

“Sweet Truths: Understanding How Sugar Affects Cancer Growth”

Link between Cancer and Sugar Consumption in India

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Abstract - This research paper summarizes the relationship between sugar and cancer, along with comparing the growth rates of the consumption of sugary products such as chocolates and soft drinks, to the number of cancer cases. Then, there is the correlation of each sugar product along with cancer cases and multi correlation between all of them.

1. INTRODUCTION

In India, 1 in 9 people are at the risk of developing cancer in their lifetime. Myriads of lives have been ravaged by the disease, and yet, cancer remains an unavoidable illness in people’s minds. However, recent research points towards multiple factors that are associated with one’s chances of developing cancer. These include obesity, smoking, alcohol intake, and recently, excess sugar consumption.

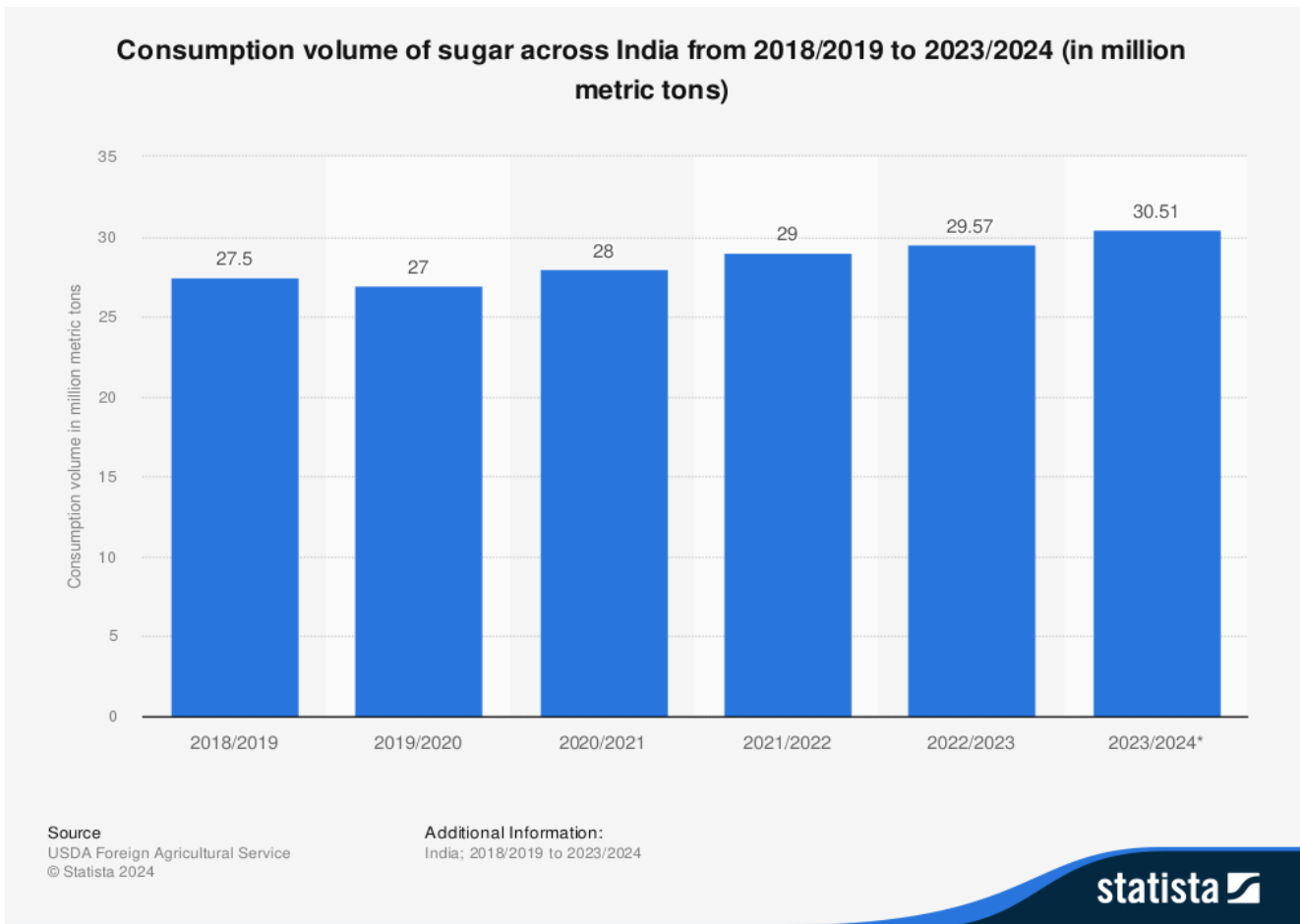
This paper will delve into the link between sugar consumption and an increased incidence of cancer in the country. The research does not intend to establish causation, that is, to say that an increased sugar consumption has led to more people developing cancer. Rather, the aim is to comment on the trends proving that both sugar consumption and cancer rates are following alarmingly similar trajectories in the country.

2. FOOD HABITS OF INDIANS:

India has a varied cuisine, but the Indian diet is mainly cereal based and lacks sufficient nutrients. Most Indians consume less than the 2503 kcal/capita/day recommendation, while only the richest 5% are able to meet this guideline. Out of this, a meagre 6-8% calories come from protein, while whole grains contribute to most of the diet. Whole grains comprise of cereals like wheat, rice, bajra, maize, barley, etc. The average Indian household consumes more processed food than fruits, which it is now reflecting on the overall health of citizens. With some states being vegetarian diet-centric, a lack of fish, meat and eggs consumption may also be contributing to the illnesses.

