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The Combined Effect of Infant Birth Weight and Maternal Determinants of Health on the Development of Childhood Obesity: A Systematic Review

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Abstract

Objective: The purpose of this integrated review is to examine the current state of the literature related to the combined effect of maternal determinants of health and birth weight on the development of obesity in childhood for children age eight and younger. Reviewers sought to understand whether the combination of maternal determinants of health and birth weight posed a greater risk for the development of childhood obesity than individual factors.

Design and Method: This integrative research review is based on the framework described in Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA). A full text review resulted in 13 articles selected for inclusion in the review. Articles were selected for inclusion based on measurement of obesity in children age eight and younger, a correlation between maternal factors and childhood obesity, and a correlation between birth weight and childhood obesity. Statistical significance was not a requirement for inclusion.

Review: Of the 13 articles reviewed 62% (n = 8) discussed material influences of education and smoking and birth weight and their predictability of childhood obesity. The maternal predictor, income status, was assessed in three studies (n = 3). Findings related to the combination of birth weight and maternal determinants of health were not conclusive.

Conclusion: Our findings indicate that the association between combination of maternal health determinants and birth weight on the development of childhood obesity play a small role but needs further investigation. More studies are needed to explore the combination of maternal determinants and infant birth weight as they related to childhood obesity risk factors.

Keywords

Obesity, Childhood obesity, Determinants of health, Maternal factors, Birth weight

List of Abbreviations

AGA: Average for Gestational Age; IUGR: Intrauterine Growth Retardation; LBW: Low Birth Weight; LGA: Large for Gestational Age; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analysis; SGA: Small for Gestational Age

Introduction

Obesity is a multifaceted and non-discriminatory problem that has reached epidemic proportions for both adults and children. Multiple comorbidities are

associated with obesity and include, but are not limited to, diabetes, cardiovascular disease, musculoskeletal disorders, and some cancers [1]. Ultimately, these comorbidities lead to an overall decrease in quality of life, and increased medical intervention and cost. Medical costs associated with obesity are estimated at $147 billion while nationwide productivity cost estimates for obesity range from $3.38 billion to $6.38 billion [2]. Considering these statistics, it should come as no surprise that weight status is a major topic of focus for Healthy People 2020.

A 2016 report by the National Center for Health Statistics identified 37.9% of the adult population obese, and 70.7% of adults either overweight or obese [3]. Further, the report identified the percentage of obese children as 20.16% for children age 12-19 years, 17.4% for children age 6-11 years, and 9.4% for children age 2-5 years [3]. Obesity is difficult to reverse, especially if it develops in childhood and tracks into adulthood [4]. For this reason, prevention of the development of obesity in childhood is critical.

Since 1988, there has been no measured reduction in childhood obesity rates [5]. In fact, rates have nearly doubled in all age categories of children, with the exception of 2-5 year olds who experienced slight increases [3, 4]. Currently, childhood obesity prevention largely revolves around instilling good health behaviors by educating parents on the importance of diet, exercise, and lifestyle factors [6]. While health behaviors are indisputably an important determinant in the development of obesity, literature also implicates factors that are more difficult to modify and address including genetics, fetal development, environment, and socioeconomic status [7-9].

The prevention of childhood obesity is further complicated when considering the age of the child, as cognitive development plays a vital role in the ability to understand and adopt healthy behaviors. Children age eight years and under cannot conceptualize frequency correctly [10]. That is, they are unable to understand the length of time between meals and snacks. Furthermore, children age eight and under need adult assistance to provide dietary information because of limited reading skills and vocabulary [10]. Finally, adults largely control the food environment through the foods offered, as well as timing and frequency of eating occasions [11, 12]. Cognitive development in children age eight and younger indicates that the caregiver's ability to control the timing of meals, quality of foods, and portion sizes plays a clear role in the development of childhood obesity.

