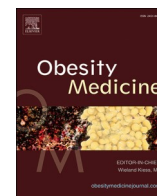




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## Junk food-induced obesity- a growing threat to youngsters during the pandemic

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### ABSTRACT

**Introduction:** Obesity has been declared an epidemic that does not discriminate based on age, gender, or ethnicity and thus needs urgent containment and management. Since the third wave of COVID-19 is expected to affect children the most, these children and adolescents should be more cautious while having junk foods, during covid situations due to the compromise of immunity in the individuals and further exacerbating the organ damage.

**Methodology:** A PAN India survey organized by the Centre for Science and Environment (CSE) among 13,274 children between the ages 9–14 years reported that 93% of the children ate packed food and 68% consumed packaged sweetened beverages more than once a week, and 53% ate these products at least once in a day. Almost 25% of the School going children take ultra-processed food with high levels of sugar, salt, fat, such as pizza and burgers, from fast food outlets more than once a week. Children and adolescents who consume more junk food or addicted to such consumption might be even more vulnerable during the third wave, which will significantly affect the younger category.

**Conclusion:** There is an urgent need to spread awareness among children and young adults about these adverse effects of junk food. There is no better time than now to build a supportive environment nurturing children and young adults in society and promising good health.

### 1. Introduction

Obesity has been declared as epidemic that does not discriminate based on age, gender, or ethnicity and thus needs urgent containment and management. Cardiovascular complications are a global threat with the rapid increase in the prevalence of obesity; by 2025, it is expected to reach upto 18% in men and 21% in women by forbidding heavy burden upon individuals, societies, and health care systems. Heart attack survivors with excess fat around their waist are at increased risk of another cardiac arrest, according to the journal of the European Society of Cardiology (Mohammadi H et al., 2020).

In the modern era, obesity is linked with various factors enhancing the production of cortisol, such as Food consumption with a high glycaemic index, chronic stress, and change in sleep patterns (Knutson et al., 2010; Cohen and Janicki-Deverts, 2012). The burden of non-communicable disease has become a major threat globally, attributing to physical inactivity, unhealthy dietary habits, unhealthy

lifestyle, and smoking. It is also observed that food with high levels of fat content is preferred to non-fat food by people (Vischers and Siegrist, 2010). Based on the reports, more than one-third of the adults eat junk food several times a week (Bauer et al., 2009). Studies have proven that Junk food tends to cause obesity (central adiposity), a primary concern of heart diseases and other non-communicable diseases (Rouhani et al., 2012; Musaiger, 2014). Poor nutrition could result in reduced immunity, susceptibility to several oral and systemic diseases, impaired physical and mental growth, and reduced efficiency (Bhattacharya, P. T et al., 2016).

Greater than 60% of the overweight child population seem to have at least one added risk factor of cardiovascular disease (Raised blood pressure, hyperlipidemia, hyperinsulinemia), and more than 20% of the obese children have two or more risk factors. The United States National Centre for Health Statistics suggests that nearly 15% of adolescents are overweight or obese, and treatment is harder in adults than children (International Life Sciences Institutes, 2000). It is observed that an

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adolescent is often negligible to his health due to improper awareness and a busy work schedule. With more than 14.4 million obese children, India has the second-largest obese child population in the world. By 2025 it is anticipated to reach a stunning 17 million.

Since the third wave of COVID-19 is expected to affect children the mostly, it is, therefore, advisable for these children and adolescents who eat Junk foods to be more cautious during Covid situations due to the compromise of Immunity in the individuals and further exacerbating the organ damage.

## 2. Junk foods overview

Children find themselves amidst a way of living that has been metamorphized to suit the new jet-setting age and the food is no exception to this. Over the last two decades, the variability of healthy eating advice has become a cliché, leading to an alarming increase in the trend of consumption of fast food and sweetened beverages in Indian children. On average, the fast-food industry is growing 40% per year (Joseph et al., 2015). A PAN India survey organized by the Centre for Science and Environment (CSE) among 13,274 children between the ages 9–14 years reported that 93% of the children ate packed food and 68% consumed packaged sweetened beverages more than once a week, and 53% ate these products at least once in a day. Almost 25% of the School going children take ultra-processed food with high levels of sugar, salt, fat, such as pizza and burgers, from fast food outlets more than once a week (Bhushan et al., 2017). The most commonly consumed junk food items are bakery products, beverages, burgers, caffeinated drinks, chips, chocolates, noodles, pizza, soft drinks, and sugar-sweetened drinks. Harmful effects of Junk foods include Overweight/Obesity, Cardiometabolic risk, High blood pressure, Behavioural symptoms and Dental caries.

