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Meta-Analysis
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Meta Analysis: Determinants of Dental Caries in Children

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ABSTRACT

Background: Dental caries in children occurred when one or more teeth that are decayed (lesions), missing (due to caries), or filled tooth surfaces in primary teeth experienced by children. The aim of this study is to analyze the influence of dental caries factors in children based on the results of several previous studies using meta-analysis.

Subjects and Method: This study is a systematic review and meta-analysis based on data obtained through various databases including Google Scholar and PubMed. This study used articles that were published from 2016 to 2022. The article search was carried out by considering the eligibility criteria defined using the PICO model. Population: children. Intervention of chocolate, candy, biscuits, soft drinks. Comparison: free sugar intake. Outcome: dental caries. This article was collected within 1 month with the following keywords used: "Chocolate" AND "Candy" AND "Biscuit" AND "Soft Drink" AND "Children" OR "Dental Caries" AND "Cross Sectional Study". The articles included in this research are full text articles with a cross-sectional study design. This article was collected by using a PRISMA flow diagram and analyzed by using the Review Manager 5.3 application.

Results: Meta-analysis of 8 cross-sectional studies from Egypt, Romania, Iran, Australia, Poland, Vietnam, Saudi Arabia, and China. Total sample was 19,514 children. The results of the meta-analysis showed that dental caries in children will increase significantly by consuming chocolate (aOR= 0.84; 95% CI= 0.57 to 1.26; p= 0.410), candy (aOR= 1.34; 95% CI= 0.37 to 4.88; p= 0.660), biscuit (aOR= 0.97; 95% CI= 0.67 to 1.42; p= 0,890), and soft drink (aOR= 1.42; 95% CI= 1.25 to 1.61; p<0.001).

Conclusion: Dental caries in children is increased by consuming chocolate, candy, biscuits and soft drinks.

Keywords: dental caries, children, chocolate, candy, biscuit, soft drink

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BACKGROUND

Oral health is one of the determinants of quality of life. Dental caries is the most common oral health problem globally. The Global Burden of Disease Study in 2019 showed that around 520 million children worldwide experienced primary tooth caries (Misrohmasari and Prihatiningrum, 2022).

Oral and dental diseases also cause restrictions in the school environment, workplace and home and as a result, it can lead to loss of school and work hours. In recent years, many studies have been conducted regarding the impact of oral health on quality of life, especially in children due to dental caries. Dental caries and dental injuries during childhood may have a negative impact on children's and parents' quality of life related to oral health (Pakhesal et al., 2021).

The American Academy of Dentistry defines dental caries in children as the presence of 1 or more teeth that are decayed (non-cavity or cavity lesions), missing (due to caries), or filled tooth surfaces in the primary teeth of children. Overall, 50% of children have one or more primary teeth that will be damaged by the end of their toddler years, however, the importance of these teeth should not be overlooked. Because healthy teeth in childhood play an important role in tooth eruption. Healthy permanent teeth, healthy nutrition, and a person's aesthetic appearance. Factors such as malnutrition, genetic predisposition, poor health performance, certain eating habits, the presence of organisms that predispose to tooth decay such as streptococci, and deficiencies of fluoride and vitamin D, excessive consumption of sugar and prolonged bottle feeding, and other factors Other factors such as age, gender and where the child lives are effective in causing tooth decay (Kazeminia et al., 2020). Children cannot be kept away from various foods that contain sugar, therefore the aim of this study is to analyze the factors that influence dental caries in children.

SUBJECTS AND METHOD

1. Study Design

The articles in this meta-analysis were collected using PRISMA flow diagrams. This study is based on data obtained through various databases including Google Scholar and PubMed. This article was collected within 1 month with the following keywords used: "Chocolate" AND "Candy" AND "Biscuit" AND "Soft Drink" AND "Children" OR "Dental Caries" AND "Cross Sectional Study".

2. Inclusion criteria

The inclusion criteria for articles included in this study were full text articles with cross-sectional research methods. The selected articles were articles that present the final results of the adjusted odds ratio (aOR) and articles that present multivariable data analysis. These articles discuss the determinants of caries in children's teeth.

3. Exclusion criteria

Exclusion criteria for articles were case-control, survey, and cohort studies, articles published before 2015, articles that presented bivariate analysis and reported final results only showing OR, percent, and mean difference.

4. Definition of Operational Variables

Chololate is the outcome of processed cocoa beans which are processed into sweet snacks or drinks and are much loved by children. Data is measured by questionnaire. The measurement scale is categorical.

Candy is a high-calorie food that uses the basic ingredients of sugar, water and fructose syrup. Data is measured by questionnaire. The measurement scale is categorical.

Biscuit is a snack made from flour and other ingredients baked into dry cakes. Data is measured by questionnaire. The measurement scale is categorical.

Soft drink is a carbonated drink that is added with additional sweeteners such as sugar. Data is measured by questionnaire.

The measurement scale is categorical.