Clearly both maternal and child factors play a role in the development of childhood obesity. However, it is unclear whether a combination of these factors increase risk. Identifying those at highest risk for the development of childhood obesity is critical to the development of interventions that lead to a true and measurable reduction in childhood obesity rates. The purpose of this integrated review is to examine the current state of the literature related to the combined effect of maternal determinants of health and birth weight on the development of obesity in childhood for children age eight and younger. Moreover, the integrative review sought to determine if the combination of maternal determinants of health, and birth weight demonstrated a higher risk for childhood obesity compared to individual factors in children age eight and younger.

Material and Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guided this review Figure 1. The target population for inclusion in this review included children with BMI measured at eight or younger with information on selected maternal factors and birth weight. The age of eight or younger was selected specifically due to the level of cognitive development in the child, and the need for caregiver control over the timing, frequency, and quality of meals. For the purpose of this review, gestation and birth weight factors were defined as small for gestational age (SGA), large for gestational age (LGA), and intrauterine growth retardation (IUGR). Maternal factors were identified as determinants of health and defined as age, education level, income, employment, physical environment, access to healthcare, social support, and smoking.

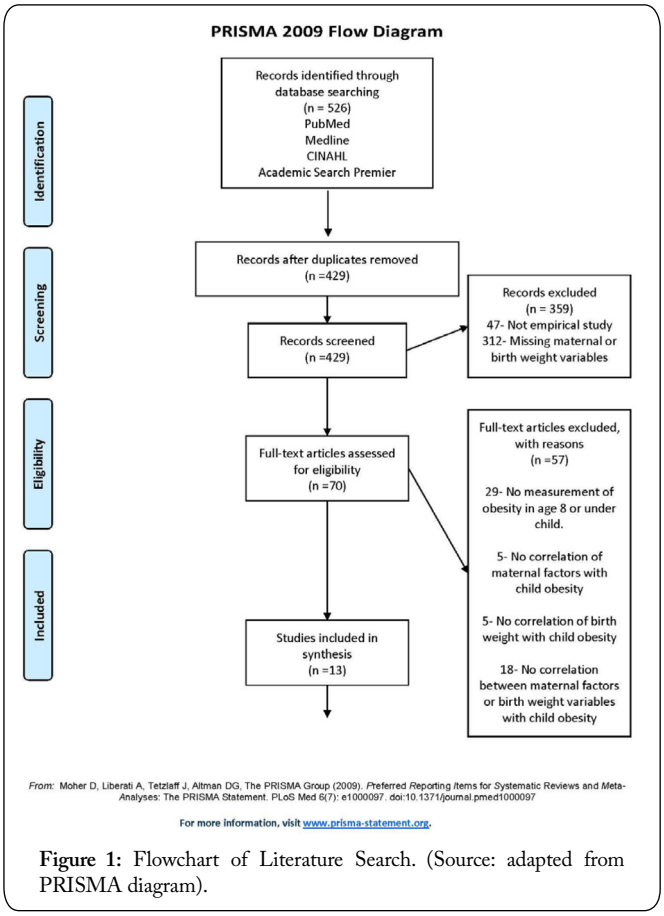

Figure 1: Flowchart of Literature Search. (Source: adapted from PRISMA diagram).

The authors conducted a comprehensive search of four electronic databases including the Cumulative Index to Nursing and Allied Health Literature, PubMed, MEDLINE, and Academic Search Premier. To summarize the most current state of the literature search criteria were limited to studies published between 2006 and 2016. English language, and publication in a peer-reviewed journal served

as additional inclusion criteria. A university librarian assisted to ensure an exhaustive search. Search terms were consistently applied across databases and included "pediatric obesity/ET" combined with "mother", "maternal", "newborn", "neonate", "infant", and "baby".

A total of 526 articles were identified through the search. Removal of duplicates resulted in an initial screen of 429 records. Article titles and abstracts were reviewed independently by all four authors. Articles were accepted for full text screen if they were empirical research studies, and contained the topics of both birth weight, and maternal factors. When two or more reviewers disagreed, the decision to include or exclude the article was made by consensus of all authors. Seventy articles were identified for full-text screening.

