

## ASSOCIATION THE PROPORTION OF CARBONATED BEVERAGE CONSUMPTION AND THE PREVALENCE OF HYPERTENSION AND DIABETES IN INDONESIA (INDONESIA HEALTH SURVEY ANALYSIS 2023)

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### ABSTRACT

**Background:** Hypertension and diabetes mellitus are non-communicable diseases with increasing prevalence in Indonesia. High consumption of carbonated beverages is suspected to be a major risk factor due to their high sugar and sodium content, which can affect blood pressure and glucose levels.

**Method:** This cross-sectional study used aggregate data from IHS 2023. The sample consisted of regional data from 38 provinces in Indonesia. Data analysis was conducted using Pearson and Spearman correlation tests to assess the relationship between carbonated beverage consumption and the prevalence of hypertension and diabetes.

**Result:** Summarize the key findings of the study. The results showed that consuming carbonated beverages  $\geq 1$  time/day had a significant relationship with the prevalence of hypertension ( $r=0.612$ ;  $p=0.001$ ) and diabetes ( $r=0.629$ ;  $p=0.001$ ). Consumption of 1-6 times/week was also associated with hypertension ( $r=0.343$ ;  $p=0.035$ ) and diabetes ( $r=0.362$ ;  $p=0.026$ ). However, consumption  $\leq 3$  Times/month showed only a weak relationship with the prevalence of hypertension and diabetes.

**Conclusion:** High consumption of carbonated beverages is significantly associated with increased prevalence of hypertension and diabetes among individuals aged  $\geq 15$  years in Indonesia. Health policies are needed to reduce carbonated beverage consumption, such as health education and the implementation of taxes on sugary drinks.

**Keywords:** Carbonated drinks, hypertension, diabetes, consumption patterns

### INTRODUCTION

Hypertension is a condition in which a person's blood pressure exceeds the normal limit, with systolic pressure  $\geq 140$  mmHg and diastolic pressure  $\geq 90$  mmHg. This condition is often referred to as 'the silent disease' because many individuals are unaware that they have hypertension until they undergo a blood pressure check at a healthcare facility (Casmuti & Fibriana, 2023). According to the World Health Organization (WHO), around 71% of global deaths are caused by non-communicable diseases, including hypertension, which contributes to approximately 17.9 million deaths annually. It is also known as the 'silent killer' because many people are unaware they have hypertension until serious complications

such as stroke or heart failure occur (Listyana et al., 2022).

According to the World Health Organization (WHO), the global prevalence of hypertension reached 26.4% or approximately 972 million people affected by the disease. This figure increased to 29.2% in 2021. WHO also estimates that each year, 9.4 million people die due to complications related to hypertension. In developed countries, 333 million cases were recorded out of the total 972 million, while the remaining 639 million cases were found in developing countries, including Indonesia. In Indonesia, hypertension ranks as the third leading cause of death after stroke and tuberculosis, contributing to 6.8% of the total mortality (Casmuti & Fibriana, 2023).

Diabetes mellitus is a metabolic disease characterized by elevated blood sugar levels

due to impaired insulin function. This hormone plays a vital role in maintaining the body's homeostasis by lowering blood glucose levels. Diabetes mellitus is closely related to lifestyle, making it important to maintain balance in daily activities such as eating, sleeping, and working. The quantity and type of food, as well as physical activity, must be properly managed and should not be neglected (Astutisari et al., 2022).

The Southeast Asia region, where Indonesia is located, ranks third in terms of diabetes mellitus (DM) prevalence, with a rate of 11.3%. Indonesia itself ranks seventh among the ten countries with the highest number of DM cases worldwide. As the only Southeast Asian country on the list, Indonesia's contribution to the regional DM prevalence is considered significant. According to the World Health Organization (WHO), the number of people with DM in Indonesia is projected to increase significantly, from 8.4 million in 2000 to around 21.3 million by 2030. Similarly, the World Diabetes Association predicts a rise in DM prevalence in Indonesia, from 9.1 million in 2014 to 14.1 million by 2035. This indicates that diabetes mellitus poses a serious public health challenge for Indonesia in the coming years (Resti & Cahyati, 2022).

