

## The development trajectory of overweight and obesity in American children and adolescents (interaction with social development)

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### Abstract

**Background:** The high prevalence rate of childhood and adolescence obesity has thrown a global threat over the past few decades. This situation has propelled the scientists towards searching for the definite biological and social factors resulting in obesity so that a stable and appropriate preventive strategies can be established in early life.

**Objective:** The objective of this study was to detect subgroups showing segmental developing phases in the course of life with distinctive weight gain trajectories and identifying the probable reasons behind this onset of obesity in childhood & early adulthood.

**Methods:** The child survey was mediated by a group of trained interviewers to assess & evaluate each child with their mothers and their family's environment. Mothers were thoroughly informed and the consent papers were signed by them moreover willingness from children were also recorded. For statistical analysis, the Hierarchical Generalized Linear Modeling (HGLM) method (developed using HLM software) was applied to study longitudinal effect on developmental obesity trajectory.

**Results:** Results clearly indicate that maternal obesity, smoking and alcohol consumption in pregnancy directly exert effect on growing trajectory of BMI. These responses are the important proof of the perinatal environment influencing the onset of obesity. The findings say, characteristics of environment, genetic factors may contribute, but excessive maternal weight and smoking in pregnancy are important predictor of childhood and adolescent obesity. Smoking of mother is suspected to limit the growth of the foetus which leads to low birth weight, which causes uncontrolled and fast development and thus obesity occurs, known as compensatory rapid postnatal growth.

**Discussion:** High maternal weight, maternal smoking and alcohol consumption in pregnancy, low educational qualification of the mother and lack of breastfeeding in infant were factors contributing in elevating the onset of childhood and adolescent obesity.

**Conclusion:** The outcomes of this study clearly allude that these advance risk factors must be controlled and thus these must be taken in account while designing preventive interventions. [*Ethiop. J. Health Dev.* 2022; 36(4): 00-00]

**Keywords:** Adolescence obesity, Hierarchical Generalized Linear Modeling (HGLM), perinatal environment, maternal weight, smoking in pregnancy, designing preventive interventions.

### Introduction

The increasing prevalence of obesity at childhood has turned to be a global concern from the past few decades, not only that, recently more rapid increase is occurring in even the low-income countries. In United States of America, childhood obesity has engulfed more than one third of children. The most common reason behind this epidemic among children and the adolescence approaching youngsters is energy imbalance; which is,

intake of more calorie than expenditure of calorie. Thus, a definite risk factor in childhood and adolescence obesity is Adiposity rebound (AR). The high prevalence of childhood and adolescent obesity invites the early age comorbidities like premature puberty in children, irregular menstrual cycle in young girls approaching adolescence, Hypertension, obstructive sleep apnea (OSA), High cholesterol levels, cardiovascular risk factors that include Prediabetes, Type 2 Diabetes

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Mellitus, Dyslipidemia, Obstructive Sleep Apnea (OSA), and Non-alcoholic Fatty Liver disease (NAFLD). To treat obesity in children and adolescents, doctors mostly depend upon exercise and dietary changes. Due to psychological abuses even, the teens grow unhealthy eating habits and psychological issues which result in Bulimia Nervosa (BN), Night eating syndrome (NES), Anorexia Nervosa (AN), anxiety, depression, poor self-esteem & body image. There is no specific reason that causes this condition, as obesity is a resultant effect of interwoven series of complexities like biological interactions, genetic issues, environmental factors, behavioral and developmental discrepancies etc. There are several reasons behind this epidemic, among them the most important contributors include, excess maternal weight; smoking of the pregnant mother; lack of maternity knowledge and lower rate of breastfeeding in infants. Not only that, social demography suggests certain modifiable factors at prenatal period and the child's birth can exert a potential effect on the obesity of the child. Some studies have found that smoking of the mother during pregnancy significantly leads to low fetal growth and after birth it pushes the ward to the higher risk of obesity (postnatal weight gain) in their childhood even can continue till the age of 33. The low body weight at birth triggers immediate accelerated growth which eventually leads to obesity. In the other hand, Heavy birth weight of the baby shows high susceptibility towards further weight gaining in childhood. An elevated weight at birth is proportionately associated with high body mass index (BMI) later and directly linked with high risk of obesity in childhood and adult, so it can be said that fluctuations in weights at birth from the proper birth weight are directly related to future obesity. Most importantly, heavy mass of a mother can strongly predict a very high risk of getting obese of offspring. Even the mother's behavior like physical activity and eating behavior can double up the obesity risk for children. But previous research papers have shown that breastfeeding can efficiently protect children from obesity in future life.

