



CARBONATED SOFT DRINK CONSUMPTION AMONG YOUNG ADULTS IN DELHI: A CROSS-SECTIONAL STUDY WITH PUBLIC HEALTH IMPLICATIONS

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ABSTRACT

Over the past two decades, the soft drink industry has come to withhold more than half of the beverage industry in India. And, of note, it's children, adolescents and young adults that form the bulk of consumers. To assess the general pattern of consumption, preferences and awareness regarding carbonated soft drinks (CSDs) among young adults, we carried out a survey (n=850) among individuals of the age group 18-26. Taste (66.94%) formed the major impulse for consumption. Coca-cola (32.11%) was the most preferred drink followed by Sprite (10.59%), Pepsi (8.71%) and Mountain Dew (8.35%). Majority (45.65%) preferred CSDs packed in plastic bottles and most (78.35%) consumed ≤ 500 ml CSD per day. Although 76.24% believed that CSDs cause health problems, still they reported to consume these drinks in parties or whenever they liked. Among respondents who were not much health conscious, there was a relative higher ignorance with respect to prospective diseases and contaminants. 24.12% of respondents honestly claimed that despite having knowledge of hazardous effects of CSDs on their health, they would continue the consumption anyway while 35.06% said 'No' and 40.82% were 'not sure'. To conclude, the CSD consumption was not rampant in our study sample, however, it was found to be a significant factor for increasing risk of diabetes in adults. Plastic toxicity was identified as another health hazard, and was a factor of concern. Hence, there is an urgent need to disseminate knowledge about the health risks associated with excessive CSD consumption.

KEYWORDS: Carbonated soft drinks, health issues, lifestyle, diabetes mellitus

INTRODUCTION

A non-alcoholic drink that contains carbonated water, a sweetener, a natural or artificial flavouring agent, coloring agents, chemical preservatives, antioxidants and acidulants, is known as *carbonated soft drink* (Acaroz et al. 2019). Soft drink consumption in India over the years has significantly risen, with children, adolescents and young adults forming the bulk of consumers. As per the Codex General Standard for Food Additives (GSFA) laid down by Food and Agriculture Organisation (FAO) of the United Nations and WHO (under the category 14.1), *non-alcoholic (soft) beverages* include natural mineral and soda waters, carbonated drinks, fruit and vegetable juices, fruit and vegetable nectars, water based flavoured drinks (including sport, energy, electrolyte and particulated drinks), herbal infusions and coffee and its substitutes, while carbonated water-

based drinks include water-based beverages with added carbon dioxide and nutritive or non-nutritive sweeteners and other food additives (Codex Alimentarius, 1995). In contrast, the Food Safety and Standards Authority of India (FSSAI) via an amendment in 2016, under sub-regulation 2.3.30, defined *Carbonated Fruit Beverages or Fruit Drinks* as any such drink prepared from fruit juice and water or carbonated water which contains sugar, dextrose or invert sugar either singly or in combination. However, it must contain less than 10% fruit juice but no lesser than 5%, except lime or lemon juice where the lower limit of fruit juice is 2.5% [Food Safety and Standards (Food Products Standards and Food Additives) Regulations, FSSAI, 2011; Food Safety and Standards (Food Products Standards and Food Additives) eleventh Amendment Regulations, 2016].

Carbonated beverages, including carbonated soft drinks (CSDs), constitute a major part of processed food and beverage industry. CSDs account for 44% share in revenue. CSD market in India lags behind i.e., it generated USD 18.5 billion in 2022 (Mukherjee et al. 2024). However, in India, soft drinks account for more than half of the beverage market (Kumar and Ray 2018) with carbonated drinks occupying 19% market share in it (Statista 2021). In the year 2015 alone, overall consumption of these beverages grew 18% in India while the worldwide growth was a meagre 3.8% (Kumar and Ray 2018).