5. Study Instruments

This study used PRISMA flow diagrams and assessed the quality of research articles using Critical Appraisal for Cross Sectional from the Master of Health Sciences, Postgraduate School, Universitas Sebelas Maret, Surakarta.

6. Data analysis

The data analysis process in this study was carried out using the Review Manager 5.3 application to determine the magnitude of influence and heterogeneity between chocolate, candy, biscuits and soft drinks. The results of processing data are presented in the form of forest plots and funnel plots.

RESULTS

The article search process is carried out by searching through databases in accordance with the PRISMA flow diagram and can be seen in Figure 1. Figure 2 shows a general overview of the research areas used in this meta-analysis which are spread across 3 continents, namely Australia, Asia, and Africa. Based on an assessment in terms of research quality using the critical appraisal checklist for cross-sectional, in the majority of research subjects, there were 8 articles at the end of the review process that met the quantitative requirements. All articles used cross-sectional studies, which fulfilled the requirements for assessing research quality. The following is a table of learning quality assessment results.

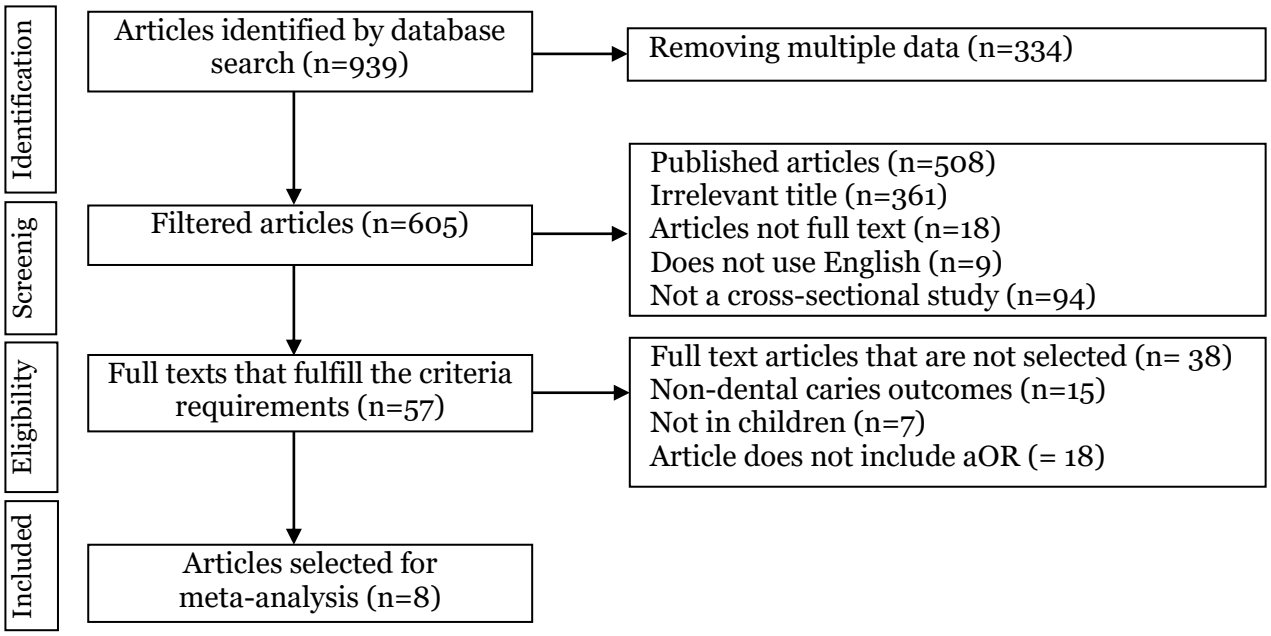

Figure 1. PRISMA Flow Diagram

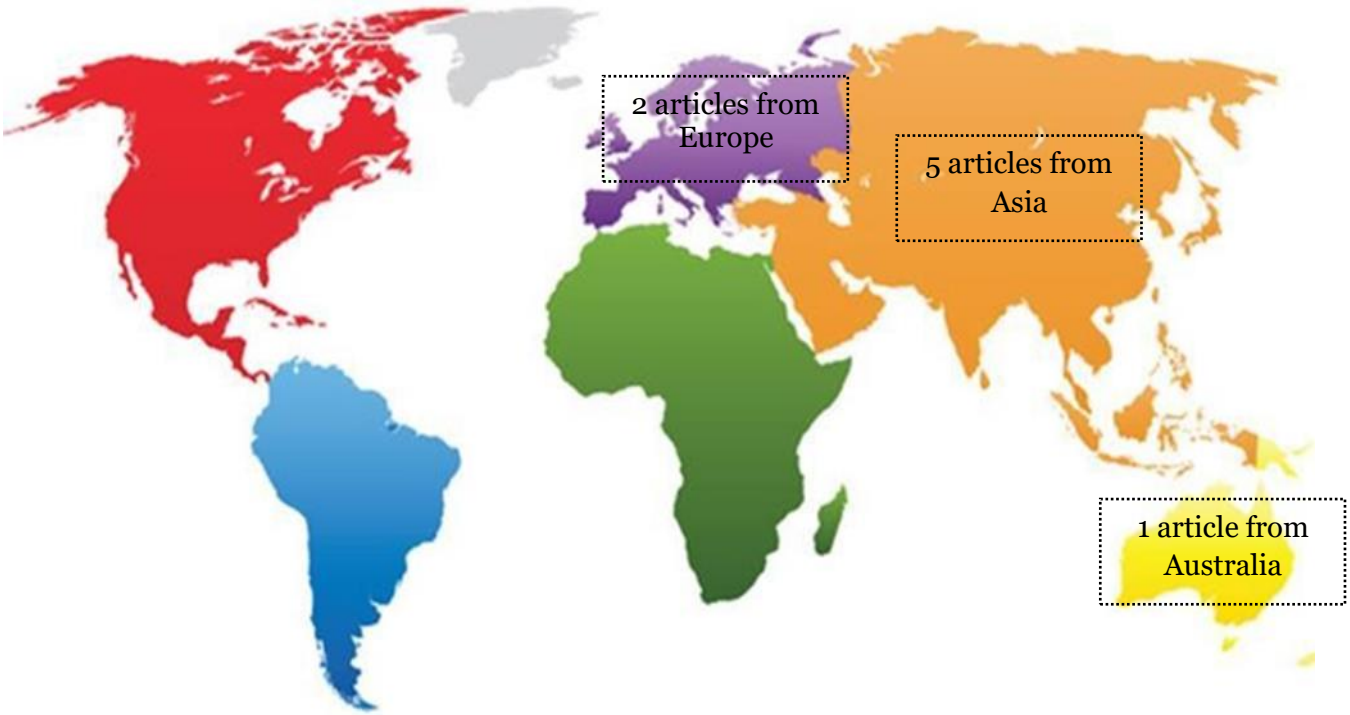

Figure 2. Research area of cross-sectional study of dental caries in children determinants

Table 1. Critical appraisal of cross-sectional study of the dental caries in children determinants

Author (Year)	Appraisal Criteria													Total
	1a	1b	1c	1d	2a	2b	3a	3b	4	5	6a	6b	7	
Almasi et al. (2016)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Arora et al. (2016)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Hung et al. (2021)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Karminska et al. (2022)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Mahmoud et al. (2022)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Rosianu et al. (2021)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Yang et al. (2021)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Alzahrani et al. (2022)	2	2	2	2	2	2	2	2	2	2	2	2	2	26

Description of the question criteria:

1. Formulation of study questions in the acronym of PICO

a. Is the population in the primary study the same as the population in the PICO meta-analysis?

b. Is the operational definition of intervention, namely the exposed status in the primary study, the same as the definition intended in the meta-analysis?