## 3. Highly consumed junk foods

Habitual physically inactive lifestyle, advertisements, media, and consumption of junk food have contributed significantly towards causing obesity in children and adolescents. Various list of Junk foods and their associated components showing the impact on health is mentioned in Table 1.

## 4. Impact of junk foods on body weight

The rates of overweight and obesity have increased tremendously over the past few decades as a health epidemic in most parts of the world (Mancino and Kinsey, 2008; LaCaille et al., 2011; Allom and Mullan, 2014). High consumption of Junk Foods contributes to the overweight among School-aged children in India from 9.7% to 13.9% over a decade (Ranjani et al., 2016). The potential adverse effects on weight status in younger population include Physical inactivity and unhealthy dietary habits and, consequently, the future health of adults (Hutchesson et al., 2015; Allom and Mullan, 2014). High intake of fried foods and artificially sweetened drinks are found to be directly linked with high body mass index and obesity in children. Additionally, diets with elevated amounts of Junk food have very little quantity of nutrients (Goel et al., 2013; Harnack et al., 1999).

## 5. Preclinical evidences of junk food and its effect

The preclinical data is essential in collecting the safety of drug, iterative testing, and the feasibility of experiment which is given in Table 2. In a study conducted in 1991, brown and white adipose tissue in high fat and junk diet and chow-fed rats with dorsomedial hypothalamic lesion rats (Bernardis and Bellinger, 1991). The animals were grouped as high fat and control rats as group 1 and 3, whereas chow diet and control were grouped as group 2 and 4. He found that obesity is not only linked to calories but rather the sort of calories consumed, brown adipose tissue

**Table 1**

List of Junk foods and its associated components showing impact on health.

Type of Junk Food	Components	Impact on health
Fish sauce, Soy sauce (Olney et al., 1972; Lemkey-Johnston and Reynolds, 1974; Holick, 2003)	Monosodium Glutamate	Overweight, Brain lesions, obesity, diabetes, neurotoxic effects, endocrine disorders
Sweetened Soda, soft drinks (DeChristopher et al., 2020; Chapman et al., 2020)	High Fructose Corn Syrup	Weight gain and Diabetes, Hypertension, atherosclerosis, coronary heart disease, vascular resistance in the kidneys
Margarine, French fries, Dough nut, Pastry, Ice-cream (Islam et al., 2019; Zhu et al., 2019)	Trans Fat	Increase in Inflammatory markers (Heart Risk), T2DM, cancer and diabetes, cardiovascular disease
Buns, Bagels, flour bleaching agent and a dough conditioner. (Kim et al., 2004; Ye et al., 2011)	Azodicarbonamide	Asthma, carcinogenicity
Frenchfry cardboard sleeves, Burger and sandwich wrappers, Bread wrappers, containing Fluorine (Hurley et al., 2018; Anderko and Pennea, 2020)	Per/poly fluoroalkyl substances (PFAS)	Breast cancer, Fertility, Weakened Immune system,
Soda, Flavoured water, processed cheese, chicken nuggets (Orozco-Guillien et al., 2021)	Phosphate additives	Kidney disease, Bone problem
Mayonnaise, Roasted pork (Ham et al., 2019; Yang et al., 2017)	Propyl gallate	Reproductive toxicant, testicular toxicity, abnormal implantation and placental development.
Burger packaging (Li et al., 2021)	Phthalates	Induce Reproductive toxicity towards the development of gonads and reproductive capability of environmental organisms.
Processed Redmeats (Soliman et al., 2021)	Sodium nitrite	Stomach cancer, T1DM, renal inflammation and oxidative stress
Canned foods, polycarbonate tableware, food storage containers, water bottles, and baby bottles. (Zhang et al., 2021; Wang et al., 2021; Bordbar et al., 2021)	Bisphenol	Reproductive toxicity, cardiotoxicity and endocrine disrupting toxicity, Delayed bone development, Hepatotoxicity

weight, lipid content, protein and turnover of NE are indicators of metabolic activity and thermogenesis that are unreliable. Oginsky et al. (2016) proposed that intake of junk food shows a rapid and long-lasting increase in NAc CP-AMPA receptors for food addiction. In general, mesolimbic circuits responsiveness is intensified in rats that are vulnerable to diet-induced obesity.

