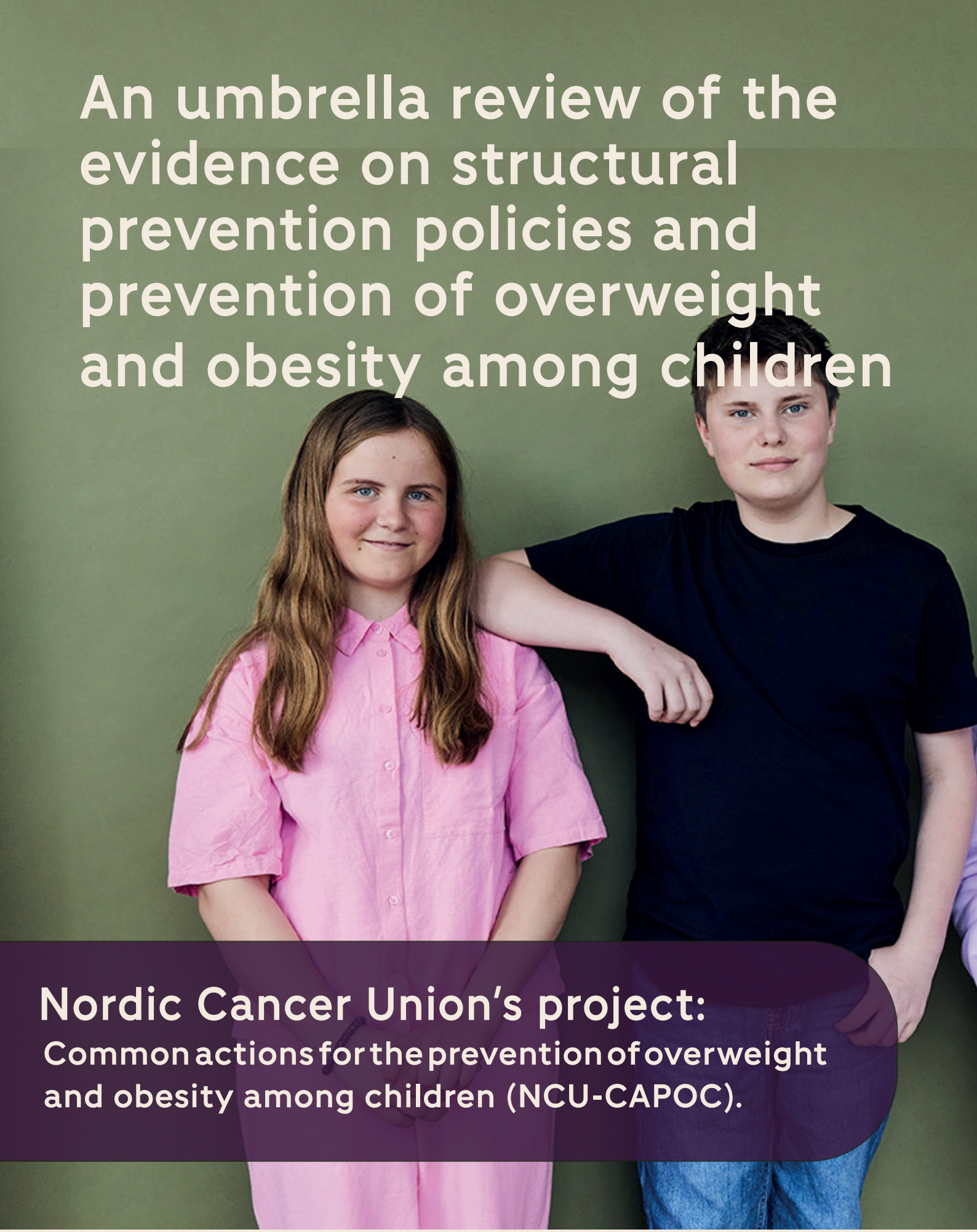
An umbrella review of the evidence on structural prevention policies and prevention of overweight and obesity among children



Nordic Cancer Union's project:

Common actions for the prevention of overweight and obesity among children (NCU-CAPOC).

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Review authors:

- Pernille Boukaïdi Lundgaard, MSc in Sociology, Danish Cancer Society.
- Sofia de Moura Lourenço, MSc in Human Nutrition, Danish Cancer Society.

Project group

Inputs to the search process and drafts of the review report were given by members of the CAPOC project-group:

Member	Institution
Susanne Tøttenborg	Danish Cancer Society
Gitte Laub Hansen	Danish Cancer Society
Carina Alm	Norwegian Cancer Society
Mona Bjelland	Norwegian Cancer Society
Maiju Wetterhall	Swedish Cancer Society
Elin Ramfalk	Swedish Cancer Society
Sigrún Elva Einarsdóttir	Icelandic Cancer Society
Steinar B. Aðalbjörnsson	Icelandic Cancer Society
Heidi Löflund-Kuusela	Cancer society of Finland
Taija Puranen	Cancer society of Finland

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Foreword

The prevalence of childhood overweight and obesity in the Nordic countries is increasing, and these children have a considerably higher risk of carrying these conditions into adulthood. Childhood obesity increases the risk of a long list of consequences for children's physical, physiological, and mental well-being. Moreover, overweight and obesity are serious risk factors for several cancers and other noncommunicable diseases during adulthood.

Structural policies are paramount for addressing risk factors for cancer and other noncommunicable diseases. As the secretary generals and directors of the Nordic cancer societies, we have witnessed this time and time again in our prevention work addressing other risk factors, such as tobacco, alcohol, and UV exposure.

This report aims to gather the newest evidence on the efficacy of structural policies for the prevention of childhood overweight and obesity, and to provide an overview in the context of the Nordic countries.

The results of this extensive umbrella review and grey literature analysis stress the importance of policy actions and show that obesity prevention policies can create supportive environments for healthy diets and physical activity for all children. These policies will not only benefit the health of all Nordic children, but potentially improve the health of the population in general, reduce social inequality, and save future costs related to the disease burden associated with obesity.

This report provides valuable insights that serve as the foundation for five common Nordic policy recommendations. It is our hope that these insights will be considered by our politicians and decision-makers as guidance for a more concerted and effective prevention of childhood obesity across the Nordic countries.

By implementing effective prevention policies now, we can ensure healthier lives for the next generation and reduce the incidence of cancer cases in the future.

Jesper Fisker
Chief Executive Officer
Danish Cancer Society

Ingrid Stenstadvold Ross
Secretary General
Norwegian Cancer Society

Juha Pekka Turunen
Secretary General
Cancer Society of Finland

Halla Þorvaldsdóttir
Secretary General
Icelandic Cancer Society

Ulrika Årehed Kågström
Secretary General
Swedish Cancer Society

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1 Summary

The aim of this report is to describe and summarise current evidence of the effects of national and global prevention policies that can contribute to the prevention of childhood overweight and obesity. Based on a systematic umbrella review and a systematic grey literature search, evidence on six policy topics is covered:

1) Fiscal policies
2) Marketing-restriction policies
3) Labelling
4) School health
5) Availability, accessibility and affordability
6) Early-childhood prevention

A total of 70 systematic reviews and/or meta-analyses were included in the umbrella review, and 54 publications were included in the supplemental grey literature review. The results presented in this report are the evidence base for the Nordic Cancer Societies' common policy recommendations for the prevention of overweight and obesity among children.

Overall, evidence on anthropometric effects of the six different policy topics that were examined is limited and inconclusive. However, several of the policies yield beneficial effects on both dietary and physical activity outcomes among children or the general population. Mixed and limited results for anthropometric outcomes is not necessarily evidence that these policies do not have the expected effects. Far more likely, the results reflect the need for the evidence base to accumulate over a longer time span, since changes in anthropometric outcomes at the population level are not likely to be significant over shorter implementation periods.

Fiscal policies:

20 systematic reviews and/or meta-analyses were included in the umbrella review, which was supplemented with 24 grey literature publications. Taxes on sugar-sweetened beverages (SSBs) are the most common fiscal policy type implemented nationally and globally. Results show that these policies increase retail prices and reduce sales, purchases, and consumption of sugar-sweetened beverages. Taxes and subsidies affecting other foods

and beverages also increase retail prices and reduce sales, purchases, and consumption, and improve the nutritional quality of the targeted products. The purchases and intake of these types of products are price sensitive. Thus, purchases and intake of subsidised products increase along with increased subsidies, and purchases and intake of taxed products decrease along with increasing taxes. The higher the tax or subsidy, the greater effects are reported. Evidence suggests that some taxes can lead to a reformulation of targeted products by the industry. Evidence on the effects of fiscal policies on anthropometric outcomes is limited and inconclusive. Evidence suggests that fiscal policies are cost-effective and effective among low-income populations, and that both taxes and subsidies should be implemented at the same time to achieve greatest health and social effects.

Marketing restriction policies:

7 systematic reviews were included in the umbrella review, which was supplemented with 14 grey literature publications. Overall, evidence on marketing restriction policies is limited even though the evidence on the harmful health effects of marketing towards children is extensive. Current evidence shows that marketing restrictions can decrease food purchases of unhealthy foods and, in some cases, exposure to children and families with children. Some evidence suggests that marketing restrictions can cause the food industry to reduce their expenditure on marketing, and some studies also suggest that marketing restrictions are cost-effective. Marketing restriction policies have the greatest impact on children's health behaviours if they are mandatory, in contrast to voluntary industry codes, which the literature shows to have little or no effect. Marketing restrictions are most effective when they cover all children under the age of 18 years, all marketing channels (e.g., tv, digital) and strategies (e.g., influencers, cartoons), and if the policy is based on a government-led nutrient profile. The supplemental grey literature highlights the United Nations Convention on the Rights of the Child as a legal framework to implement mandatory restrictions. Evidence emphasises the need for marketing restriction policies to address the marketing children are exposed to, rather than the marketing directly aimed at children.

Food-labelling policies:

13 systematic reviews and/or meta-analyses were included in the umbrella review, which was supplemented with 16 grey publications. Overall, evidence on the effects of labelling policies, such as front-of-pack nutrition labelling (FOPNL) and menu labelling, is limited regarding real-life behaviour and its impact on health behaviour and anthropometry. Current evidence is stronger on the positive effect of food labelling on increased consumer awareness, but this was not a main outcome of this umbrella review. Current evidence shows that FOPNL is the easiest label type to understand across all socioeconomic groups, compared to a standard back-of-pack label. FOPNL is reported to increase consumer awareness and understanding of the nutritional content of products, which emphasises that labelling policies can improve circumstances for individuals to make more informed food and beverage choices. The most correct FOPNL interpretations are achieved through interpretive, simple, colour-coded, and evaluative label designs. Current evidence suggests mandatory labelling policies have the greatest health impacts, due to heightened compliance by the industry, and if combined with fiscal policies and marketing restrictions.

School health policies:

The umbrella review is based on 157 original studies extracted from 21 systematic reviews and/or meta-analyses, and it is supplemented with 21 grey literature publications. This section is based on original studies due to severe methodological heterogeneity in the included systematic reviews and/or meta-analyses. Overall, the clearest evidence concerns the positive effects of fruit and vegetable programmes/policies in schools and of increased consumption of fruit and vegetables among school children. Nutritional standards, increased availability, and reduced prices of healthy foods and beverages are also reported to improve school children's diets. Some evidence suggests free school meals have positive effects on diet, but evidence on long-term health outcomes and anthropometric outcomes is limited. Current evidence suggests that multicomponent policies that include both diet and physical activity components have the greatest impact on physical activity levels among school children and improve consumption of healthy foods/beverages. Further evidence suggests

that implementation of mandated physical education as part of the formal curriculum; creating school environments that promote active travel; providing access to physical activity during break times; and incorporating more movement into the classroom via the curriculum are effective school policies to increase physical activity levels among school children. Evidence for anthropometric outcomes is either limited or mixed.

Availability, accessibility, and affordability policies:

The umbrella review is based on 156 original studies extracted from 15 systematic reviews and supplemented with 16 grey literature publications. This section is based on original studies due to severe methodological heterogeneity in the included systematic reviews and/or meta-analyses. Overall results show that healthy food procurement policies and financial incentives (e.g. price incentives, discounts, or price/multi-buy offer restrictions) have a positive impact on consumption, purchases, and sales among all age groups. Most of the evidence in the umbrella review covers cash transfers/food benefits programmes with mixed results on anthropometric measures. The grey literature also suggests that policies that increase the availability of healthy foods/decrease the availability of unhealthy foods and/or regulate where food outlets can operate, as well as policies that limit portion and package sizes/restrict or ban trans fats and reduce salt content can have positive effects on health behaviours (purchase, sales, consumption) among all age groups.