In Indonesia, diabetes mellitus (DM) ranks as the third leading cause of death, accounting for 6.7%, following stroke (21.1%) and heart disease (12.9%). According to Basic Health Research in 2013, the prevalence of DM in Indonesia was 1.5%, which increased to 2.0% in the 2018 Riskesdas. This reflects a 0.5% increase in DM prevalence over five years. In addition, the prevalence of DM based on blood tests among individuals aged over 15 years also rose, from 6.9% to 8.5% in 2018. This indicates the emergence of approximately 25% of new cases, underscoring that diabetes mellitus is becoming an increasingly serious health issue in Indonesia (Resti & Cahyati, 2022).

Various factors can contribute to increased blood pressure, one of which is dietary patterns, including food and beverage consumption. The intake of carbonated beverages—both calorie-containing and calorie-free—has drawn attention in numerous studies due to its potential impact on blood pressure. Soft drinks often contain sodium, artificial sweeteners, and other additives that may contribute to elevated blood pressure through various mechanisms, including increased fluid retention and alterations in glucose metabolism (Wirawan et al., 2015).

The consumption of carbonated beverages has become a part of modern lifestyle. These drinks are widely consumed due to their sweet and refreshing taste; however, various studies have shown that excessive consumption of carbonated beverages can increase the risk of non-communicable diseases, including hypertension and diabetes mellitus. Carbonated drinks contain high levels of sugar, which can lead to insulin resistance and elevated blood pressure (BKPK, 2018).

Recent data show that the prevalence of prediabetes and diabetes mellitus among younger age groups continues to rise, driven by changes in consumption patterns and decreased physical activity. Considering the serious health impacts of soft drink consumption habits, research on the relationship between the proportion of carbonated beverage consumption and the prevalence of hypertension and diabetes mellitus in Indonesia is essential (Agung & Hansen, 2022), however, there are no research results that explain the relationship between the proportion of carbonated beverage consumption and the prevalence of hypertension and diabetes mellitus using aggregate data in Indonesia.

This study aims to analyze the overview of carbonated beverage consumption, examine the prevalence of hypertension and diabetes mellitus across the seven regions of Indonesia, and assess the relationship between

the proportion of carbonated beverage consumption and the prevalence of hypertension and diabetes among Indonesian residents aged  $\geq 15$  years based on the 2023 IHS data. The results of this study are expected to serve as a foundation for formulating health policies and more effective interventions to prevent metabolic diseases.

## METHODS

This study uses a cross-sectional design with aggregate data from the 2023 IHS. The data analyzed include the proportion of carbonated beverage consumption, as well as the prevalence of diabetes mellitus and hypertension in 38 provinces across Indonesia. This design allows researchers to measure the prevalence of diabetes mellitus and hypertension at a single point in time across provinces, which are grouped into seven regions of Indonesia.

The population in this study includes all Indonesian residents covered in the 2023 Indonesian Health Survey (IHS). The research sample consists of regional data taken from 38 provinces in Indonesia, as presented in the relevant tables, namely Table 11.61 (Proportion of Soft Drink or Carbonated Beverage Consumption Habits among the Population Aged  $>3$  Years by Province), Table 7.10 (Prevalence of Diabetes Mellitus Diagnosed by a Doctor among the Population Aged  $\geq 15$  Years by Province), and Table 7.34 (Prevalence of Hypertension Based on Doctor Diagnosis and Measurement among the Population Aged  $\geq 15$  Years by Province). The data used in this study were obtained from the 2023 Indonesian Health Survey (IHS), conducted from August to October 2023.

The independent variable in this study is the proportion of soft drink or carbonated beverage consumption habits, obtained from Table 11.61. The dependent variables consist of two aspects: the prevalence of Diabetes Mellitus (DM) based on doctor diagnosis

(sourced from Table 7.10) and the prevalence of hypertension based on both doctor diagnosis and measurement results (sourced from Table 7.34). This study uses provinces as the unit of analysis to serve as a control variable, ensuring that the analysis is conducted specifically based on regional distribution. The status of DM and the prevalence of hypertension are calculated using the following formulas: the prevalence of DM based on doctor diagnosis among individuals aged  $\geq 15$  years is defined as the number of individuals aged  $\geq 15$  years who have ever been diagnosed with DM divided by the number of individuals aged  $\geq 15$  years who were interviewed, while the prevalence of hypertension based on doctor diagnosis is defined as the number of individuals aged  $\geq 15$  years who have ever been diagnosed with hypertension by a doctor divided by the number of individuals aged  $\geq 15$  years who were interviewed.