The disparity in the country is evident as both rural and urban households receive fewer than required calories, while rich households consume 3000 kcal/ day. This is 20% higher than required, and almost twice as the poorest households’ diets. The imbalance in diet has given rise to malnutrition and diseases such as obesity, anemia, and diabetes.

An even more alarming statistic is that of sugar-sweetened beverages. In urban India, every week adolescents consume 1.8 cans of cola per week, and this might result in a weight gain of 1.3 kg per child per year. Indians consume roughly 25.17kg of sugar per person per year, which exceeds the worldwide consumption of 23.7 kg/year. A change in the Indian lifestyle is leading to an even greater increase in sugar consumption every year. During 2018-2019, the sugar consumption was 27.5 million metric tons, which shot up to 30.51 million metric tons during 2023-2024.



This is owing to the fact that in India, celebrations are synonymous to sugar consumption. An extravagance of fried and sweetened delicacies marks the success of any celebration. An amalgamation of a sedentary lifestyle and a poor diet has resulted in excess body fat, liver fat, insulin resistance and multiple metabolic disorders that contribute to the declining health of the country.

3. TYPES OF DISEASES

A disease is a condition that leads to ill-health and interferes with our ability to function normally. It is coupled with specific signs and symptoms that help detect the root cause of the disease. Typically, there are 4 types of diseases: Genetic disease, infectious diseases, deficiency diseases, and physiological diseases.

Cancer is a result of mutations in the DNA, and is classified as a genetic disease. It falls under the bracket with diseases like diabetes, cystic fibrosis, sickle-cell anaemia, and heart disease. If the allele for the disease is present in the parents' genome, they risk the chance of passing it down to their offspring even if the disease is not expressed in their phenotype.

The main risk factors for developing genetic diseases are chemicals like tar and mustard gas, smoking, radiation exposure and UV rays from the sun. These can affect the bonds between nucleotides and alter their sequence, which results in a mutation.

4.HOW CANCER DEVELOPS

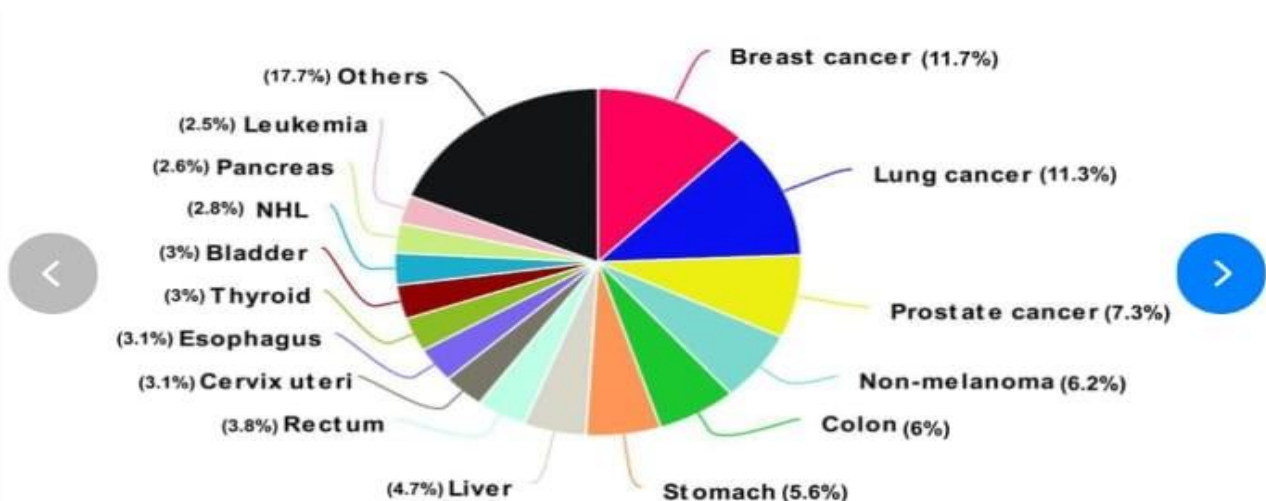
The root cause of cancer is a mutation. A mutation that either activates oncogenes or deactivates tumor suppressor genes. Both these genes, once altered, allow uncontrollable cell growth, instead of normal cell division. This can happen during DNA replication in mitosis, when there are errors which disrupt the cell- cycle. The cell-cycle checkpoints are no longer regulated, and the cells divide uncontrollably regardless of external signals to stop dividing. These cells are no longer functional, and form a mass of tissue called a tumor. This tumor then develops a network of capillaries around them which help in providing enough nutrients for maintenance and growth.

There are two types of tumors: A benign tumor, which cannot move to other parts of your body, such as fibroids, and a malignant tumor, which is a cancer. A malignant tumor can metastasize and invade other tissues in the body.