Furthermore, overall results show that active transportation policies that improve walking and bicycling opportunities have positive effects on physical activity among all age groups. Evidence on the effect of policies aiming to improve the built environment is mixed. Also, current evidence on the effect of policies that prescribe physical activity and provide financial incentives to support physical activity participation is too limited among children.

Early childhood prevention policies:

2 systematic reviews were included in the umbrella review, which was supplemented with 6 grey literature publications. Overall, evidence is very limited, and we only found studies reporting the effects of the Special Supplemental Nutrition Program for Women, Infants

and Children (WIC) in the USA. Evidence from the WIC programme suggests a positive association between participation and maternal/child health on consumption, anthropometry, and child mortality. Findings from the grey literature on early childhood prevention policies mainly cover evidence-based recommendations on breastfeeding, the International Code of Marketing for Breast-milk Substitutes, and the double burden of malnutrition, but lack implementation reports. However, the existing literature greatly emphasises that early childhood is an important period to establish prevention policies.

2 Introduction

Overweight and obesity among children is a global health problem. The prevalence of overweight and obesity among children in the Nordic countries is increasing, and children living with either overweight or obesity have a higher risk of carrying these conditions into adulthood [1-5]. Childhood obesity increases the risk of a long list of consequences for children's physical, physiological, and mental health on the short term, but it also increases the risk of noncommunicable diseases, including at least 15 types of cancer, type-2-diabetes, and cardiovascular diseases in adulthood [6-9]. This emphasises the importance of preventing further increases of overweight and obesity as well as reversing the increasing trends among Nordic children to avoid the potential health, societal, and economic consequences.

Overweight and obesity are complex and multifaceted metabolic conditions influenced by genetics, biology, individual habits, social relations, economy, culture, environment, as well as the national/global context people interact with during their life [10, 11]. Evidence suggests that preventing these conditions cannot be achieved by focusing solely on single aspects related to diet and physical activity, but instead through multifaceted interventions and holistic strategies at the individual, community, environmental, societal, and political levels [11, 12]. Also, evidence strongly suggests that structural, universal policies have the greatest potential to achieve widespread health effects among whole populations (including children); are the most cost-effective; balance social health inequalities by changing default choices; and change habits by regulating the environmental determinants through physical, normative (legislative) and economic measures [13-18]. Existing research has mainly focused on determining the most efficient smaller-scale interventions that can help prevent overweight and obesity among children, while research evaluating the effects of real-world policies implemented in different national and global contexts is sparse.

This umbrella review aims to cover current evidence on the effects of national and global prevention policies. Results were supplemented with findings from a systematic grey literature search. Six policy topics are covered in separate chapters: 1) Fiscal policies, 2) Marketing-restriction policies, 3) Labelling, 4) School health, 5) Availability, accessibility, and af-

fordability, and 6) Early-childhood prevention. The results presented in this report are the evidence base for the Nordic Cancer Societies' common policy recommendations for the prevention of overweight and obesity among children. The policy recommendations can be accessed here:

https://www.cancer.dk/om-os/udgivelser-og-rapporter/forebyg-kraeft/policy-paper-preventing-childhood-overweight-and-obesity/

3 Background

The prevalence of overweight and obesity among children in the Nordic countries is increasing [1-4]. The most recent figures show that between 17-25% of children in the Nordic countries are living with either overweight or obesity (Table 1) [19-23]. Overweight and obesity trends among children are heavily affected by the socioeconomic status of families, and inequality in childhood obesity is also increasing in the Nordic countries. Higher overweight and obesity rates are seen among children from families with low incomes, lower educational attainment, ethnic minorities (immigrants or their descendants), and from rural municipalities/districts [24, 25]. Overweight and obesity in childhood can lead to numerous negative harms, both short- and long-term. In the short term, childhood obesity increases the risk of physical conditions

	Denmark [19]	Sweden [20]	Norway [21]	Finland [22]	Iceland [23]
Total overweight and obesity prevalence	18 % of 9-17 year-olds	23 % of 6-9 year-olds	17-21 % of 8-15 year-olds	22 % of 2-16 year-olds	25 % of 6-14 year-olds
Cut-off used	IOTF[a]	IOTF	IOTF	IOTF	IOTF
Year of data collection	2023	2021	2019	2022	2023

Table 1: Prevalence of childhood overweight and obesity in the Nordic countries

[a] IOTF = The International Obesity Task Force.

such as sleep apnoea, reduced exercise tolerance, breathing problems such as asthma, and non-alcoholic fatty liver disease [7, 26]. Furthermore, childhood obesity is associated with psychological problems such as anxiety, depression, low self-esteem, and social problems, including higher risk of suffering discrimination, loneliness, bullying, and weight stigma compared to peers [6, 7, 26-30]. In the long term, there is a high risk that children living with overweight and obesity carry these conditions into adulthood [5]. Evidence shows that overweight and obesity in adulthood increases the risk of at least 15 cancer forms, type 2 diabetes, cardiovascular diseases, sleep apnoea, psychosocial problems, and reproductive problems [25, 31-33]. Furthermore, recent evidence suggests that overweight and obesity in childhood increase the risk of some forms of cancer as an adult [8, 9]. A simulation-model study predicts that over 200.000 cancer cases could be avoided in the Nordic countries if overweight and obesity were totally eliminated before the year 2045 [34].

Previous Cochrane systematic reviews mostly evaluated smaller-scale interventions aiming to prevent overweight and obesity or related health behaviours among children, while evidence from real-life prevention policies is more limited. A Cochrane review from 2005 reports that nearly all interventions that focus on either diet and/or physical activity components lead to some improvement of these behavioural outcomes among children. However, improvements of BMI were only found in some studies focusing on either dietary or physical activity approaches in isolation [35]. An update of a more recent Cochrane review and meta-analysis reports that school-based obesity prevention interventions have small beneficial effects on children's BMI [36]. Furthermore, a more recent literature review on childhood obesity prevention in individuals with a healthy weight [37] base their findings on results from a Cochrane review from 2019 [38]. The authors conclude that several interventions showed positive effects on diet and physical activity, but the risk of developing overweight was not affected. In sum, interventions focusing on a healthy diet and physical activity have the potential to improve health-related behaviours but only few or no effects on weight outcomes. However, these effects can still contribute to maintaining a healthy weight or avoiding unhealthy weight development. Furthermore, most of the interventions examined are

smaller-scale interventions, meaning that the intervention ends after a certain time frame, usually within months or a few years. Meanwhile, structural prevention policies are intended to be implemented over a longer period such as several decades. Thus, structural prevention policies might have beneficial effects on anthropometric outcomes, such as on BMI, that would be evident after longer time periods.

Overall, most of the existing literature on preventing overweight and obesity covers effects from smaller-scale interventions such as individual and local interventions that are limited to certain groups, timelines, or contexts, while there is a lack of evidence on the effects of existing national and global prevention policies. Findings from an earlier umbrella review [39] show that pricing policies (taxes/subsidies), policies targeting the availability in retail and food establishments, targeting provision in school settings, and targeting product reformulation and portion/package sizes appear effective in improving population diets. Another umbrella review [40] also reports that economic tools, product reformulation, and environmental measures are effective in reducing sugar intake or even weight outcomes. However, there is a need for more research on the effects of existing prevention policies on a national and global level, which can inform the Nordic governments towards more effective political initiatives and legislation that contributes to the long-term prevention of childhood overweight and obesity.

The aim of the CAPOC umbrella review is to expand the existing evidence base on the beneficial effects of national and global prevention policies aimed at the prevention of overweight and obesity in children. The results of the CAPOC umbrella review are therefore supplemented with findings from a systematic grey literature search covering six policy topics:

1) Fiscal policies
2) Marketing-restriction policies
3) Labelling
4) School health
5) Availability, accessibility, and affordability,
6) Early-childhood prevention

3.1. Abbreviations and glossary

Abbreviations and general terms used throughout the report are presented and defined below. Subject-specific terms will be provided at the beginning of each chapter.

Abbreviations:

- SSB: Sugar-sweetened beverage
- NNS: Non-sugar sweeteners
- HFSS: High in fat, salt, and/or sugar
- FB: Food and beverages
- BMI: Body Mass Index = weight (kg)/height (m2)
- PA: Physical activity
- PE: Physical education
- DALYs: Disability-adjusted life years
- SLR: Systematic literature review
- MA: Meta-analysis
- UR: Umbrella review

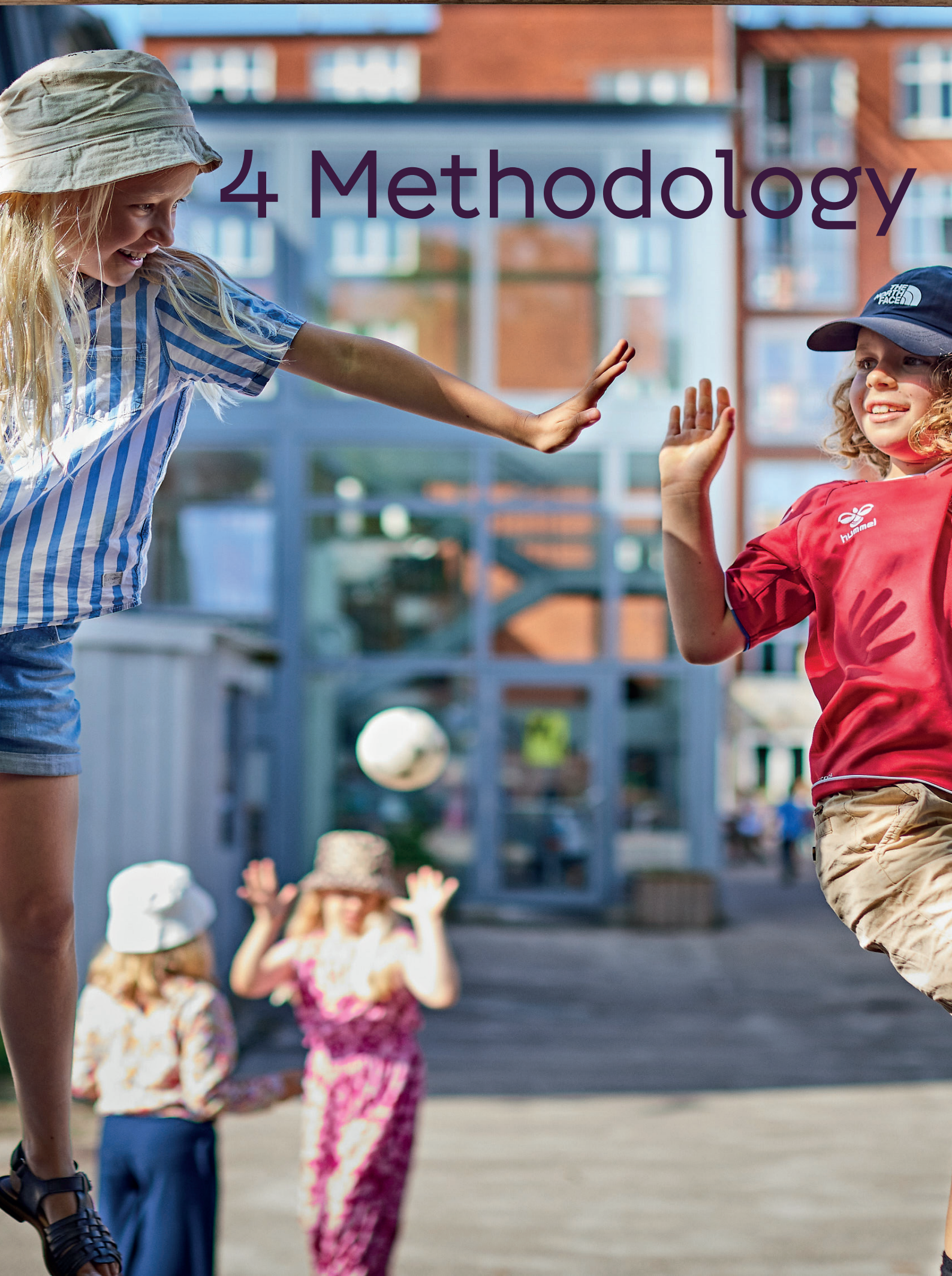
Glossary – general terms used in the report:

- **Children:** Humans less than 18 years of age [6].
- **Adolescents:** Humans between 10 and 19 years of age [6].
- **Overweight:** From birth to less than 5 years of age: weight-for-height more than 2 SD (standard deviations) above the WHO Child Growth Standards median. From age 5 to less than 19 years: BMI-for-age more than 1 SD above WHO growth reference median [6, 41].
- **Obesity:** From birth to less than 5 years of age: weight-for-height more than 3 SD above the WHO Child Growth Standards median. From age 5 to under 19 years: BMI-for-age more than 2 SD above the WHO growth reference median [6, 41].
- **Healthier diet:** A shift from a more energy-dense diet (e.g., foods and beverages containing high levels of salt, sugar, or fat and/or that are ultra-processed) to a lower energy-dense diet and/or a higher consumption of healthy foods, e.g., fruit and vegetables [42] [b].