In recent research it indicates about some other crucial reasons behind this increasing rate of obesity at childhood, which includes, role of microbiome present in the gut; the epigenetics, intrauterine abnormalities and intergenerational effects. The large section of children is found to be affected with obesity and its consequences, which has become a serious social and

medical concern to conduct researches identifying the protective and risk factors that deals with family environment and conducts; prenatal health; prenatal adverse exposures. Initial findings from the interventional drug trials with agonists of GLP-1 stated achievement in shedding of weight among obese children, youngsters approaching adolescence and adult patients.

To rectify this condition some alterations in the environment of the community is essentially required such as healthy food choices promoting programs, increase in daily school physical activity, limited screen time for children and adolescents because of the sedentary nature of it, improving lunch food quality, banning advertisements of unhealthy food that aim children, recruitment of proper rules in the family exerts chance for adopting self-regulation in children and adhering green spaces at housing apartments where families can feel safe about their children to recreate. Severely obese adolescents and adults in USA prefer to undergo bariatric surgery as a way to restrict excess fat accumulation. In some cases, it is found that bariatric surgeries help patients to control the comorbidities that may occur due to obesity.

In the other hand, parental engagement and control positively affects the obesity risk for children. Engagement of parents in parent-child activities building close parent-child relationship. Parental control on the children helps them to learn the importance of time bound activities and punctuality, even it may increase nutritious food consumption, developing healthy habits and most importantly children learn to be more responsible, and as result the risk of obesity gets lowered. But, in adolescents, the effect of parental control becomes unclear on obesity. Lack of responsibility with less supervision from parents and absence of understanding of healthy lifestyle in adolescents directly contribute to the risk of obesity. Thus, a better understanding of good and healthy family environment is extremely important in controlling the risk factors of getting obese in children and youngsters approaching their adolescence.

This work aims to sum up the understandings of the factors causing obesity at an increasing trajectory from children to adolescents, the physical and mental impact of being overweight on children and youngsters approaching their adolescence, and intervening generalship that may restrict further consequences of

obesity and to evaluate of the status of obesity because of the prenatal and familial factors.

### **Methods**

The current study included total 10304 American children aging between 14 to 21 years from the sample of children from the 1989 National Longitudinal Survey of Youth (NLSY89). Data have been biennially collected since 1997. During the entire tenure of the study, we were able to conduct total 8 biennially rounds of interviews with the participating children (the initial one, the concluding one and the intermediate 6 interviews with 2 years of gapping). Because of the longitudinal manner of this study, children born in years from 1998 to 2019 were included phase wise. That is why at the beginning in 1997, 4,791 children participated in the interview, but in 2011 it ended with 10500 interviewed participants. Total 10304 interviewed participants were found to successfully complete the 8 rounds of interviews and all were aging between 10 & 18 years within 1997 to 2019. Our interview not only dealt with the measuring parameters of the participants but also included variables like the maternal health, food habits, family environment and daily routine etc. 50.0% of the study sample was found female.

### **Procedures**

A group of well-trained interviewers were appointed from 1997 to question, assess and evaluate with documents, the overall health status while interacting in person, the participating children and their mothers along with the family's home environment & households. From 1999, computer assisted personal interviewing (CAPI) was adopted to conduct these interview rounds. From 2000, in-person interviews were replaced by telephonic interview sessions for grown-up children aging 18 or older.