Being the ready-to-drink beverage, it's no wonder that they easily find their place in every millennial's diet, with product innovation and marketing strategy compounding the advances further. However, what remains largely hidden under the covers is that they are often laced with artificial sweeteners, preservatives, synthetic food colours, and caffeine (in energy drinks) among others. CSDs contain artificial sugars to increase the total energy content of beverages. Consuming CSDs does not give a feeling of fullness as regular food, hence consumers continue to maintain regular diets of the day. Such habits provide extra calories which are a cause of overweight and obesity, which in turn, are associated with risks of other diseases such as cardiovascular diseases, Type 2 diabetes etc. (WHO 2014).

Caffeine is responsible for health risk associated with non-alcoholic beverages and overdosage might cause serious cardiovascular problems such as increase in blood pressure and heart rate. It is also associated with anxiety, sleep problems, dehydration and digestive problems. In pregnant women, it can cause developmental anomalies in cardio-vascular and nervous system (National centre for Complementary and Integrative Health 2018). And, this might explain why FSSAI mandates that caffeinated or carbonated soft drinks carry no more than 300 mg/litre of caffeine and explicitly expresses an inscription on label barring pregnant or breast-feeding women and children from the consumption of such drinks. Further, each such drink should carry a maximum recommended consumption of not more than 500 ml. However, the actualisation of such rules is far from reality as beverages do not carry the quantity of caffeine, let alone the warning inscriptions on label [FSSAI Regulations for Caffeinated Beverages: Food Safety and Standards (Food Products Standards and Food Additives) eleventh Amendment Regulations, 2016; Gazette Notification by FSSAI, Standards for

Caffeinated Beverages and use of blue tint in plastic container, 2016].

Although, carbonated drinks might provide instant energy and refreshment (Vartanian et al. 2007), they are low in nutrient value and health risks associated with overconsumption still need to be tackled. Acid regulators such as phosphoric acid, malic acid and citric acid in such drinks lower the pH to 2.5-3.5 and cause dental caries and erosion. Even diet soft drinks contain comparable amounts of artificial sweeteners and acidity regulators (Tahmassebi and BaniHani 2019). Phosphoric acid in itself has been believed to cause kidney stones (Kregiel 2015). Artificial sweeteners (saccharine, aspartame) have been linked to conditions of obesity, lymphomas, leukemias, and cancers of the bladder and brain among other diseases (Tahmassebi and BaniHani 2019).

In totality, over-consumers are at an increased risk of developing kidney stones, osteoporosis, cardiovascular diseases, asthma, obesity, Type-2 diabetes, reproductive issues in addition to deteriorating oral health and caffeine overdose (McCusker et al. 2006; Vartanian et al. 2007; Tahmassebi and BaniHani 2019; Wasiullah et al. 2023; Khalid 2024). Further, there is dearth of studies on the pattern of soft drink consumption among youth in India. In the light of all these concerns and potential health risks, this study was conducted to assess the consumption pattern, general attitude, and awareness regarding the consumption of commonly available soft drinks by the young adults of Delhi.

MATERIALS AND METHODS

A detailed pre-tested questionnaire was prepared targeting the consumption pattern of carbonated soft drinks, general attitude, preferences of CSDs, lifestyle, awareness about additives and contaminants, and future consumption by young people. The questionnaire was circulated in both offline and online mode (Google form) from January, 2020 to November, 2020. The respondents were in the age group 18-26, as this group constitutes a major proportion of the consumers of CSD industry. A total of 850 responses were considered for analysis (offline: 355; online: 495). The participation in the study was purely voluntary and an informed written consent was taken from all the respondents.

The results are expressed as frequency and percentage, and were analysed using MS Excel.



RESULTS

Of the total 850 respondents, 79.29% were females. The most consumed CSD was Coca-Cola followed by Sprite, Pepsi and Mountain Dew (Fig. 1A).