[b] The Nordic Nutrition Recommendations (2023) recommend: A predominantly plant-based diet high in vegetables, fruits, berries, pulses, potatoes, and whole grains; ample intake of fish and nuts; moderate intake of low-fat dairy products; limited intake of red meat and poultry; minimal intake of processed meat, alcohol, and processed foods containing high amounts of fats, salt, and sugar.

- **Unhealthy diet:** A nutrient-poor and/or energy-dense diet (e.g., with too many foods and beverages containing high levels of salt, sugar, or fat and/or that are ultra-processed, exceeding national guidelines. These products include, e.g., sugar-sweetened beverages, beverages with artificial sweeteners, salty/high-fat crisps, confectionary, or desserts).
- **Nutrient profile:** An overall evaluation/summary of the nutritional content in foods or beverages.
- **Obesogenic environment:** An environment that promotes high energy intake and sedentary behaviour [6].
- **Anthropometric measures:** Different measurements and proportions of the human body, e.g., weight, BMI, waist circumference, skinfold, etc.
- **Health behaviour outcomes:** Different measurements for health behaviour that can positively or negatively affect the overall health as well as anthropometric measures in the end. These outcomes regard, e.g., purchases, consumption, and physical activity levels.
- **Food reformulation:** Changing the processing or composition of the nutritional content in a food or beverage product to improve the nutritional content or reduce certain ingredients.
- **Policy:** A predetermined action established by a government or union (e.g., EU) guiding and determining decision making and specific goals. Policies serve either as guidelines or rules that must be complied with for members of a society, such as individuals, organisations, and private companies (e.g., the food industry).
- **Food environment:** The collective physical, economic, political, and sociocultural surroundings, opportunities, and conditions that influence people's food and beverage choices and nutritional status. Examples of the food environment are the availability of food products, the monetary value of food products, the physical distance to food products, and the marketing of food products, all of which shape the individual's food and beverage preferences and choices [43, 44].

4 Methodology



The evidence included in this report is based on the results of the CAPOC umbrella review supplemented with results from a systematic grey literature search. We chose to conduct an umbrella review due to the large number of policy topics covered, and to examine whether research within one policy topic posed the same questions and reached the same conclusions. The benefit of this method is that it provides an overview of the existing research, identifies gaps, and summarises the findings of existing published systematic reviews and meta-analyses [45]. Limits of the CAPOC umbrella review are the inclusion of data that have been selected by previous systematic reviews and meta-analyses; quality problems and risks of bias in the original studies can be difficult to clarify; and double- or triple-accounting of data may occur. However, we have accounted for the latter issue with tables that provide an overview of the original data and state the potential overlaps among reviews (see Appendix C for overlap tables for each policy topic). We included a vast amount of grey literature as a supplement to the umbrella review, since national governments or public health organisations often evaluate different prevention policies or give evidence-based recommendations on this topic. Thus, grey literature in this area might at times be more updated and compensate for the previously mentioned risks of bias and low-quality study selection.

Systematic reviews and meta-analyses range highest in the evidence hierarchy when based on data from randomised controlled trials (RCTs) [46]. However, due to a lack of control within a country, prevention policies that are implemented in the real world are very difficult to measure through study designs like RCTs if the policies are implemented nationally/globally. Instead, policies are often studied through observational study designs, such as interrupted time series, cohorts, or other longitudinal data. Thus, the CAPOC umbrella review includes all study designs, since available data is better than no data.

4.1. Search strategy and study selection

Nine systematic searches were conducted in PubMed between March 6th-13th, 2023, covering nine different policy topics: Tax and fiscal policies; Marketing; Labelling; Early childhood prevention; Food reformulation; Availability, accessibility and affordability; Public standards;

Health literacy, and School health. We ended up only including results on six out of nine topics. Reasons for excluding results on 'Public standards', 'Food reformulation' and 'Health literacy' can be found in Appendix A3.

The systematic grey literature searches were conducted between November 2022 and January 2023. Based on a list of websites provided by the Canadian Agency for Drugs and Technologies in Health's 'Grey Matters' tool, relevant websites were attained and supplemented with other websites from relevant organisations. A list of 83 websites in total was gathered.

The inclusion and exclusion criteria for the CAPOC umbrella review and the grey literature was agreed upon before going through potential hits. Searches for the CAPOC umbrella review were limited to include only systematic reviews, meta-analyses, and government reports. All results for each search string were reviewed systematically and selected for relevance by two researchers independently (PBL & SL), based on the inclusion/exclusion criteria. Studies were compared by the two researchers and, if any inconsistency in the selected studies was found, they reached agreement on whether a study was relevant or not (see the final number of studies for umbrella review in Figure 1).

For a detailed description of search strings, list of websites used for the grey literature search, strategy for examining the websites, and inclusion and exclusion criteria, see Appendices A1, A2, A4, and A5.

A total of 4.601 hits were yielded from the PubMed searches. In all, 70 unique reviews were included in the CAPOC umbrella review [c].

A total of 441 potential grey literature publications were originally identified, and six publications were added during the search process. Thus, a total of 447 potentially relevant grey

[c] 8 reviews overlapped across the six policy topics.

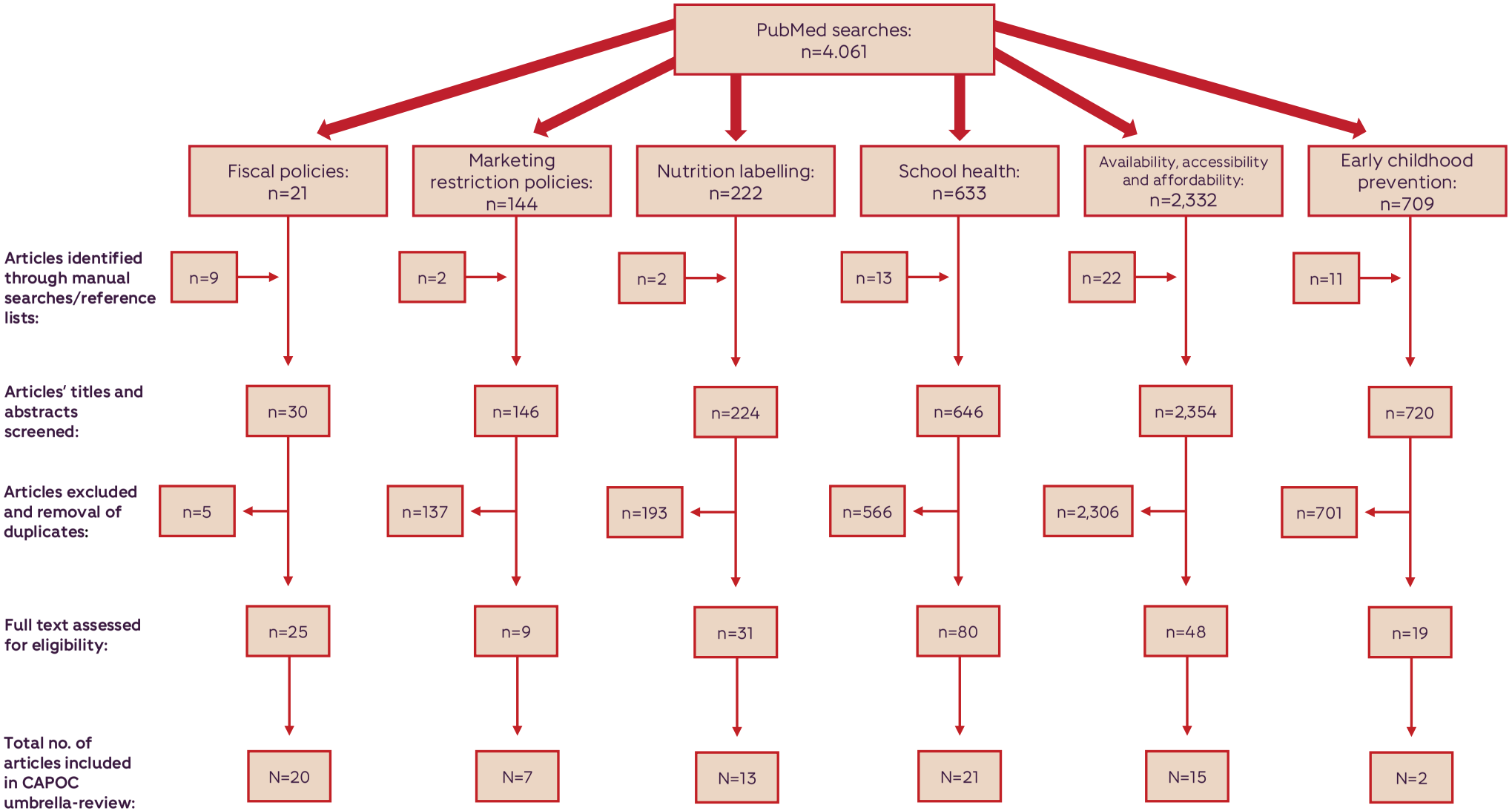


Fig. 1: Flowchart for the selection of relevant studies for all six policy topics:

literature hits were assessed. After applying the exclusion criteria, at total of 54 relevant grey literature publications across the six topics were included.

4.2. Data analysis and evidence judgement

For the included systematic reviews and meta-analyses, predefined information on descriptive characteristics and results were extracted and consolidated into overview tables (see Appendix B). These data included: study characteristics (number, type, country of origin); policy type (exposure); outcomes (e.g., anthropometry or health behaviour); aim; analyses performed; sample (size, age); strengths and limits; and overall results. For all six policy topics, a narrative synthesis was made of the overall results from the systematic reviews and meta-analyses, and for two topics, the narrative synthesis was based on the results of the relevant original studies due to too much heterogeneity across the included systematic reviews and meta-analyses. The narrative synthesis was supplemented with results from the grey literature for each policy topic.

The quality of the evidence of the CAPOC umbrella review was assessed and rated with the AMSTAR2 Checklist. AMSTAR refers to A MeaSurement Tool to Assess Systematic Reviews, which was used to assess the methodological quality (incl. risk of bias) of the included systematic reviews and meta-analyses. The quality ratings of the separate systematic reviews and meta-analyses are provided in each policy chapter, and individual quality ratings can be attained by contacting the authors of this report.

For a detailed description of the AMSTAR2 Checklist as a quality rating tool and the full checklist, see Appendix A6.

Results

5 Fiscal policies

5.1. Definition of subject-specific terms

Revenue: Income.

Subsidies: A sum of money provided by the government to either citizens, companies, or associations to keep the price of specific goods and services at a lower level than its actual cost.

Tax: A charge of money imposed by the government on specific goods and services. Citizens, companies, and associations can be eligible for paying taxes.

Excise taxes: A type of tax typically imposed on specific goods or services, rather than on income or property. It is a tax levied by the government on the production, sale, or use of certain goods or services. Usually, an excise tax must be paid by companies, which often increase the prices for consumers indirectly, but it can also be put on the consumer directly. Thus, excise taxes can serve the purpose of creating revenue to fund other public programmes, as well as modify and regulate behaviour. Excise taxes can take on the following formats:

- **Ad valorem tax:** A tax calculated as a percentage of the value of a good or service.
- **Specific tax:** A fixed or set sum imposed on a specific quantity (e.g., volume of sugar) or unit (e.g., total sugar content) of a product or service, regardless of its price or value. This type of tax reduces incentives to switch to less expensive brands [47, 48].