c. Is the comparison, namely the unexposed status used by the primary study, the same as the definition intended in the meta-analysis?

d. Are the outcome variables examined in the primary studies the same as the definitions intended in the meta-analysis?

2. Methods for selecting study subjects

a. In analytical cross-sectional studies, do researchers choose samples from the population randomly?

b. As an alternative, if in a cross-sectional

analytical study the sample is not selected randomly, does the researcher select the sample based on outcome status or based on intervention status?

3. Methods for measuring exposure (intervention) and outcome variables (outcome)

a. Are the exposure and outcome variables measured with the same instruments (measuring tools) in all primary studies?
b. If the variable is measured on a categorical scale, are the cutoffs or categories used the same across primary studies?

4. Design-related bias

If the sample was not selected randomly, has the researcher made efforts to prevent bias in selecting research subjects? For example, selecting subjects based on outcome status is not affected by exposure status (intervention), or selecting subjects based on exposure status (intervention) is not affected by outcome status.

5. Methods for controlling confusion (confounding)

Have primary study researchers made efforts to control the influence of confounding? (For example, performing a multivariate analysis to control for the influence of a number of confounding factors).

6. Statistical analysis methods

a. Does the researcher analyze the data in this primary study with a multivariate analysis model? (e.g., multiple linear regression analysis, multiple logistic regression analysis)
b. Does the primary study report effect sizes or associations resulting from multivariate analysis? (e.g., adjusted OR, adjusted regression coefficient)

7. Conflict of interest

Is there no possibility of a conflict of interest with the research sponsor, which could cause bias in concluding the study results?

Rating guide:

1. Total number of questions= 13.

Answer "Yes" to each question gives a score of "2". The answer "Uncertain" gives a score of "1". The answer "No" gives a score of "0".

2. Maximum total score= 13 questions x 2= 26.
3. Minimum total score = 13 questions x 0= 0. So the range of total scores for a primary study is between 0 and 26.
4. If the total score of a primary study is ≥22, then the study can be included in the meta-analysis. If the total score of a primary study was <22, then the study was excluded from the meta-analysis.

