmosphere during shared meals and, ultimately, prove disadvantageous for children's nutritional health. At the same time, research on the concept of family functioning suggests that implementing routines, such as regular family mealtime practices, can attenuate the impact of stressors and positively influence children's health and family climate (Fiese, Hammons, &

Grigsby-Toussaint, 2012; Howe, 2002). Clearly, in order to discern between these possibilities, more systematic and controlled research is needed, taking preexisting differences across families into account.

Another potentially confounding variable of interest is gender. Specifically, a few studies suggest that gender may influence the relation between certain family mealtime practices and nutritional health (Haapalahti, Mykkanen, Tikkanen, & Kokkonen, 2003; Sen, 2006; Wansink & van Kleef, 2014). For example, one study found a significant association between involvement in meal preparation and nutritional health for girls only (Wansink & van Kleef, 2014). However, because too few primary studies reported the relevant information, we were unable to test the potential moderating effects of gender in this analysis.

Finally, the *frequency* of family meals is another potentially confounding variable. Some mealtime practices may per se be associated with higher or lower family meal frequency. For example, a positive family climate seems to be associated with more regular family meals (Kornides et al., 2014), whereas consumption of convenience and fast food seems to be associated with less frequent family meals (Kornides et al., 2014). Importantly, not controlling for family meal frequency could also lead to an underestimation of effect sizes. For illustration, consider the role of TV during shared meals: In some families, it might be easier to get the family around the table when the TV is turned on. Various protective practices present during such family meals will likely have positive effects on nutritional health. A higher family meal frequency could thus buffer the detrimental effect of watching TV. In the adult context, one study suggests that watching TV during family meals and eating home prepared meals may be linked to overweight even among adults who do not regularly participate in family meals (Tumin & Anderson, in press). Unfortunately, the studies included in our meta-analysis did not take the

role of family meal frequency into account. Consequently, we could not investigate to what extent different mealtime practices mediate the link between family meal frequency and nutritional health.

Small Effect Sizes

The effects obtained were not large. This should not be surprising. Obesity is influenced by a complex interplay of environmental, biological, and behavioral factors. Each can have a meaningful, albeit not necessarily large, effect. Our results suggest that family mealtime practices are one such factor. The effect sizes found are in the range of effect sizes from other large observational studies of well-known risk factors of obesity, for which interventions such as public health campaigns have proved effective. Consider, for illustration, breakfast skipping: In their meta-analysis, De la Hunty, Gibson, and Ashwell (2013) found an overall effect size of $d = 0.24$, which translates to $r = 0.12$. Controlled interventions aiming to increase the frequency of breakfast consumption have resulted in healthier dietary intake and body weight (e.g., Ask, Hernes, Aarek, Johannessen, & Haugen, 2006). Furthermore, campaigns employing persuasive messages to increase breakfast consumption have been successfully implemented in several countries, including the United States, the United Kingdom, China, and Norway. These interventions have been found to have positive effects on both beliefs about breakfast consumption and breakfast frequency (see Kothe & Mullan, 2011, for a review).

This example illustrates that factors with small effect sizes can still be meaningful in the context of complex behaviors under multiple influences, even more so if all or most effect sizes are small. In the present case, moreover, it is likely that the combined effect of different family mealtime practices is larger than that of each individual practice (although the effect is probably not additive).

Future Research

The main goal of this systematic review and meta-analysis was to advance the research on social dynamics associated with eating behavior in general and family meals in particular. We have discussed various limitations of our findings, such as small effect sizes from observational studies. We have also noted that these effect sizes identified in our meta-analysis are comparable to those reported for other well-known risk factors for obesity. Promisingly, first randomized control studies support our results: One study has found that manipulating attributes of the family meal context can decrease the consumption of healthy foods in children (Fiese et al., 2015). Another experimental study with parent-child pairs found that involving children in meal preparation leads to children consuming more vegetables (van der Horst, Ferrage, & Rytz, 2014). For these reasons, the limitations identified are no reason for disinterest or inaction. Rather, we see our meta-analysis, with its limitations, as an optimistic progress report that we hope will stimulate future research. A synthesis of cross-sectional studies as presented here can identify necessary future steps, namely, randomized control studies focusing on specific mealtime practices, ideally using longitudinal designs and standardized constructs and measures, and covering a variety of age groups that reflect different onsets or potential "sensitive periods" of the proposed mechanisms (Table 3 summarizes our suggestions for future research).

Herman and colleagues (2003) investigated three social mechanisms that potentially operate when people eat with others, often their peers. Our focus was on an important subsample of situations involving the shared consumption of food, namely, the family meal. We discussed further mechanisms potentially underlying the effects of family meals, including some that are not necessarily social (e.g., a mere-exposure effect as a potential mechanism of food quality; emotional eating as a potential mechanism of mealtime atmosphere). Future research should

examine to what extent these mechanisms also apply to the peer context and beyond. For example, it is not unlikely that atmosphere also influences eating behaviors and nutritional health in the peer context. Further, in the same way as parents function as role models during family meals, kindergarten and schoolteachers may also model dietary behaviors.

Finally, we noted a lack of systematic research on different feeding styles during family meals. Although many studies have investigated feeding styles and children's nutritional health, most have not exclusively tackled behaviors during family meals.

Practical Implications

The mealtime practices analyzed here are part of the social institution of family meals. It may be argued that there is no need to communicate these findings beyond the interested scientific community. Families will continue to act the way they do; some of their behaviors may happen to be advantageous for children's nutritional health, others less so. We disagree with this point of view for three reasons. First, a popular recommendation often made in the media is that families should eat together more often. Our findings suggest that the beneficial role of family meals may depend to a substantial extent not on their mere existence but on *how* families eat together. Thus, simply advising families to eat together more often may fail to produce the desired effects. Furthermore, it may be easier to change qualitative aspects of family meals (e.g., TV off) than quantitative aspects (i.e., family meal frequency). Second, some of the protective practices identified in this meta-analysis are likely to be in decline because of lifestyle changes such as eating on the go, use of electronic devices during mealtimes, and increasing numbers of dual-earner families (Adams et al., 2015; Breaugh & Frye, 2008; Chen et al., 2015; Nielsen et al., 2002; Smith et al., 2013). Third, some of the practices are likely not part of people's intuitive

theories about healthy nutritional behaviors. When asked about reasons for their eating behavior, people mention hunger and palatability of food but, somewhat surprisingly, not the presence of others (Roth, Herman, Polivy, & Pliner, 2001; Vartanian, Herman, & Wansink, 2008). To the extent that people lack insight into the less obvious determinants of their eating behaviors (e.g., the importance of atmosphere or distractions), they have little control over them and fail to prioritize them.

Based on these considerations, we think that the present results are of interest beyond the scientific community. Nevertheless, given the limitations discussed before (e.g., small effect sizes from observational studies; potentially detrimental effects in some families), caution must be taken in deriving practical implications. Yet evidence-based mealtime practices are worthy of consideration as one approach to fight obesity. They are non-intrusive and actionable interventions. They can be relatively easily communicated, learned, and practiced, and they can become part of a family's set of routines. Last but not least, they maintain the nutritional gatekeeper's agency and autonomy and boost self-efficacy (Hertwig, 2016).

Next, we briefly discuss existing interventions that address family meals and suggest some other approaches. Few intervention studies have examined the promotion of family meals as a method to address childhood obesity and obesity-related outcomes (DeBar et al., 2012; Fulkerson et al., 2015; Haines et al., 2013; Sepulveda, Lu, Sill, Young, & Edington, 2010), and most of them have focused exclusively on family meal frequency. To our knowledge, only one randomized control intervention study has considered several mealtime practices, such as eliminating electronic devices at mealtimes or promoting positive conversations (Fulkerson et al., 2015). Despite promising results, such as reduction in weight gain, it is difficult to draw conclusions about the effect of family meal frequency and individual mealtime practices from

these findings, because the interventions simultaneously addressed multiple aspects of family meals and the home environment.

If randomized control studies continue to confirm the protective role of family mealtime practices, their significance could and should be systematically communicated to parents and other architects of children's food environments, such as kindergarten and school teachers. According to behavior change theories (e.g., the transtheoretical model), health messages are more likely to be successful when people lack knowledge about the respective behavior (Prochaska, DiClemente, & Norcross, 1992). As mentioned before, there seems to be a dearth of intuitive knowledge about social influences on eating behavior (Roth, Herman, Polivy, & Pliner, 2001). Communication campaigns have already proved to be successful in the area of nutrition and eating behavior (e.g., campaigns about the dangers of high cholesterol or the value of eating breakfast; Cutler, 2004; Kothe & Mullan, 2011). Communication campaigns concerning family meals seem particularly promising because of their wide reach (e.g., Atkin & Rice, 2012). Action-oriented recommendations could include the following: (1) turn the TV off during family meals; (2) opt for home-cooked food; (3) be a role model to your child; (4) create a positive mealtime atmosphere; (5) involve your child in meal preparation; and (6) take time for meals. Of course, these action-oriented suggestions need to be conveyed in an engaging format. They also need avoid a "boomerang effect," with parents feeling criticized, anxious, or demoralized (Simpson, 2001).

Communicating the significance of protective family meal practices is only one potential lever that can be harnessed in the fight against obesity. Of course, it does not make other interventions, including environmental and behavioral changes, any less important (e.g., taxing sugar-sweetened beverages; Nestle, 2015; educational programs; DeBar et al., 2012). On the

contrary, the success of communicating protective practices may well depend on the resources of both the individual and the social network (Johnson et al., 2010). For instance, key barriers to serving up frequent family meals are cost and time constraints (Dwyer, Oh, Patrick, & Hennessy, 2015). A pluralistic approach that (i) explains and promotes the significance of family meals in community groups (e.g., The Family Dinner Project, 2016) and (ii) modifies the convenience and costs of unhealthy and healthy foods (tax versus subsidy; Powell & Chaloupka, 2009) may thus be promising, especially in low-SES neighborhoods.

Let us conclude with a final thought. One way to interpret the present results is that they revive out-of-date role expectations such as "a woman's place is in the home." Our interpretation is very different. Some of the protective effects identified may generalize across all kinds of social eating occasions, not just family meals (e.g., TV off, atmosphere). Similarly, parental modeling could also be harnessed when eating out. Furthermore, digitalization is making office hours and locations more flexible, and avant-garde employers are providing cafeterias in which families can eat together. Modern architecture designs feature shared kitchen space for more than one family to use, permitting them to take turns with cooking. There are many ways to implement the protective family mealtime practices we have identified. The interesting challenge is to adapt the time-honored social institution of the family meal to today's world.

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Table 1

Overview of Studies Investigating the Association of Feeding Styles with Nutritional Health
Due to the heterogeneity of feeding style definitions and means of assessment, a meta-analysis was not conducted.