Tax structure: Both ad valorem taxes and specific taxes can be applied with either a **uniform tax structure**, meaning a unique tax rate, or a **tiered tax structure**, where different tax rates vary based on the price and/or characteristics of the goods and services. A tiered tax typically contains a threshold where a higher tax rate is applied when the good or service exceeds it.

Own price elasticity: Price elasticity of demand is measured as the percentage change in demand (purchase/sales or consumption) over the percentage change in price. A negative price elasticity reflects that demand for a product decreases when the price increases, and a positive price elasticity reflects that demand increases when the price increases [49].

Cross-price elasticity: Cross-price elasticity is the percentage change in demand (purchase/sales or consumption) for substitute products over the percentage change in price for another product. A positive cross-price elasticity reflects that demand for another product, e.g., light soft drinks, increase if the price of, e.g., SSB products increases. A negative cross price elasticity reflects that demand for other products also decreases when the price is raised [50].

Price premium: Reflects the relative price in percentage of a product's selling price when it exceeds or falls short of a benchmark price. A positive price premium reflects that costumers are willing to pay a higher price for a product compared to the benchmark price [51].

5.2. Background: Fiscal policies

Fiscal policies like taxation and subsidy initiatives are well known for their positive health-promoting effects and for reducing unhealthy dietary choices, which can contribute to the prevention of overweight and obesity [52-55]. The evidence shows that changes in prices of food and beverages can modify health behaviours like purchases and consumption among both children and their families [39, 40].

So far, the most widespread fiscal initiative is the taxation of sugar and/or sugar-sweetened beverages (SSBs). The WHO [56] recommends taxing SSBs as a policy option for tackling childhood obesity. Evidence is well-established on the association between a high SSB consumption and an increased risk of overweight and obesity, type 2 diabetes mellitus, and other metabolic conditions, as well as an increased risk of caries and tooth erosion [57]. Recent evidence also suggests an association between a high consumption of beverages containing non-nutritive sweeteners (NNS) and obesity, type 2 diabetes, cardiovascular disease, and all-cause mortality [58-60]. Long-term evidence of the health effects of NNS in children is limited since these ingredients have only been in use more widely for a few decades. However, several health experts suggest that beverages with NNS should be included when introducing either price or marketing regulations, as a precaution, at least because these products tend to replace healthier products, e.g., water [59].

The existing evidence also pinpoints that unhealthy food and beverage products are more often subject to price promotions, and when both unhealthy and healthy products are price-promoted, consumers tend to buy more unhealthy products

[61]. Furthermore, individual background factors like age, sex, weight status, and educational level are relevant influences on consumers' willingness to pay more for healthier foods [62]. These aspects are important to keep in mind when introducing fiscal policies to promote healthier dietary choices among children and their families.

The next section covers results from the NCU-CAPOC umbrella review and grey literature searches on the effects of fiscal policies as a way of contributing to the prevention of childhood overweight and obesity.

5.3. Search results

A total of 20 systematic reviews [63-82], four of which included meta-analyses [63, 68, 71, 78], were included in the umbrella review, which was supplemented with 24 grey literature publications [12, 52, 56, 57, 83-102]. A depiction of the selection of relevant articles for the CAPOC umbrella review can be seen in Figure 2:

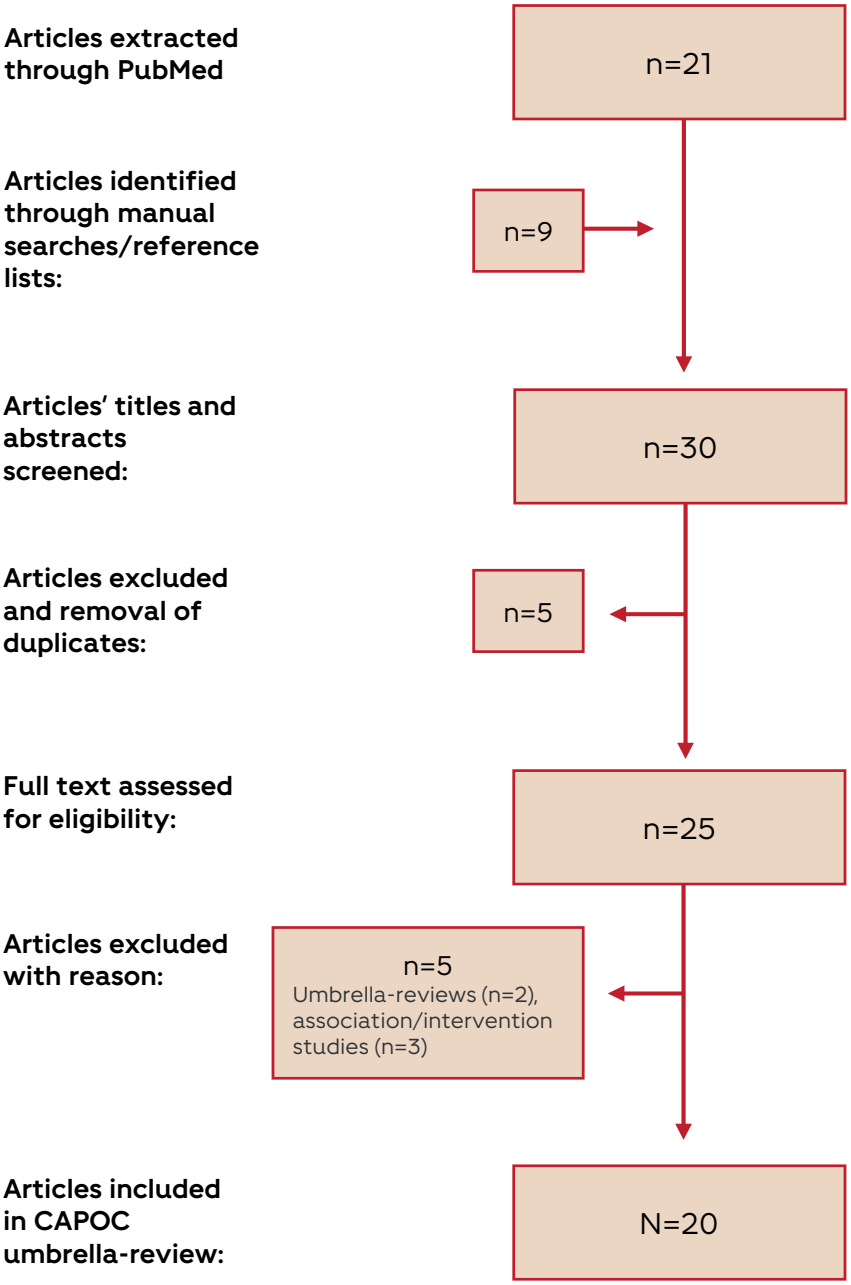


Fig. 2: Flowchart for the selection of relevant studies pertaining to the fiscal policies section

One of the included reviews was rated as having high quality [68], six as moderate quality [65-67, 69, 76, 78], one was rated as having low quality [81], and 12 were rated as critically low quality [63, 64, 70-75, 77, 79, 80, 82].

The included reviews encompass a broad range of study designs such as experimental and modelling studies like random controlled trials, laboratory studies, simulation studies, and quasi-experimental studies (n=12) [64, 67, 69-74, 77, 79, 81, 82]. Most included studies (n=19) [63-66,

[68-82] contain observational studies like natural experiments, surveys, and comparisons between pre- and post-policy implementations with study designs like interrupted time series, longitudinal studies, cross-sectional studies, cohort studies, and prospective studies. One review [67] only included modelling studies. The number of original research studies included in the articles ranged from 2 to 94.

Data originates primarily from high-income countries, such as the United States of America, the United Kingdom, France, Denmark, Finland, Barbados, Norway, Spain, the Netherlands, Canada, Ireland, Germany, New Zealand, Australia, Italy, Singapore, and the Western Europe region (n=18) [63-71, 73-80, 82]. 17 reviews are also based on local data from singular states or cities in the United States (California, Pennsylvania, Illinois, Berkeley, San Francisco, and Seattle) [63, 64, 67-71, 73-82]. Some data (n=12) originates from middle-income countries, such as Mexico, Chile, Hungary, India, Egypt, Brazil, Taiwan, the Pacific Islands region, and South Africa. None of the studies are based on data from low-income countries, and 5 reviews [68, 76-78, 82] also note a lack of evidence from both middle-income and low-income countries. The reviews differ as to whether data is based on the general population, children, adolescents, or adults.

All included reviews aim to evaluate the effects of fiscal measures on a state or at a national level. In general, the evaluated fiscal measures are either taxes, price increases of a product, or subsidies, which decrease the price of a product. The taxes and subsidies investigated in the reviews varied greatly, including a wide range of taxes like single-tier volume-based excise taxes, tiered volume-based excise taxes, sales taxes, import tariffs, ad valorem taxes, and volumetric taxes. Furthermore, a range of subsidies spanning discounts, vouchers, or coupons are evaluated. The categorisations of foods or beverages to which the taxes or subsidies apply also differ. They are either applied to broad categories like 'unhealthy and healthy foods/beverages', junk food, high-in-fat foods, and snacks, or more specifically to sugar-sweetened beverages, sugar, specific nutrients, or fruits and vegetables. Effects of the taxes/subsidies are reported for outcome measures such as price, sales, and demand, but also as health outcomes like consumption, energy intake, diet, weight, and overweight/obesity prevalence.

5.4. Results for policy effectiveness

To provide the best overview of the gathered evidence, the results are described in three sections: a) effects of taxes on sugar-sweetened beverages; b) effects of other taxes and subsidies; and c) other findings related to all types of food and beverage taxes/subsidies.

a. Taxes on sugar-sweetened beverages

The majority of reviews report on the effects of taxes on sugar-sweetened beverages (SSBs) (n=14) [63, 64, 67-73, 77-80, 82], and one study focuses on sugar levels in foods (n=1) [66]. All 14 reviews report that taxes on SSBs are successful fiscal measures and show significant effects in increasing prices (n=2) [63, 72], reducing sales (n=3) [63, 64, 68], and reducing purchases, consumption or dietary intake (n=12) of SSBs [64, 68-73, 77-80, 82] in the majority of the original studies included in each review.

Most of the grey literature publications (n=18) also cover taxes on sugar-sweetened beverages (SSBs) [12, 52, 56, 57, 83-87, 89, 90, 93-96, 98, 99, 101]. The grey literature confirms that this type of tax is the most widely implemented one globally, and thus the most evaluated approach. Examples of SSBs taxes covered in this review include the UK's Soft Drink Industry Levy, Portugal's tiered volume-based tax, South Africa's healthy promotion levy on SSBs, taxes on sugary drinks in different states of the US, Mexico's sugary drink tax, Chile's soft drink tax, Hungary's taxation of syrups or concentrates for SSBs, and France's excise tax on added sugar/sweeteners targeting manufacturers.

Aligned with the findings of the CAPOC umbrella review, the grey literature publications also report that taxes on SSBs are effective in increasing retail prices (tax pass-through), and reducing demand, sales, and consumption of the targeted products [52, 57, 83, 84, 86, 87, 89, 90, 92-96, 98, 99, 101]. The most recent publication regarding SSB taxes, by the WHO [57], reports that evidence from real-world settings shows that SSB taxes lead to changes in pricing, purchasing, and consumption, and towards a healthier diet.

Effect on prices and sales

Two reviews report that taxing SSBs results in higher retail prices [63, 72]. Results from the most recent meta-analysis [63] are based on 46 data estimates from 18 policies. It finds that the overall tax pass-through is 82%, meaning that a 10% tax would lead to an 8.2% increase in end-consumer prices.

Three reviews report effects on sales and show that sales are significantly reduced as a result of SSB taxation [63, 64, 68]. In 14 out of 16 studies, Itria et al. [64] find that sales decreased following the introduction of an SSB-tax.

Effects on purchases, consumption, and dietary intake

12 reviews consistently report desirable effects of SSB taxes and reductions in outcomes such as purchases, consumption, and intake of SSBs [64, 68-73, 77-80, 82].

Itria et al. [64] report that 14 out of 16 studies show a decrease in consumption and purchases. Similar findings emerge from the meta-analysis of Teng et al. 2019 [68]. The authors also find that a 10% SSB tax was significantly associated with a 10% decline in purchases and dietary intake. This is corroborated by another meta-analysis based on 5 studies [71], showing that SSB-intake was reduced by 7% following a 10% price increase.