1. Chocolate

Table 2. Description of primary study on the effect of chocolate on dental caries in children with a cross-sectional design (n=2736)

Author (Year)	Country	Sample	P (Population)	I (Intervention)	C (Comparison)	O (Result)
Mahmoud et al. (2022)	Egypt	369	Children aged 5-10 years old	Chocolate	No sugar intake	Dental caries
Rosianu et al (2022)	Romania	814	National school children	Chocolate	No sugar intake	Dental caries
Almasi et al (2016)	Iran	689	Children aged 10-12 years old	Chocolate	No sugar intake	Dental caries
Arora et al (2017)	Australia	495	Children aged 5-10 years old	Chocolate	No sugar intake	Dental caries
Mahmoud et al (2022)	Egypt	369	Children aged 5-10 years old	Chocolate	No sugar intake	Dental caries

Table 3. Adjusted Odd Ratio data on the effect of chocolate on dental caries in children with a cross-sectional design (n= 2,736)

Author (Tahun)	aOR	95% CI	
		Lower bound	Upper bound
Mahmoud et al (2022)	0.99	0.75	1.23
Rosianu et al (2022)	0.12	0.01	0.25
Almasi et al (2016)	1.32	0.74	2.30
Arora et al (2017)	1.52	1.19	1.93
Mahmoud et al (2022)	0.92	0.90	1.71

a. Forest Plot

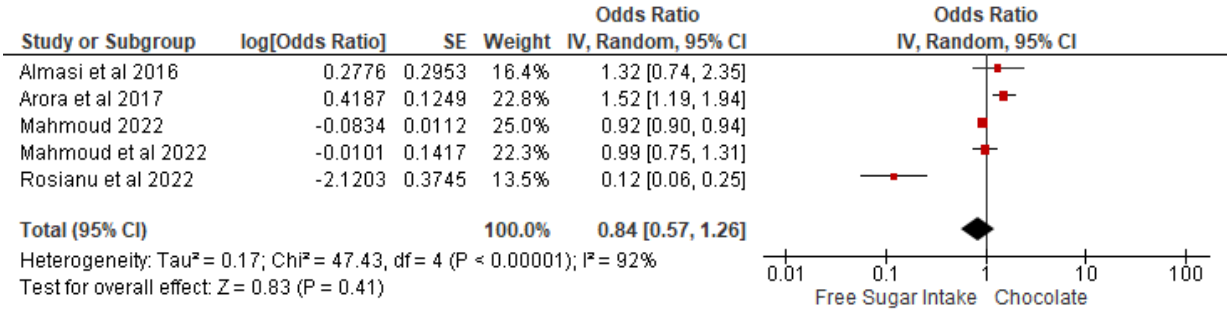

Figure 3. Forest plot of the effect of chocolate on dental caries among children

The forest plot results show that chocolate increased dental caries in children by 0.84 times higher compared to foods that do not contain sugar, and this result was not statistically significant (aOR= 0.84; 95% CI= 0.57 to 1.26; p= 0.41). The forest plot also showed high heterogeneity of effect estimates between primary studies I2 = 92%; p<0.001, which mean that the effect estimates between primary studies in this meta-analysis vary. Thus, the calculation of the average estimated effect was carried out using a random effect model approach.

b. Funnel Plot

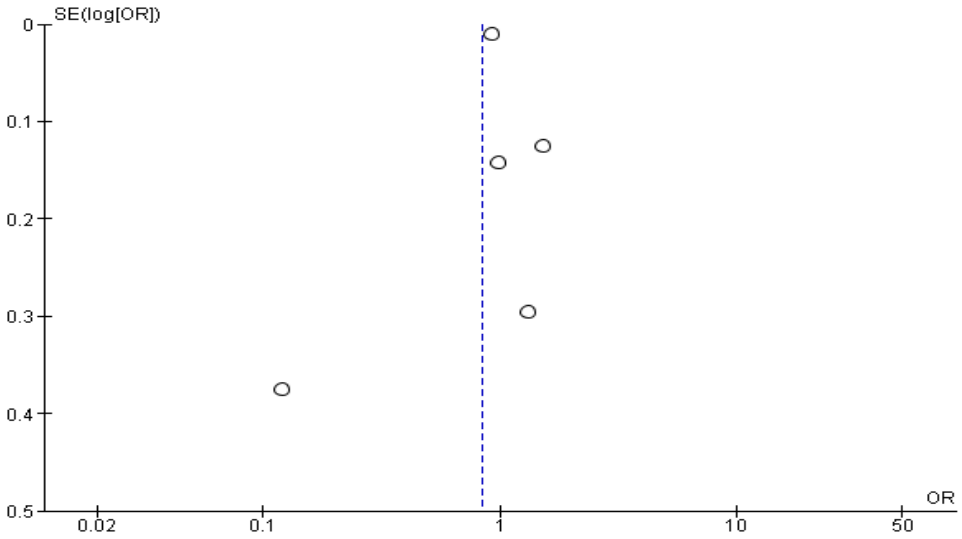

Figure 4. Funnel plot of the effect of chocolate on dental caries among children

The funnel plot results show that the distribution of effect estimates was uneven. The distribution of effect estimates shows that the distribution of effect estimates tend to lie more to the right of the vertical line of average effect estimates than to the left. Thus, this funnel plot image showed the existence of publication bias. Because the distribution of the estimated effect was located to the right of the average vertical line, which was opposite to the location of the average estimated effect (diamond) which was located on the left, publication bias tend to reduce the true effect (underestimate).