Feeding style	Items, subscales (examples)	Measures	Association with nutritional health		
			k (+)	k (−)	k (0)
Control					
General control	Authoritarian, follow obligation rules, decide about portions, manners, high meal structure, restricting certain food or forcing child to eat certain food	FEEDS, FPSQ, IFIRS, MICS, CFSQ and scales developed for study purpose	4 [1, 2, 3, 4]	5 [5, 6, 7, 8, 9]	10 [10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
Pressure	Finish plate, praise or reason with child to eat, physical and verbal prompts	FEEDS, CFPQ, FMCS, PMAS, FPSQ, FMCS, PFP, IFIRS, and scales developed for study purpose	4 [20, 21, 22, 23,]	4 [9, 24, 25, 26,]	9 [19, 21, 23, 25, 27, 28, 29, 30, 31,]
Restriction	Restrict dessert, overt control, fat reduction	FMCS, PMAS, CFSQ & scales developed for study purpose	2 [21]	3 [25, 32, 33]	4 [11, 19, 25, 33]
Permissive	Uninvolved, inconsistent behavior, child decides, indulgent	MICS, CFSQ, IFRIS, PMAS, and scales developed for study purpose	1 [11]	3 [12, 25, 34]	1 [12]
Reward	Punish unhealthy eating, reward healthy eating, use sweets as reward	FMCS, IFRIS, PMAS, FPSQ, and scales developed for study purpose	1 [28]	2 [9, 26]	4 [21, 25, 29, 30]
Support	Take care in a positive manner, make food interesting, reason with child, compliment, help	MICS; CFSQ, PMAS, CFPQ, and scales developed for study purpose	4 [16, 21, 33]	2 [21, 25]	7 [11, 14, 22, 23, 24, 25, 35]
Other/mixed categories	Pressure and reason, know better if child is full, negotiation, encouragement and pressure, distrust in appetite	FPSQ, and scales developed for study purpose	4 [24, 36, 37]	2 [21]	6 [14, 21, 25, 28, 31, 35]

Note. k = number of study outcomes; FEEDS = Feeding Demands Questionnaire (Faith, Storey, Kral, & Pietrobelli, 2008); FPSQ = Feeding Practice and Structure Questionnaire (Jansen, Mallan, Nicholson, & Daniels, 2014); IFIRS = Iowa Family Interaction Rating Scale (Williamson, Bradbury, Trail, & Karney, 2011); MICS = Mealtime Interaction Coding System (Moens et al., 2007); CFSQ = Caregivers Feeding Strategy Questionnaire (Hughes, Power, Orlet Fisher, Mueller, & Nicklas, 2005); CFPQ = Comprehensive Feeding Practices Questionnaire (Musher-Eizenman, Holub, Hauser, & Young, 2007); FMCS = Family Mealtime Coding System (Haycraft & Blissett, 2008b); PMAS = Parent Mealtime Action Coding System (Hendy, Williams, Camise, Eckman, & Hedemann, 2009); PFP = Parent Feeding Practices (Tschann et al., 2013); (+) positive association with nutritional health, (−) negative association with nutritional health, (0) no association with nutritional health; [1] Berge, Wall, Larson, Loth, & Neumark-Sztainer, 2013; [2] Pearson, Ball, & Crawford, 2012, [3] Vereecken, Van Damme, & Maes, 2005; [4] Edelson, Mokdad, & Martin, 2016; [5] Moroshko & Brennan, 2013; [6] Berlin, Kamody, Banks, Silverman, & Davies, 2015; [7] Wardle, Carnell, & Cooke, 2005; [8] Jacobs & Fiese, 2007, [9] Berge, Rowley et al., 2014; [10] Crossman, Sullivan, & Benin, 2006; [11] Hennessy, Hughes, Goldberg, Hyatt, & Economos, 2012, [12] Hennessy, Hughes, Goldberg, Hyatt, & Economos, 2010; [13] Faith et al., 2008; [14] Hughes et al., 2006; [15] Murashima et al., 2011; [16] Moens et al., 2007; [17] Vanhala, Laitinen, Kaikkonen, Keinänen-Kiukaanniemi, & Korpelainen, 2011, [18] Weatherspoon, Venkatesh, Horodynski, Stommel, & Brophy-Herb, 2013; [19] Haycraft & Blissett, 2008a; [20] Carnell & Wardle, 2007; [21] Hendy, Williams, & Camise, 2009; [22] Tschann et al., 2015; [23] Mosli et al., 2015; [24] Vereecken, Legiest, De Bourdeaudhuij, & Maes, 2009; [25] Petty, Escrivao, & Souza, 2013; [26] Spurrier et al., 2008; [27] Blissett & Bennett, 2013; [28] Bante, Elliott, Harrod, & Haire-Joshu, 2008, [29] Jansen et al., 2014; [30] Wyse, Campbell, Nathan, & Wolfenden, 2011; [31] Farrow, Blissett, & Haycraft, 2011; [32] Melbye et al., 2016; [33] Melbye & Hansen, 2015; [34] Hughes et al., 2011; [35] Boucher, 2014; [36] Verzeletti, Maes, Santinello, Baldarassi, & Vereecken, 2010; [37] Verzeletti Maes, Santinello, & Vereecken, 2010.

Table 2

Characteristics of the Studies Included in the Meta-Analysis by Mealtime Practice

Variable	Category	TV (*k*=14)	QU (*k*=11)	RO (*k*=12)	AT (*k*=9)	IN (*k*=6)	DU (*k*=5)
Country	United States, Canada	9	9	7	6	2	4
	Europe[a]	1	0	4	2	2	1
	Australia	2	2	1	1	2	0
	Middle and South America[b]	2	0	0	0	0	0
Years of study	2000–2009	3	4	1	1	2	1
	2010–2015	11	7	11	8	4	4
Study design	Cross-sectional	14	9	12	9	6	4
	Longitudinal	0	1	0	0	0	1
	Both (cross-sectional & longitudinal)	0	1	0	0	0	0
Child age	Children (2–10 years)	8	4	8	5	3	5
	Adolescents (11–18 years)	6	7	4	4	3	0
Nutritional health outcome assessed	BMI	6	7	2	5	1	4
	Diet quality	7	3	9	3	4	1
	Both (BMI & diet quality)	1	1	1	1	1	0
Definition of family meal	Meal (unspecified)	8	7	8	4	3	1
	Dinner	6	4	4	5	3	4
Mealtime practice assessed	Food quality						
	Home-cooked meal		2				
	Vegetables at meal		2				
	Fast food (take away or at restaurant)		7				
	Role modeling						
	Direct: model healthy eating			9			
	Indirect: no special meal for child			3			
	Atmosphere						
	Expert rating of atmosphere				4		
	Parent report of atmosphere				5		
	Duration of meals						
	Objective (minutes)						4
	Subjective (mealtimes are a rush)						1
Controlled for SES	Yes	5	3	5	1	2	1
	No	9	8	7	8	4	4

Note. k = number of studies; TV = Television; QU = Food quality; RO = Role modeling; AT = Atmosphere; IN = Children's involvement; DU = Duration, SES = socioeconomic status; [a] = Netherlands, Norway, UK, Germany, Italy, Spain, Sweden, Scotland, Bulgaria; [b]= Brazil, Puerto Rico.

Table 3

Summary of Suggestions for Future Research

Type of study	Research topics
Randomized control interventions/experiments	- Causal relationships between individual mealtime practices and children's eating behavior and BMI - Mechanisms underlying individual mealtime practices and nutritional health (e.g., emotional eating in negative mealtime atmosphere) - Family mealtime practices as potential mediators between family meal frequency and children's nutritional health - Generalizability of mealtime practices to other settings, such as school, workplace, or community - Research on feeding styles as mealtime practices, including a standard battery of instruments to make findings comparable across studies
Controlled longitudinal studies	- Long-term outcomes of single mealtime practices - Sensitive periods in which specific mealtime practices are particularly effective or can be more successfully established
Epidemiological studies	- Role of potential moderators of the relationship between family mealtime practices and nutritional health, such as family functioning - Prevalence of different mealtime practices, also differentiated by age, gender, SES, and other potential influences - Intercorrelations between different mealtime practices (e.g., is watching TV associated with a shorter meal duration?)

Identification

Records identified through database searching
(*n* = 4,052)

Additional records identified through other sources
(*n* = 13)

Screening

Records after duplicates removed
(*n* = 3,447)

Abstract screened
(*n* = 3,447)

Records excluded
(*n* = 2,899)

Eligibility

Full-text articles assessed for eligibility
(*n* = 548)

Full-text articles excluded
(*n* = 475):

- Not child or adolescent focused (*n* = 15)
- Special population (*n* = 48)
- No mealtime practice (*n* = 271)
- Irrelevant outcome (*n* = 96)
- Insufficient primary studies for meta-analytic investigation of the respective mealtime practice (*n* = 32)
- insufficient statistics to calculate r (*n* = 13)

Studies included for further analyses
(*n* = 73) [a]

Feeding styles (n = 37)
Mealtime practices (n = 43)

Included

Studies included in meta-analysis
(*n* = 43) [b]

Identified mealtime practices:
TV off (*n* = 14)
Food quality (*n* = 11)
Parental modeling (*n* = 12)
Atmosphere (*n* = 9)
Involvement (*n* = 6)
Duration (*n* = 5)

Figure 1. PRISMA flow diagram documenting how articles were identified for the meta-analysis.
Note. n = number of studies; [a] note that *n* = 7 studies examined feeding styles and mealtime practices; accordingly, the number of studies included in the meta-analysis (*n* = 73) is not equal to the sum of studies on feeding styles and mealtime practices; [b] note that some of the studies included reported more than one mealtime practice: *n* = 34 studies examined one mealtime practice, *n* = 5 studies examined two, *n* = 3 studies examined three, and *n* = 1 study examined four mealtime practices; accordingly the number of studies included (*n* = 43) is not equal to the sum of studies addressing each mealtime practice.