The research instrument used was a questionnaire that included information regarding household members aged  $\geq 15$  years who had been diagnosed with diabetes mellitus and those who had been diagnosed with hypertension. All data collection processes were conducted by trained personnel with a minimum educational background of a three-year diploma in health sciences to ensure data accuracy. Data were collected through direct interviews using a structured questionnaire instrument.

Descriptive analysis in this study will present the distribution of the proportion of carbonated beverage consumption, as well as the prevalence of Diabetes Mellitus (DM) and hypertension in each province. Furthermore, correlation analysis will be conducted using Pearson or Spearman correlation tests to examine the relationship between carbonated beverage consumption and the prevalence of DM and hypertension. The data will be processed and statistically analyzed using SPSS version 27. This survey gathered health-related information. The implementation of the 2023

IHS received ethical approval from the Health Research Ethics Committee under Approval Number HK.01.07/MENKES/156/2023, ensuring that all research procedures adhered to established health research ethics standards.

## RESULTS AND DISCUSSION

Table 1 shows that the highest proportion of carbonated beverage consumption  $\geq 1$  time/day was found in the Maluku region (8.0%), while the lowest was in

the Java and Bali regions (1.7%). The highest proportion of carbonated beverage consumption 1-6 times/week was also observed in the Maluku region (23.5%), and the lowest in the Java and Bali regions (10.2%). Conversely, the highest proportion of carbonated beverage consumption  $\leq 3$  Times/month was found in the Java and Bali regions (88.0%), while the lowest was in the Maluku region (68.4%). Nationally, the average proportion of carbonated beverage consumption  $\geq 1$  time/day was 3.6%, 1-6 times/week was 16.2%, and  $\leq 3$  Times/month was 80.2

**Table 1.** Distribution of Carbonated Beverage Consumption Proportion by Region, IHS 2023

Province	Carbonated Beverage Consumption Habits (%)								
	$\geq 1$ time/day			1-6 times/week			$\leq 3$ times/month		
	Max	Min	$\bar{X} \pm SD$	Max	Min	$\bar{X} \pm SD$	Max	Min	$\bar{X} \pm SD$
Sumatera	3.3	2.0	2.6 $\pm$ 0.4	17.5	11.6	14.4 $\pm$ 2.0	85.8	80.0	83.0 $\pm$ 1.9
Jawa dan Bali	2.6	1.3	1.7 $\pm$ 0.5	17.2	5.4	10.2 $\pm$ 4.1	93.3	81.1	88.0 $\pm$ 4.4
Nusa Tenggara	3.4	2.7	3.0 $\pm$ 0.4	14.7	10.8	12.7 $\pm$ 2.7	85.8	82.7	84.2 $\pm$ 2.1
Kalimantan	3.0	2.4	2.6 $\pm$ 0.2	25.4	11.6	17.4 $\pm$ 5.5	85.5	71.7	79.9 $\pm$ 5.5
Sulawesi	5.2	3.5	4.2 $\pm$ 0.7	23.2	13.9	17.9 $\pm$ 4.0	82.7	72.3	77.8 $\pm$ 4.2
Maluku	10.0	6.1	8.0 $\pm$ 2.7	27.5	19.5	23.5 $\pm$ 5.6	74.4	62.5	68.4 $\pm$ 8.4
Papua	8.9	4.9	6.3 $\pm$ 1.4	28.7	13.9	22.2 $\pm$ 6.7	80.4	64.5	71.4 $\pm$ 6.3
Indonesia	10	1.3	3.6 $\pm$ 2.0	28.7	5.4	16.2 $\pm$ 5.8	93.3	62.5	80.2 $\pm$ 7.2

Table 2 shows that the highest prevalence of hypertension diagnosed by doctors was found in the Java and Bali regions (9.5%), while the lowest was in the Maluku region (4.3%). The highest prevalence of diabetes mellitus diagnosed by doctors also occurred in the Java and Bali regions (2.7%), whereas the lowest was in the Papua region, specifically in Maluku Province (1.0%). The highest prevalence of hypertension based on

measurements was observed in the Kalimantan region (31.8%), while the lowest was in the Maluku region (23.2%). Nationally, the average prevalence of hypertension diagnosed by doctors was 7.2%, the average prevalence of diabetes mellitus diagnosed by doctors was 1.9%, and the average prevalence of hypertension based on measurements was 26.6%.