2. Candy

Table 4. Description of primary study on the effect of candy on dental caries in children with a cross-sectional design (n=5697)

Author (Year)	Country	Sample	P (Population)	I (Intervention)	C (Comparison)	O (Result)
Mahmoud et al. (2022)	Egypt	369	Children aged 5-10 years old	Candy	No sugar intake	Dental caries
Karminska et al. (2022)	Poland	2018	Children aged 12 years old	Candy	No sugar intake	Dental caries
Rosianu et al (2021)	Romania	814	National school children	Candy	No sugar intake	Dental caries
Houng et al (2021)	Vietnam	234	Children aged 36-71 months old	Candy	No sugar intake	Dental caries
Alzahrani et al. (2021)	Saudi Arabia	2262	Children aged 12-15 years	Candy	No sugar intake	Dental caries

Table 5. Adjusted Odd Ratio data on the effect of candy on dental caries in children with a cross-sectional design (n=5,697)

Author (Year)	aOR	95% CI	
		Lower bound	Upper bound
Mahmoud et al (2022)	0.81	0.61	1.07
Karminska et al (2022)	1.04	0.55	1.96
Rosianu et al (2021)	0.12	0.01	0.23
Houng et al (2021)	12.20	9.98	15.66
Alzahrani et al (2021)	1.08	0.87	1.33

a. Forest Plot

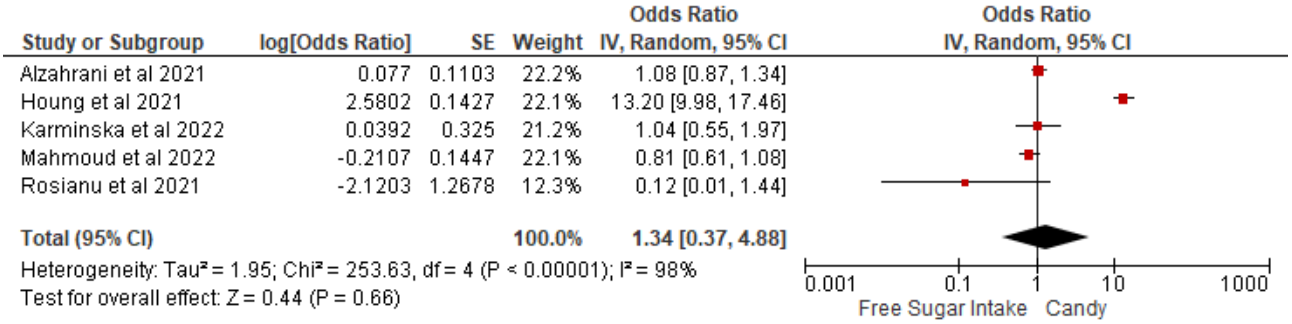

Figure 5. Forest plot of the effect of candy on dental caries among children

The forest plot results show that candy increased dental caries in children by 1.34 times higher compared to foods that do not contain sugar, and this result was not statistically significant (aOR= 1.34; 95% CI= 0.37 to 4.88; p= 0.66). The forest plot also showed high heterogeneity of effect estimates between primary studies I^2= 98%; p<0.001, which mean that the effect estimates between primary studies in this meta-analysis vary. Thus, the calculation of the average estimated effect was carried out using a random effect model approach.

b. Funnel Plot

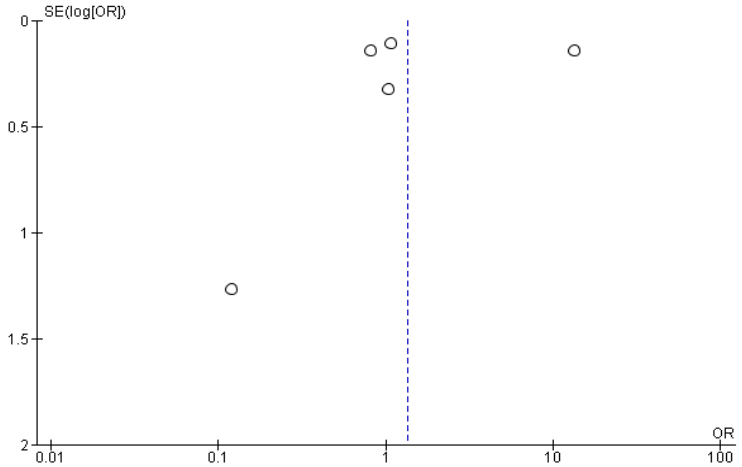

Figure 6. Funnel plot of the effect of candy on dental caries among children

The funnel plot results showed that the distribution of effect estimates was uneven. The distribution of effect estimates showed that the distribution of effect estimates tend to lie more to the left of the vertical line of average effect estimates than to the right. Thus, this funnel plot image showed the existence of publication bias. Because the distribution of the estimated effect was located to the left of the average vertical line, which was opposite to the location of the average estimated effect (diamond) which was located to the right, publication bias tend to reduce the true effect (underestimate).