Author, Date   **r [95% CI]**

TV off (N=13,140)
Coon et al., 2001   0.33 [0.17 , 0.47]
Horodynski et al., 2010   0.19 [0.09 , 0.28]
Roos et al., 2014   0.15 [0.10 , 0.20]
Berge et al., 2014   0.14 [−0.08 , 0.36]
Petty et al., 2013   0.10 [0.02 , 0.18]
Serrano et al., 2014   0.10 [−0.07 , 0.27]
Fitzpatrick et al., 2007   0.08 [0.02 , 0.13]
Stephens et al., 2011   0.07 [−0.01 , 0.15]
Goldman et al., 2012   0.05 [−0.07 , 0.17]
Wansink & van Kleef, 2014   0.03 [−0.13 , 0.19]
Hauser et al., 2014   0.02 [−0.04 , 0.09]
Santiago–Torres et al., 2014   0.02 [−0.18 , 0.21]
Larson et al., 2013   0.01 [−0.03 , 0.04]
van Zutphen et al., 2006   0.00 [−0.06 , 0.06]
Weighted mean effect size for mealtime practice   0.08 [0.04 , 0.12]

Food quality (N=9,878)
Ayala et al., 2007   0.28 [0.16 , 0.38]
Fulkerson et al., 2011   0.21 [0.14 , 0.27]
Appelhans et al., 2014   0.14 [0.01 , 0.26]
Chan & Sobal, 2011   0.14 [−0.03 , 0.30]
Ferran–Alexander, 2012   0.13 [−0.15 , 0.39]
Ayala et al., 2008   0.12 [0.06 , 0.17]
Arcan et al., 2007   0.10 [−0.04 , 0.24]
Masse et al., 2012   0.10 [0.04 , 0.16]
MacFarlane et al., 2009   0.09 [−0.02 , 0.19]
Larson et al., 2013   0.03 [−0.01 , 0.06]
Babajafari et al., 2011   0.03 [0.00 , 0.05]
Weighted mean effect size for mealtime practice   0.11 [0.06 , 0.16]

Parental modeling (N=7,966)
Harris & Ramsey, 2015   0.19 [0.05 , 0.32]
Skafida, 2013   0.18 [0.14 , 0.22]
Goldman et al., 2012   0.16 [0.06 , 0.26]
Sweetman et al., 2011   0.14 [0.04 , 0.23]
Draxten et al., 2014   0.14 [−0.02 , 0.29]
Vereecken et al., 2004   0.13 [0.05 , 0.20]
Stephens et al., 2011   0.11 [0.05 , 0.18]
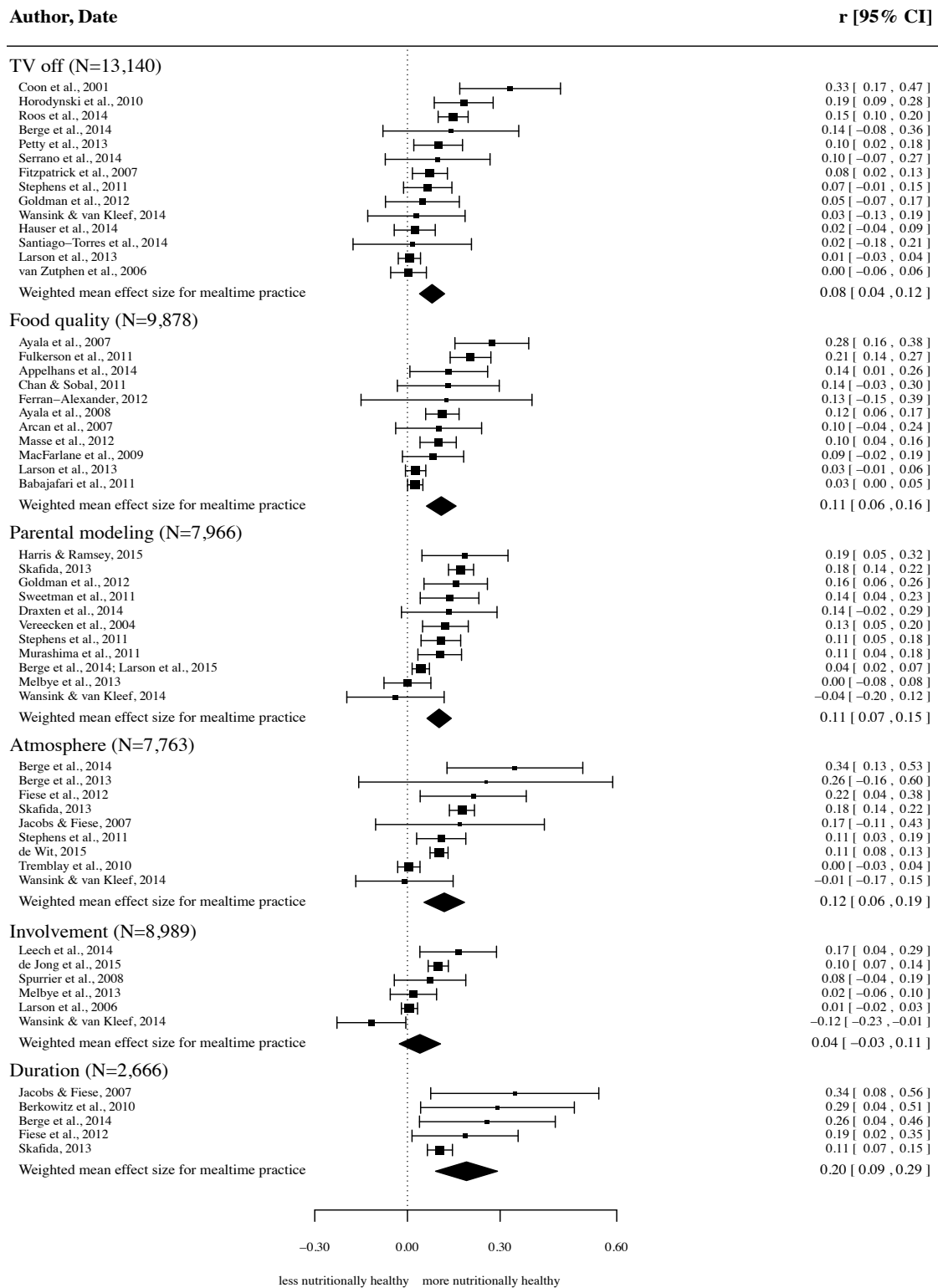Murashima et al., 2011   0.11 [0.04 , 0.18]
Berge et al., 2014; Larson et al., 2015   0.04 [0.02 , 0.07]
Melbye et al., 2013   0.00 [−0.08 , 0.08]
Wansink & van Kleef, 2014   −0.04 [−0.20 , 0.12]
Weighted mean effect size for mealtime practice   0.11 [0.07 , 0.15]

Atmosphere (N=7,763)
Berge et al., 2014   0.34 [0.13 , 0.53]
Berge et al., 2013   0.26 [−0.16 , 0.60]
Fiese et al., 2012   0.22 [0.04 , 0.38]
Skafida, 2013   0.18 [0.14 , 0.22]
Jacobs & Fiese, 2007   0.17 [−0.11 , 0.43]
Stephens et al., 2011   0.11 [0.03 , 0.19]
de Wit, 2015   0.11 [0.08 , 0.13]
Tremblay et al., 2010   0.00 [−0.03 , 0.04]
Wansink & van Kleef, 2014   −0.01 [−0.17 , 0.15]
Weighted mean effect size for mealtime practice   0.12 [0.06 , 0.19]

Involvement (N=8,989)
Leech et al., 2014   0.17 [0.04 , 0.29]
de Jong et al., 2015   0.10 [0.07 , 0.14]
Spurrier et al., 2008   0.08 [−0.04 , 0.19]
Melbye et al., 2013   0.02 [−0.06 , 0.10]
Larson et al., 2006   0.01 [−0.02 , 0.03]
Wansink & van Kleef, 2014   −0.12 [−0.23 , −0.01]
Weighted mean effect size for mealtime practice   0.04 [−0.03 , 0.11]

Duration (N=2,666)
Jacobs & Fiese, 2007   0.34 [0.08 , 0.56]
Berkowitz et al., 2010   0.29 [0.04 , 0.51]
Berge et al., 2014   0.26 [0.04 , 0.46]
Fiese et al., 2012   0.19 [0.02 , 0.35]
Skafida, 2013   0.11 [0.07 , 0.15]
Weighted mean effect size for mealtime practice   0.20 [0.09 , 0.29]