All four authors independently reviewed the full text articles for the inclusion of a measurement of obesity in children age eight and younger in combination with either (1) a correlation between maternal factors and childhood obesity or (2) a correlation between birth weight and childhood obesity. Statistical significance of findings was not required for inclusion. The full text review resulted in 13 articles selected for inclusion in the review [13].

Review

Individual Factors

During the review of the literature, the authors identified three common individual factors associated with the prediction of childhood obesity. These factors included, (1) maternal influences (smoking and education), (2) income, and (3) birth weight (LGA, SGA, and AGA). These areas of emphasis were identified after examining the literature for commonalities and differences across the 13 various articles (Table 1). Very few studies measured the strength of combined association between maternal influences, income, and birth weight factors in the development of childhood obesity for children age eight and younger.

Maternal influences

When considering maternal health determinants, the most frequently identified predictors of childhood obesity were mother's educational attainment and maternal smoking. Of the 13 articles reviewed 63% (n = 8) discussed education and/or smoking in combination with birth weight. Educational attainment was defined as a mother's educational level and was reported in study sample demographics. Smoking was self-reported by mothers and was defined as smoking during pregnancy. As an individual factor, two studies identified a statistically significant correlation between higher maternal educational attainment and obesity in preschool children [14, 15]. The maternal influence of smoking was established as a contributor along with LGA to predict childhood obesity, however, the findings did not discuss the relationship of maternal influences of smoking and SGA as a predictor for childhood obesity. Two studies [16, 17] concluded prolonged exposure to smoking after birth further increased the risk of childhood obesity. Two studies examined the predictor of maternal smoking influences and LGA on childhood obesity [18, 19] Two studies examined the predictors of maternal influences of both education and smoking on childhood obesity, two studies found a correlation [20, 16] and two studies did not [21, 18].

Income

The maternal predictor, income status, was assessed in three studies (n = 3) [22-24]. These studies were inconclusive whether low socioeconomic status was a predictor of childhood obesity; nor did they show statistically significant relationships between the maternal determinants of low socioeconomic status and birth weight as a predictor of childhood obesity. Four studies [22-25] offered no measurement of the combined effects of education and income as a predictor for childhood obesity although both factors were discussed individually.

Birth Weight

Research studies examining maternal educational attainment LGA in infants reported non-significant results [16, 25, 26]. Meaning it is inconclusive whether the combined effects of maternal educational attainment and LGA can be used to predict the development of childhood obesity. Individually, no association was found between infants born SGA and the development of childhood obesity [21]. Research measuring IUGR as a predictor for childhood obesity was not obtained in this review. Therefore, it is unclear whether infants born with IUGR are at higher risk for the development of childhood obesity.

Conclusion

The purpose of this review was to examine the combined effects of maternal health determinants and birth weight on the development of obesity in childhood; and to determine if the combination of maternal determinants and birth weight demonstrated a higher risk for childhood obesity compared to individual factors. Although the literature undeniably shows the prevalence of overweight and obesity in children, most studies rely on mothers' self-report, and lacked measurement of combined factors. The few studies that did measure combined factors inconsistent findings [27-29].

Many of the maternal health determinants intertwine closely with other comorbidities as well as with one another. For example, one study found that maternal obesity is closely related to the mother developing gestational diabetes and preeclampsia [30]. Furthermore, the study concluded a link between these maternal determinants, an increased risk for fetal macrosomia, and childhood obesity [31, 32].

There has been evidence linked to maternal smoking during pregnancy and a significant reduction of birth weight (120-150 g) of infants. Among these children born SGA, it was found that at 3 years of age, boys had an increased BMI compared to children born to non-smoking mothers. [33]. When looking at studies of premature newborns, it was found that infants with longer gestational age and higher birth weight were at an increased risk of being obese during adolescence [34].

Table 1: Summary of articles included in the integrated review.