3. Biscuit

Table 6. Description of primary study on the effect of biscuits on dental caries in children with a cross-sectional design (n=3,992)

Author (Year)	Country	Sample	P (Population)	I (Intervention)	C (Comparison)	O (Result)
Mahmoud et al (2022)	Egypt	369	Children aged 5-10 years old	Biscuit	No sugar intake	Dental Caries
Rosianu et al (2021)	Romania	814	National school children	Biscuit	No sugar intake	Dental Caries
Houng et al (2021)	Vietnam	234	Children aged 36-71 months	Biscuit	No sugar intake	Dental Caries
Almasi et al (2016)	Iran	689	Children aged 10-12 years old	Biscuit	No sugar intake	Dental Caries
Yang et al (2021)	China	1517	Children aged 12-15 years old	Biscuit	No sugar intake	Dental Caries
Mahmoud et al (2022)	Egypt	369	Children aged 5-10 years old	Biscuit	No sugar intake	Dental Caries

Table 7. Adjusted Odd Ratio data on the effect of biscuits on dental caries in children with a cross-sectional design (n=3,992)

Author (Year)	aOR	95% CI	
		Lower bound	Upper bound
Mahmoud et al. (2022)	1.53	1.08	2.17
Rosianu et al. (2021)	0.03	0.07	0.13
Houng et al. (2021)	0.40	0.11	0.81
Almasi et al. (2016)	1.56	1.13	1.98
Yang et al. (2021)	1.01	0.99	1.02
Mahmoud et al. (2022)	1.14	0.83	1.55

a. Forest Plot

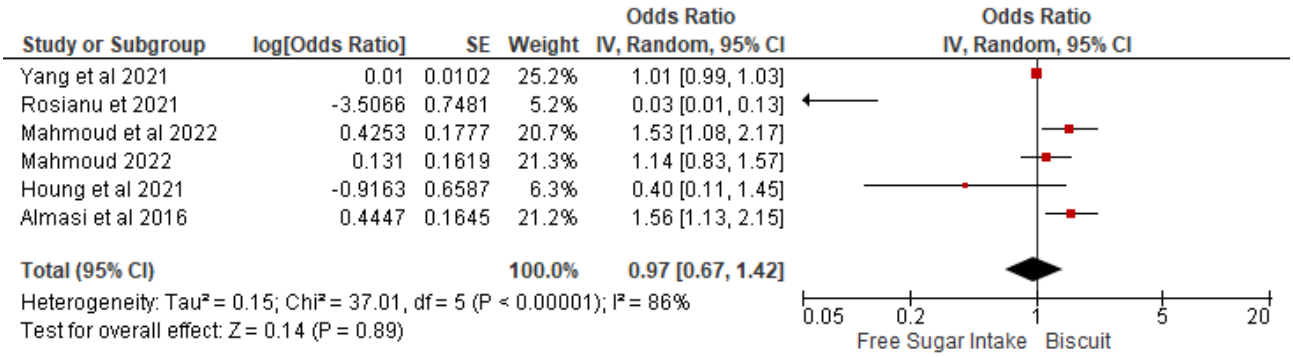

Figure 7. Forest plot of the effect of biscuits on dental caries among children

The forest plot results showed that biscuits increase dental caries in children by 0.97 times higher compared to foods that do not contain sugar, and this result was not statistically significant (aOR= 0.97; 95% CI= 0.67 to 1.42; p= 0.89). The forest plot also showed high heterogeneity of effect estimates between primary studies I^2= 86%; p<0.001, which mean that the effect estimates between primary studies in this meta-analysis vary. Thus, the calculation of the average estimated effect was carried out using a random effect model approach.