−0.30   0.00   0.30   0.60

less nutritionally healthy   more nutritionally healthy

Figure 2. Forest plot showing the distribution of effect sizes for each mealtime practice.
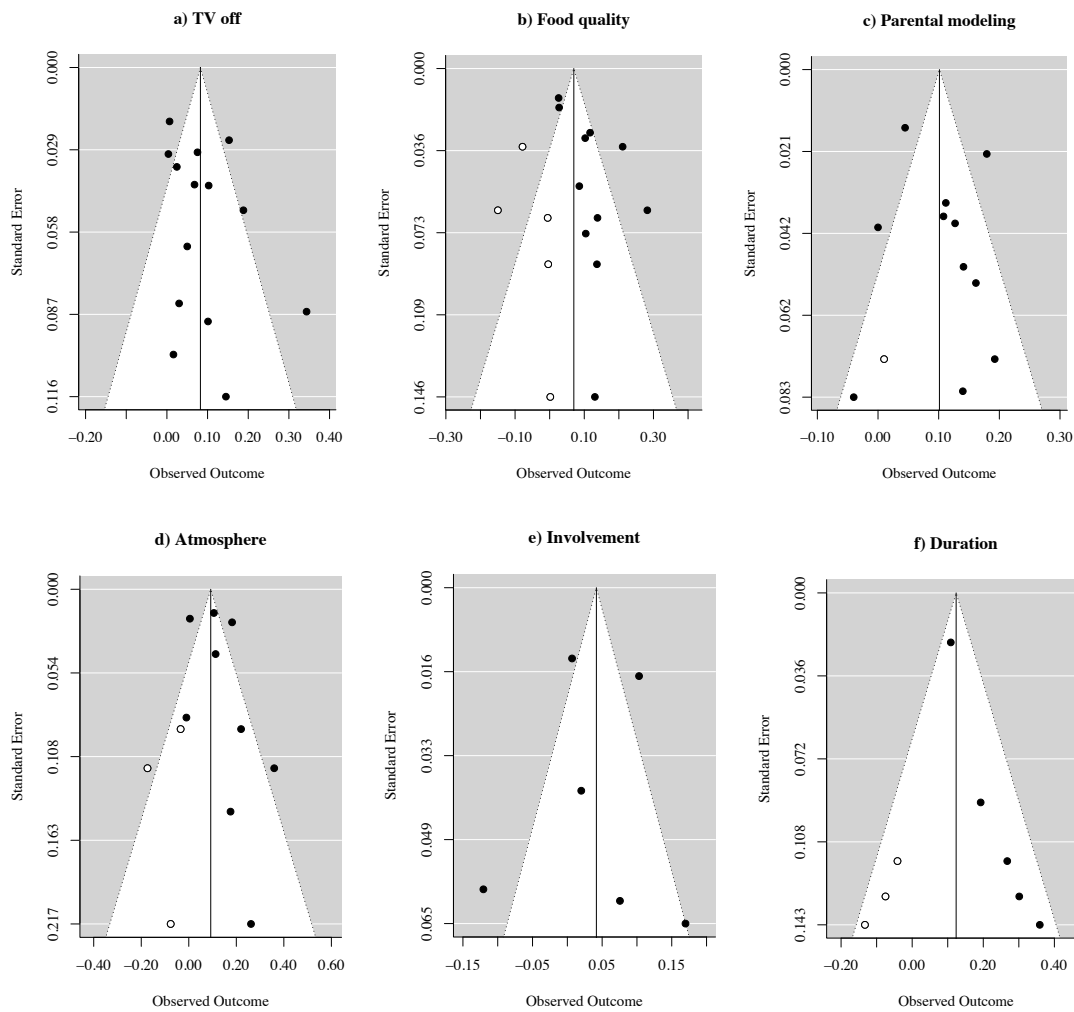
Figure 3. Funnel plots with trimmed and filled effect sizes for (a) TV off, (b) Food quality, (c) Parental modeling, (d) Atmosphere, (e) Involvement.
Note. The vertical lines reflect the pooled mean effect size after trim and fill correction. The diagonal lines are corresponding 95% confidence intervals. Solid circles are the original effect sizes; open circles, the imputed filled effect sizes.
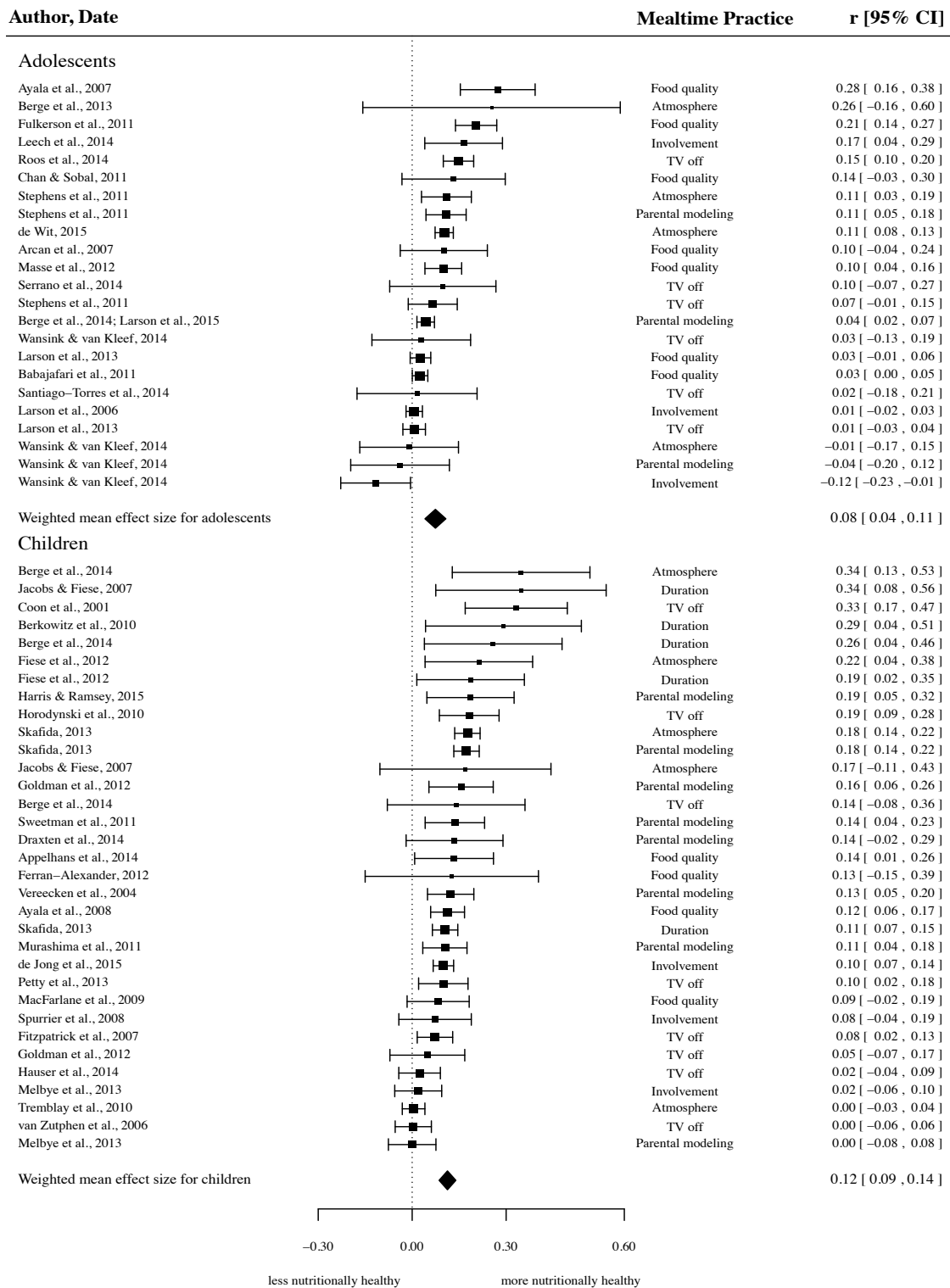
Figure 4. Forest plot showing the distribution of effect sizes across all mealtime practices, separately for adolescents and children.

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Lower Parental Numeracy is Associated With Children Being Under- and Overweight

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Abstract

Background: In adults, lower numeracy is associated with poorer nutrition label comprehension and higher BMI. It remains unclear whether parental numeracy also impacts children's body weight. ***Purpose:*** We examined the relationship between parental numeracy and children's z-BMI and analyzed whether weight-related numerical information processing skills—specifically, portion size estimation skills, comprehension of nutrition labels, and comprehension of growth charts—mediated that relationship. ***Design and Methods:*** Numeracy, portion size estimation skills, comprehension of nutrition labels, and comprehension of growth charts were assessed in face-to-face interviews with 320 parents of children aged 6 to 12 years in Germany. Parent and child body weight were measured; parents reported both their own height and that of their children. ***Results:*** Lower parental numeracy was significantly associated with having a child who was either underweight ($\beta = 0.126$, $P = 0.048$) or overweight ($\beta = -0.299$, $P < 0.001$). Lower parental numeracy was also associated with poorer portion size estimation skills ($r = -0.08$, $P = 0.023$) and inferior comprehension of growth charts ($r = 0.33$, $P < 0.001$) and nutrition labels ($r = 0.26$, $P < 0.001$). However, these weight-related numerical information processing skills did not mediate the association between parental numeracy and children's BMI. ***Conclusion:*** This is the first study to find lower parental numeracy to be a risk factor for children being either over- or underweight. However, portion size estimation skills, comprehension of nutrition labels, and comprehension of growth charts did not mediate the association between parental numeracy and children's BMI. The present findings thus winnow down the set of mechanisms potentially underlying this association. Parental numeracy is an as yet largely overlooked factor that can be targeted when developing interventions to prevent and treat malnutrition and to achieve and maintain a healthy body weight in children.

Introduction

Numeracy is the ability to understand and use numbers in daily life. It is known to play a role in people's health decisions and to affect health outcomes (Lipkus & Peters, 2009). For example, numeracy has been shown to be important for understanding medical instructions (Williams et al., 1995), health risks (Gigerenzer, Gaissmaier, Kurz-Milcke, Schwartz, & Woloshin, 2007), and health information expressed in probabilities, graphs, or tables (Peters, Hibbard, Slovic, & Dieckmann, 2007; Sheridan, Pignone, & Lewis, 2003). These findings may also be relevant in the context of nutrition and healthy body weight. Thus far, however, only a few studies have investigated the role of numeracy in weight outcomes and weight-related numerical information processing. Their findings suggest that lower numeracy is associated with poorer comprehension of nutrition labels (Rothman et al., 2006) and inferior portion size estimation skills (Huizinga et al., 2009). Further, lower numeracy skills have been associated with a higher body mass index (BMI) in adult primary care patients (Huizinga, Beech, Cavanaugh, Elasy, & Rothman, 2008). The effects of numeracy on weight-related information processing or BMI persist when other important factors, such as education or socioeconomic status, are controlled (Huizinga, Beech et al., 2008; Rothman et al., 2006).

Research Goals

This study examines three issues that have not been addressed in previous research:

First, we examine the extent to which lower parental numeracy may represent a risk factor for children being over- or underweight. This question is important because a growing consensus exists among experts that parents, as "nutritional gatekeepers" (Wansink, 2006, p. 162), play a key role in the nutritional health of their dependents. Consequently, interventions targeting a

child's obesity do not necessarily need to involve the child as an active agent to be effective—it suffices to target the parents (Golan & Crow, 2004). We therefore examine how the numerical skills of parents relate to the weight status of their children.

Second, malnutrition can lead to individuals being either underweight or overweight. Both states are associated with negative health outcomes. Underweight children have an increased risk of osteoporosis, bone disease, and reduced fertility in adulthood. They also report a negative body image more often than children with normal weight (Luder & Alton, 2005). Childhood obesity is associated with serious health conditions such as diabetes or asthma and predicts adult obesity (Daniels, 2009; Guo & Chumlea, 1999; Weiss & Caprio, 2005). Importantly, previous studies investigating the relationship of adults' numerical skills and BMI have included few, if any, underweight participants. It therefore remains unclear whether the link between numeracy and deviations from recommended BMI levels applies to both over- and underweight. This issue is particularly relevant for children, who are more likely than other subsections of the population to be underweight (Kurth & Schaffrath Rosario, 2007; Mensink et al., 2013). Examining children therefore allows us to study how parental numeracy is associated with children being either over- or underweight.

Third, the mechanisms potentially underlying the link between numeracy and BMI are unexplored. This study examines three numerical information processes that may mediate the association between parents' ability to understand and use numbers and their children's BMI (see Fig. 1): (a) comprehension of nutrition labels (important for judging the nutritional value and healthiness of food; Temple & Fraser, 2014), (b) portion size estimation skills (essential for following dietary recommendations; Huizinga, Pont, et al., 2008; Pourshahidi, Kerr, McCaffrey, & Livingstone, 2014), and (c) comprehension of growth charts (which provide information about

a child's weight status and serve, in turn, as a basis for decisions about nutrition and portion sizes; Ben-Joseph, Dowshen, & Izenberg, 2009). All three processes require, among other skills, the ability to understand and use numbers. However, it is likely that not all parents are able to enlist such numerical skills. For instance, in one study with a nationally representative sample of U.S. parents, 77% misinterpreted information contained in growth charts (Ben-Joseph et al., 2009). This misinterpretation may originate, at least partly, in inadequate numerical skills (Peters, Meilleur, & Tompkins, 2013).

Hypotheses

We hypothesize that (1) lower parental numeracy will co-occur with their children being under- or overweight; and that (2) weight-related numerical information processing skills—specifically, portion size estimation skills, comprehension of nutrition labels, and comprehension of growth charts—will mediate the relationship between parental numeracy skills and their children's BMI.

Methods

Participants

Parent–child dyads were recruited and interviewed by the Gesellschaft fuer Konsumforschung (GfK), one of the largest commercial market research institutes in Europe. Interviews were conducted between November and December 2014. The sample was representative of the German population with respect to gender, age, region, size of place of residence, size of household, and profession of head of household. Parents were included if they identified themselves as nutritional gatekeepers and had one or more children aged between 6 and 12 years who were at home during the face-to-face interview. When more than one child was at home, the

child with the birthday closest to the day of the interview was selected. Parents were classified as nutritional gatekeepers if they identified themselves as "the person in the household who has the strongest influence on what and how much [the] child eats" and who is "responsible for planning and preparing [the] family's food" (Wansink, 2006, p. 162). The total sample consisted of 326 parent–child dyads. Five dyads were excluded due to omissions or measurement errors in height or weight data and one dyad was excluded due to an error in data entry, resulting in a final data set of 320 dyads (see Table 1, which also compares the demographics of the study sample with that of the overall German population).