- Mothers were completely informed and signed consent were collected along with acceptance consents from participating children were recorded.
- A table of variables intended to represent the conceptual model were documented from the main NLSY89 survey with the entire necessary information of mothers and their child's life situations. This table constructed information including the items like the status of children (e.g., order of birth and weight at birth)

Development trajectory of overweight and obesity at the time of birth, maternal health-threats in conception with the child, practice of mother (e.g., age, weight, education, breastfeeding), and work report of the mother before and after the pregnancy. To further examine the study model, comprehensive measures inclusion on both mothers and children over time was extremely needed.

### **Measures**

The chronological manner of the measures taken in the study helped to address the experiences and facts on the obesity developmental status at the stages of developmental from the period of before birth through childhood, and then to adolescence of the children was important. Measures from the gestational period to the birth of the child provided the important factors on specific health-risk behaviors of individual mothers during pregnancy, as well as characteristics and health practices of the mother and children at birth. Moderations in childhood mainly revealed environmental factors of the families, like screen exposure hours, degrees of family rules establishment, control and engagement of parents in activities of their wards. Such chronological measures directly exhibited effects on the thorough evaluation of longitudinal linkage with engagements and experiences with parents and their families through developmental trajectories of obesity status of the children from 10 to 18 years.

#### **Gestational measures:**

The weight of the mothers before pregnancy were collected. Before pregnancy weight of the mothers were segregated into 4 groups, which are less than 56 kg, 56–67 kg, 68–79 kg and over 79 kg. Also, cigarette smoking (no. of cigarettes smoked in a day) and alcohol consumption (frequency- days of alcohol consumption in a month) report of the mother during and after pregnancy was documented. Now the documents were categorized through a numeric scale, like, in case of cigarette smoking- mothers who did not smoke, mothers smoked with less than one pack of cigarettes per day and mothers who smoked one or more packs of cigarettes per day; similarly in case of alcohol drinking in mothers during pregnancy – consumption of no alcohol; use of less than once per month; consumption of alcohol for 1 to 4 days per month, and lastly consumption of alcohol for 5 or more days per month.

**Birth order and birth weight of children:** Child's weight at birth and birth order were reported. Children with birth weight less than 2.5 kg were marked as low birth weight and those with birth weight greater than 4 kg were marked as high birth weight. Order of birth of the children was sectioned as 1, 2, 3, and 4 showing the children were born at the first, second, third, or fourth order.

#### **Age and health practices of the mother**

Data regarding age of the mother at the time of birth of the child was distributed in 4 groups, i.e.,  $\square$  20 years, 20–24 years, 25–30 years, and 30+ years. The breastfeeding of the child was also taken in account of the study.

#### **Educational level of the mother at child's birth**

Duration of mother's education before the child's birth was reported and distributed in groups of less than high school (0–11 years), high school completion (12 years), and higher education (13 or more years).

#### **Childhood familial factors**

Measures of the familial factors like, environment of the family of children between the ages of 10 and 18 were included.

#### **Screen exposure**

Children aged 10 to 18 as well as their mothers were questioned on amount of screen exposure or television viewing on weekdays as well as each weekend days. Average hours of screen exposure mentioned by mothers were recognized as mothers are expected to be capable of reporting flawlessly on the hours of television viewing.

#### **Family rules and Parental control**

The participating children were asked about their family rules and their involvement in setting those rules regarding doing homework, keeping parents informed about their moves, watching television etc. Results were recorded in yes or no format. In case of child's involvement in setting these rules, the responses were noted from 1=no say at all to 4=a lot of say. The record of responses was counted; higher the score greater the parental control.

#### **Parental engagement**

Children were asked about the relationship status and involvement of their parents in their daily lives like, going to movies, to dine out, going for shopping, outing for weekends, planning for vacations and visiting

religious places in the last few months. Answers were taken in the form of yes or no and the total counts of activities with parents was used in the evaluation of the study.