Redondo et al. [69] find that in 4 out of 5 studies, SSB-taxes reduce purchases when the tax is higher than 8%. Wright et al. [70] report a reduction in consumption and purchasing in 3 out of 8 studies when the tax rate is less than 20%. However, the authors find that a tax rate above 20% reduces consumption and purchasing in 8 out of 8 studies. This suggests that the higher the tax, the stronger its impact on consumption and purchasing behaviour will be. In accordance with this, the meta-analysis by Escobar et al. [78] (n=9) found a negative price elasticity (pooled own-price elasticity of -0.299), meaning that an increase in the price of SSBs was associated with a decrease in demand, and thereby consumption of SSBs. Powell et al. [80] also found a negative mean price elasticity at -1.21 based on 12 estimates.

One systematic review evaluates the effects of the Hungarian public health tax on sugar products in foods [66], and reports that the mean consumption of taxed sugar-added foods decreased, but they note that the evidence is too uncertain, since only one study is included in the review.

Findings of subgroup analyses on SSB taxes in Teng et al. [68] showed that results on sales, purchases, and consumption varied across American jurisdictions, but tax type (ad valorem tax and volumetric tax) did not have any significant effect on the results. However, some of the grey literature publications report that the pass-through rate's effects on dietary outcomes and the potential for reformulation highly depend on the type of tax, tax structure, and the tax rate [52, 56, 57, 85-87, 89, 90, 93, 96, 99, 100].

Effects on product reformulation

Only one review [63] investigates whether the taxation of SSBs leads to product reformulation and finds that tiered SSB taxes lead to beverage reformulation and a reduction in sugar content. The UK's Soft Drinks Industry Levy is emphasised, and results towards reducing the share of beverages exceeding the lower levy threshold for sugar are reported. Some of the grey literature publications also report that SSB taxes can lead to reformulation of the targeted products in some cases [52, 57, 83, 84, 86, 87, 89, 90, 92-96, 98, 99, 101].

Furthermore, most of the grey literature publications recommend specific excise taxes since they are preferred from a public health perspective, because they raise the price of SSBs compared to other products and make the targeted products less affordable. However, some countries, such as the UK, Portugal, and South Africa, have introduced tiered taxes on sugar content which has shown significant effects on product reformulation [57, 85, 86, 90, 99, 100].

b. Evidence for other taxes and subsidies

Seven reviews examined taxes and subsidies on a broader scale [64, 74, 76, 77, 79, 80, 82].

Evidence from the grey literature also covers taxes on unhealthy food products, such as those high in fat, sugar, and salt (HFSS-products), and the implementation of subsidies to increase the intake of fruit and vegetables [12]. Once more, the WHO underlines that SSB taxes are the most implemented ones globally, while fewer policies for HFSS products or subsidies for healthy foods are implemented. The evidence from real-world policy evaluations of these fiscal initiatives is therefore limited [56, 92].

Furthermore, current evidence on subsidies is primarily based on modelling studies and intervention studies examining subsidies (e.g., vouchers, price discounts, or public distribution systems) aimed at reducing the price of fruit and vegetables. This evidence shows that subsidies are effective in increasing purchases and consumption of these foods and improving overall diet quality [52, 56, 84, 87, 91, 92].

Effects on purchases/demand, consumption, and intake

All (n=7) of the reviews [64, 74, 76, 77, 79, 80, 82] report desirable effects on health-related outcomes such as reduced purchases/demand, consumption, and intake as a result of food and beverage taxes and subsidies. The evidence also suggests that changes in intake are price-sensitive, meaning that higher taxes lead to greater reductions in consumption, and conversely, higher subsidies lead to greater increases in consumption. This applies to both SSBs, HFSS foods, and fruit and vegetables [64, 74, 76, 79, 82]. Furthermore, Powell et al. [80] found a negative price elasticity for both SSBs (-1.21), fast food (-0.52), and fruit and vegetables (-0.48), meaning that the demand for these products decreases as prices increase.

Evidence from the grey literature supports this, and reports that evidence concerning taxes on foods that contribute to unhealthy diets (e.g., saturated fats, trans-fatty acids, free sugars, and salt) shows reduced purchases, demand, and consumption of the taxed food products. Furthermore, these types of taxes can encourage product reformulation, generate revenue that can be used for health purposes, increase awareness of healthy eating, and raise retail prices [52, 56, 88, 89, 91-93, 97, 99]. Additionally, evaluations of the Hungarian Public Health

Tax showed that adults living with overweight and obesity were more likely to reduce their consumption of unhealthy products following the introduction of the tax [88, 97].

As with SSB taxes, several organisations recommend using specific excise taxes and potentially employing tiered taxes to encourage healthier consumer substitution behaviour and industry reformulation [56].

Effects of taxing individual nutrients vs. food and beverage products based on nutrient profiles

One review [77] compared the effects of taxing individual nutrients versus products assessed by nutrient profiling. The authors conclude that taxes applied by nutrient profiling, which is broader and aimed at products categorised as unhealthy, red-labelled food, soft drinks, or high-calorie items, show greater effects than taxing individual nutrients (e.g., fats or sugar). Maniadakis et al. [79] report similar findings with reduced consumption resulting from taxes aimed at HFSS products. Only one review examines the taxation of saturated fat exclusively, and the evidence is uncertain and limited with only two studies included, both evaluating the Danish tax on saturated fats [65].

Grey literature publications support these conclusions, and several organisations recommend that food taxes should target a nutrient profile or an entire nutrient composition (e.g., defining unhealthy foods, HFSS products) rather than taxing individual nutrients, since the latter is more likely to include healthy products and can lead to unhealthy substitution [52, 56, 84, 85, 88].

c. Other findings related to all types of food and beverage taxes/subsidies:

Cost-effectiveness of taxation and subsidies

Two reviews [67, 74] examined whether taxation or subsidies are cost-effective. Both reviews conclude that these measures are cost-effective, and Olm et al. [67] also report that taxation is cost-saving regardless of the type and extent of taxation. In line with this, the European

Commission [92] reports moderately strong evidence of the effects of taxation on consumption and strong evidence of the effects of subsidies on consumption, both of which are recommended and considered cost-effective [52, 91, 92].

Furthermore, grey literature highlights that growing evidence indicates that the most effective fiscal means is a combination of taxing foods and beverages that contribute to an unhealthy diet and subsidising foods that contribute to a healthy diet [52, 56, 91, 92].

Long-term effects - anthropometric outcomes

12 of the included reviews investigate the effects of both taxes and subsidies on various anthropometric outcomes, such as body mass index (BMI), weight, and the prevalence of overweight/obesity [63, 64, 67, 71-73, 75, 76, 78]. However, the evidence was mixed for all outcomes evaluated, and no significant effect has been conclusively established. Furthermore, the analyses were primarily based on simulation studies, making it difficult to draw conclusions regarding real long-term effects.

The same conclusion can be drawn from the grey literature, where the effect of taxes and subsidies on anthropometric outcomes, as well as their effects on other long-term outcomes, such as type 2 diabetes, dental caries, and DALYs, remains unclear and limited to modelling/simulation studies [52, 56, 57, 84, 86, 91, 92, 99, 101]. However, the results of such studies show that SSB taxes might lead to significant reductions in DALY prevalence incidence rates for obesity, type 2 diabetes, and dental caries, depending on the size of the tax. This emphasises that the tax must be sufficiently large to have effects on long-term outcomes.

Findings of the CAPOC umbrella review underline the mixed evidence regarding anthropometric outcomes. For example, Andreyeva et al. [63] did not find significant effects of SSB taxes on BMI in the US. Itria et al. [64] found mixed evidence for the effectiveness of SSB taxes in reducing overweight/obesity prevalence. Most of the simulation studies included in their review reported an expected reduction in obesity prevalence, and two observatio-

nal studies reported a reduction in obesity prevalence in upper middle-income countries. However, some studies did not find any changes in BMI or overweight/obesity prevalence, underlining that the long-term evidence for these outcomes and of taxation is still unclear.

Mixed results were also reported in the meta-analysis by Afshin et al. [71], where a reduction in the price of fruit and vegetables was found to reduce BMI, but increases in the price of SSBs or fast food were not found to affect BMI. Nakhimovsky et al. [72] found that a 10% decrease in soft drink prices led to an increase in obesity prevalence and BMI in one study, while two studies found a 20% tax to decrease obesity and overweight by 3%.

This finding underlines that the tax level must be quite high before effects can be measured in weight outcomes. Thow et al. [82] also stress a need for an extremely high tax on dairy fat (50%) for it to influence body weight.

These mixed results emphasise the difficulty of attributing effects of fiscal policies alone on body anthropometry, especially when considering long-term effects.

Minimum tax and subsidies threshold

Four reviews explore whether there is a minimum tax threshold for effectiveness. Redondo et al. [69] discovered that taxes on the production of SSBs lead to reduced purchases of the taxed beverages. However, this association was only significant when the tax exceeded 8%. Evidence from Itria et al. [64] also suggests that higher taxation (20% compared to 10%) has a greater effect, while Wright et al. [70] found mixed results for the effects on purchasing and consumption when the SSB tax rate was below 20%. Still, the authors noticed that all studies evaluating an SSB tax rate of 20% or higher found a positive impact of the tax. The same pattern applied to tax rates on food products, where all studies found an effect if the tax rate was 20% or higher. Niebylski et al. [74] recommend that taxes and subsidies be set at a minimum of 10% to 15% to maximise success, and that they are used in combination. In a meta-analysis, Escobar et al. [78] also demonstrated a negative own-price elasticity[d] follow-

[d] The percentage change in demand quantity to the percentage change in price.

ing an SSB tax, indicating that higher prices of SSBs would lead to lower demand.

Findings of the grey literature support this, reporting that if taxes are too low, such as those on soft drinks in different states of the US (ranging between 1-8%), they might not alter the affordability of the product and thereby consumer behaviour [57, 85]. It is further reported that the higher the tax, the larger the decline in purchases and sales will be, and many organisations suggest a tax rate of 17.5% to 20% to detect the effects of the tax with most evidence, emphasising that a 20% tax rate is most effective in reducing consumption and shifting behaviour, with respect to both SSB taxes and taxes on other unhealthy food products [52, 57, 85-87, 90, 94, 98, 100, 101].

As for subsidies, three grey literature publications report that subsidies (e.g., on fruit and vegetables) must lead to a minimum of 10-15% price reduction to be effective in increasing consumption [52, 90, 102].

Shifts to untaxed beverages: substitution products

A concern regarding the taxation of products is that consumers might shift consumption towards untaxed products. Four [69, 72, 78, 82] out of six reviews [63, 68, 69, 72, 78, 82] found that taxing SSBs could lead to an increase in the consumption of non-taxed beverages. Both Nakhimovsky et al. [72] and Escobar et al. [78] observed significant increases in the demand for milk, and Escobar et al. also noted an increased demand for fruit juice. Results of simulation studies in the grey literature also suggest that SSB taxes might lead to substitution behaviour with an expected increase in the purchase of diet drinks, tea and coffee, milk, and fruit juice [86, 87, 99]. Furthermore, WHO [57] reports that specifically taxing SSBs could lead to an increase in sales and purchase of water. Meanwhile, two systematic reviews [63, 68] did not find any significant changes in the substitution to, and consumption of, untaxed beverages as an effect of SSB taxes.

Evidence on other food taxes also suggests that consumption is affected by con-

sumer substitution, with individuals choosing cheaper and often healthier products, consuming less of the taxed products, or changing to another brand of the product and substituting for some other food (often healthier) [88, 97, 99].

Socioeconomic effects

Six reviews conducted sub-analyses on the socioeconomic effects of taxation and subsidies, and all conclude that both types of fiscal measures most greatly impact the reduction in consumption and purchases of unhealthy products among low-income populations [69, 72, 73, 76, 77, 80]. Backholer et al. [73] report that SSB taxes have a greater reducing effect on SSB consumption among children from low-income families. Alagiyawanna et al. [76] also found that soft drink taxes are most strongly associated with consumption among at-risk children, including those who are already overweight or come from low-income families. Thow et al. [77] and Thow et al. [82] similarly reported that low-income groups are most sensitive to higher prices, resulting in the most significant reductions in consumption due to taxation.