Materials and Procedure

Computer-assisted face-to-face interviews were conducted, with the interviewer being present while the parent completed computerized tasks and questionnaires. The body weight of parent and child was measured with a scale after the interview; parents reported their own height and that of their child. Parents' BMI was calculated from height and weight measures; children's measures were transformed into BMI z-scores (z-BMI) based on the distributions of a German reference population (Neuhauser, Schienkiewitz, Schaffrath Rosario, Dortschy, & Kurth, 2013). This procedure permits comparisons across children of different ages and across girls and boys (Wang & Chen, 2012). Specifically, the z-BMI indicates in what direction (above/positive or below/negative) and by how much a child's BMI deviates from the reference mean, defined as normal weight. For instance, a z-BMI score of -2.0 indicates that a child's z-BMI is 2.0 standard deviations below the reference mean (and a z-BMI score of 2.0 indicates that a child's z-BMI is 2.0 standard deviation above the reference mean). Additionally to the z-BMI score, we computed the absolute z-BMI score, which indicates how much the child's z-BMI deviates from the

reference mean *without* taking into account the direction of the deviation (above/positive or below/negative). For instance, an absolute *z*-BMI score of 2.0 indicates that a child's *z*-BMI is 2.0 standard deviations away from reference mean, without indicating the direction of the deviation (above or below the reference mean). Children were then classified as underweight (BMI < 10th percentile; *z*-BMI < −1.28), normal weight (BMI 10th–90th percentile; *z*-BMI: −1.28–1.28), overweight (BMI > 90th percentile; *z*-BMI > 1.28), or obese (BMI > 97th percentile; *z*-BMI > 1.88) on the basis of recommended guidelines (The German Working Group of Obesity in Childhood and Adolescence [AGA], 2011; Neuhauser et al., 2013).

Parental numeracy was assessed using the eight-item scale by Weller and colleagues (2012). This scale measures participants' understanding of numerical information (e.g., "If the chance of getting a disease is 20 out of 100, this would be the same as having a __ % chance of getting the disease"; "Imagine that we roll a fair, six-sided die 1,000 times. Out of 1,000 rolls, how many times do you think the die would come up as an even number?"). Numeracy was scored as the number of correct responses out of eight and was used as a continuous measure in the analyses. This abbreviated numeracy scale was developed and intended for use in large, diverse samples; Cronbach's *alpha* = 0.71 (Weller et al., 2012).

Physical activity of the child was measured by asking the parent to estimate the number of days per week on which the child was physically active for a total of at least 60 minutes.

Comprehension of nutrition labels was measured using questions from the Nutrition Label Survey (NLS; Rothman et al., 2006). In the NLS, participants are shown nutrition labels of typical food products and asked about their nutritional value. For example, they are shown the nutrition label for a bottle of Coca-Cola and asked, "You drink this whole bottle of Coca-Cola. How many grams of total carbohydrates does this contain?" (see Supplementary Materials).

After testing the NLS items in a pilot study, we selected five items from the original 24-item instrument based on their inter-item correlations in the pilot study, their loading on the common factor, and their varying item difficulty (low, medium, and high difficulty). Nutrition label comprehension was scored as the total number of correct responses. Internal consistency and reliability of the five-item questionnaire was good, Cronbach's *alpha* = 0.74.

Comprehension of growth charts was measured using seven items from the growth chart survey developed by the Nemours Center for Children's Health Media (KidsHealth) and Cogent Research (www.kidshealth.org/misc/surveys/GrowthChartSurvey.pdf). Parents were presented with a growth chart that is routinely used by German health care providers to, for example, monitor children's growth during pediatric check-ups. They then indicated their familiarity with the chart (e.g., "Prior to this survey, had you ever seen this before?") and understanding of the chart (e.g., "Please look at the chart above, and locate the point showing the child's measurement. Based on this point, how old is this child?"). Growth chart comprehension was scored as the total number of correct responses. A pilot study revealed good reliability of the seven-item growth charts scale (Cronbach's *alpha* = 0.73).

Portion size estimation skills were assessed using five sets of food pictures portraying typical foods for children (e.g., cornflakes for breakfast or lentil stew for lunch). Each set contained 15 pictures depicting varying amounts of the same food. The first picture showed an empty plate with a fork or spoon as a reference for magnitude, followed by a picture with a very small amount of the respective food. The remaining 13 photos presented increasing amounts of the food, with standardized increases in gram amounts corresponding to approximately one tablespoon (see Supplementary Materials for an example). The pictures were presented one at a time on a computer screen. Parents were asked: "The recommended amount for children aged

[XX] years is [YYY] grams. Among the following pictures, please choose the one that shows the recommended amount." They were shown how to scroll through the pictures and instructed to click the "recommended amount button" to select the relevant picture. We scored the portion size estimates by calculating the absolute deviation between the chosen and the recommended amount so that lower scores meant better performance. Menus and food amounts came from the Optimized Mixed Diet (OMD; Alexy, Clausen, & Kersting, 2008). The Optimized Mixed Diet adheres to the WHO standards for Food-Based Dietary Guidelines and takes into account meal patterns and children's preferences. The predictive validity and reliability of the picture sets were tested in a pilot study, in which parents estimated portion sizes from real food and from pictures. The results of the pilot study revealed good predictive validity ($r = .60 - .80$) and high re-test reliability ($r > .80$).

The ethics committee of the [name withheld to maintain anonymity] approved the study. All participants gave their informed consent prior to the study.

Statistical Analyses

One missing value was observed for education level (n=1, see Table 1) and was deleted list-wise. To examine the first hypothesis, according to which lower parental numeracy co-occurs with children being under- or overweight, we conducted three multiple linear regression analyses of the child's z-BMI: (1) To examine the association between lower parental numeracy and children's underweight, we included only children with z-BMI scores lower than or equal to the recommended z-BMI, using their z-BMI score as the dependent variable; (2) to examine the association between lower parental numeracy and children's overweight, we included only children with z-BMI scores equal to or higher than the recommended z-BMI, using their z-BMI score as the dependent variable, and (3) to capture both associations in one analysis, we included

all children, using their absolute z-BMI scores as the dependent variable. All three regressions included parental numeracy as the independent variable and parents' education level and BMI as well as child's age, gender, and physical activity as covariates.

To examine the second hypothesis, according to which weight-related numerical information processing skills mediate the relationship between numeracy and absolute z-BMI, we conducted an adjusted multiple mediation analysis. Specifically, we separately tested the mediating role of nutrition label comprehension, growth chart comprehension, and portion size estimation skills. The bootstrapping sampling method (with 5000 re-samples) was used to assess the significance of a mediation effect. All statistical analyses were performed using SPSS v.22.0 (IBM Corp. Armonk, NY, USA) and R software (R Development Core Team, 2011). For the mediation analysis, we used the SPSS PROCESS script by Hayes (2012).

Results

Descriptive Sample Characteristics

The sociodemographic characteristics of the 320 nutritional gatekeepers in this study were generally comparable to those of a representative German sample of household managers (defined as the person in the household responsible for household duties, including food purchases and preparation) from Media Perspective Data, 2014 (ARD-Werbegesellschaften, 2014) with regard to gender, age, size of household, and size of place of residence (Table 1). However, a higher proportion of participants in our sample had a lower level of formal education than in the representative sample. Consequently, we controlled for education level in all analyses. Moreover, a larger proportion of children in our sample were underweight or obese than in the same age group in the representative sample.

Link Between Parents' Numeracy and Children's BMI

Figure 2 plots parental numeracy as a function of children's BMI categories. A linear multiple regression analysis including only children with z-BMI scores *lower than or equal to* the recommended z-BMI as the outcome variable revealed a positive association between the child's z-BMI and parental numeracy, indicating that lower parental numeracy predicts lower z-BMI in these children ($\beta = 0.126$, $P = 0.048$). A linear multiple regression analysis including only children with z-BMI scores *equal to or higher* than the recommended z-BMI as the outcome variable revealed a negative association between the child's z-BMI and parental numeracy, indicating that lower parental numeracy predicts higher z-BMI in these children ($\beta = -0.299$, $P < 0.001$). Including all children and using the absolute z-BMI score as the outcome variable, we found a negative association between the child's absolute z-BMI and parental numeracy,

indicating that lower numeracy predicts greater deviation from normal weight ($\beta = -0.369$, $P <$ 0.001). With respect to the control variables, the child's z-BMI was only significantly associated with the child's age (in the sample with lower than or equal to recommended z-BMI: $\beta = 0.151$, $P = 0.017$; higher than or equal to recommended z-BMI: $\beta = -0.114$, $P = 0.039$, absolute z-BMI: $\beta = -0.175$, $P = 0.001$) and parents' education level (in the sample with higher than or equal to recommended z-BMI: $\beta = -0.114$, $P = 0.03$; see Table 2 for correlations between all measures used in the study).

Mediating Role of Weight-Related Numerical Information Processing

Results of the mediation analysis are summarized in Table 3. There were significant associations between higher numeracy and better performance on the three weight-related numerical information processing skills: comprehension of nutrition labels: a $= 0.259$, $P < 0.001$; comprehension of growth charts: a $= 0.334$, $P < 0.001$, and portion size estimation skills: a $= -0.077$, $P = 0.023$. However, the indirect effects of numeracy on absolute z-BMI score via the three weight-related numerical information processes were not significant (comprehension of nutrition labels: ab $= 0.015$, SE $= .01$, $Cl_{95\%} = -0.0019$ to 0.0432, comprehension of growth charts: ab $= -0.011$, SE $= 0.12$, $Cl_{95\%} = -0.0433$ to 0.0071; portion size estimation skills: ab $= 0.003$, SE $= 0.01$, $Cl_{95\%} = -0.0078$ to 0.0164; total: ab $= 0.007$, SE $= 0.01$, $Cl_{95\%} = -0.0197$ to 0.0317).

Although all relationships observed were in the predicted direction, none of the variables mediated the link between numeracy and the absolute z-BMI scores. This non-significant mediation can be partly explained by the lack of associations between the candidate mediators and child's absolute z-BMI (see Table 2).

Discussion

To the best of our knowledge, this is the first investigation of the link between parents' numeracy and children's BMI. Furthermore, we tested cognitive mechanisms potentially underlying such a link. We found support for the hypothesized link between lower parental numeracy and a larger absolute deviation of the child's z-BMI from the recommended z-BMI: Importantly, lower parental numeracy scores were associated with deviations in both directions, that is, with both under- and overweight in children. Furthermore, higher numeracy was associated with better comprehension of nutrition labels, better comprehension of growth charts, and better portion size estimation skills. However, we found no support for the hypothesis that the link between parental numeracy and children's BMI was mediated by these weight-related numerical information processing skills.

The present findings complement previous results on the role of parental numeracy and children's health. For instance, above and beyond the effects of education or socioeconomic status, lower parental numeracy has been found to be associated with insufficient glycemic control in children with diabetes (Pulgaron et al., 2014), with inappropriate usage of cough medicine for children (Lokker et al., 2009), and with asthma morbidity in children with asthma (Rosas-Salazar et al., 2013). Furthermore, our findings extend the work of Huizinga and colleagues (2008), who reported a link between numeracy and BMI in adults.