**Table 2.** Distribution of Hypertension and Diabetes Mellitus by Region, IHS 2023

Region	Diagnosed Hypertension (%)			Diagnosed DM (%)			Measured Hypertension (%)		
	Max	Min	$\bar{X} \pm SD$	Max	Min	$\bar{X} \pm SD$	Max	Min	$\bar{X} \pm SD$
Sumatera	8.8	4.3	6.9 $\pm$ 1.2	2.8	1.3	1.8 $\pm$ 0.4	28.3	21.4	24.2 $\pm$ 2.0
Jawa dan Bali	12.6	6.9	9.5 $\pm$ 2.2	3.9	2.1	2.7 $\pm$ 0.7	32.8	21.7	29.3 $\pm$ 3.9
Nusa Tenggara	6.8	6.3	6.5 $\pm$ 0.3	1.8	1.0	1.4 $\pm$ 0.5	26.4	24.5	25.4 $\pm$ 1.3
Kalimantan	11.1	7.2	8.4 $\pm$ 1.5	3.1	1.7	2.1 $\pm$ 0.5	38.7	28.0	31.8 $\pm$ 4.5
Sulawesi	12.1	5.3	7.8 $\pm$ 2.3	2.7	1.4	2.0 $\pm$ 0.4	29.5	26.5	27.7 $\pm$ 1.1
Maluku	4.4	4.3	4.3 $\pm$ 0.0	1.2	0.9	1.0 $\pm$ 0.2	25.6	20.8	23.2 $\pm$ 3.3
Papua	7.0	2.2	5.0 $\pm$ 1.9	1.8	0.2	1.2 $\pm$ 0.6	27.5	19.4	23.7 $\pm$ 2.9
Indonesia	12.6	2.2	7.2 $\pm$ 2.3	3.9	0.2	1.9 $\pm$ 0.7	38.7	19.4	26.6 $\pm$ 4.0

**Table 3. The Relationship Between the Proportion of Carbonated Beverage Consumption and the Prevalence of Hypertension and Diabetes Mellitus in Individuals Aged  $\geq 15$  Years in Indonesia (IHS 2023)**

Proportion of Carbonated Beverage Consumption	Hypertension Prevalence (Diagnosis)	Diabetes Mellitus Prevalence (Diagnosis)	Hypertension Prevalence (Measurement)
<b>Consumption <math>\geq 1</math> Time/Day</b>			
Beta	0.703	0.228	0.854
Constant	9.823	2.742	29.752
Correlation Coefficient (R)	0.612	0.629	0.426
p-value	0.001	0.001	0.008
<b>Consumption 1–6 times/week</b>			
Beta	0.135	0.045	0.159
Constant	9.474	2.648	29.254
Correlation Coefficient (R)	0.343	0.362	0.232
p-value	0.035	0.026	0.161
<b>Consumption <math>\leq 3</math> times/month</b>			
Beta	0.141	0.047	0.170
Constant	4.042	1.816	13.033
Correlation Coefficient (R)	0.444	0.464	0.307
p-value	0.005	0.003	0.061

Diabetes mellitus (DM) is a metabolic disease characterized by hyperglycemia resulting from abnormalities in insulin action, insulin secretion, or both. Classic symptoms of DM include polyuria, polydipsia, polyphagia, and unexplained weight loss (Damayanti et al., 2023). One of the factors that influence fluctuations in blood pressure is blood glucose levels. Hyperglycemia is one of the risk factors for the development of hypertension (Ira Maulidah Dwi Julianti, 2024).