Author (year)	Design	Population/Variables	Results
Anderson, Hayes, & Chock (2014) [20]	Prospective Cohort	15,141 children age 0-2 enrolled in the WIC program in Hawaii. Variable: Infant birth weight, maternal tobacco use, maternal age.	Children with a high birth weight of > 4000 g are more likely to become obese by age 2. Children of mothers who smoke are more likely to become obese by age 2. Maternal age was not a statistically significant predictor.
Camurdan, Camurdan, Polat, & Beyazova (2011) [21]	Retrospective Cohort	304 AGA, 85 LGA, 18 SGA n = 407. BMI of children age 0-4 years of age. Variables: Maternal education, maternal smoking during pregnancy,	Variations in BMI at 4 years statistically significant across birth weights. Maternal education and smoking during pregnancy statistically significant across birth weights. No measurement of combined effect of birth weight and maternal smoking, or combined effect of birth weight and maternal education on BMI.
Florath (2012) [16]	Prospective Cohort	1045 birth records of German children born in 2000 and followed for 8 years. Variables: Maternal smoking, maternal education, maternal income, maternal age, infant birth weight, child BMI at age 8.	Actively smoking mothers were more likely to have low birth weight infants, lower education, and lower family income. The BMI of children of actively smoking mothers was significantly increased compared with children of non-exposed non-smokers only at 8 years of age. While inferred, there was no direct measurement combing birth weight, maternal factors, and the development of childhood obesity.
Gaillard (2013) [26]	Prospective Cohort	4571 Netherland mothers and children from the prenatal period through age 4. Variables: Maternal education, maternal income, maternal age, maternal smoking, infant birth weight, child weight at age 4.	Lower maternal education and lower maternal income were associated with and increased risk of maternal obesity. Maternal obesity was associated with a greater risk of delivering large for gestational age infants, and a greater risk for development of childhood obesity in children age 4. Maternal smoking was associated with excessive maternal weight gain. Excessive maternal weight gain had a weak association with the development of childhood obesity in the study cohort at age 4. No direct measurement combining maternal factors, birthweight, and childhood obesity were provided.
Gebremedhin (2015) [25]	Cross Sectional Cohort	Records of 155,726 sub-Saharan African children age 0-59 months. Variables: Maternal age, maternal education, income, infant birth weight, weight at age 59.	There was an increased risk of childhood obesity by age five in children born large for gestational age. As maternal age and education level increase, the risk for childhood obesity decreased. Income was not statistically significant for the development of childhood obesity. No calculation for the combined effect of maternal factors, and birth weight on the development of obesity.
Gibbs & Forste (2014) [23]	Prospective Cohort	Records of 8030 American children age birth to 24 months. Variables: Maternal smoking, Maternal Age, Socioeconomic status, Infant birth weight.	A negative relationship exists between socioeconomic status and the development of obesity in children at age 24 months. When looking at the combined effect of birth weight and maternal socioeconomic status, the risk of obesity at 24 months was greater for infant born LBW than those born in a normal weight range. Children were at greater risk of obesity at age 24 months when born of LBW, had a mother who smoked, and were from a lower socioeconomic status.
Goncalves, Amorim, Eickmann, Lira & Lima (2014) [22]	Cross Sectional Cohort	167 full term infants followed to 8 years of age. Variables: LBW, maternal socio-economic status, BMI at age 8.	LBW is a determinant of postnatal rapid weight gain, and is associated with increased BMI and WC at age 8. Rapid weight gain significantly high in mothers of higher education level, and increased socioeconomic status. No measurement of the combined effect of LBW and maternal education, or LBW and socioeconomic status on BMI and WC was provided.
Layte, Bennett, McCrory, & Kearney (2014) [18]	Prospective Birth Cohort	11,134 children and parents followed from 9 months until age 3. Variables: Infant birth weight, household social class, smoking in pregnancy, maternal age.	High birth weight and smoking in pregnancy were significantly associated with a higher odds of obesity at age 3 years. Children of manual unskilled laborers were more likely to be overweight than their professional counterparts. Child born weighing > 4500 g at birth are 4.3 times more likely to become obese at age 3. Smoking in pregnancy, and maternal age were not statistically significant predictors. No statistical analysis of the combined effect of maternal factors and birth weight on the development of obesity was provided.