Importantly, the relation between lower numeracy and underweight had not previously been investigated. Our findings show that parental numeracy also seems to be involved in children's underweight. This is an important observation because being under- or overweight as a child has been found to have detrimental effects on health and development (Daniels, 2009; Luder &

Alton, 2005). Our findings highlight the potentially important role that parental numeracy plays for their children's healthy body weight.

Another goal of our study was to examine cognitive mechanisms potentially underlying the hypothesized link between numeracy and BMI. Contrary to our hypothesis, weight-related numerical information processing skills did not mediate the link. This finding can be at least partly explained by the lack of associations between parental weight-related numerical information processing skills and children's BMI. Yet we did find an association between higher parental numeracy and better portion size estimation skills, better comprehension of nutrition labels, and better comprehension of growth charts. This result underlines the importance of numerical skills for processing weight-related numerical information. Possible negative health outcomes of poor weight-related numerical information processing skills include macro-malnutrition (inappropriate level of energy, protein, fat) and micro-malnutrition (inappropriate level of vitamins, minerals). Neither macro- nor micro-malnutrition will necessarily result in children being over- or underweight, but they are associated with various long- and short-term health risks (Chandra, 2002; Liu, Raine, Venables, & Mendick, 2004; Tulchinsky, 2010). We can think of several possible explanations for the finding that weight-related numerical information processing skills did not mediate the association between parental numeracy and children's BMI. One is that we investigated processing skills that are assumed to play a role in children's dietary behavior. For example, if parents misinterpret nutrition labels on fitness drinks, they may underestimate the amount of sugar contained and allow their children to consume more than recommended amount. However, parental numeracy could also affect children's BMI through cognitive processes that are not directly related to dietary behavior. For example, it may take effect by parents competently monitoring the time their children spend in

sedentary (e.g., watching TV) relative to physical activities. Alternatively, parents' numeracy (or lack thereof) may increase (or reduce) their perception of the risk involved in their child being overweight or underweight and its long-term consequences (e.g., a quadrupled risk of adult hypertension in obese children; Watson et al., 2013). Still another reason is that numeracy goes beyond comprehension (Peters, 2012, p. 31); higher numeracy coincides with, for instance, lower sensitivity to framing effects and lower susceptibility to non-numerical information (Peters, 2012). In fact, the processing of non-numerical information may be particularly relevant in highly engineered choice architectures such as supermarkets and fast food restaurants, in which a myriad of non-numerical drivers such as a food's taste and images are designed to stimulate food consumption (Cohen & Babey, 2012).

To conclude, our investigation suggests that parental numeracy—an important cognitive skill in a world rife with numerical information—predicts children's weight status. Specifically, low parental numeracy appears to be a risk factor for children's under- and overweight. However, this risk can evidently not be attributed to high-numeracy parents being better able to processes numerical weight-related information. We discussed several possible reasons for this finding. Our focus in this study was on numeracy and the ability to process weight-related numerical information as potentially important skills for parents who are their children's food choice architects. Yet many other parental behaviors and cognitions shape children's dietary behavior and BMI, including parents' motivation, attitudes, control beliefs, and planning behavior (Baranowski, Cullen, Nicklas, Thompson, & Baranowski, 2003). Some of them could also play a role in the association between parental numeracy and children's BMI. Consider, for instance, motivation. A parent struggling with low numeracy may underestimate the risks associated with childhood obesity and thus be less motivated to monitor and modify the child's behavior. Further

research is required to winnow down the set of potential factors mediating the link between numeracy and BMI.

Strengths and Limitations

Our study is the first to show that parental numeracy relates to deviations (in both directions) from normal weight in their children. It does so by investigating a community-based sample that, in many important respects, reflects the German population at large. Another strength is that we tested three cognitive factors potentially mediating the association between parental numeracy and children's BMI. Identifying the mechanisms underlying this relationship will be an important step toward developing effective interventions promoting healthy body weight in children.

Our study also has limitations. First, the data collected are cross-sectional; consequently, we could not explore temporal dynamics in the relationship between parental numeracy and children's BMI, and no causal inferences can be drawn. Second, as in previous studies, we found parental education and numeracy to be correlated, suggesting that education could drive the effects found. Specifically, we found that lower parental numeracy scores were associated with a lower education level. However, as we controlled for education level in all analyses, our results reflect the effects of numeracy on children's BMI above and beyond the effects of education. Therefore, the results suggest that numeracy could in fact be one of the explanations for why lower education level is associated with poorer health. Third, our results were not entirely representative of German households. In particular, the nutritional gatekeepers in the present sample had a lower education level than did heads of households in the German population at large. Accordingly, it is possible that numeracy scores in the present sample are lower than in the

German population at large. To the best of our knowledge, no previous study with a nationally representative sample has used the eight-item Weller scale. However, four items from the Weller scale stem from the Lipkus, Samsa, and Rimer (2001) numeracy scale. This scale has been tested in a probabilistic, national sample representative for the German population (see Galesic & Garcia-Retamero, 2010). The percentage of participants correctly answering these four items was lower in our sample than in the representative sample (depending on the item, 40–60% participants in our study vs. 68–88% in the representative sample). Fourth, the proportion of children in our study sample who were underweight or obese was larger than in the same age group in the reference population. This added variability permitted us to examine a previously neglected group at risk, namely, underweight children. We have thus been able to conclude that parental numeracy may also be a key factor in children being underweight. Fifth, because of the number of constructs assessed, we used shortened scales to measure comprehension of nutrition labels and growth charts. This may have limited our ability to detect meaningful relations. However, a pilot study showed that the short scales had satisfactory psychometric properties. Sixth, we cannot exclude the possibility that spatial awareness may contribute to portion size estimation or growth chart use. We are not aware of any study examining the role of spatial awareness in either context. Further research is warranted here. Finally, parents reported their child's height, which may have influenced results. Importantly, body weight was measured directly, and previous research has shown that parents only slightly overestimate body height; the bias between self-reported and measured BMI stems mainly from parents underestimating children's body weight (Huybrechts et al., 2011; Nyholm et al., 2007).

Practical Implications

Our results have potentially important practical implications: In numerous OECD member countries, including Germany and the US, large segments of the population have relatively poor numeracy skills (OECD, 2013). Our study shows that parental numeracy, that is, parental ability to comprehend numbers across domains, is a significant predictor of children's BMI as well as of the parent's nutrition label comprehension, growth chart comprehension, and portion size estimation. These results imply that parents with lower numeracy will have more difficulty estimating how much their children eat, determining whether their child eats according to nutritional recommendations, and monitoring their child's healthy growth over time. The role of parental numeracy should be taken into account when developing strategies to prevent and treat childhood malnutrition and weight-related issues (being obese or seriously underweight). Such strategies could include easily understandable and transparent communication of children's weight status and dietary recommendations by health care providers. Visual aids and colored information labels could help parents with lower numeracy skills to understand important crucial health- and weight-related information. For example, traffic light coding could be applied to growth charts, with green and red components indicating that the child's weight falls within or outside of a healthy range. Importantly, however, this and other communications would need to be tested carefully with the target audience of less numerate parents. Another important component of policy interventions may be to consider the role of numerical skills in understanding educational materials about healthy weight management. For example, it may be helpful to use non-numerical descriptions or color coding, or simple tools that help to determine proper portion sizes. Finally, it seems important to make information on food packages more transparent—for example, by providing information on portion sizes in non-numerical ways such

as "the size of your child's fist" or explicitly stating that one bottle of this drink contains all the sugar a child should consume in a day. Such tools and information on food packages could support parents with lower numeracy, in particular, to determine appropriate portion sizes and to handle other quantitative information when making everyday weight-related decisions.

Conclusion

This is the first study to identify lower parental numeracy as a predictor of children being under- and overweight. Importantly, parental numeracy was a more important predictor than were specific weight-related numerical information processing skills, such as food label comprehension and portion size estimation. Our findings highlight the role of parental numeracy for interventions targeting childhood obesity and malnutrition.

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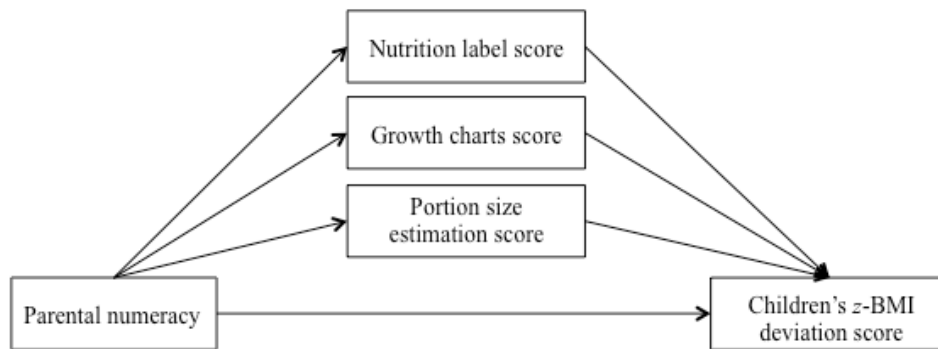
Figure 1. Mediation model of the relationship between parental numeracy and children's *z*-BMI deviation score, as mediated by nutrition label score, growth charts score and portion size estimation.
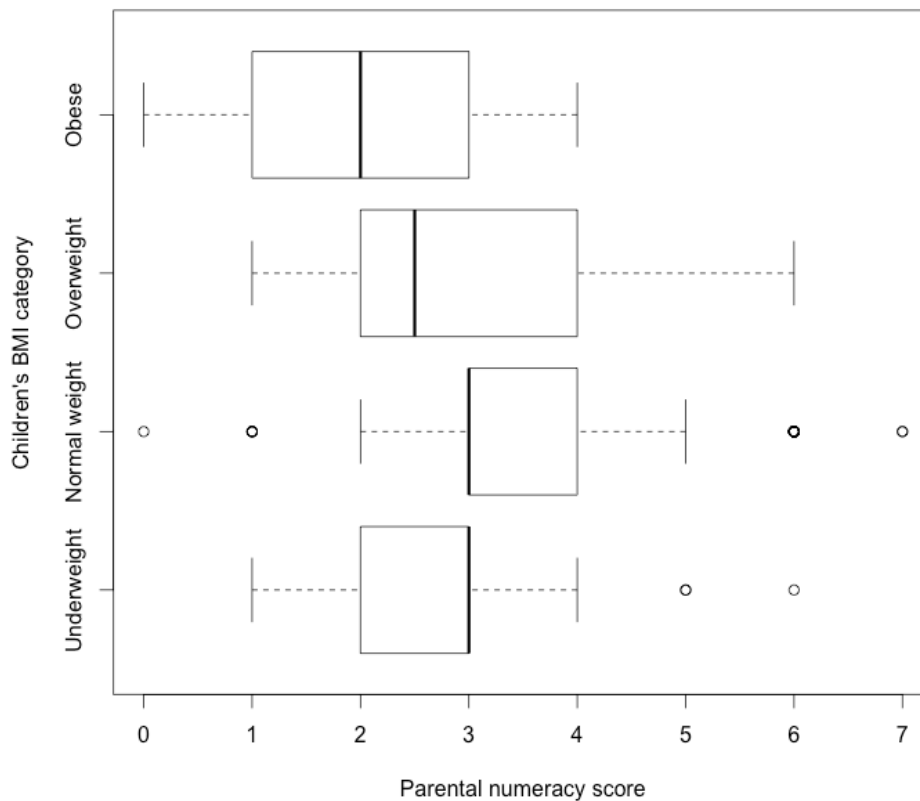

Figure 2. Distribution of parental numeracy scores, separately for children's BMI categories. The dark lines represent the median parental numeracy score whereas the ends of the boxes represent the 25% and 75% of scores, and the whiskers represent the maximum and minimum without taking into account outliers which are shown in dots. Values are considered as outliers if they are at least 1.5 interquartile ranges below the first quartile (Q1) or at least 1.5 interquartile ranges above the third quartile (Q3).