Based on the analysis results in Table 3, there is a relationship between carbonated drink consumption and the prevalence of hypertension and diabetes mellitus, both medically diagnosed and measured directly. In the group consuming carbonated drinks  $\geq 1$  time per day, there is a significant association with the prevalence of hypertension based on medical diagnosis, indicating that high consumption of carbonated beverages is closely related to an increased risk of hypertension. A significant association is also observed with the prevalence of diabetes mellitus based on diagnosis, suggesting that daily consumption of carbonated drinks may increase the risk of diabetes mellitus. Meanwhile, regarding the prevalence of hypertension based on blood

pressure measurements, a negative but still statistically significant relationship was found.

In the group consuming carbonated drinks 1–6 times per week, the relationship with hypertension based on diagnosis remains significant, although weaker compared to the group that consumes them daily. For diabetes mellitus, the association is still significant, albeit smaller than in the more frequent consumption group. However, for hypertension based on measurement, the relationship found is not significant, indicating that carbonated drink consumption at this frequency is not directly associated with measured blood pressure during the study.

In the group that consumed carbonated drinks  $\leq 3$  Times per month, the relationship with hypertension based on diagnosis showed a significant association, although weaker compared to groups with more frequent consumption. For diabetes mellitus, the results indicate that a significant association still exists, though not as strong as in the daily consumption group. However, for hypertension based on measurement, the relationship found was not statistically significant (p-value > 0.05), meaning that low-frequency consumption of carbonated drinks did not show

a clear impact on measured blood pressure during the study.

Based on the research findings, there is a significant relationship between the consumption of carbonated beverages and the prevalence of hypertension and diabetes mellitus among individuals aged  $\geq 15$  years in Indonesia. The data indicate that individuals who consume carbonated drinks more than once a day have an increased risk for both conditions compared to those who consume them less frequently or not at all. This is evident from the higher regression coefficient (Beta) values in the group with more frequent consumption, as well as the significance ( $p$ -value  $< 0.05$ ), which suggests that the relationship is not due to chance. Daily consumption of carbonated beverages is strongly associated with high blood pressure, based on both blood pressure measurements and medical diagnoses of hypertension. Moreover, this group also shows a significant correlation with the prevalence of diabetes mellitus based on medical diagnosis.

In addition to metabolic factors, the consumption of carbonated beverages also affects the body's electrolyte balance. The phosphoric acid content in these drinks can disrupt the balance of calcium and magnesium, which are involved in the regulation of blood pressure (Liwanto & Santoso, 2021). Several studies have also indicated that high consumption of carbonated beverages is associated with an increased risk of metabolic syndrome, which includes hypertension, insulin resistance, and central obesity (Susanti et al., 2024). Therefore, understanding the relationship between carbonated beverage consumption and the prevalence of hypertension and diabetes mellitus is essential as a foundation for public health interventions (Muna & Rukminiati, 2023).

The link between carbonated beverage consumption and hypertension has also been widely discussed in research. The high sugar content in these drinks can lead to increased

blood pressure due to alterations in glucose metabolism in the body (Ramadhani & Mahmudiono, 2019). In addition, excessive fructose intake from these beverages may trigger endothelial dysfunction, which contributes to the development of hypertension (Liwanto & Santoso, 2021).

Several studies have shown a positive association between soda consumption and increased blood pressure. For example, research indicates that consuming a single serving of soda can significantly raise both systolic and diastolic blood pressure. This effect may be more pronounced in individuals with a history of hypertension or other risk factors such as obesity and diabetes (Wirawan et al., 2015). However, some studies have found no significant association between soda consumption and the incidence of hypertension. A study conducted in Blang Bintang Subdistrict, Aceh Besar Regency, found that the consumption of soft drinks, coffee, salt, junk food, and physical activity had no significant relationship with the incidence of hypertension among the working-age population (Listyana et al., 2022).

Changes in lifestyle and consumption patterns have led to an increase in the intake of high-calorie foods and beverages, including carbonated drinks or soft drinks. Previous studies have shown that soft drink consumption can contribute to various health problems, including obesity, insulin resistance, and an increased risk of metabolic diseases such as type 2 diabetes mellitus (Yulinar et al., 2022). In Indonesia, the habit of consuming carbonated beverages is on the rise, particularly among younger age groups, with a significant frequency of consumption observed among adolescents (Yulinar et al., 2022).