a. Funnel Plot

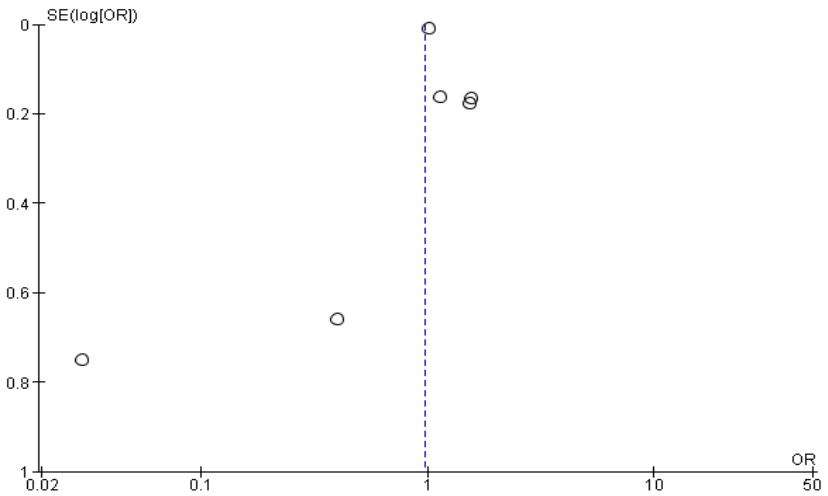

Figure 8. Funnel plot of the effect of biscuits on dental caries in children

The funnel plot results show that the distribution of effect estimates was uneven. The distribution of effect estimates showed that the distribution of effect estimates tend to lie more to the right of the vertical line of average effect estimates than to the left. Thus, this funnel plot image showed the existence of publication bias. Because the distribution of the estimated effect was located to the right of the average vertical line, which was opposite to the location of the average estimated effect (diamond) which was located on the left, publication bias tend to reduce the true effect (underestimate).

4. Soft Drink

Table 8. Description of the primary study on the effect of soft drinks on dental caries in children with a cross-sectional design (n=7089)

Author (Year)	Country	Sample	P (Population)	I (Intervention)	C (Comparison)	O (Result)
Karminska et al (2022)	Poland	2018	Children aged 12 years old	Soft drink	No sugar intake	Dental Caries
Houng et al (2021)	Vietnam	234	Children aged 36-71 months old	Soft drink	No sugar intake	Dental Caries
Alzahrani et al (2021)	Saudi Arabia	2262	Children aged 12-15 years old	Soft drink	No sugar intake	Dental Caries
Mahmoud et al (2022)	Egypt	369	Children aged 5-10 years old	Soft drink	No sugar intake	Dental Caries
Almasi et al (2016)	Iran	689	Children aged 10-12 years old	Soft drink	No sugar intake	Dental Caries
Yang et al (2021)	China	1517	Children aged 12-15 years old	Soft drink	No sugar intake	Dental Caries

Table 9. Adjusted Odd Ratio data on the effect of soft drinks on dental caries in children with a cross-sectional design (n=7,089)

Author (Year)	aOR	95% CI	
		Lower bound	Upper bound
Mahmoud et al (2022)	1.53	1.08	2.17
Rosianu et al (2021)	0.03	0.07	0.13
Houng et al (2021)	0.40	0.11	0.81
Almasi et al (2016)	1.56	1.13	1.98
Yang et al (2021)	1.01	0.99	1.02
Mahmoud et al (2022)	1.14	0.83	1.55

a. Forest Plot

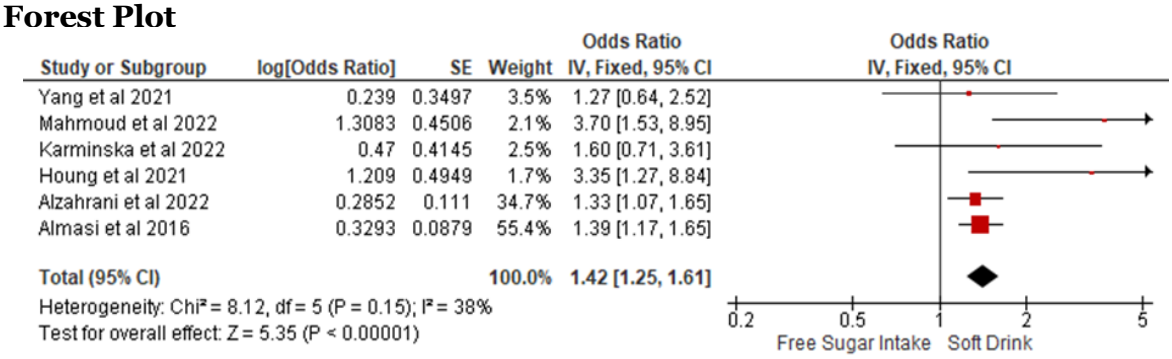

Figure 9. Forest plot of the effect of soft drink on dental caries among children

The forest plot results showed that soft drinks increase dental caries in children by 1.42 times higher compared to foods that do not contain sugar, and this result was statistically significant (aOR= 1.42; 95% CI= 1.25 to 1.61; p<0.001). The forest plot also showed low heterogeneity of effect estimates between primary studies I2 = 38%; p= 0.15, which mean that the effect estimate between primary studies in this meta-analysis does not vary. Thus, the calculation of the average estimated effect was carried out using a fixed effect model approach.