Table 1

Sociodemographic characteristics of the study sample as compared to the German population (in %)

		Nutritional gatekeeper N = 320		Child N = 320	
		Study sample	German population	Study sample	German population
Gender	Male	14.8	15.2[a]	45.2	51.4[b]
	Female	86.2	84.8[a]	54.8	48.6[b]
Age	6			16.3	13.8[b]
	7			11.9	13.9[b]
	8			11.3	13.8[b]
	9			17.2	14.5[b]
	10			12.8	14.2[b]
	11			14.1	14.5[b]
	12			16.5	15.3[b]
	18–29	8.4	6.8[a]		
	30–39	44.3	41.9[a]		
	40–49	39.8	45.9[a]		
	50+	7.2	5.1[a]		
Education level[a]	Vocational-track secondary ed.	25.7	20.9		
	Intermediate-track secondary ed.	49.9	33.5		
	Academic-track secondary ed.	14.7	14.6		
	University degree	9.4	30.7		
	Not specified	0.3	0.3		
Size of household[a]	2	8.7	7.8		
	3	27.4	26.1		
	4	41.1	44.7		
	5+	22.7	21.4		
Size of place of residence[a]	< 5,000	22.1	15.7		
	5000–19,999	25.9	27.5		
	20,000–99,999	27.7	27.4		
	100,000–499,999	10.9	14.1		
	≥ 500,000	13.4	15.3		
Body Mass Index[d]	Underweight				
	3–6 years			9.6	5.2[e]
	7–10 years			22.4	7.8[e]
	11–13 years			7.1	8.6[e]
	Adults	2.5	2.3[c]		
	Normal weight				
	3–6 years			65.4	85.6[e]
	7–10 years			61.2	76.8[e]
	11–13 years			79.6	72.7[e]
	Adults	49.5	51.4[c]		
	Overweight				
	3–6 years			9.6	6.2[e]
	7–10 years			6.5	9.0[e]
	11–13 years			12.2	11.4[e]
	Adults	32.7	31.4[c]		
	Obese				
	3–6 years			15.4	2.9[e]
	7–10 years			10.0	6.4[e]
	11–13 years			1.0	7.2[e]
	Adults	15.3	14.9[c]		

[a]Most comparable representative data for nutritional gatekeepers are for German household managers (defined as "the person in the household responsible for household duties, including food purchases and preparation") from Media Perspective Data, 2014 (ARD-Werbegesellschaften, 2014). [b]Representative data for German children from the 2014 microcensus (Kurt & Schaffrath Rosario, 2007). [c]There are no representative data for the BMI of nutritional gatekeepers; as an approximation, we use representative data for married women in Germany, based on the German Health Update (GEDA) study (Mensink et al., 2013). [d]Underweight is defined as a BMI < 18.5 for nutritional gatekeepers and < 10th percentile for children; normal weight as a BMI between 18.5 and 25 for nutritional gatekeepers and between 10th and 90th percentile for children; overweight as BMI > 25 for nutritional gatekeepers and > 90th percentile for children; obese as BMI > 30 for nutritional gatekeepers and > 97th percentile for children on the basis of recommended guidelines (AGA, 2011). [e]Representative data from the KiGGS study (Kurt & Schaffrath Rosario, 2007) for age groups 3–6 years, 7–10 years, 11–12 years.

Table 2

Correlations between children's z-BMI, parental education level and numeracy, nutrition label score, growth charts score, and portion size estimation score

Measures	1	2	3	4	5	6	7	8
1. *z*-BMI (*N* = 320)								
2. Absolute *z*-BMI (*N* = 320)	−							
3. *z*-BMI (normal and overweight; *n* = 293)	−	−						
4. *z*-BMI (normal and underweight, *n* = 253)	−	−	−					
5. Education	−0.14*	−0.06	−0.18	−0.10				
6. Numeracy	−0.10	−0.38*	−0.32*	0.13*	0.13*			
7. NL score	−0.08	−0.04	−0.12	−0.05	0.11	0.26*		
8. GC score	−0.04	−0.14*	−0.13	0.02	0.14*	0.27*	0.34*	
9. PSE score	−0.16*	0.00	−0.17	−0.11	0.06	−0.12*	−0.09	−0.15

Notes. *z*-BMI = *z*-standardized body mass index indicating in what direction (above/positive or below/negative) and by how much a child's BMI deviates from the reference mean; absolute *z*-BMI = absolute deviation from *z*-standardized body mass index indicating how much the child's *z*-BMI deviates from the reference mean without taking into account the direction of the deviation; NL score = comprehension of nutrition labels, GC score = comprehension of growth charts, PSE score = portion size estimation; * $p < .05$

Table 3

Summary of results from the mediation analysis (5000 bootstrap samples)

Independent variable (IV)	Mediating variable (M)	Dependent variable (DV)	Effect of IV on M (a)	Effect of M on DV (b)	Direct effect (c')	Indirect effect (ab)	Total effect (c)
Numeracy	NL score	*z*-BMI deviation	0.259**	−0.041	−0.264**	0.015	−0.257**
	GC score		0.334**	−0.035		−0.011	
	PSE score		−0.077*	0.058		0.003	
	Total					0.007	

Note. *N* = 319. NL score = comprehension of nutrition labels, GC score = comprehension of growth charts, PSE score = portion size estimation; * $P < .05$. ** $P < .01$.

Manuscript 4

Dallacker, M., Hertwig, R., & Mata, J. (2017). *Parents' considerable underestimation of sugar and their child's risk of overweigh*. Manuscript under review.

Parents' considerable underestimation of sugar and their child's risk of overweight

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Abstract

High sugar intake is associated with an increased risk of overweight. Because parents are their children's nutritional gatekeepers, having knowledge about sugar is an important prerequisite for regulating sugar consumption in children. Yet little is known about parental ability to estimate the sugar content of foods and beverages and how this ability is associated with children's body mass index (BMI). With a sample of 305 parent–child pairs, we investigated to what extent parents under- and overestimate the sugar content of foods and beverages commonly found in a child's diet as well as potential associations with children's z-BMI. Parents considerably underestimated the sugar content of most foods and beverages (e.g., 92% of parents underestimated the sugar content of yogurt by on average 7 sugar cubes). After controlling for parents' education and BMI, parental sugar underestimation was significantly associated with a higher risk of their child being overweight or obese (odds ratio=2.01). There was a small dose–response relationship between the degree of underestimation and the child's z-BMI. These findings suggest that providing easily accessible and practicable knowledge about sugar content through nutritional labeling has promise as a way to help curtail sugar intake in children and, consequently, prevent overweight.

Introduction

Sugar intake has been found to be a potential contributor to overweight and obesity.[1] The World Health Organization (WHO) recommends reducing consumption of free sugars to less than 10% of total daily energy intake (approximately 50 grams or 16 sugar cubes for an average adult).[2] Yet a large proportion of the population exceeds this threshold (e.g., added sugar alone makes up 17% of energy intake in U.S. adults and 14% in children).[3] High sugar consumption in children is of particular concern, because food preferences are established early in life and track into adulthood.[4] Importantly, children rarely make independent food choices: Their parents, being their nutritional gatekeepers, determine approximately 70% of what and how much they eat.[5] Many countries are currently working on public health measures aimed at reducing sugar consumption, particularly in children, such as stricter regulations for the advertisement of sugary food[6] and higher taxation of sugar-sweetened beverages.[7] Another promising approach is to boost parents' decision competence.[8] Adequate nutritional knowledge is often seen as a building block for making healthy dietary decisions.[9] For example, providing caloric information on sugar-sweetened beverages has been shown to lead to attitude changes[10] and reduced purchases.[11]

  To monitor children's sugar consumption, parents need to know how much sugar different foods and beverages contain. For public health policies to be efficient in reducing children's sugar consumption, more research is needed to understand the role of parental (intuitive) sugar knowledge and its relation to children's body weight. This is the first study to examine systematic under- and overestimation of the sugar content of common foods and beverages and to explore the consequences such a misestimate might provoke. The enormous amount of added sugar defies reasonable expectation, in particular when the foods in question is

not perceived as prototypical treat. Therefore, we hypothesized that most parents are likely to underestimate the sugar content of common foods and beverages and that systematic underestimation of sugar content would be associated with a higher risk of their child being overweight.

Materials and Methods

In 2015, a market research institute recruited and interviewed 309 parent–child pairs. The child's and parent's body weight and height were measured by a trained interviewer. To be included in the study, the parent had to be the family's nutritional gatekeeper, that is, be responsible for planning and preparing the food. Children's mean age was 9.07 ± 2.21 years (range 6–12 years); 50% were girls. Data from a representative reference population[12] indicate that 12% of the children were obese, 13% overweight, and 10% underweight. Parents' mean age was 40.01 ± 7.31 years; 79% were female; 15.7% were obese (body mass index [BMI]>30), 35.7% overweight (BMI>25), and 1.3% underweight (BMI<18.5). Four parent–child pairs were excluded due to biologically implausible standardized BMI (z-BMI) values in the children (z-BMI<-4),[13] resulting in a final data set of 305 parent–child pairs. All participants gave informed consent; the ethics committee of the *Max Planck institute for Human Development* approved the study.