Majority of the respondents preferred CSDs in plastic bottles followed by canned bottles (Fig. 1B). The most influential factor for buying/intake of CSDs was taste (66.94%), followed by the ease of availability (10.94%) and calories (8.47%) (Fig. 2).

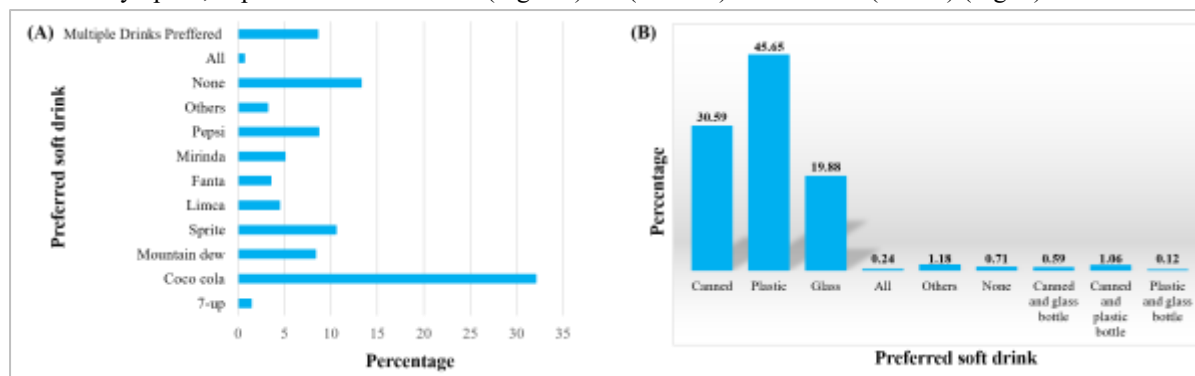


Figure 1. Preferred soft drinks (A) and packaging (B) (n=850)

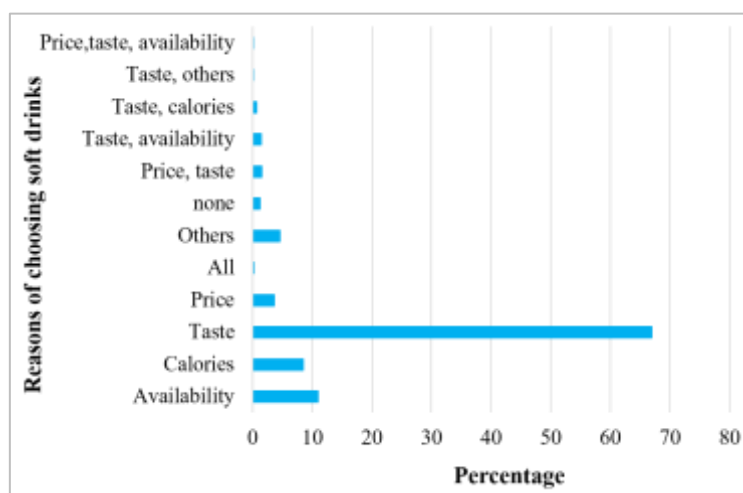


Figure 2: Factors impacting consumption of soft drinks (n=850)

Majority of the respondents said that they rarely consumed CSDs (Fig. 3A). 78.35% of the respondents consumed ≤ 500 ml CSDs per day, while only 4.35% consumed more than 2000 ml per day (Fig. 3B).