The grey literature notes that all types of food and beverage taxes are often criticised for being financially regressive, meaning that people with low socioeconomic status spend a larger proportion of their income on these goods than people with higher socioeconomic status. However, in accordance with the findings of the CAPOC umbrella review, evidence shows that people with low socioeconomic status are more sensitive to price changes, meaning that they will reduce consumption of the taxed products more. A good example of such effect is reported in the evaluation of the Hungarian tax, which showed that consumers with primary education chose cheaper products after the tax was introduced, compared to consumers with a higher educational level [88, 97].

Thus, from a health perspective, evidence shows that the benefits of taxes, as well as the decreasing healthcare expenditures, have progressive effects. Furthermore, subsidies can be used as a means to target health inequalities by directing them towards households of lower socioeconomic status [52, 56, 86-90, 92, 97, 99, 101].

Revenue from taxes

Evidence from the grey literature shows that SSB taxes can be and are used in several countries to raise revenue. The increased revenue can be earmarked towards health functions and supporting initiatives to subsidise healthier food and beverage options. However, the evidence suggests that the exact revenue from a tax is difficult to predict with accuracy before implementing the tax. The use of revenue for health and social purposes is also recommended in the grey literature publications, since evidence shows that this will lead to higher levels of public support [56, 57, 85-87, 90, 100, 101]. Revenues from SSB taxes could, e.g., be used for subsidising fruit and vegetables for low-income populations or subsidising healthy school meals. Revenue from the public health tax in Hungary (not only covering SSBs), was also used to raise wages among 95,000 health sector workers to keep them in the workforce [88].

5.5. Conclusion

A total of 20 systematic reviews and/or meta-analyses and 24 grey publications were included. Results regarding effects on anthropometric outcomes are limited and largely mixed or non-significant. Most of the current evidence covers taxes on sugar-sweetened beverages (SSBs), as this is the most common type of fiscal policy implemented so far. SSB taxes increase retail prices and reduce sales, purchases, and consumption of SSBs. Evidence on other types of taxes and subsidies also shows positive results on outcomes that contributing to positive health effects: increasing retail prices, reducing sales, purchases, consumption, and improving the dietary quality of the targeted foods and beverages. For all types of taxes and subsidies, it is reported that both purchases and intake of the targeted products are price sensitive, meaning that a higher tax leads to greater reductions in purchases and intake, and higher subsidies lead to greater increases. Thus, the higher the tax and subsidy, the greater health effects can be achieved, and a tax rate of 20% is consistently reported to have significant positive effects on purchases and consumption.

Furthermore, specific types of taxes (e.g., tiered taxes) could lead to the reformulation of

the taxed products. The evidence suggests that using broader nutrient profiling, rather than targeting individual nutrients, could yield greater health effects and decrease opportunities for consumers to switch to non-taxed unhealthy products. Finally, both taxes and subsidies are reported to be cost-effective and most effective in reducing unhealthy diets among low-income populations, and a broad range of health organisations recommend combining both types of fiscal measures to obtain the greatest health and social effects.

The findings of the CAPOC umbrella review align with previous research. Other umbrella reviews focusing on different types of pricing policies, such as taxes (on SSBs, foods with added sugar, or both) and subsidies, also report that these fiscal policies reduce the consumption and purchase of the targeted foods and beverages significantly. Furthermore, both report that changes in intake are price-sensitive, meaning that higher taxes lead to greater reductions in consumption, and conversely, that higher subsidies lead to greater increases in consumption [39, 40].

6 Marketing restriction policies

6.1. Definition of subject-specific terms

Marketing: Any form of commercial communication, message, or action that acts to advertise or otherwise promote a product or service, or its related brand, and is designed to increase, or has the effect of increasing, the recognition, appeal, and/or consumption of products or services [103].

Advertising: One form of marketing that covers the paid public presentation and promotion of ideas, goods, or services by a sponsor that intends to bring a product to the attention of consumers through a variety of media channels, such as broadcasts, cable television, radio, print, billboards, the internet, or personal contact [104].

Branding: A marketing feature that provides a name or symbol that legally identifies a company, a single product, or a product line to differentiate it from other companies and products in the marketplace [104].

Digital marketing: Marketing delivered through a digital medium that seeks to maximise impact through creative and/or analytical methods. Examples of this are, e.g., 'influencers' popular among children, such as YouTube 'vloggers' (video bloggers), online games and virtual environments [104].

Exposure: The reach and frequency of the marketing message. Reach is the percentage of people in a target market who are exposed to the campaign over a specific period, and frequency is a measure of how many times the average person is exposed to the marketing message [104].

Marketing power: The extent to which the message achieves its communication objectives through its content and the strategies used [104].

Marketing techniques: Reflect the power of marketing, e.g., the use of cartoons, celebrities, influencers, brand mascots, brand marketing, packaging, product placement, and other techniques that children are vulnerable to.

Marketing channels: The physical and digital levels that marketing is displayed at, such as TV, films, advertisements, billboards, outdoor marketing, social media, and advergames.

6.2. Background: The harmful health effects of marketing of unhealthy products

A comprehensive body of evidence shows that marketing of foods and non-alcoholic beverages affects children and adolescents negatively on various health and behavioural parameters, underlining the importance of marketing restrictions. Evidence from several systematic reviews and meta-analyses shows that marketing of foods and non-alcoholic beverages significantly affects intake, food choices, and preferences regardless of marketing channel [105]. Marketing through different channels like TV, film commercials, the internet, social media, and advergames influences food intake [105-111], food choices [105, 109, 111] and ‚preferences [105, 107], and the recollection of products [110] among children and adolescents.

Evidence also shows that marketing techniques such as the use of cartoons [112], celebrities/influencers [110, 111, 113], or popular media characters [114] particularly influence children's and adolescents' preferences and intake of such products. The negative effects of food and non-alcoholic beverage marketing on children's health behaviours are much more well-established in the literature than the same effects on adults, emphasising how children are particularly susceptible to this type of marketing [105].

It is also important to note that children's and adolescents' media use has increasingly moved from classic media platforms to social media platforms, such as TikTok, Snapchat, Reddit, and YouTube, and from linear TV to streaming, making it even more important to apply restrictions on these platforms [6, 115-117].

It is therefore crucial to keep in mind that the harmful and negative health effects of marketing towards children act across a broad range of media channels and by different techniques particularly aimed at children and adolescents.

The next section covers the results of the NCU-CAPOC umbrella review and grey literature searches on the effects of marketing restriction policies as a way of contributing to the prevention of childhood overweight and obesity.

6.3. Search results

A total of seven systematic reviews [118-124] were included in the NCU-CAPOC umbrella review, and these were supplemented with 14 grey literature publications [52, 87, 91, 103, 104, 125-133]. A depiction of the selection of relevant articles for the umbrella review is shown in Figure 3.

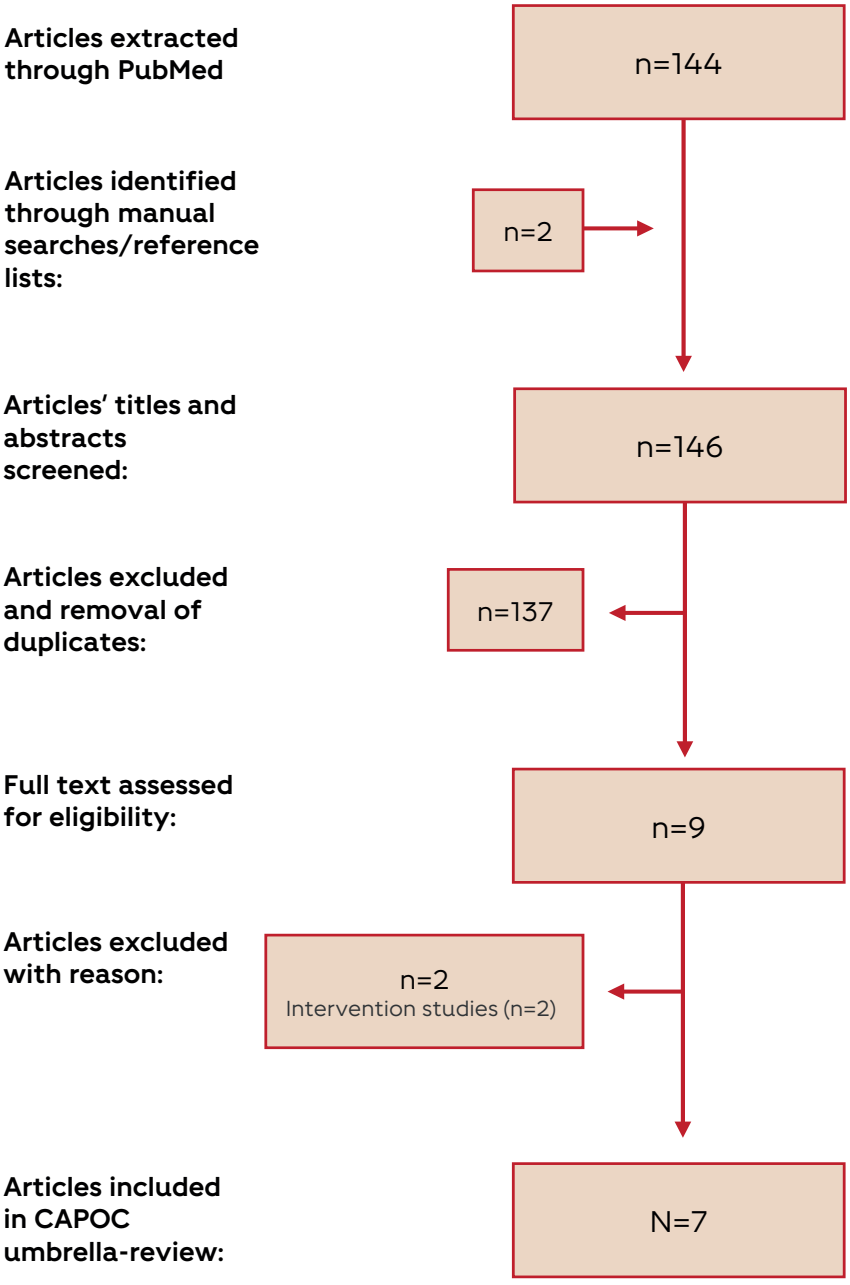


Fig. 3: Flowchart for the selection of relevant studies pertaining to the marketing section

Two of the systematic reviews included in the umbrella review were rated as having moderate quality [118, 124] and five were rated as having critically low quality [119-123].

The systematic reviews encompass observational studies, such as natural experiments, quasi-experimental or cross-sectional studies [118, 119, 121-124], one RCT [120], and two reviews also encompass simulation studies and experimental studies [122, 123]. The number of studies included in the reviews ranged from 3 to 44.

The studies included in the systematic reviews stem primarily from high-income countries, such as the United States, the United Kingdom, Canada, Australia, Sweden, Norway, Denmark, Austria, Singapore, South Korea, and Spain, and some originate in middle-income countries, such as Greece, Portugal, Brazil, Chile, Mexico, Philippines, while a few are from low-income countries, such as Jamaica, Honduras, and Guatemala.

All included reviews aimed to measure the effectiveness of policies imposing marketing restrictions on foods and/or non-alcoholic beverages, focusing on exposure, health, or economic outcomes, but only five reviews [118, 119, 122-124] cover these types of studies.

Although Pérez-Ferrer et al. [121] and Pereira et al. [120] searched for policy evaluations, they did not find any peer-reviewed studies focusing on such, and Chung et al. [119] only found one study reporting on the effectiveness of a marketing restriction policy in Chile. These reviews systematically investigated the potential health and economic impacts of implementing a government-led policy that restricts unhealthy food advertising in outdoor spaces/public assets, but only reported on the extent and prevalence of this type of advertising. Instead, these three reviews include studies that report either on the prevalence of marketing among children and adolescents, or associations between marketing exposure and health outcomes, such as obesity levels/rates, dietary behaviour, consumption, or marketing extent/use among children.

6.4. Results for policy effectiveness

In this section, results of the CAPOC umbrella review, supplemented by findings from the grey literature, are presented under three sub-headings: a) effects of marketing restrictions on health, exposure, and at the industry level b) effective mandatory marketing restrictions, and c) legal framework for policy implementation.

a. Effects of marketing restrictions on health, exposure, and the industry level

The NCU-CAPOC umbrella review identified one systematic review that examines the effects of marketing restrictions on health behaviour outcomes, exposure, and at the industry level, namely that of Boyland et al. [118]. Five comparisons were made between any kind of marketing policy, mandatory policies (fully implemented and partially implemented), voluntary policies, no policies, and no policies at all. The authors also identified six desirable outcomes that could be positively affected: exposure, power, purchasing/sales, dietary intake, reformulation, and unintended consequences favouring public health.