Sugar-Estimation Task

The computer-based task was tested in a pilot study. Before prompting them to estimate sugar content, parents were informed about the WHO recommendation not to obtain more than 10% of their total daily energy intake from sugar, namely, the equivalent of approximately 16 sugar cubes for an average adult. We also informed them that a sugar cube is equivalent to 3 gram of

sugar. Next, parents saw pictures of six common foods and beverages, components of a typical

diet of children and adults alike, and were asked to estimate the total amount of sugar (e.g.,

"How many sugar cubes in total do you think are in this 330-ml glass of Coca-Cola?"). All items

represented a usual serving size (Cronbach's alpha =.70; items were orange juice, Coca-Cola,

pizza, yogurt, granola bar, and ketchup). To generate a robust summary score, items were

weighted equally. We excluded one item (i.e., a jar of red cabbage) from further analyses

because a jar does not represent a single serving size. Importantly, though, all effects (odds ratios

[ORs], correlation coefficients, and respective significance levels) did not change and, in fact,

were even slightly larger when this item was included. Parents' estimations were scored using

the deviation between estimated (e_i) and true number (t_i) of sugar cubes. Three scores were

calculated: (*a*) a summary estimation score (ES), indicating the total deviation across all food

and beverage items (the summary score was further differentiated into a measure of

underestimation [ES<0] and a measure of overestimation [ES>0]); (*b*) an underestimation score

(US), summarizing only sugar underestimations (overestimations and correct estimations=0);

note that the US was inverted for easier interpretation, so that a higher US indicates a higher

degree of underestimation; and (*c*) an overestimation score (OS), summarizing only sugar

overestimations (underestimations and correct estimations=0).

$$\text{ES} = \sum_{i=1}^{6} (e_i - t_i); \quad \text{US} = \left(\sum_{i=1}^{6} \begin{cases} \text{if } (e_i - t_i) < 0 \\ 0 \text{ otherwise} \end{cases} \right) \times (-1); \quad \text{OS} = \sum_{i=1}^{6} \begin{cases} \text{if } (e_i - t_i) > 0 \\ 0 \text{ otherwise} \end{cases}$$

Statistical Analyses

A multinomial logistic regression analysis was performed to assess the association

between parental sugar underestimation and children's weight status. Overweight and

underweight served as dependent variables and normal weight as reference. Sugar underestimation (ES<0) served as independent variable with overestimation (ES>0) as reference. ORs were adjusted for parental education and BMI. Correlation analyses were conducted to investigate the relationships between children's z-BMI, ES, US, and OS. A regression analysis was conducted to test the association between US and z-BMI in children while controlling for parental education and BMI. All statistical analyses were performed using SPSS v.22.0 and R software (Version 1.0.136).

Results

Performance on Sugar-Estimation Task

Table 1 summarizes for each food and beverage item the percentage of parents who underestimated, overestimated, or correctly estimated the sugar content, and the mean under- and overestimation expressed as sugar cubes.

Association Between Sugar Estimation and Children's BMI

A total of 224 parents (74%) had a negative summary score (ES<0); that is, they underestimated the sugar content across all food and beverage items. Furthermore, the logistic regression analysis revealed that underestimation was a significant predictor of overweight (OR: 2.01; 95% confidence interval, CI [1.04-3.91], P=0.039) but not of underweight (OR: 2.52; 95% CI [0.826-7.721], P=0.104). Table 2 shows the correlations between the parental summary estimation score (ES), underestimation score (US), overestimation score (OS) and children's z-BMI. A regression analysis controlling for educational level and BMI of parents indicated a significant dose-

response relationship between the degree of underestimation and children's z-BMI (β=-.110; P=0.026).

Discussion

Parents tended to greatly underestimate the sugar content of common foods and beverages, in particular those wearing a "health halo" (e.g., orange juice or yogurt).[14] Only the sugar content of granola bars and ketchup was generally over- and not underestimated. More than 80% of the parents underestimated the amount of sugar in orange juice and yogurt—frequently consumed by many children[15]—by, on average, seven sugar cubes. This amounts to more than 60% of their total sugar content.

This is the first study to demonstrate that parental underestimation of sugar content is a potential risk factor for childhood obesity. Above and beyond the influence of parental education and BMI, the underestimation of sugar is associated with a twofold increase in risk of children being overweight or obese. We also found a dose–response relationship; that is, the more a parent underestimated the amount of sugar, the higher the BMI of the child. We found a reversed (albeit not significant) association between overestimation and BMI. This suggests that it is not misestimation per se, but specifically parental underestimation of sugar that represents a potential risk factor for children's overweight.

The main limitation of our study is the use of cross-sectional data. We cannot draw firm conclusions on the basis of the current results about potential mechanisms underlying the sugar-underestimation–overweight link. One mechanism, as suggested above, might be that parents who underestimate the amount of sugar in certain foods and beverages (e.g., yogurt or juice) monitor or regulate their child's consumption of these products less. This, in turn, may permit the

child to consume more sugar. Future research should investigate this and potential other mechanisms underlying the link between underestimating sugar (and perhaps other nutritional information, such as calories) and overweight.

Knowledge about sugar content can inform behavior, particularly that of nutritional gatekeepers. Nutrition labels that make the sugar content more prominent, for example, a traffic light system indicating levels of sugar as high (red), medium (yellow), or low (green), could be one way to remedy parents' underestimation of sugar. Traffic light front-of-package labels can help consumers identify healthier products.[16] Of course, this is not a stand-alone strategy but rather one measure in a comprehensive approach that includes other measures, such as taxation and bans of advertisement targeting children.

Conclusion

This study shows that most parents tend to underestimate the sugar content of common foods and beverages, frequently consumed by adults and children. Further, parental underestimation of sugar was associated with a higher risk of the child being overweight or obese. Offering easily accessible information about sugar content could be one way to curtail its consumption in children and, consequently, help to prevent overweight.

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Table 1.

Descriptive statistics of parents' sugar estimation scores

Item	% of parents estimating sugar content			Mean (SD) under- and overestimation [a,b]		Estimate as % of total sugar content [a,b]	
	Under	Over	Correct	Under	Over	Under	Over
100% orange juice (one glass)	84.6	8.5	6.8	-7.18 (2.20)	5.73 (3.22)	71	57
Coca-Cola (one glass)	56.1	44.3	0	-4.74 (3.56)	5.39 (3.23)	41	47
Frozen pizza (one box)	67.9	32.1	0	-3.85 (1.93)	4.77 (4.22)	59	873
Yogurt (one container)	92.1	7.6	0.3	-7.00 (2.74)	4.13 (2.82)	64	38
Chocolate granola bar (one bar)	29.8	66.2	4.0	-1.10 (0.82)	3.87 (3.56)	44	152
Ketchup (single serving packet)	25.6	46.9	27.5	-1.10 (0.52)	4.44 (4.40)	61	293

N=305; [a] in number of sugar cubes; [b] parents who correctly estimated the sugar content were not taken into account

Table 2.

Correlations between parental summary estimation score (ES),
underestimation score (US), overestimation score (OS) and children's *z*-
BMI

	ES	US	OS
ES	-		
US	-.907**	-	
OS	.951**	-.733**	-
z-BMI	-.117*	.141*	-.085

* P<0.05, ** P<0.01

Manuscript 5

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Social nature of eating could explain missing link between food insecurity and childhood

obesity

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Abstract: We suggest that social factors are key to explain the missing link between food

insecurity and obesity in children. Parents and public institutions are children's nutritional

gatekeepers. They protect children from food insecurity by trimming down their consumption or

by institutional support. To gauge children's food insecurity, evaluations across the different

nutritional gatekeepers need to be integrated.

The insurance hypothesis offers an intriguing environment-based account of the global

obesity crisis. Considering the mismatch between ancestral food scarcity and the unprecedented

The insurance hypothesis offers an intriguing environment-based account of the global

obesity crisis. Considering the mismatch between ancestral food scarcity and the unprecedented

energy- density of contemporary food environments, it attributes socioeconomic differences in

obesity to an evolved adaptive mechanism. Specifically, individuals are hypothesized to store

more fat when cues indicate that access to food is uncertain, thus buffering against future

shortages. The authors acknowledge the multicausality of obesity, with no single factor

explaining all or most of the variance. Against this background, they also consider the role of

genes and psychological factors such as impulsivity and inhibition in explaining the complex

phenomenon of obesity. However, one important factor is missing from their account: the role of

others, namely, nutritional gatekeepers.

Although Nettle et al. emphasize the role of society in explaining obesity, they depict

food choice – perhaps the single most important behavioral act associated with obesity or lack

thereof – as an individualistic decision. They thus overlook social dimensions that are crucial in

explaining some of the perplexing patterns surrounding obesity. Eating is not a solitary intake of

energy but often a social activity shaped by others' dietary behavior and choices (Herman et al.,

2003). "Company" literally means "with bread" – company is those with whom we break bread.

Few, if any, health-related behaviors are as closely embedded in the social context as eating –

especially where children are concerned. By the age of 10, a child has eaten about 10,000 meals,

most of them in the company of their family. Yet, children rarely enjoy autonomy in their food

choices. Nutritional gatekeepers – not only parents and grandparents, but also institutions (e.g.,

kindergartens, schools, policymakers) determine the food choice architecture. One of the most

important food contexts for children is the family, with nutritional gatekeepers determining more

than 70% of what the family eats (Wansink, 2006) through, for example, their economic

resources (Keane et al., 2012), family mealtime practices (Dallacker et al., under review), nutritional knowledge, and numerical abilities, which are associated with comprehension of nutrition labels or portion size estimation skills (Dallacker et al., 2016; Mata et al., 2008).

Why do the authors not find a relationship between food insurance and obesity in children? We suggest that recognizing the social nature of eating–and, in particular, of children's food choices – can offer answers for this missing link. Not all participants in the shared activity of eating (e.g., Sobal & Nelson, 2003) will be equally affected by (perceived) food insecurity. Despite eating at the same table, the last-born child is often less well-nourished than the first-born. For example, in a family of seven, the height for age of the last-born child is up to 2.5 standard deviations less than that of the first-born (Hertwig et al., 2002). Yet ethical norms and legal policies aim to protect children from malnutrition or starvation. For example, mothers report abstaining from food to ensure that their children are adequately nourished (McIntyre et al., 2003; Piperata et al., 2013). In wealthy societies, institutional settings such as day care centers and schools often provide free lunches or free milk to children from impoverished families. In the United States, for example, 16 different food assistance programs were funded in 2002, and one in five Americans participated in them at one point during that year (Fox et al., 2004). Thus, relatively rich societies aim to protect children from the detrimental effects of food insecurity through social norms, welfare assistance, and institutionalized arrangements. Admittedly, despite these efforts, even high-income countries appear to suffer from "hidden hunger" and malnutrition caused by vitamin and mineral deficiencies that threaten to impair children's intellectual and physical development (Biesalski & Black, 2016).

The authors suggest a methodological explanation for the missing link between food insecurity and body mass index: The studies included in the meta-analysis measured a child's

food insecurity through parental reports, which are likely to differ from the child's perception (Connell et al. 2005; Fram et al. 2011). Importantly, this is not only a methodological, but also, again, a social explanation. As described above, wealthy societies aim to protect children from hunger and food poverty both within the family and beyond (Fox et al. 2004). As a consequence of the multiple individual and institutional nutritional gatekeepers involved in children's nutrition, parental perceptions – being just one piece of the social puzzle – may not be a veridical and integrative proxy of a child's food (in-)security – even more so when parents equate food security with lack of hunger and thus neglect the risk of malnutrition.

To conclude, eating was, has been, and will likely continue to be a shared activity – not always, but often. Any comprehensive model of obesity therefore needs to account for the social nature of food choice and consumption. This is particularly the case for children, whose food choice autonomy is restricted. The authors did not find a link between food insecurity and children's obesity. The reason could be that this link simply does not exist or is relatively weak because parents, institutions, and policymakers buffer children from food insecurity. Alternatively, a link may exist, but it may be moderated by who is competent to gauge children's experience of food security or lack thereof: the children, their parents, institutional settings, policymakers? A stringent test of the food insecurity hypothesis in children demands that proper attention be paid to the social dynamics of food choice and eating.

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