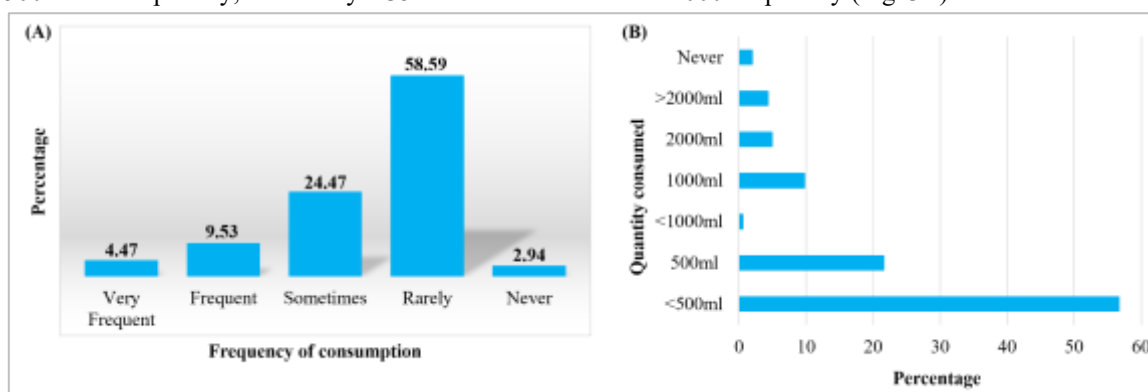


Fig. 3. Frequency (A) and quantity (B) of consumption of carbonated soft drinks p (n=850). *Rarely = only on occasions; frequent = twice a week; sometimes = once a week; very frequent = almost daily

While 51.29% of respondents consumed CSDs during parties, 40.71% consumed it whenever they wished. Only 3.88% consumed CSD when they were thirsty. Though majority of respondents (47.53%) reported that they can consume CSDs at any time irrespective of the carbonation stage, 29.18% preferred to consume at carbonation and 20.71% after carbonation. Further, 76.24% respondents believed that excess consumption of CSDs can cause health hazards. The respondents were concerned about sugar, artificial sweeteners and flavourings in the carbonated drinks (55.53%), they knew that carbonated drinks contain heavy metals, pesticide, caffeine, aspartame etc. (37.41%), CSD consumption negatively affects dental health (83.41%), and that consumption of CSDs can cause several health issues like obesity, type-2

diabetes, osteoporosis and low nutrient level (74%). However, when asked if they will still continue consumption, opinions were divided. While 24.18% said that they will continue, the remaining either said no (35.06%) or were not sure (40.82%).

Majority of respondents followed a moderate lifestyle (Fig. 4). Among those who followed active lifestyle, majority (31.62%) preferred Coca-cola followed by Sprite and Mountain Dew (9.97% each). Among those leading a moderate lifestyle, the preferred drink was Coca-cola (32.81%) followed by Sprite (10.94%) and Pepsi (8.79%), while among those leading a sedentary lifestyle, majority preferred Coca-cola (27.03%) followed by Mirinda (10.81%), Sprite and Mountain Dew (8.11% each) (Fig 5).

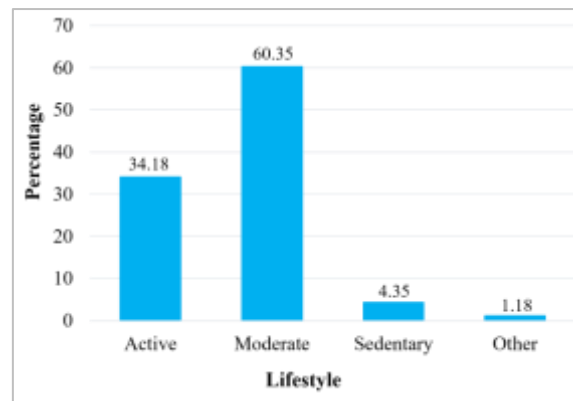


Fig. 4. Lifestyle of respondents (n=850)