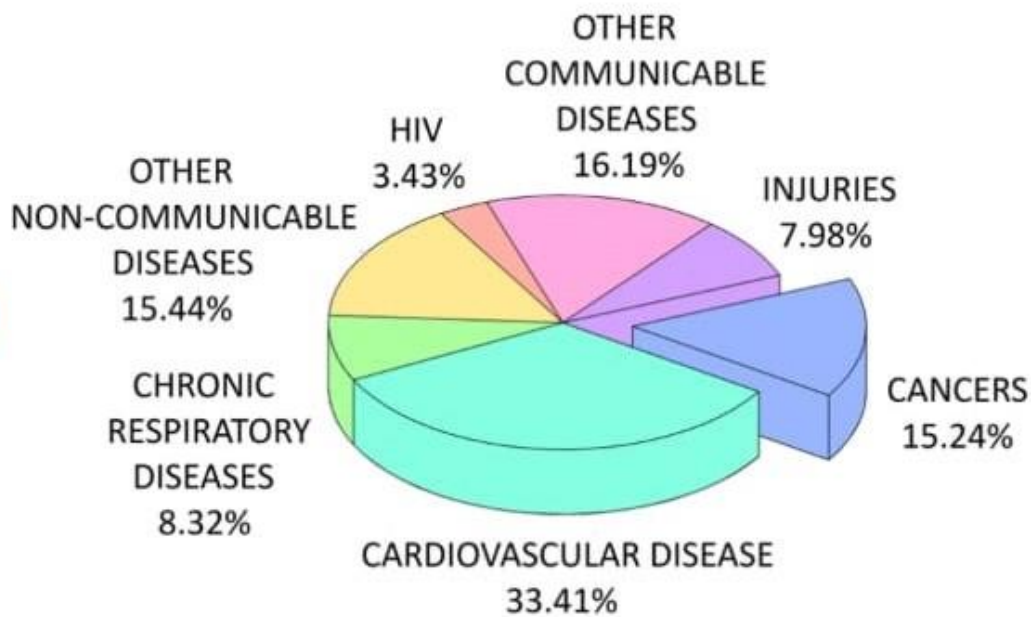
Cancer cells also possess a unique enzyme that normal cells don't: Telomerase. Chromosomal ends called telomeres are nucleotide sequences that allow repeated divisions in cells without the loss of important genes. However, there are limitations as the telomeres shorten after every cell division. After a point, the cells can't divide anymore and enter a state called senescence, or they trigger a self-destruct program called apoptosis.

Telomerase, however, repairs the telomeres and prevents them from depleting. As a result, cancer cells can divide indefinitely, without losing an important genes. They are immortal.

These tumors keep growing indefinitely and press against body tissues, preventing them to function effectively. This results in cancer.



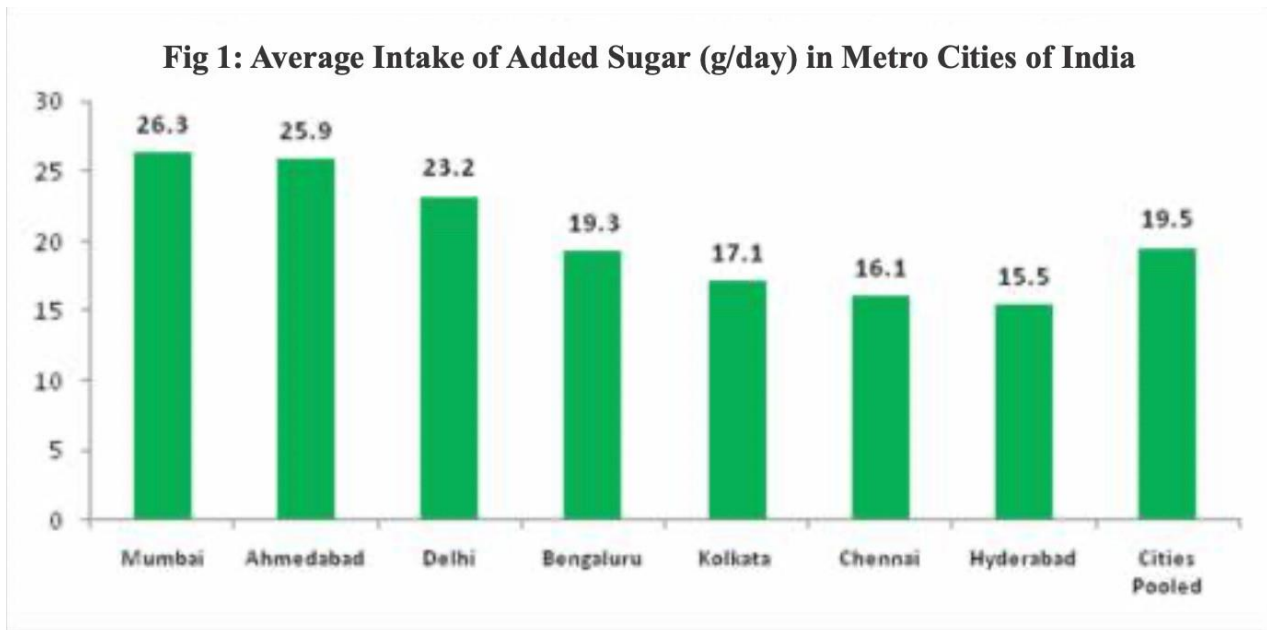
Global cancer statistics. Pie chart depicting the percentage of new cases in each tumor type in 2020 for women globally. The data used to prepare the chart were taken from GLOBOCAN 2020 (27).