Mehta, Kruger, & Sokol (2012) [19]	Longitudinal Case-Control	493 mother-child pairs age 2-5 children. Variables: LGA and overweight and obesity, economic and employment status, smoking, nutrition history.	LGA newborns 2.5x more likely to be obese in childhood than the average size newborn. LGA and mothers who smoked during pregnancy were significant (p = 0.02) LGA and mother's diet was not significant (p = 0.105) .
Møller, Ajslev, Andersen, Dalgard, & Sorensen (2014) [17]	Cohort	32,747 families followed children to 7 years of age Variables: Exposure to smoking during pre and postnatally and the rick for childhood obesity.	Significant prenatal dose response relationship found in children born AGA and LGA. One cigarette a day increases risk of overweight was risk of overweight children (OR: 1.28, 95% CI: 109-1.50) compared to the prenatal period.
Rathnayake, Satchithananthan Mahamithawa, & Jayawardena (2013) [14]	Case Control	1087 Preschool children age 3-5. Variables: Maternal education, maternal age, marital status, maternal employment, infant birth weight.	Birth weight did not have a significant relationship with the development of childhood obesity. Having a working mother, or a mother with a higher degree were individual risk factors in the development of childhood obesity. Maternal age and marital status were not significant. This study did not combine the effect of maternal determinants and birth weight.
Rossiter & Evers (2013) [24]	Longitudinal Cohort	483 Canadian children at 48 months. Variables: Maternal smoking, maternal age, poverty, maternal education, birth weight, marital status.	Single-parent mothers were three times more likely to have a child who was obese than were mothers who were married or with a partner (OR = 3.35, CI = 1.39-8.06). Maternal smoking, maternal age, poverty, maternal education, and birth weight were not statistically significant predictors of childhood obesity.
Tchoubi, et al, (2015) [15]	Cross-Sectional Cohort	4518 children age 6- 59 months living in Cameroon. Variables: Infant birth weight, maternal education level, maternal economic status, maternal age, and maternal marital status.	The likelihood of childhood obesity increased with the increase in maternal education in univariate analysis, but was not statistically significant in multivariate analysis. Birth weight of greater than 4000g was nearly twice the risk of developing childhood obesity in univariate analysis, but was no statistically significant with multivariate analysis. Maternal age, marital status, employment, and economic status were not statistically significant factors in the development of childhood obesity in either univariate or multivariate analysis. A combined effect of birth weight and maternal factors were not studies.

"Obesity, type 2 diabetes mellitus, hypertension, coronary artery disease, and stroke might be the health consequences of being born SGA." [35].

Studies focusing on the linkage of maternal health determinants and prediction of childhood obesity were minimal in the literature. While the association between birth weight and childhood obesity has been reported results are inconsistent [36]. Further study of the combined effects of mothers' health determinants and infant birth weight on the development of childhood obesity could be helpful in identifying risk factors and effective interventions for prevention [37, 38]. Obesity as multiple causes. Therefore, research that incorporates a multidimensional approach to the problem would provide a robust view on this issue.

Limitations

While the authors' intent was to provide a timely and comprehensive summary of the literature, there are some limitations worth noting. Search criteria for the review were limited to English language, and peer reviewed journals. Therefore, there may be other sources of information available. Further, studies heavily represented developed countries within the Western region. Because obesity prevention relies so heavily on health behaviors, the influence of culture cannot be ignored. Therefore, the findings reported may be difficult to translate internationally.

Clearly, each of the individual factors contribute to an increased risk of childhood obesity; however, the question remains whether combining maternal determinants and infant birth weight leads to an even greater risk of childhood obesity than these individual risk factors. More research that supports preventative measures can be tailored to address childhood obesity more effectively is needed. Gaining this knowledge will arm clinicians with the evidence needed to break the vicious cycle of obesity.

Conflict of Interest Statement

The authors declare that they have no competing interests.

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