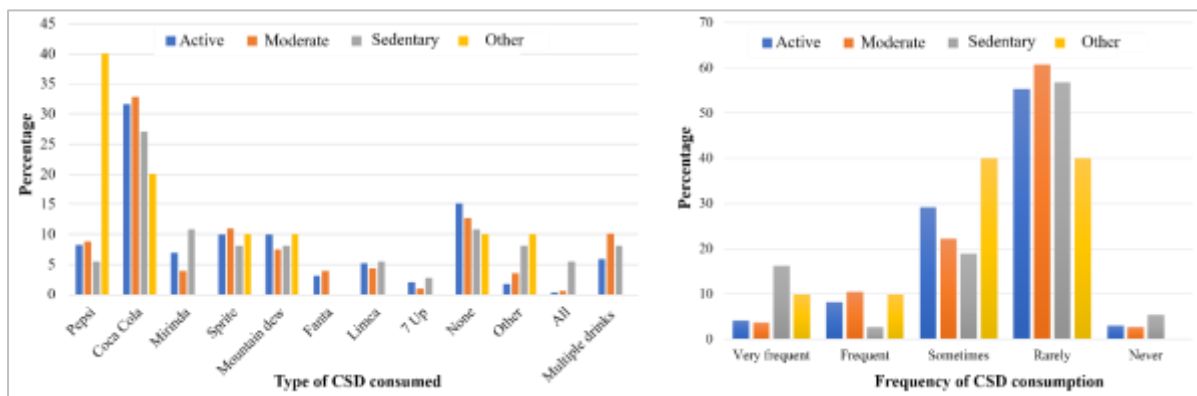


Fig. 5. Preferred CSD and frequency of its consumption among respondents following different lifestyles (n = 850)

FDA and FSSAI mandate display of all components on food products, including CSDs, while packaging, however, not all brands explicitly display all information (Table 1)



Table 1. Nutritional information of different CSDs (per 100 ml) as per the labels

S. No.	Nutritional information	Pepsi	Coca-cola	Sprite	Mounta in dew	Limca	Fanta	Mirinda	Thums Up	7 Up
1	Energy	43 kCal	44 kCal	49 kCal	49 kCal	44 kCal	56 kCal	55 kCal	42 kCal	1 kCal
2	Carbohydrates (g)	10.9	10.9	12.2	12.3	11.1	14	13.8	10.6	0
	Total sugars (g)	10.9	10.6	11.7	12.3	10.7	13.7	13.8	10.4	0
	Added sugar (g)	10.9	10.6	11.7	12.3	10.7	13.7	X	10.4	0
3	Total Fat (g)	0	0	0	0	0	0	0	0	0
	saturated fat (g)	0	X	X	0	X	X	0	X	X
	Trans fat (g)	0	X	X	0	X	X	0	X	X
4	Protein (g)	0	0	0	0	0	0	X	0	0
5	sodium (mg)	3	8.5	10.1	8	5.5	22.3	14	0.81	28
Components:										
1	Carbonated water	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	Sweeteners	X	X	X	X	X	X	X	X	Yes: 951, 955, 950
3	Caffeine	Yes	Yes: 8.7mg/100g	X	Yes: 13mg/100g	X	X	X	Yes: 8.3mg/100g	X
4	Colour agents	Yes: 150d	Yes: 150d	X	Yes: 102	X	Yes: 110	Yes: permitted synthetic food color (110)	Yes: 150d	X
5	Acid	Phosphoric acid	X	X	X	X	X	X	X	X
6	Flavouring substances	Natural flavouring substances (including caffeine)	Natural flavouring substances	Natural flavouring substance	Natural flavouring substance	Added flavours (natural, natural-identical, and artificial flavouring substances)	Natural, natural-identical	Natural flavouring substance	Natural, identical and artificial (Cola) flavouring substances	Natural flavouring substances
7	Acidity regulators	Yes: 338	Yes: 338	Yes: 330, 331 (iii)	Yes: 330; 331	Yes: 330, 331	Yes: 330	Yes: 330, 331	Yes: 338	Yes: 330, 331, 296
8	Preservatives	X	X	Yes: 211	Yes: 211	Yes: 211	Yes: 211	Yes: 211	X	Yes: 211
9	Stabilizers	Yes: 436	X	X	Yes: 445(iii)	Yes: 414, 471	Yes: 414, 445	Yes: 1450, 445	X	Yes: 436