1 Pie chart showing worldwide causes of death as percentages, 2013. [1]

5. SIDE EFFECTS OF SUGAR AND ITS PRODUCTS:

- Added Sugars are sugars that are externally added while manufacturing food products, such as glucose and fructose.
- Free sugars are sugars that may be naturally present in food items, such as honey, fruit juices, etc.
- Sugary foods are perceived to be harmful primarily because they can cause weight gain. However, weight is not the only determinant of health.
- The current AHA guidelines recommend a daily limit of six teaspoons (30 g, or 120 calories) of added sugar for women and nine teaspoons (45 g, or 180 calories) for men. The WHO also recommends dietary sugar intake less than 10% of daily energy intake (50 g per 2000 daily calories) and conditionally recommends that less than 5% of daily energy intake consist of added sugar.
- Consumption of sugar stimulates dopamine release in the hypothalamus, which activates reward pathways and overrides satiety signals.
- Repeated exposure to sugar alters the dopamine circuitry, which dysregulates homeostatic controls and reinforces food cues. These pathways are thought to be crucial for reward motivation and memory. Activation of reward pathways leads to further sugar consumption, eventually leading to an association that links sugar to rewards and joy.
- Sugar also activates the hypothalamus and inhibits the production of leptin, which prevents feelings of satiety and leads to overconsumption.
- In a study conducted with rat models, excessive sugar consumption led to signs of addiction. This was coupled with bingeing, depression and withdrawal like symptoms. It also increased their shock-resilience.

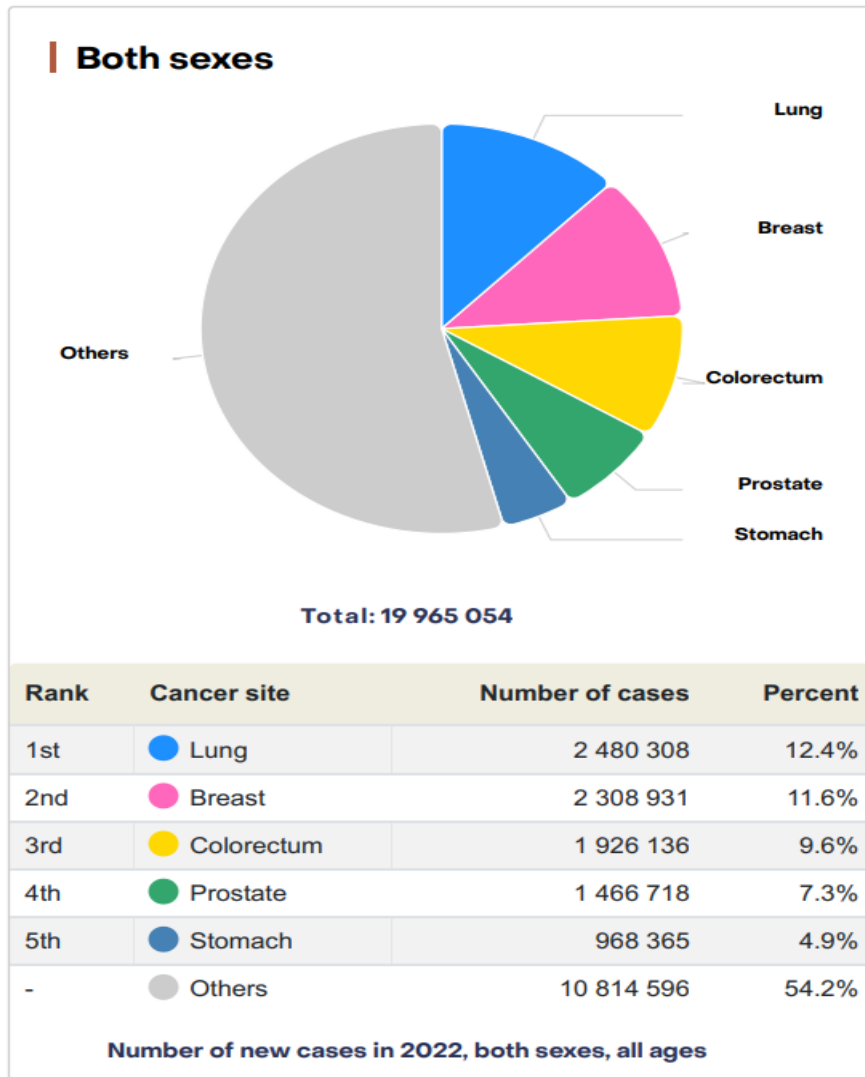


MECHANISM

- Glucose normally stimulates pancreatic b cells to release insulin, which allows glucose to enter cells and provide energy.
- When there are high levels of carbohydrate and glucose in your body—more insulin is secreted to increase their uptake.
- More insulin means more IGF-1 (Insulin growth factor): This helps in growth of muscles and tissues, and both work together to reduce the glucose concentration of your body.
- Normally, this would be a good thing. For cancer patients, it's not. This can lead to an aggressive growth of the tumor.
- Glucose in the body is taken up by this tumor and used as a source of nutrition for its growth.
- When glucose is scarce, the body looks for alternative sources of energy: The liver produces ketones, which provide for normal cells but not for cancer cells.
- Normal cells have mitochondria, which converts glucose to release energy, in the form of a molecule called ATP (Adenosine triphosphate)
- Cancer cells get their energy from glycolysis: This is when they breakdown glucose to release ATP. They can't do the same for ketones because their cells don't have the required machinery. Ketones act as a backup, when the body doesn't have enough glucose, and effectively 'starve' cancer cells of the required nutrients.