Data from the 2018 Basic Health Research (Riskesdas) show that the prevalence of diabetes mellitus among individuals aged  $\geq 15$  years in Indonesia increased from 1.5% in 2013 to 2% in 2018 (BKPK, 2018). In addition, regular consumption of sugar-sweetened

beverages is significantly associated with increased blood glucose levels and a higher risk of insulin resistance (Astuti, 2021).

Type 2 diabetes mellitus is one of the major health problems with a continuously increasing prevalence worldwide, including in Indonesia (Agung & Hansen, 2022). High blood glucose levels, the primary indicator of diabetes, are often associated with excessive sugar consumption, including from carbonated beverages (Anjangsari & Isnawati, 2020). A study found that high soft drink consumption can lead to insulin resistance, which in turn increases the risk of diabetes (Aringaneng et al., 2020). Moreover, obesity—a major risk factor for diabetes—is often rooted in the habit of consuming high-sugar foods and beverages (Asriati, 2023). The results of this study have important implications for public health policy in Indonesia. There is a need for more intensive education and health campaigns to raise public awareness about the dangers of excessive consumption of carbonated beverages. The government and health institutions can play a role in limiting the promotion and distribution of carbonated drinks, especially among younger age groups who are more susceptible to advertising influences. In addition, fiscal policies such as the implementation of a tax on sweetened beverages could be an effective strategy to reduce consumption. Studies in various countries have shown that taxing sugary drinks can decrease consumption and ultimately reduce the incidence of obesity and metabolic diseases. Beyond restrictive policies, efforts are also needed to encourage the public to adopt healthier consumption patterns, such as increasing the intake of plain water and natural beverages without added sugar.

However, this study also has several limitations that should be considered when interpreting the results. One of the main limitations is the observational nature of the study, which means that the relationships found cannot be directly interpreted as causal. Although statistical analysis showed a

significant correlation between carbonated beverage consumption and hypertension and diabetes mellitus, other factors such as overall dietary patterns, physical activity, and genetic predispositions may also have influenced the outcomes. Furthermore, since the data were obtained through surveys and blood pressure measurements as well as medical diagnoses, there is a possibility of reporting bias in respondents' food and beverage consumption, which could affect the validity of the study's findings. Therefore, further research with a stronger design, such as longitudinal studies or clinical trials, is needed to confirm a causal relationship between carbonated beverage consumption and the risk of hypertension and diabetes mellitus.

Overall, this study provides strong evidence that excessive consumption of carbonated beverages can increase the risk of hypertension and diabetes mellitus among individuals aged  $\geq 15$  years in Indonesia. These findings highlight the importance of public health interventions to reduce the consumption of such beverages and promote healthier lifestyles. With proper education, regulation, and health policies, it is expected that a more health-conscious society can be formed, leading to a reduction in the incidence of non-communicable diseases related to excessive sugar intake.

This differs from longitudinal studies such as the one conducted by Agung & Hansen (2022) which used a cohort approach to observe the long-term effects of junk food and sugary drink consumption on type 2 diabetes mellitus. In addition, this study did not examine the relationship between carbonated beverage consumption and the prevalence of stunting. Previous research has shown that consuming carbonated beverages can negatively impact children's growth, as the high sugar content may displace essential nutrient intake. A study by (Asriati, 2023) found that the consumption of high-sugar foods and beverages is associated with an increased risk of prediabetes among



adolescents, which may also affect their growth and development.

Previous studies have shown that individuals who consume carbonated beverages more frequently tend to have a more active lifestyle or a more controlled diet compared to those who consume them less frequently (Yulinar et al., 2022). A more active lifestyle may offset the negative effects of high sugar intake found in carbonated beverages, thus not directly increasing the risk of hypertension and diabetes mellitus (Agung & Hansen, 2022).

Carbonated beverages come in various types, ranging from high-sugar versions to low-calorie options (diet soda). Several studies have found that the consumption of low-calorie carbonated beverages is not directly associated with an increased risk of diabetes but rather influenced by other factors such as total daily caloric intake (Anjangsari & Isnawati, 2020). If respondents who frequently consume carbonated drinks tend to choose low-calorie or unsweetened variants, the negative impact on blood pressure and blood glucose levels may be smaller compared to those who consume sweetened beverages in smaller amounts but more sporadically.