*X = Information not displayed on product. Sweeteners: 950 - Acesulfame Potassium; 951- aspartame; 955- sucralose. Color agents: 150d – caramel color IV; 102- Tartrazine; 110- synthetic yellow-orange azo dye. Acidity regulators: 338 -phosphoric acid; 330-citric acid; 331- sodium citrate; 296- malic acid. Preservative: 211 – sodium benzoate. Stabilizers: 436- polyoxyethylene (20) sorbitan tristearate; 414- Acacia gum; 471- mono- and diglycerides of fatty acids; 445 or 445 (iii)- Glycerol esters of wood resins or ester gum; 450 -diphosphates.

DISCUSSION

With increasing modernisation, there have been changes in lifestyle which are strongly associated with changing food habits. In our study, we made an attempt to gain insight into the consumption pattern of carbonated soft drinks (CSDs) among young adults in Delhi. Coca-cola and Sprite were choice of the majority, and plastic bottles were preferred over canned bottles. Taste and availability were the major drivers for purchase. Prevalence of use of CSDs in plastic bottles is a concern. Polyethylene terephthalate (PET) in CSD bottles (Indian Centre for Plastics in the Environment, n.d.), may leach as phthalate esters into the beverages, after long time exposure and at high temperatures, thus contaminating it. The concentration of phthalate esters in CSD stored in PET bottles, for long durations, range from 5- to 40- times higher than mineral water stored in PET bottles (Xu et al. 2020). Long term exposure to phthalate esters has been associated with several health risks in humans such as low sperm quality in males, attention-deficit/hyperactivity disorder (ADHD) in children, cardiovascular diseases, respiratory diseases, obesity, diabetes, diseases of thyroid and kidney, reduced intelligent quotient in children etc. (Chang et al. 2021). It must be noted here that CSDs are not the only source of phthalate esters.

More than three-quarters of the respondents consumed ≤ 500 ml CSD per day. However, among those who consumed ≥ 1000 ml per day (19.64%), they frequently consumed it, either daily or once a week or twice a week. The plastic bottles come in different volumes ranging from 250/300 ml to 1.5 litres. Different CSDs contain different quantities of sugars and other constituents like caffeine, carbohydrates, added flavours, natural colors, caffeine, acidity regulators etc. The nutritional facts stated on the label of the different CSDs (Table 1) give information about the various components of CSDs, including the amount of sugar content present in them. The normal sugar intake for a young adult should not be more than 25 g per day as prescribed by WHO (WHO 2015). Thereby, if we calculate the amount of sugar present in a 300 ml bottle, the sugar consumed exceeds the prescribed sugar intake of WHO. Soft drinks use artificial sweeteners to increase sweetness; however, the exact nature and concentration of sugar is hardly mentioned on the labels. FSSAI has permitted use of certain artificial sweeteners like saccharin sodium (100 ppm), aspartame (methyl ester) (700 ppm), acesulfame potassium (300 ppm), sucralose (300 ppm), and neotame (33 ppm) in the final product of soft drinks

(Food Safety and Standards (Food Product Standards and Food Additives) Regulations 2011) but lack of explicit information about them on labels keeps consumers in dark (Table 1).

In general, if the amount consumed rises over 250 ml in a day, the sugar uptake exceeds the normal prescribed value. The studies have shown that reduced sugar intake is associated with reduced incidences of dental caries and weight gain among the individuals. WHO recommends sugar intake less than 10% of the total energy intake (WHO 2015). Consumption of less than 2 g sodium or <5 g salt per day is the prescribed limit as per WHO Global Action Plan on the Prevention and Control of NCDs. Excess dietary sodium content increases the risks of high blood pressure and cardiovascular diseases (Ojo et al. 2022). However, CSDs don't contribute significantly to sodium intake and is generally not detrimental for health, unlike sugar.