STATISTICS

- Countries such as Brazil, India, and China, which previously reported low rates of breast, prostate, and colon cancer, are now seeing significant increases in the incidence and mortality of these cancer. The number of patients with cancer in India were 1,392,179 for the year 2020, and the common 5 leading sites were breast, lung, mouth, cervix, and tongue. An even more alarming statistic is that the cancer cases are projected to shoot up to 1.57 million by 2025. This tragic decline in health has made India the 'Cancer capital of the World', as labelled by Apollo Hospitals in their report.
- The International Agency for Research on Cancer (IARC) reported as strong evidence that excess body fat is a major risk factor for many cancers, including esophageal, pancreatic, colorectal, post-menopausal breast, endometrial, renal, ovarian, gallbladder, hepatic and gastric cardia, among others.
- Moreover, a sugar study report conducted in 2015-2016 by the ICMR National Institution of Nutrition found that adults and older people consumed more sugar than younger ones. The highest intake of sugar was observed between adults aged 36-59, at 20.5 grams.
- Coinciding with this report, the American Cancer Society states that 35.4% cancer cases occur in people aged 45-64. The link between these statistics points towards how sugar consumption is contributing to the incidence of cancer.



6. CANCER CASES AND SUGAR PRODUCTS IN INDIA

1. Consumption of soft drinks (in billion Lts.) in India:

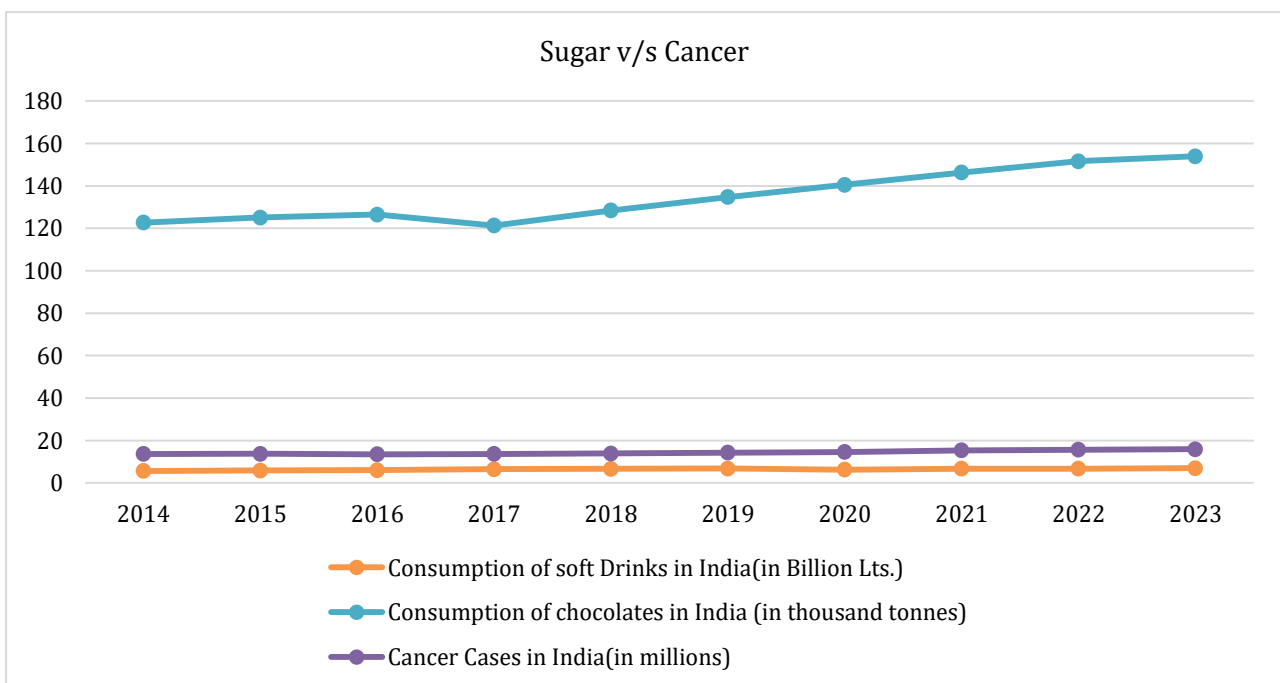
Year	Consumption of soft Drinks in India(in Billion Lts.)
2014	5.61
2015	5.9
2016	6.06
2017	6.49
2018	6.63
2019	6.82
2020	6.26
2021	6.68
2022	6.75
2023	6.94

2. Consumption of chocolates in India (in thousand tonnes):

Year	Consumption of chocolates in India (in thousand tonnes)
2014	122.7
2015	125.1
2016	126.5
2017	121.3
2018	128.4
2019	134.7
2020	140.5
2021	146.3
2022	151.6
2023	153.9

3. Cancer Cases in India:

Year	Cancer Cases in India(in millions)
2014	13.68
2015	13.71
2016	13.52
2017	13.66
2018	13.92
2019	14.26
2020	14.57
2021	15.39
2022	15.7
2023	15.9