#### **BMI percentage and status of getting obese**

Body Mass Index (BMI; kg/m<sup>2</sup>) is a process to assume the body mass modified with height and is the mostly used step in distinguishing overweight adolescent and children. BMI measurement was utilized to biennially address the status of getting obese at each of the children with respect to time. Depending upon the self-assessed mass and height from ages 10 to 18, the BMI scores were calculated. Age percentage and gender-specific BMI were listed and segregated using the standardized growth charts, indicating, those with BMI percentage at 95% or above were sectioned as approaching adolescent obesity. This observation procedure was repeated to obtain the trajectory of obesity. Longitudinal conventional growth model method is used to observe bodyweight changes during different ranges ages in growing phases to adulthood.

It is a relatively new approach to evaluate risks related to the life-course, identifying subgroups with distinct weight gain developmental trajectories. With the data of BMI of last seven years was accounted to identify 4 subgroups: (a) the high-risk group with mean BMI >30, (b) the moderate-to-high risk group with mean BMI >25 after 12 years and >30, (c) the low-to-moderate risk group with mean BMI >25, and (d) the low-risk group with mean BMI ranging below 25.

The study aims to recognize the subgroups of specific developing stages in life with distinct weight gain trajectories. We identified the subgroups whose susceptibility to weight gain according to age exhibits distinct trajectories corresponding to the main alterations in life during adulthood approaching period.

#### **Statistical Analysis**

The Hierarchical Generalized Linear Modeling (HGLM) method (developed using HLM software) was applied to study longitudinal effect on developmental obesity trajectory from ages 10 to 18 in relation with prenatal conditions along with childhood familial environments. The multilevel approach of HGLM processes longitudinal, hierarchical and structured data to account the intra-correlation among the repetitive measures.

#### **Results**

- Characteristic segregation of the Participants aging

between 10 to 18 by obesity status (BMI percentile  $\geq$  95%). Among the total count of 10304 children, 2742 participants aging from 10 to 18 at least once faced the status of obesity across these five biennial observations. Males aging from 10 to 18 showed greater prevalence of obesity if compared to the female participants. However, maternal alcohol consumption and cigarette smoking in pregnancy exhibited significant association with a lower probability to adolescent obesity.

The birth experiences of the children were found to have connection with adolescence obesity. Children with high birth weight were found susceptible adolescence obesity. Children with ever breastfeeding report, exhibited a lower susceptibility to adolescence obesity. Not only that, the link between the obesity status of the children and educational qualification of the mothers was found to be inversely proportional.

Longer hours of screen exposure to the children aging from 10 to 18 is a major sedentary part of their lives so, it can be the most effective familial factor having great influence on the adolescence obesity status and the relation seems to be directly proportional to each other. Though, Family rules conventions, parental engagement and control on their wards did not exhibit any significant effect on status of obesity of adolescents through these two-way comparisons.

- The HGLM analysis:

The two-way method of comparison mediated by the HGLM on prevalent obesity in adolescent shows the results of the trajectory indicating status of obesity. The trajectory of obesity risk gradually decreased in the rate of advancements in onset of obesity in children and adolescents. Females showed deceleration of obesity risk over time when compared to males.

Among the gestational factors, weight of the mother before and during pregnancy was proved to be closely linked with initial onset of obesity. With the increase of maternal weight, the risk of initial obesity of children up to age 10 also increases. Consumption of alcohol in mothers in pregnancy was found to be linked to initial low risk of obesity in children aging 10 if compared to maternal smoking; where children having mothers, who did not drink alcohol in pregnancy, in contrast to children whose mothers drank alcohol 1 to 4 days per month in pregnancy, showed a decreased obesity risk. Also, children with prenatal smoking of mothers evidenced higher initial risk of obesity till age 10. However, both prenatal maternal cigarette smoking and

Development trajectory of overweight and obesity alcohol drinking were not found linked with alterations in the risk of obesity over time.