Previous studies have shown that individuals who consume large amounts of carbonated beverages tend to be more health-conscious and may adopt a more balanced diet to compensate for their higher sugar intake (Resti & Cahyati, 2022). In other words, they may pay more attention to fiber, protein, and healthy fat intake, which can help regulate blood sugar and blood pressure levels. Individuals who rarely consume carbonated beverages may come from lower socioeconomic groups, who also have limited access to healthy foods, physical activity, and adequate healthcare services (Casmuti & Fibriana, 2023). Therefore, the higher prevalence of hypertension and diabetes in this group may be more related to other factors beyond carbonated beverage consumption itself.

Low consumption of carbonated beverages, if not accompanied by a healthy diet and active lifestyle, can still increase the risk of metabolic diseases. Several studies have shown that factors such as consumption of ultra-processed foods, high salt intake, and sedentary behavior have a greater impact on hypertension and diabetes than sugary drink consumption alone (Aringaneng et al., 2020). For policymakers in the health sector, this study can serve as a consideration in formulating evidence-based policies. For instance, although carbonated beverages are often linked to health risks, these findings suggest that the relationship is not always linear and may be influenced by other factors such as diet and physical activity. Therefore, policies that focus solely on restricting carbonated beverages may be less effective without a more holistic approach, such as promoting balanced diets and active lifestyles.

However, this study also has several limitations that should be considered. The cross-sectional research design does not allow for causal inferences, meaning that the relationship between carbonated beverage consumption and the prevalence of hypertension and diabetes cannot be confirmed as causal. Confounding factors such as overall dietary patterns, levels of physical activity, and genetic predispositions that may influence the results were not fully controlled. In addition, this study relied solely on secondary data from IHS 2023, which presents limitations in terms of the variables that could be analyzed. There was no information regarding the specific types of carbonated beverages consumed (e.g., low-sugar or calorie-free drinks), making it difficult to determine whether the observed effects were due to added sugars or other components within the beverages. The study did not specifically differentiate the types of carbonated beverages consumed, such as those with high sugar content, artificial sweeteners, or low-calorie versions (diet soda). Further research is recommended to include these variables to



evaluate whether the effects differ depending on the type of beverage. This is important, as previous studies have shown that artificial sweeteners in diet soda may affect glucose metabolism and increase the risk of diabetes.

## CONCLUSION

This study found a surprising inverse relationship between daily carbonated beverage consumption ( $\geq 1$  time/day) and the prevalence of hypertension and diabetes in Indonesia, while infrequent consumption ( $\leq 3$  times/month) showed a positive correlation. These findings differ from prior research linking sugary drinks to higher metabolic disease risk, suggesting that the relationship may be influenced by confounding factors such as lifestyle, diet, or beverage type. However, due to the cross-sectional design and limitations in the secondary data, including a lack of detail on beverage types and lifestyle variables, the results should be interpreted cautiously. Future research should adopt longitudinal or experimental designs to establish causality and better control for confounders like physical activity, dietary habits, and socioeconomic status. Objective health measurements, such as blood pressure and glucose levels, are also recommended to improve data reliability. From a public health perspective, interventions should focus on comprehensive nutrition and lifestyle education rather than solely restricting carbonated drink intake. Policies like sugar-sweetened beverage taxes may be effective if paired with impact assessments and public awareness campaigns, particularly targeting youth to prevent early adoption of unhealthy dietary habits.

## ACKNOWLEDGMENT

The authors would like to appreciation to the organizing team of the 2023 Indonesia Health Survey (IHS) for providing the data that

served as the primary basis of this study. In addition, sincere thanks are given to fellow academics and technical staff who contributed to the data analysis and the preparation of this article, even though they are not listed as main authors. We hope that the findings of this study will be useful in advancing public health science and serve as a reference for the formulation of evidence-based health policies.

## CONFLICT OF INTEREST

All authors declare that there is no conflict of interest influencing the research process, data analysis, or the preparation of this manuscript.

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