Overall, Boyland et al. [118] report that evidence is low for exposure, power, dietary intake, and reformulation change outcomes, and no conclusions are drawn regarding these parameters. However, for outcomes such as purchasing and unintended consequences favouring public health, the evidence is strong enough to suggest that:

- any food marketing policy may result in reduced food purchasing
- any food marketing policy may result in unintended consequences favourable to public health, such as less expenditure on marketing from the in dustry (meaning less advertising).

Furthermore, the authors report positive results on reduced exposure, power, purchasing, dietary intake, and unintended consequences if marketing restriction policies are mandatory. This finding is elaborated under Subheading B on effective mandatory marketing restrictions.

Evidence gathered from several grey literature publications suggests that marketing restrictions reduce purchases and perhaps consumption/intake of the unhealthy products that the marketing restrictions are applied to [52, 91, 103]. Furthermore, an OCED evaluation [87] found that restrictions can impact both children and adolescents, but also the industry. Restrictions implemented in South Korea in 2010 led to a decrease in the total budget for television advertising of energy-dense, nutrient-poor (EDNP) foods by 31%, a reduction from 9.6 million USD to 6.6 million USD. This decrease was reported as an effect of restricting TV advertising of EDNP foods between 5 p.m. and 7 p.m. and during commercial breaks of children's programmes. However, the total budget for non-EDNP foods increased by 17%, so that the total spent on food advertising increased [87]. WHO [103] also pinpoints that mandatory restrictions/bans can lead to decreased marketing expenditure by the industry.

Cost-effectiveness of marketing restrictions

One review [122] investigated whether social marketing and media interventions are cost-effective and found that all three included studies demonstrate economic benefits. One original study found that a national restriction on food and beverage television advertising to children in Australia has an estimated health benefit (changes in BMI) at a cost-effectiveness ratio of 3.7 Australian dollars per Disability-Adjusted Life Year (DALY), and the total savings amount to 37,000 DALYs.

Two grey literature publications also report marketing bans and restrictions to be cost-effective [91, 129]. For example, future marketing restrictions in the UK were modelled[e] to be cost-effective within a 25-year appraisal period when health benefits were appraised over a 100-year period. The findings emphasise that the total implementation costs (e.g., transition costs and lost revenue) of 1) a total ban of online advertising of HFSS products and 2) a 9 p.m. watershed for the online advertising of HFSS products are smaller than its total benefits (e.g., QUALYs, social care savings, health benefits, etc.). For the first policy option, the total cost is estimated at 4.724 £m with a total benefit of 7.772 £m, while the total cost

[e] These modellings were based on data such as the total size of online marketing in 2019; estimates of the food, drink, and restaurant advertising market; estimates of the total size of the HFSS advertising market; estimates of the total number of impacts from HFSS adverts, and estimates on the number of child HFSS impacts.

of the second option is estimated at 4.507 £m with a total benefit of 6.717 £m. In comparison, not implementing mandatory restrictions is cost-free, but no health-benefits would be achieved [129].

b. Effective mandatory marketing restrictions

The literature gathered through the NCU-CAPOC umbrella review, and the supplemental grey literature also describes different characteristics that make marketing restrictions the most effective on health behaviour outcomes, exposure, and at the industry level.

Mandatory vs. voluntary measures

Three systematic reviews report that mandatory restriction policies have greater health effects among children and reduce marketing exposure more than voluntary and self-regulatory actions. Voluntary measures are reported to have no, few, or undesirable effects [118, 123, 124].

Boyland et al. [118] found that mandatory policies are associated with a greater proportion of desirable effects on five outcomes (marketing exposure, marketing power, purchasing, dietary intake, and unintended consequences) compared to a lack of policies. Furthermore, voluntary measures are associated with more undesirable effects than desirable effects on three outcomes (marketing exposure, marketing power, and product change) when compared to a lack of policies in the area altogether. Additionally, the review found that mandatory policies had more desirable effects on purchasing outcomes compared to voluntary measures but showed mixed results for marketing exposure and power. Thus, the evidence suggests that mandatory policies are more effective and yield more desirable outcomes than voluntary measures.

Chambers et al. [123] also concluded that statutory regulation has the highest potential to reduce the volume of and children's exposure to advertising of HFSS foods compared to self-regulatory actions. The authors further concluded that the effectiveness of self-regu-

latory actions in reducing children's exposure to marketing varies considerably depending on the source of the conducted studies. All seven studies in the review that were conducted by the industry found that self-regulation has desirable outcomes in reducing marketing exposure and expenditure. Meanwhile most studies (11 out of 18) conducted by academics/governments/advocacy groups found that self-regulation did not have desirable impacts on the volume of, exposure to, and expenditure on advertising for HFSS foods. However, seven studies found that self-regulation had positive effects on most of these outcomes. Hence, the authors point to a need for more evidence and independent evaluations of industry self-regulation initiatives.

Galbraith-Emami et al. [124] also conclude that voluntary codes, e.g., among the industry, may not reduce children's exposure to advertising sufficiently. They find only low or no improvement in reducing marketing exposure over time following the introduction of both statutory and voluntary marketing restrictions. However, they point out that the evidence regarding statutory restrictions/bans in South Korea, Quebec, and the UK is stronger compared to voluntary measures. Despite the potential benefits of statutory restrictions and bans, the authors note that mandatory regulation could be strengthened by including all advertising channels and media, a clear definition of marketing that should encompass all food companies and ensuring effective enforcement and high penalties for violators. Galbraith-Emami et al. also included grey literature and found that industry-sponsored reports identify very strong evidence for a positive effect of voluntary measures, but other reports and peer-reviewed studies do not support this conclusion. They suggest that this inconsistency can be a result of different measurements and outcomes.

The same is supported by the grey literature publications included here. All publications recommend mandatory restrictions and report that mandatory restrictions are more effective than voluntary measures [103, 104, 125-128, 130, 133]. Furthermore, voluntary measures, such as self-regulation at the national level and the 'EU pledge' by the industry, are reported to have little to no impact on reducing marketing exposure and are currently failing to restrict

marketing. Complaints of violations of voluntary measures are often not accepted and very seldom lead to consequences for the industry.

These publications further highlight that voluntary measures focus on marketing that *targets children* rather than marketing that children are exposed to, while they should focus on the latter [104, 126, 132, 133]. This is well illustrated in a new study evaluating marketing restrictions on HFSS products in Chile. The study shows that a time-based ban on advertising between 6 a.m. and 10 p.m. lead to a 77% drop in advertising during programmes attracting children, whereas restrictions on advertisements targeting children under 14 years only lead to a 29% decrease in programmes attracting children. This evaluation underlines that both means have a positive effect in reducing children's exposure, but broader marketing restrictions that not only focus on advertising aimed directly at children manage to decrease the amount of advertising children are exposed to much more effectively [134].

Age group

Boyland et al. [118] conducted age sub-analyses and report that policies designed to include children and adolescents older than 12 years have more desirable effects regarding outcomes on both marketing exposure and power. Aligned with this finding, all grey literature publications highlight the importance of including all children and adolescents, up to 18 years of age, since restrictions directed at children under 12 years of age are less effective [103, 104, 127, 128, 130, 133].

Nutrient profile

Boyland et al. [118] also demonstrate a greater desirable impact on marketing exposure if policies follow a government-led nutrient profile model, compared to a company-led nutrient profile model. This is supported by some of the grey literature publications, which further argue that such a model will help clearly define which foods and beverages are covered by marketing restrictions [103, 127, 130, 133].

Scope

Boyland et al. [118] also found that policies addressing TV and packaging have more desirable effects on marketing exposure and power compared to policies addressing digital marketing. However, all evaluated policies that address digital marketing are voluntary measures. Furthermore, existing mandatory policies on digital marketing are more recently introduced, and some delay may be expected before their effect can be documented.

The grey literature also highlights that the criteria and definitions of what counts as marketing are too narrow in existing voluntary measures, and thereby insufficient [87, 103, 104, 125, 126, 128, 133]. Across all publications, it is underlined that *restrictions should* cover *all strategies and channels, including digital channels*, that marketing exists in, be comprehensive and include a broad set of communication channels, since existing measures are too narrow [104, 126-128, 130-133].

c. Legal framework for policy implementation

The United Nations Convention on the Rights of the Child (UNCRC) is highlighted in the grey literature as a feasible legal approach for implementing mandatory restrictions to protect children from the harmful impact of food marketing, as it emphasises that protecting children from harmful marketing is a human right issue – the right to health, privacy, and information [104, 126, 127, 130, 133]. Furthermore, it is stressed that restriction policies must be enforced more effectively than current measures [127, 128, 130] by an independent agency [130]. The World Cancer Research Fund International [104] also reports that international or regional approaches to regulation are needed to approach challenges caused by cross-border marketing and the lack of regulation of the digital space.

6.5. Conclusion

From a total of seven systematic reviews and 14 grey publications, it can be concluded that the evidence on marketing restriction policies, especially mandatory marketing restrictions on digital media, is thus far very limited. No effects on weight outcomes are reported yet.

Current evidence suggests marketing restrictions can decrease purchasing of unhealthy foods and, in some cases, marketing exposure among children. Furthermore, some evidence suggests that marketing expenditure by the food industry will be reduced due to marketing restrictions/bans, and some studies report that marketing restrictions are cost-effective.

So far, there is a limited number of studies on the effects of policies restricting the marketing of unhealthy foods and beverages. However, the existing evidence clearly concludes that marketing of unhealthy foods and beverages leads to harmful effects on children's intake, food choices, and preferences for these types of products, which underlines the need for restriction policies.

Evidence further shows that voluntary measures, such as industry codes, either have little or no effect on health outcomes and marketing exposure. For marketing restriction policies to yield the greatest health effects among children and reduce marketing exposure, measures therefore need to be:

- mandatory
- covering all children under the age of 18
- covering all media channels and strategies
- based on a government-led nutrient profile
- and cover the marketing that children are exposed to, and not just the marketing that is directly aimed at children.

Finally, findings from the grey literature emphasise the United Nations Convention on the Rights of the Child as a legal framework that can be used to promote mandatory marketing restrictions.

7 Food and beverage labelling

7.1. Definition of subject-specific terms

Food labelling: Presents information such as ingredients, nutritional value, and quality on a food product. The labelling can take the form of a tag, brand, mark, picture, claim, or any descriptive matter, such as written, printed, stencilled, marked, embossed, or impressed on, or attached to or nearby a container of food or food product [135].

Back-of-pack labelling (BOP): Labelling on the back of the packaging of a food product. In 2016, EU made it mandatory to present a nutrient declaration on food products. This labelling must contain information on energy value, amount of fat, saturates, carbohydrates, sugars, protein, and salt [136].

Front-of-pack nutrition labelling (FOPNL): A simplified labelling on the front of the package of a food product aiming to help consumers with their food choices. FOPNL is currently not mandatory in the EU [137].

7.2. Background: Labelling information and health choices

Food and beverage products can contain a broad range of visual and informative front-of-pack cues. Informational cues can be labels, tables, and written information that can enhance health literacy and inspire conscious food and beverage choices [138].

Due to a lack of existing labelling initiatives, evidence from previous umbrella reviews is conflicting and uncertain regarding the effects of labelling initiatives on various health and health behaviour outcomes, such as food product selection, purchases, consumption, and BMI [39, 40, 139].

Existing literature also highlights that the effectiveness of labels depends on consumers' understanding and interpretation of the labelling [140]. Some evidence suggests that simple labelling, such as traffic-light labels, is the most effective in influencing health behaviour

outcomes [138, 140]. However, a general lack of understanding of nutrition label terms [141-143], as well as serving and portion sizes, are highlighted in the literature [144].

Evidence of the effect on children of front-of-pack visual and informational cues is very limited. Evidence does indicate that both children and adolescents are more receptive to visual cues, e.g., marketing. However, the impact of informational cues, such as labelling, is predominantly studied among adults [138]. Three original studies [145-147] examine the influence of labelling on children and their parents, with only one study [145] showing that labelling affects children's choices, demonstrating the weak and unclear evidence in this area. As for effects on adults' food behaviour, results are mixed and inconsistent [138].

Thus, current evidence regarding the effectiveness of nutrition information on labels is unclear and mixed. However, existing literature emphasises the importance of the labelling design and individual health literacy for consumers to interpret, understand, and potentially use labels as a guide towards making healthier food choices.