b. Funnel Plot

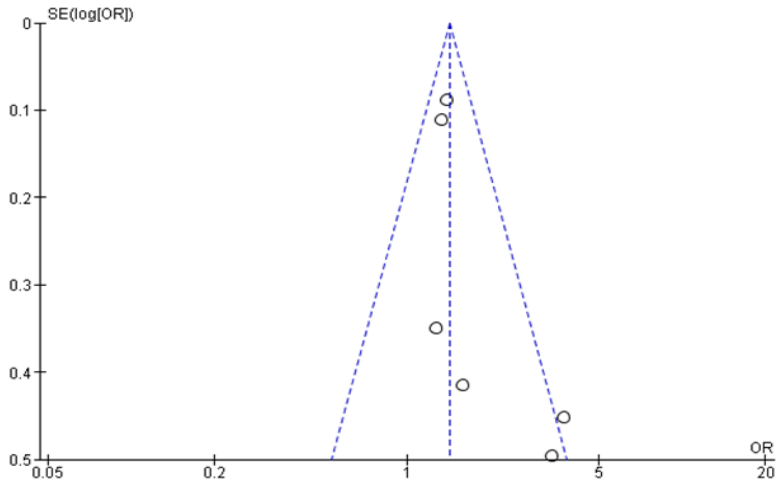

Figure 10. Funnel plot of the effect of soft drink on dental caries in children

The funnel plot results showed that the distribution of effect estimates was uneven. The distribution of effect estimates showed that the distribution of effect estimates tend to lie more to the right of the vertical line of average effect estimates than to the left. Thus, this funnel plot image shows the existence of publication bias. Because the distribution of the estimated effect was located to the right of the average vertical line in the same direction as the diamond in the forest plot, publication bias tend to exaggerate the true effect (over-estimate).

DISCUSSION

This meta-analysis study analyzed the factors that influence dental caries in children, which obtained from 8 articles from 2 data bases. This study uses aOR statistics from multivariate analysis.

1. The effect of chocolate on dental caries in children

The results showed that chocolate increased dental caries in children by 0.84 times higher compared to foods that did not contain sugar, and this result was not statistically significant (aOR= 0.84; 95% CI= 0.57 to 1.26; p= 0.41). The results of this study are in line with Que et al., (2021) which states that 52.01% of dental caries is caused by chocolate. Chocolate contains sugar which provides energy and nutrients for the growth of bacteria, which is the most important factor causing caries. Frequent sugar consumption can lead to a long-term acidic oral environment and demineral-ization of enamel, leading to caries.

High consumption of sugar, such as in chocolate, is one of the main risk factors for caries and is the main factor that needs to be considered in the prevention, control

and treatment of caries. Sugar produces a substrate for the growth of cariogenic bacteria, which produce acid and cause demineralization of tooth enamel (Lendrawati et al., 2019).

2. The effect of candy on dental caries in children

The results showed that candy increased dental caries in children by 1.34 times higher compared to foods that did not contain sugar, and this result was not statistically significant (aOR= 1.34; 95% CI= 0.37 to 4.88; p= 0.66). The results of research from Kaewkamnerdpong and Krisdapong (2018) also showed insignificant results on the effect of candy on dental caries in children. These findings reveal the confounding impact of other school environments on the relationship between environmental variables and sweet food consumption behavior and caries.

Several studies also reported insignificant results between candy consumption and dental caries. However, consuming sweets before bed increases the risk of caries, which is caused by reduced saliva flow and low plaque pH (Mahmobi et al., 2021)

3. The effect of biscuit on dental caries in children

The results showed that biscuits increased dental caries in children by 0.97 times higher compared to foods that did not contain sugar, and this result was not statistically significant (aOR= 0.97; 95% CI= 0.67 to 1.42; p= 0.89). The results of a systematic review research conducted by Hancock et al. (2020) also gave insignificant results. This is because biscuits are classified as foods that use starch and little sugar which have a lower risk of caries compared to other foods that contain a lot of sugar.

4. The effect of soft drink on dental caries in children

The results showed that soft drinks increased dental caries in children by 1.42 times higher compared to foods that did not contain sugar, and this result was statistically significant (aOR= 1.42; 95% CI= 1.25 to 1.61; p<0.001). These results are in line with research by Alhabdan et al. (2018) that consuming soft drinks can increase dental caries by 5.30 times higher compared to foods that do not contain sugar (aOR=5.30; CI95%= 1.50 to 18.0). The acid content of soft drinks is known to lower oral pH and increase the cariogenic potential of teeth.

Children who consume soft drinks may also consume foods containing sugar at the same time, this causes poor eating patterns (Burt and Sowers, 2014). High sugar content is associated with dental caries. Putrefaction is caused by acids produced primarily from the interaction of certain bacteria with these sugars. Although bacteria produce acids that are thought to cause caries, the bacteria themselves do not produce enough acid to demineralize tooth enamel (Gomez et al., 2016).

AUTHORS CONTRIBUTION

Attila Yulaicha Advendila Siregar is the main researcher who selected the topic, searched for and collected articles, analyzed the data, and wrote the manuscript. Rosalia Indri Dewanti helped to select topics, wrote and analyzed the data. Qumara Wilda Khulwani helped with writing, analyzing data and finding topics. Bhisma Murti and Rizki Aqsyari D helped in data analysis and document review.

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CONFLICT OF INTEREST

There is no conflict of interest in this study.

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