7. CALCULATIONS:

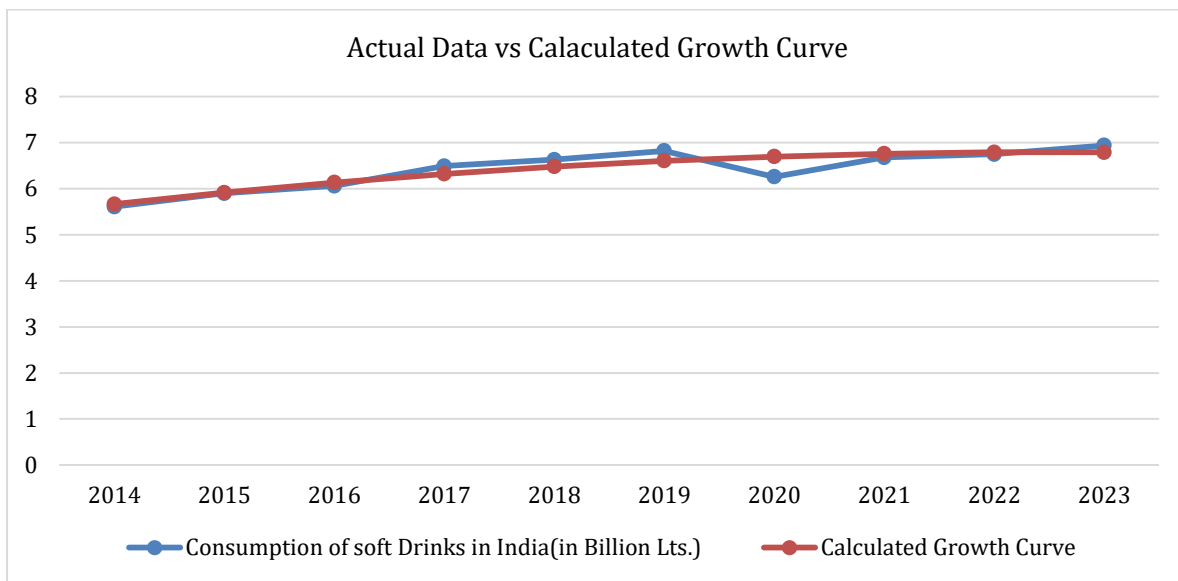
a. Growth Curve of Soft Drinks Consumption in India:

In the graph, the x-axis is years from 2014 to 2023 and the y-axis shows 'Soft Drinks Consumption in India'.

Let's consider 2014 as 1, 2015 as 2... and 2023 as 10.

After manually drawing the graph on excel, we concluded the biquadratic equation which covers maximum number of plots

Considering $y = Ax^2 + Bx + C$.



Formula: $y = -0.0158x^2 - 0.2989x + 5.38$

Where 'y' is Soft Drinks Consumption in India (in billions Lts.) and 'x' represents 1, 2, 3... (1 represents 2014, 2 represents 2015 and so on).

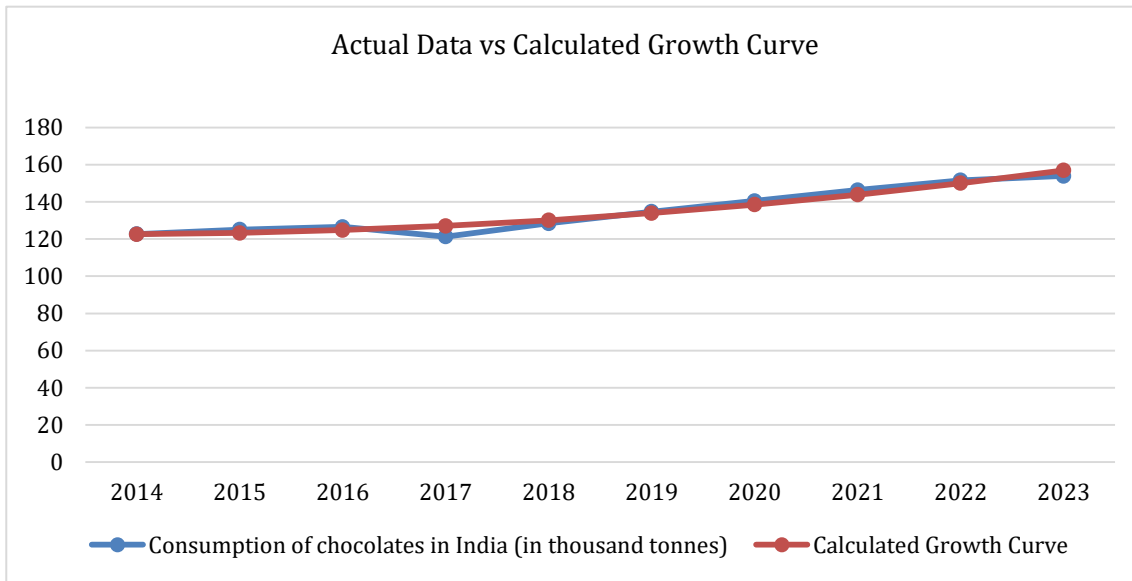
b. Growth Curve of Chocolate Consumption in India:

In the graph, we took the x-axis as years from 2014 to 2023 and the y-axis as 'Chocolate Consumption in India'.