Additionally, junk food was found to increase NAc CP-AMPA function in obesity-susceptible rats. AMPA upregulation occurred more promptly in obesity-susceptible rats and preceded the development of obesity. Cocaine-induced locomotion was seen, and post-junk-food deprivation, cocaine-induced movement was enhanced in Junk-Food-Gainers than in the Non-Gainers, i.e., Junk-Food gainers were more sensitized when compared to non-gainers. He concluded that it will be significant to determine the extent to which these food-induced changes occurring in the striatal function could be part of normal, adaptive processes vs maladaptive, 'addictive-like behaviors. A study conducted on 2010 by StephanieA stated in a study that a junk food diet in pregnancy and lactation promotes Non-alcoholic fatty liver in the rat offspring. It was observed that those junk food-fed mothers moved to an

**Table 2**  
Pre-clinical and clinical evidence of Junk food and its effect.

S. no	Author name & Year of study	Junk Food Composition	Outcome
1	Lee et al., 1991	Chocolate chip cookies and for the following month in addition to the high-fat diet, potato chips and marshmallows	HFJF-DMNL rats showed more fat than CHOW-DMNL rats significantly, and they were significantly less fat than HFJF-CON rats.
2	Oginsky et al., 2016	Mash of Ruffles original potato chips, Chips Ahoy original chocolate chip cookies, Jif smooth peanut butter, Nesquik powdered chocolate flavouring, powdered Lab Diet 5001 and water combined in a food processor.	Eating Junk-food more readily increases NAc CP-AMPA expression and function in obesity-susceptible rats
3	Stephanie A et al., 2010	RM3 chow plus eight types of palatable industrially processed foods (biscuits, potato crisps, sweets, cheese, etc.) all supplied ad libitum.	Aggravated signs of NAFLD characterized by exacerbated hepatic steatosis, oxidative stress
4	Bayol et al., 2008	RM3 chow plus eight types of palatable industrially processed foods (biscuits, potato crisps, sweets, cheese, etc.) all supplied ad libitum.	Junk-food diet induced adiposity and associated metabolic disturbances were increased in adult offspring whose mothers had been fed a Junk food diet in pregnancy and lactation.
5	Gugusheff et al., 2013	Cafeteria diet comprising of peanut butter, hazelnut spread, chocolate biscuits, savory snacks, sweetened cereal, and a lard and chow mix	No difference in fat mass was observed in male offspring.
6	Jason B et al., 2017	cafeteria diet consisting of high calorie Junk food items including cheesecake, bacon, cookies, sugar wafer, potato chips, high sugar breakfast cereals, marshmallows, or chocolate candies was provided to the cafeteria diet group	It was observed that cafeteria diet feeding reduces ethanol drinking in rats, while withdrawal from cafeteria diet results in prolonged suppression of ethanol drinking and suppresses consumption of natural rewards (i.e., sucrose and chow pellets)
7	Zahedi et al., 2014	sweets (Biscuits, cookies, cakes, chocolates, candies), sweetened beverages (Soda, soft drinks, fast foods (Hot dog, hamburger, cheeseburger, fried chicken, pizza) and salty snacks (chips, cheese curls, popcorn, pretzels).	Junk food may increase the psychiatric distress risk and violent behaviours in children and adolescents.
8	Azemati Bahar et al., 2018	Sugar-sweetened beverages, salty snacks, sweets and fast foods were considered as Junk foods	Junk food consumption plays an important role in childhood overweight and is related to high blood pressure in this population
9	Zhu et al., 2019	Deep fried food, pickled food, processed meat products, biscuits, coke or alike drinks, convenience/ fast food, canned food, dried or preserved fruit, cold and sweet food, barbecue food etc.	Eating Junk food is a popular event among children and adolescent in Beijing
10	Payab et al., 2015	salty snacks, sweets, sweetened beverages, and fast food	Junk food consumption enhances the risk of both general and abdominal obesity.

exclusive chow diet from weaning which resulted in the increase of triglyceride compared to the CCC group at the end of adolescence. The histological analysis did not disclose any signs of fibrosis or inflammation confirmed by unaffected TNF-alpha, IL-6, Collagen, and keratin expressions, suggesting that although they showed NAFLD signs, they did not suffer from NASH. He also mentioned that exacerbated steatosis in those offsprings did not coexist with an increase in carnitine palmitoyltransferase I (Cpt1a) mRNA expression, which might be an indicator of mitochondrial Beta-oxidation saturation leading to further lipid accumulation in the liver. In 2008 an observation was made on off springs of Junk food-fed mothers in pregnancy and lactation exhibited aggravated adiposity, which is highly found in females (Bayol et al., 2008).