Children with 3rd or greater in order of birth when compared to first-birth-order children, faced lower initial risk of obesity. Children with low birth weight ( $<2.500$  kg) had a lesser initial risk of obesity. In the other hand, children with high birth-weight ( $>4$  kg) had an increased initial risk of obesity, but eventually were found to be decreased risk of obesity with time. Also, infants with a report of breastfeeding exerted a lesser obesity risk at the age of 10. Relatively, children of younger mothers ( $\leq 20$  years) exhibited a higher risk of obesity at age 10 when compared to the children of mothers with increased age (25 - 29 years), but children comparatively of mothers with increased age were likely to have a decreased risk of obesity in adolescence.

In case of factors in socioeconomic scenario, educational qualification of mothers was found negatively linked to obesity risk of children. Children having mothers with high school education or less than high school education exerted higher obesity risk at the initial age of 10 when compared to children with mothers having more than high school education (**Table 1, 2**).

If it comes to the terms of familial experiences, then hours of screen exposure on daily basis is linearly linked with the initial risk of obesity; the relation between the hours of screen exposure and initial risk of obesity was found directly proportionate to each other. Added to the factors, implementation of rules in family was intricately linked to lesser risk of obesity at initial age of childhood. Higher level of parental engagement exerts good effect on risk of obesity in adolescence.

## Discussion

The aggravated number of proofs directly shows that there are multifaced important determining prospects of a child's environment contributing in their risk for obesity. The advantages of this longitudinal study are the approach with multivariate modeling method to evaluate potential variables of obesity in children and adolescents. The study successfully identified the prenatal and childhood factors regarding the increased susceptibility of adolescent obesity, and exhibited pertaining evidence stating the regulating process and influences of the determinants of obesity at different life stages on obesity status in the growing ages to adolescence. The tenure of the influence on obesity in childhood and adulthood

vary due to these factors. Prenatal factors like including high maternal weight and age before and during pregnancy, cigarette smoking of mothers in pregnancy, less education of the mother at child's birth and child's birth statuses including birth weight of the children, lack of infant breastfeeding etc., were linked with the elevation in the obesity risk in childhood and early adolescence. But, the impact of these factors related to prenatal and child-birth may be abrupt on risk of obesity in adolescence. Similarly, the factors like poor familial environment which includes longer screen exposure, lack of family rules, lesser engagement of parents in children's life directly complemented the obesity risk across the childhood and years of adolescence. This study showed the link between the frequency of alcohol drinking of mother in pregnancy and obesity in children can be distinguished.

However, age of the mother at child's birth and increased weight at birth (>4 kg) exert a long-term and stable connection with long lasting development of adolescent obesity (ages 10 to 18), but it gradually decreases the risk of obesity across the years in adolescence which indicates that although high weight at birth of children displays greater BMI in childhood, but a majority also exhibited a slower rate of mass gain in adolescence, which gradually leads to potential non-obese status. Similarly, children with mothers of older age show increased risk of obesity at age 10, but also show sharp decrease in obesity risk with time. Though maternal education is linked with risk of obesity at the initial year of adolescence (age 10) but has no impact on the alterations of obesity risk from ages 10 to 18.

This study further depicts a marked connection between childhood adolescent obesity and familial experiences. Risk of obesity in adolescent linearly increase with hours of screen exposure in a day where the existence of family rules can eliminate adolescent obesity risk. Parental engagement in activities of the children can decrease the risk of adolescent obesity across years. An expected demonstration of these results is that the recruitment of family rules manages to maintain equilibrium in the home, which can enhance the disciplinary skills of the children through tightening family bonds. The limitation of the findings is self-reporting, as opposed to BMI used in this study.

### **Conclusion**

Despite all the limitations, the study's findings can

improve the prevention of recent obesity scenario. Maternal smoking can steadily predict obesity in adolescence. This fact can also be weaved into existing interventions of smoking discontinuance so that the mothers with potential negative consequences of smoking can be informed on their children's physical health conditions. Furthermore, incorporating family rules and increasing parental engagement can efficiently buffer the vulnerability to adolescent obesity.