Let's consider 2014 as 1, 2015 as 2... 2023 as 10.

After manually drawing the graph on excel, we concluded the biquadratic equation which covers maximum number of plots.

Considering $y = Ax^2 + Bx + C$.



Formula: $y = 0.3879x^2 - 0.453x + 122.66$

Where 'y' refers to 'Chocolate consumption in India' (in thousands tonnes) and 'x' represents 1, 2, 3... (1 represents 2014, 2 represents 2015 and so on).

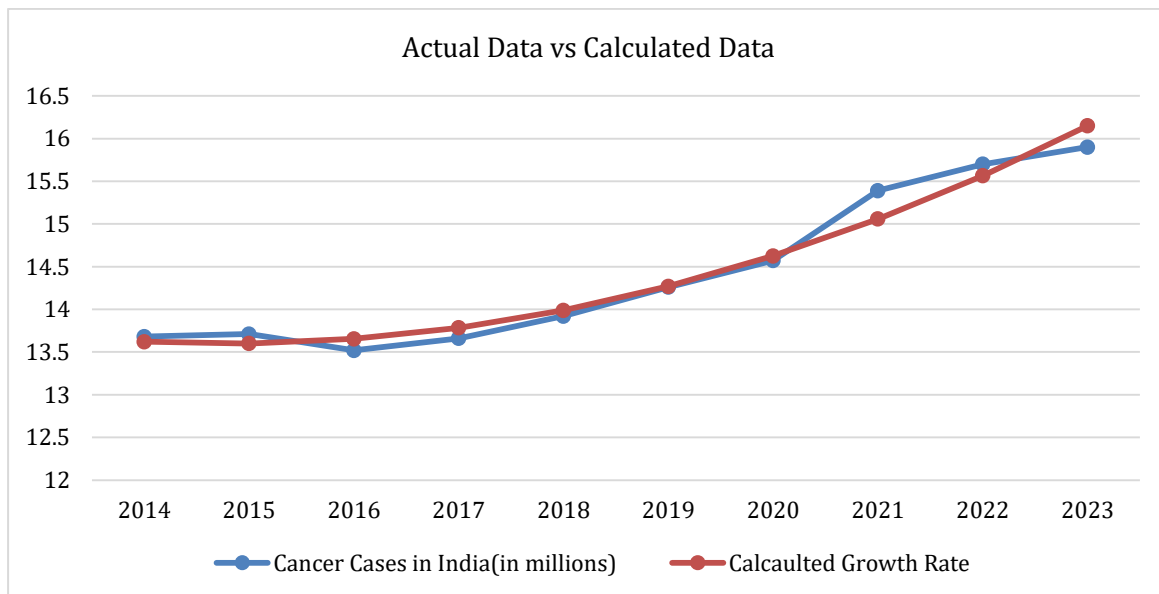
c. Growth Curve of Cancer Cases in India:

In the graph, we took the x-axis as years from 2014 to 2023 and the y-axis as cancer cases in India.

Let's consider 2014 as 1, 2015 as 2...2023 as 10.

After manually drawing the graph an on excel, we concluded the biquadratic equation which covers maximum number of plots.

Considering $y = Ax^2 + Bx + C$.

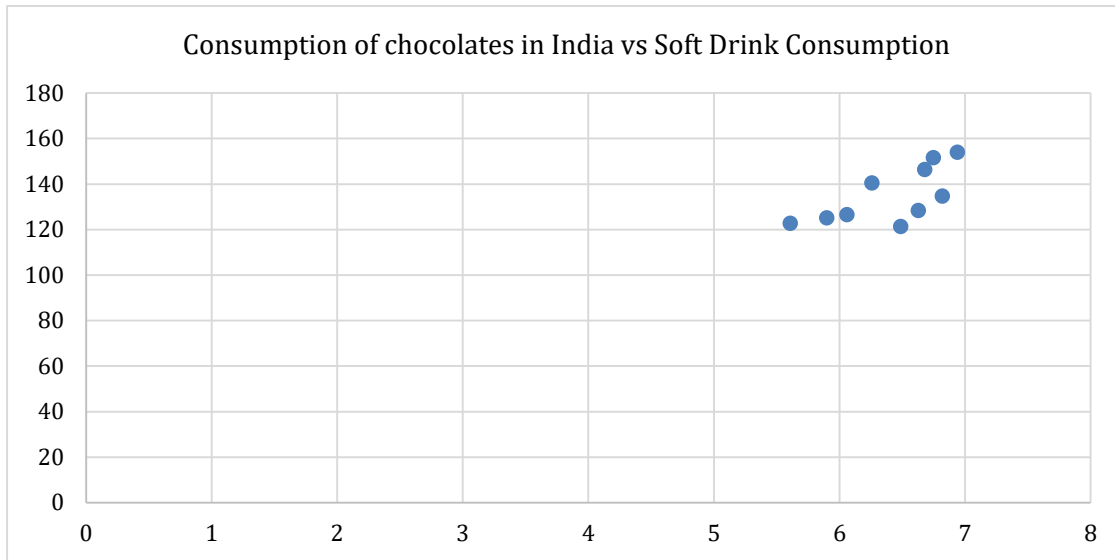


Formula: $y = 0.0378x^2 - 0.135x + 13.7183$

Where 'y' is Cancer cases in India (in millions) and 'x' represents 1, 2,3...(1 represents 2014, 2 represents 2015 and so on).