The perirenal fat pad mass linked to body weight was greater in the offsprings fed with junk food throughout the study than those fed with junk food diet postweaning. The increase in adiposity is associated with the weight gain previously reported in the same animals. The study on gene expression and changes in adipose tissue cellularity showed that an increase in IGF-1 transcription indicated higher proliferation of pre-adipocyte in females fed with junk food diet after weaning compared to males. Gugusheff et al., 2013 studied extensively the effects of pre-natal junk food exposure on food preferences of offspring and how fat deposition can be alleviated by enhanced nutrition during lactation (Gugusheff et al., 2013). He found that habitual cafeteria diet during the suckling period, independent of dietary exposure before birth, led to the development of diet-induced obesity in females and an increase in preference for appetizing foods in male offspring in young adulthood. The animals were given free access to the cafeteria diet. Female offspring suckled by JF dams had increased fat mass compared to those offspring suckled by control dams independent of the diet consumed by the mother during pregnancy. It is to be noted that it took place in the absence of high food consumption, suggesting that these animals had an enhanced propensity to accumulate fat in the body.

## 6. Clinical evidence of junk food and its effect

The clinical data collection is very much helped by the quality of information generated, which plays a significant part in yielding the study results whose clinical data are given in Table 2.

Zahedi et al. (2014) studied the relationship between junk food consumption and mental health in a Sample of Iranian Children and Adolescents (Zahedi et al., 2014). In this study, a notable link between junk food consumption and mental health problems in children and adolescents was observed. Students that consumed junk food daily were more likely to be subjected to mental health problems. The Western Australian Pregnancy Cohort Study proposed that the Western dietary pattern of increased consumption of takeaway foods, red meat, and confectionary was significantly associated with poor behavioral outcomes in adolescents. Similarly, two cohort studies in adolescents instigated that increased intake of unhealthy foods like sweets, savory snacks, sweetened soft drinks, chocolate, and fast foods was associated with a high risk of behavioral problems and mental distress such as anxiety worthlessness, and dizziness.

Azemati et al., 2020 studied an association between consumption of junk food and cardiometabolic risk factors in Iranian children and adolescent population (Azemati et al., 2020). A population-based study in Korea showed that fast food consumption was linked to metabolic syndrome in adolescents. The study demonstrated that sweet dietary habits were positively related to metabolic syndrome, and those under junk food consumption were more likely to be overweight. Junk foods are found to be associated with obesity due to their high energy content and the amount of fat present or free sugar, chemical additives, and sodium with the presence of a low amount of micronutrients and fiber. Among junk foods, intake of sweetened beverages is in close relationship with weight fluctuations as it can increase food intake through decreasing satiety mechanisms. In Conclusion, junk food intake among

Iranian children and adolescents had undesirable effects on cardiometabolic risk factors. Thus, enhancing knowledge of junk foods among adolescents is one of the possible ways to help them to make healthy food choices and get rid of overweight and obesity.

Zhu et al. (2019) investigated on the current situation and influencing factors on consuming junk foods among children and adolescents in Beijing city (Zhu et al., 2019). He used a questionnaire survey method to survey the junk food habits and their effects. One month before the survey, all individuals have an intake of one type or the other junk foods. Mostly they didn't have an understanding of nutrition, and mostly they have misunderstandings about nutritional value and effect on the human body. Their behavior is affected mainly by personal factors like physiological, psychological, social, family factors, and the food itself. In Conclusion, children and adolescents in Haidian District ate different types of junk food, and the safety, nutritional issues of junk food should be paid great attention to prevent and control the risk factors of children and adolescents eating junk food. Payab et al. (2015) studied the relationship between junk food consumption with high blood pressure and obesity in Iranian children and adolescents (Payab et al., 2015).

This study showed significant link between sweet consumption and both general and abdominal obesity. Nonetheless, there was no meaningful relationship between sweets consumption and high blood pressure. Several studies also showed that in general, central obesity is inversely associated with healthy dietary habits, while the Western dietary habits (refined grains, Red meat, sweets, desserts, pizza, French fries, and soft drinks) were directly linked to obesity.

## 7. Junk food and compromised immune system

### i) Effect of Junk foods on the signaling pathway

The intake of appetizing food is primarily under the control of the limbic system and stimulates endogenous opioids release, which binds to the opioid receptors present in the ventral tegmental area (VTA). VTA activates dopaminergic neurons in the brain, and in the nucleus accumbent, the site of dopamine release to potentiate dopamine signaling pathway (Bergevin et al., 2002; Fields and Margolis, 2015; Berridge, 1996). The stimulation of the dopamine signaling pathway by opioid interactions is thought to be involved in the mediation of the short-term pleasurable sensation linked with the consumption of appetizing food (Bodnar et al., 2005; Bodnar, 2015). It is observed that a reduction in MuR expression in the offspring of dams maintained on a junk food diet during pregnancy and lactation is present in the VTA at the weaning stage, i.e., 3 weeks after birth (Gugusheff et al., 2013). Nonetheless, MuR expression in the NAcis found in elevated levels during the first postnatal week and declining to adult levels over the next two weeks (Tong et al., 2000).