Though majority of respondents reported that they can consume CSDs at any time irrespective of the carbonation stage, 29.18% preferred to consume at carbonation and 20.71% after carbonation. The more carbonated the drink is, the more harm it will cause due to its erosive behaviour. This is because, CSDs contain acidity regulators like citric acid and phosphoric acid which augment their more acidic behaviour. Enamel dissolution begins when pH is reduced below 5.5. CSDs have a pH of about 2.5, and become erosive and a hazard for dental health (Inchingolo et al. 2023). Many CSDs like Coca-Cola, Pepsi, Thumbs Up and Mountain Dew contain caffeine. The recommended caffeine intake for adults is <400 mg/day, for children is 2.5mg/kg/day and for pregnant women it is 300mg/day. Consumption of >500 mg per serving causes acute toxicity (Akter et al. 2025). There are many side effects of excess caffeine consumption in pregnant women and children (National centre for Complementary and Integrative Health 2018). While FSSAI mandates that each such beverage should carry a maximum recommended consumption of not more than 500 ml/day on the label, and explicitly expresses an inscription barring pregnant or breast-feeding women and children from the consumption of such drinks, however, most do not display warning inscriptions on label [FSSAI proposes regulation of energy drinks and caffeine (Revised) n.d.].

The awareness about the health hazards due to excess CSD consumption was high in our study, and one-fourth respondents reported that they will not consume CSDs after knowing these hazards. However, celebrations often incite youth to consume CDSs.



Similar results have also been observed in studies by Kumar and Ray (2018) who reported that social functions, cafes and restaurants serve as major hotspots where the youth consume CSDs as “special drinks” on celebratory occasions for relaxation. They also reported that although, less-frequent consumers do outnumber more-frequent consumers, they form a stable (and fairly large) population dependent on carbonated drinks and serve as target population for manufacturers.

In the light of all the health hazards associated with carbonated drinks, particularly sugar content, it is evident that the need of the hour might be changing and remodelling our current habits. As an attempt to reduce the high dependence and growing addiction of the youth, regulating the sale of the carbonated drinks around and inside educational institutions, cafeterias of hostels and nearby localities might prove to be an effective measure. Further, as an alternative, healthy and savoury fruit or dairy-based drinks could be preferred in restaurants and on other special occasions.

CONCLUSION AND RECOMMENDATIONS

While a general consensus regarding contaminants, additives and ill effects of the CSDs does prevail among the consumers, it's interesting to note that a vast majority of respondents would still continue consumption of CSDs in future. The results mirror how deeply ingrained are these drinks in our current diet and lifestyle. Taste forms the major impulse of consumption which often exceeds the recommended sugar consumption per day. Our results do indicate that CSDs are not consumed as substitutes to water, milk, coffee, or tea but rather as discrete drinks. As such, the marketing strategy advertises them to be substitutes for “traditional food and drinks” or products to “quench thirst”. The regulation on marketing of CSDs could be one way of reducing their consumption. Further, as most people resort to them at parties or on special occasions, an alternative approach to reduce consumption could be switching them with savoury healthy drinks (dairy or fruit based). As far as amount of CSD to be consumed is concerned, we recommend the following:

1. 250 ml/day CSD may be taken which fulfils the sugar intake per day as per WHO, if no other food is taken. However, it is practically impossible, hence, depending upon the food consumed per day, ≤ 50 ml (~ 4 g sugar) CSD may be consumed.

2. It would be best to discontinue consumption of CSDs. However, on certain occasions, it may be consumed taking into consideration the food consumption.
3. Only sugar factor is not risky, but the erosive nature of CSDs also poses threat to the dental and overall health. Moreover, they have no nutritive value, so excess consumption would deprive the youth of the necessary nutrients.
4. The frequency of consumption should be decreased significantly.
5. CSDs with glass packaging should be preferred, owing to harmful effects of plastics.
6. It is important to monitor the consumption of CSDs among adolescents and young adults as the habits during these years may become permanent, thus risking their health in future.

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Conflict of interest

Authors declare that there is no conflict of interest

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