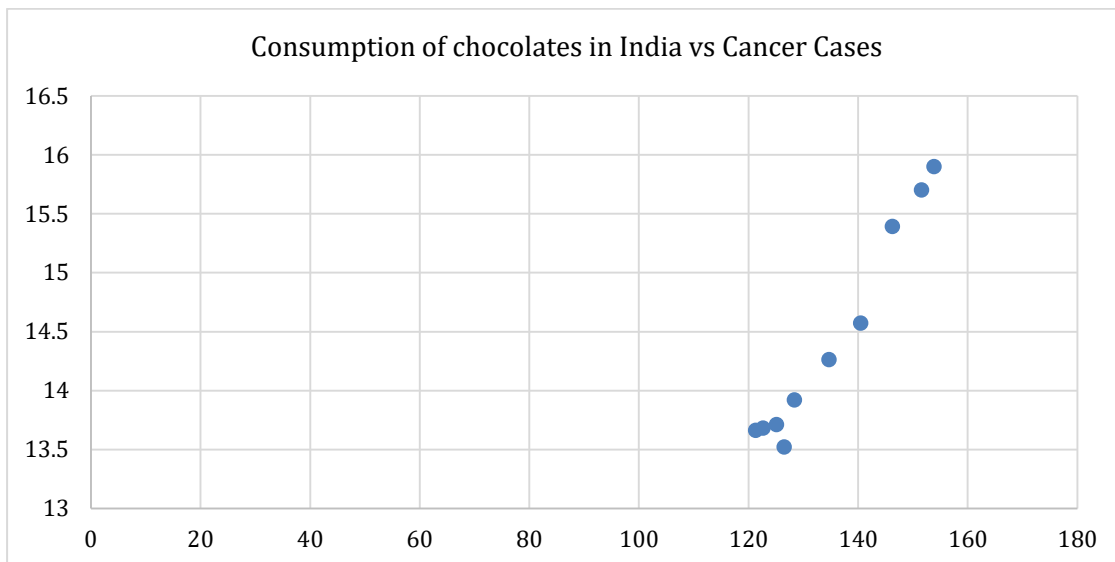
d. Correlation Between Various factors:

1. Soft drink consumption and soft drink consumption:



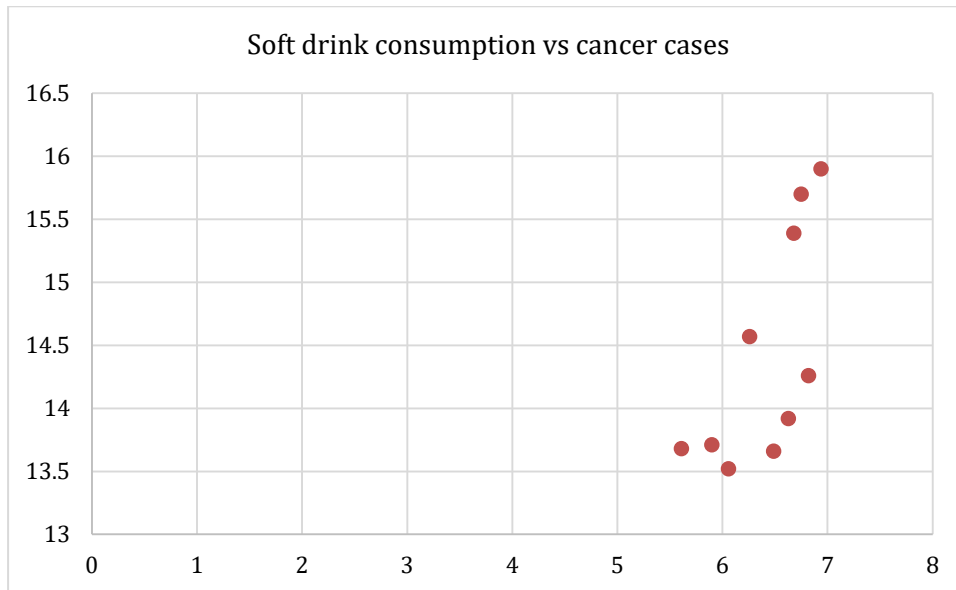
Correlation Factor = $r_{12} = 0.6899$

2. **Chocolate consumption vs cancer cases:**



Correlation Factor = $r_{23} = 0.6846$

3. Soft Drink consumption vs cancer cases:



Correlation Factor = $r_{13} = 0.9812$

Multi Correlation Formula:

$$R_{123} = \sqrt{\frac{r_{12}^2 + r_{13}^2 - 2 * r_{12} * r_{13} * r_{23}}{1 - r_{23}^2}}$$

8. Conclusion:

After analyzing the trends in sugar consumption and cancer cases in India, we can mathematically conclude that they are both continuously increasing each year. The correlation between the two is positive, and their growth rates are increasing at comparatively similar paces. Through this research we can infer that sugar plays a significant role in the occurrence of cancer, despite not being biologically termed as a carcinogenic substance. The biological mechanisms behind this remain unknown. However, it would be fit to say that limiting the consumption of added sugars and maintaining a healthy diet are stepping stones towards avoiding cancer.

9. References:

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10. Bibliography:

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