In summary, this longitudinal study results unveil that gestational conditions and childhood familial experiences are adhered to a developing obesity trajectory in children and adolescent. In addition, the mothers are an important target group for current prevention strategies by engaging them in other fitness activities pairing with physical activity, eating nutritious meals, sleeping sufficiently. Our additional analyses also showed that low maternal education, low breastfeeding are other factors for heightening the risk of adolescent obesity. The findings show that mothers who consumed alcohol in pregnancy were more intended to feed breastmilk to their infants, which made them more attentive in the nutrition and health care of children, which actually contributes to lower chances of obesity. It is mostly like mothers with greater age, compared to young mothers, are experienced in serving appropriate baby care, which would nullify the negative effects of the high maternal age at child's birth. Implementation of the findings of this study should be applied in designing the preventive measures to eradicate this epidemic called obesity from the children heading towards their adolescence.

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### **Conflict of interest**

The author declares that no conflict of interest is associated with this study.

### **Authors' contribution**

This study was done by the authors named in this article, and the authors accept all liabilities resulting from claims which relate to this article and its contents.

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**Table 1.** Childrens data with higher education

<b>Table:1</b> Age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total
12	574											574
13	881	51										932
14	902	837	57									1796
15	841	908	873	29								2651
16	696	864	895	836	31							3322
17	279	811	890	914	848	33						3775
18	16	653	767	794	871	917	52					4070
19		76	660	855	803	860	864	42				4160
20			77	684	797	875	898	865	31			4227
21				68	678	805	858	900	870	71		4250
22					65	688	816	872	865	907	95	4308
23						52	657	754	815	855	865	3998
24							43	630	748	794	903	3118
25								31	623	718	865	2237
26									26	606	808	1440
27										20	643	663

**Table 2:** Different Characteristic features of groups

<b>Table:2</b> Characteristic features	<b>Normal BMI Percentage &lt; 95%, n=7562</b>	<b>Obesity BMI Percentage ≥ 95%, n=2742</b>	<b>Total count, n=10304</b>
<b>Demographics: Genders</b>			
Male	48.5	53.6	51.0
Female	52.0	46.4	49.0
<b>Gestational Factors:</b>			
Weight of mother before pregnancy:			
< 56 kg	43.6	26.4	41.6
56 – 67 kg	37.3	39.1	38.1

68 – 79 kg	12.4	20.2	12.5
< 79 kg	3.6	18.2	8.0
Cigarette smoking of mother during pregnancy:			
No smoking	71.8	70.7	73.7
Less than 1 pack per day	20.5	23.7	20.5
1 pack or more per day	7.7	6.4	7.0
Drinking of alcohol of mother in pregnancy:			
No alcohol use	68.44	71.0	70.0
Less than once a month	16.0	12.0	16.1
1 to 4 days a month	11.2	10.1	11.8
5 or more days a month	4.2	4.1	4.4
<b>At &amp; after birth factors of child:</b>			
Birth Order of children:			
1 <sup>st</sup>	46.0	46.2	48.3
2 <sup>nd</sup>	33.1	32.7	31.7
3 <sup>rd</sup>	12.6	15.2	12.8
4 <sup>th</sup> & more	5.6	8.0	6.2
Children with low birth weight:	8.2	7.0	7.8
Children with high birth weight:	8.6	13.8	11.6
Children with breast feeding:	19.0	20.8	19.7
Maternal age:			
<20	22.1	22.7	22.6
20 – 24	40.3	39.6	41.0
25 – 29	28.7	33.2	31.7
30 - 34	6.0	5.6	5.6
Maternal education:			



## Development trajectory of overweight and obesity

Less than high school	31.7	39.6	36.2
High school	41.4	38.2	39.1
College / Higher studies	25.9	22.2	24.7
<b>Childhood familial factors:</b>			
Family rules implementation:	3.5	3.2	3.3
Hours of screen exposure on a typical weekday:			
0 – 2	12.4	7.3	11.3
3 – 4	25.7	20.2	23.3
5 – 6	21.4	20.8	19.9
7 – 8	13.5	12.9	12.9
9+	28.5	36.3	30.7
Parental control:	10.3	10.5	10.4
Parental engagement:	3.7	3.6	3.7

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