### ii) Effect of Junk foods on Immunity

Micronutrients like trace elements, antioxidants, and vitamins play a significant role in the regenerative process, coping with existing oxidative stress in the body tissues and providing Immunity against pathogens (Chapple et al., 2007; Enwonwu et al., 2002). Obesity in the early years of life alters the immune system by inducing changes in cytokines concentrations and proteins and the number and function of the immune cells, ultimately leading to a pro-inflammatory condition, leading to the onset or exacerbation of numerous diseases like asthma, atopic dermatitis, allergy and sleep apnea (Kelishadi et al., 2017). Various per- and polyfluorinated substances (PFAS) might affect growth, infantile behavior, learning, and older children. It also lowers the chance of pregnancy, interferes with the defense of natural hormones, increases the cholesterol levels, reduces vaccine-induced immune protection in children, and increase the risk of cancer (Velez et al., 2015; Grandjean et al., 2017; Bach et al., 2015). Various reports from the conducted human studies conclude that some PFAS can take as long as 8–9 years to

get cleared from the body (Bartell et al., 2010). It can also cross the placental barrier and be secreted through breastmilk (Mondal et al., 2013; Kingsley et al., 2018). It was observed that the immune response was impaired in children, especially cellular to influenza virus, and also inadequate vaccine responses were seen when they were obese (Green and Beck, 2017). Thus, the importance of nutrition must be considered when it comes to Immunity. Similarly, there is enhanced knowledge about food, nutritional habits, and other lifestyle aspects, which are essential in aiding the proper functioning of the immune system (Gombart et al., 2020).

In concern with obesity, there is a negative relationship between BMI and the intake of trace elements identified in obese people (Farhat et al., 2019). Therefore, obesity has a strong correlation with an increased risk of infectious diseases accompanied by severe complications, elevated critical illnesses, and prolonged hospitalization (Ritter et al., 2020). Systemic inflammatory reactions occur in covid 19 due to cytokine storms which leads to the imbalance of the immune system observed in obesity, and it contributes to a worse clinical outcome. Adipocytokines, mainly leptin, play an integral role in Immunity, as they influence the number and the function of immune cells through direct effects on cell metabolism (Kim and Nam, 2020).

## 8. Influence of junk food during COVID-19 pandemic

COVID-19 lockdown had drastically altered the regular food pattern. When compared before pandemic, it shows both negative and beneficial impact on dietary practice associated with poor lifestyle management such as lack of physical activity and obesity. Nonetheless, poor eating habits were noticed such as changes in meal frequency and increased snacking with comfort foods (food bringing emotional comfort). It shows that alteration in dietary habits during the pandemic are at higher risk of further complications (Bohlouli et al., 2021).

Since junk food tends to impact the immune system, it poses a greater risk during the pandemic. Children and adolescents who consume more junk food or are addicted to such consumption might be even more vulnerable during the third wave, which will especially affect the younger category (Janssen et al., 2021; Preethi et al., 2021).

## 9. Conclusion

Overweight and obesity are predominantly associated with numerous cardiac complications and are mostly mediated through the risk of metabolic syndrome. Obesity, like other malnutritional states, is known to impair immune function by altering leucocyte count as well as cell-mediated responses and causes organ damage. Not only is it causing physiological repressions, but it has significant psychological manifestations-that can damage a child's intellect and personality. Covibesity associated individuals are more prone to alteration of the immune system, and thus those people having junk food habits should be more cautious in this pandemic by maintaining health hygiene and getting vaccinated. It is to be noted that junk foods and packaging materials have drastic outcomes on health by impairing the immune system.

Thus, a combination of junk food, physical inactivity, and constant psychological stressors on children and adolescents during the pandemic makes them more vulnerable to increased weight along with decreased Immunity and thus an increased chance of infectivity during the third wave of COVID-19. There is an urgent need to spread awareness among children and young adults about these adverse effects of junk food, and they are not a good substitute for good healthy nourishment. There is no better time than now to build a supportive environment nurturing children and young adults in society and promising good health.

## CRedit authorship contribution statement

AS: Methodology and Writing.

**DD:** Data curation and Review.  
**NG:** Investigation and Resource.  
**LP:** Writing and Editing.  
**SS:** Conceptualization and Supervision.

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