The next section covers results from the NCU-CAPOC umbrella review and grey literature searches on the effects of food labelling initiatives as a way of contributing to the prevention of childhood overweight and obesity.

7.3. Search results

A total of 13 systematic reviews [120, 148-159], six of which included meta-analyses [149, 151, 152, 155-157], were included in the CAPOC umbrella review, which was supplemented with 16 grey literature publications [87, 91, 93, 160-172]. A depiction of the selection of relevant articles for the umbrella review can be seen in Figure 4.

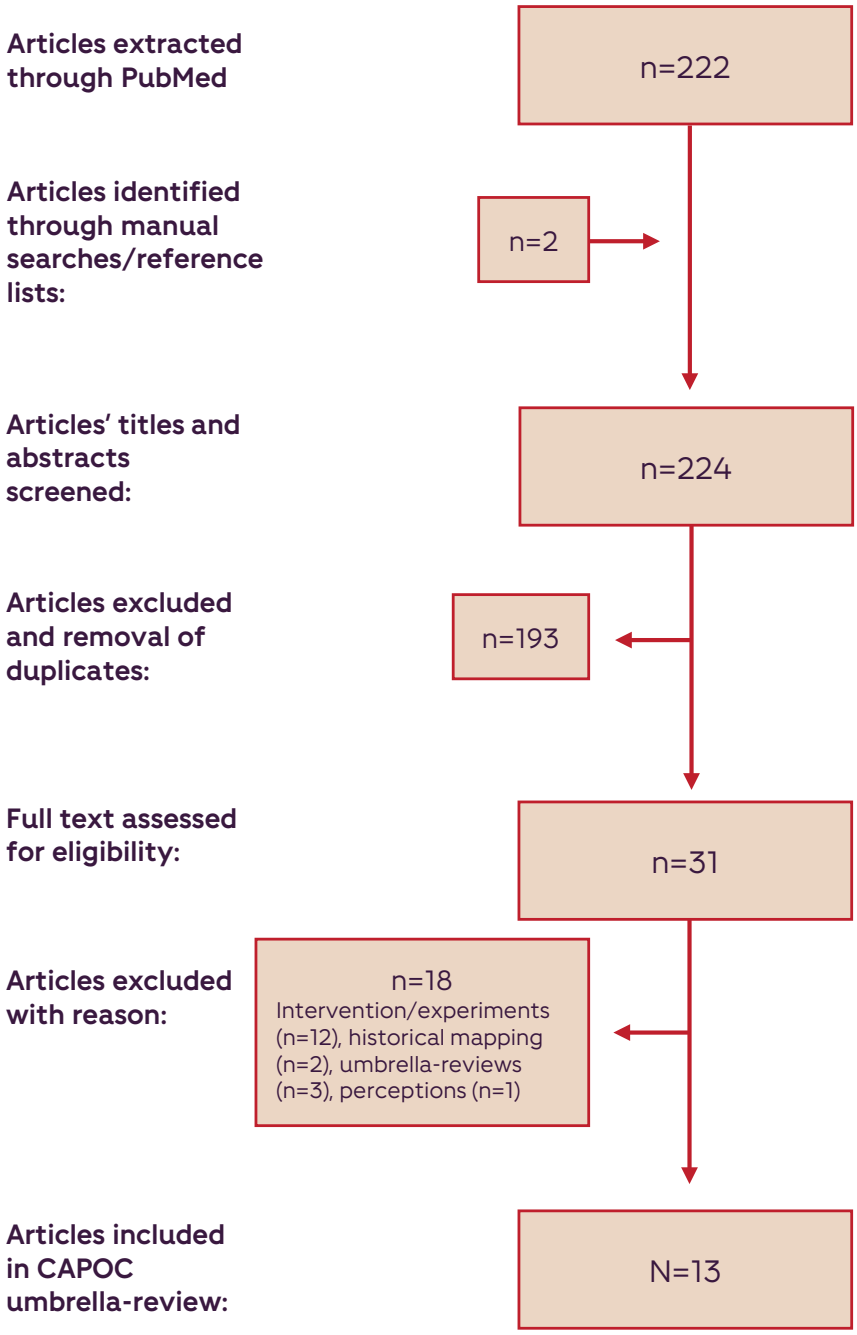


Fig. 4: Flowchart of the selection of relevant studies pertaining to the labelling section

One of the systematic reviews was rated as high quality [151], one as moderate [150], seven rated as low quality [148, 149, 152-155, 159], and four as critically low quality [120, 156-158].

The included reviews encompass a broad range of study designs, such as experimental and modelling studies like random controlled trials, laboratory studies, and simulation studies (n=10) [120, 148, 149, 151-156, 159]. Furthermore, all included reviews (n=13) contain observational studi-

es, like natural experiments, quasi-experimental studies, surveys, and pre- and post-policy implementation comparisons with study designs like interrupted time series, longitudinal studies, cross-sectional studies, cohort studies, and prospective studies [120, 148-159]. The number of studies included in the reviews range from 4 to 59.

The data in the included reviews stem primarily from high-income countries (n=13 reviews), and most of the included studies are from the United States, the United Kingdom, Canada, and Australia/New Zealand. Much data come from areas in the US, such as New York City, Philadelphia, and King County, Washington, where legislation requires chain restaurants to post calorie information on menus. Only one review [149] includes studies from upper-middle income countries, e.g., Brazil and Uruguay. Thus, none of the data is from lower-middle and low-income countries. 10 reviews include studies conducted among both children, adolescents, and adults, or the general population [148-156, 158, 159]. One review is based on adults only [120], and three reviews also include sales data [150, 157, 159].

Studies on the effects of a broad range of labelling types include analyses of the effectiveness of different types of food labelling on packages or menus displaying nutrition content, such as front-of-pack traffic lights, numeric labels, warning signs, tailored front-of pack labelling, menu-board calorie labelling, energy menu labelling, and Guideline Daily Amount (GDA). The effects of these labelling types are examined in relation to effects on food choice, purchase intentions, dietary intake/consumption, purchases, body mass index (BMI), and overweight/obesity. Two reviews examine the effect of labelling on sugar-sweetened beverages (SSBs) exclusively, measuring effects through outcomes such as sales, product selection, or purchase of SSBs [149, 150].

7.4. Results for policy effectiveness

In this section, results of the CAPOC umbrella review, supplemented by findings from the grey literature, are presented in four sections: a) health intentions, awareness, and health behaviour, b) anthropometry, and c) industry level. A summary of the characteristics of an effective labelling initiative is presented at the end (Section D).

a. Effects of food and beverage labelling on health intentions, awareness, and health behaviour

Health intentions and awareness

Purchase intentions and awareness

Two reviews [149, 153] examine the effect of labelling on awareness (n=1) or purchase intentions (n=2). Sarink et al. [153] find a positive effect for awareness, and both reviews find mixed results for purchase intentions [149, 153].

A systematic review reports mixed results in a meta-analysis and in original studies on the effect of SSB warning labels on purchase intentions [149]. Two out of five studies report that SSB labels reduce purchase intentions, one reports no effects, and two report some effects but not for all warning labels. Sarink et al. [153] investigate the effect of menu energy labelling on self-reported use and intended purchase among groups with low socioeconomic status and report mixed results. Two of the original studies included found that consumers visiting fast food chain outlets in low-income neighbourhoods in New York City self-report that calorie labels influence their choices towards buying fewer calories (9% among adolescents and 12% among adults), but a similar study found no significant differences in self-reported use of calorie labels.

All studies included in the Sarink et al. review show an increase in awareness among groups with low socioeconomic status following the introduction of menu energy labelling policies. For example, an increase in awareness was registered among both adolescents (from 0% to 58%) and adults (from 16% to 54%) in New York City after the introduction of mandatory energy menu labelling in chain restaurants.

Aligned with these findings, the grey literature highlights strong evidence of that nutrition labelling can influence consumers' awareness of healthy food options [91].

Food choice

Three reviews examine the effect of labelling on food and beverage choices (stated choice and not actual purchase), and all find positive effects, meaning that labelling either reduced the odds of choosing SSBs or increased odds of choosing healthier food products [149, 151, 156]. In a meta-analysis, An et al. [149] find that, compared to a no-label control group, an SSB warning label is associated with reduced odds of choosing SSBs (OR=0.49, CI95% 0.41 to 0.56). Across label categories (graphic with health effects: OR=0.34; text of health effect: OR=0.47; graphic nutrient profile: OR=0.58; or symbol with health effect: OR=0.67), graphics with health effect labels showed the largest impact on reduced odds of choosing SSBs.

Another meta-analysis [151] finds that traffic light systems that include three tiers significantly increased the selection of healthier green (+1.9%) and mid-level food options (+0.4%). Furthermore, it was found that two-tier traffic light systems significantly affect the selection of healthier options (+6.1%, n=16 estimates), but not of unhealthy options. The results of another meta-analysis [156] also indicate that food labelling increases the amount of people that select a healthier food product by about 17.95% (CI95%=11.24 to 24.66%). Three categories of food labelling are examined (traffic light, GDA, and other labelling types), and there is a positive significant effect of all three categories, with the traffic light being the most effective labelling scheme. The labels increase the number of people choosing a healthier option by 29.36 %, 11.85%, and 14.69%, respectively.

Health behaviour

A common conclusion in all grey literature publications is that there is a considerable lack of evidence regarding the effects of front-of-pack-nutrition labelling (FOPNL) schemes on real-life purchasing, consumption, and other health outcomes. These publications highlight a need for more evidence that is not solely based on laboratory, experimental, and modelling studies [91, 160, 161, 163, 164, 166, 168].

Purchases/sales

Eight reviews examine the effect of labelling on actual purchases/sales [148, 150, 152-154, 157-159]: two report positive effects [150, 152], five report mixed results [148, 153, 154, 157, 158], and one review reports null effects [159].

In a systematic review [150] based on eight studies, the authors report that there is moderate-certainty evidence that traffic-light labelling is associated with decreased SSB sales. Furthermore, the authors report low-certainty evidence for an association between nutritional rating score labelling and decreasing sales of SSBs, while evidence for the effect of menu board labelling on SSB sales varied. On the other hand, a meta-analysis [152] based on three studies reports a significant reduction (47 kcal) of energy purchased from energy labelling on menus in restaurants (MD 46.72 kcal, CI95% -78.35 to -15.10, n=1.877 respondents). The analysis assumes that if an average menu contains 600 kcal, energy labelling on menus will reduce the energy per purchased meal by 7.8% (CI95% 2.5% to 13.1%). However, the authors note that the quality of the studies included in the meta-analysis is deemed low, making the results uncertain.

The grey literature also suggests a small beneficial effect of FOPNL on 'on-the-spot' purchasing [161]. However, the effect of FOPNL is estimated to be substantially smaller in real life compared to laboratory settings.

Although evidence is limited, some positive results are found on purchases in countries that have implemented FOPNL schemes, such as Chile [160, 166, 167, 170]. Chile has implemented a mandatory nutrient-specific FOPNL warning system along with marketing restrictions, as a part of their Food Labelling and Advertising Law, implemented in 2016. In 2018, compliance with the labelling system was 80%. Furthermore, evaluations show significant reductions in purchases of products with warning labels for calories (23.8%), sodium (36.7%), saturated fats (15.7%), and sugars (26.7%) from 2015-2017 [160]. Purchases of 'high-in' beverages (high levels of nutrients of concern, i.e., sugars, sodium, saturated fat, or energy) decreased by 22.8 mL

per capita per day after the regulation was implemented [170].

Besides Chile's legislation on food labelling and advertising, SSB taxes were also introduced in Latin America (2015 in Chile), and purchase regulations imposed in schools, emphasising that effects cannot be attributed to one policy initiative alone. Hence, several of the grey literature publications also highlight that mandatory FOPNL systems should be accompanied by other policies (such as marketing restrictions), as seen in Chile, because reductions in purchases were greater after the introduction of several policies, compared to those observed from single policies in other countries [87, 160, 165-167, 170].

However, mixed results are reported for purchases in most of the systematic reviews (five out of eight) except for one that reports no significant results [159]. In a systematic review by Sacco et al. [154], no significant results are reported either, except for the studies conducted in school cafeterias. Aligned with this, Nikolaou et al. [157] find mixed results on calories purchased. In three out of seven studies, significant reductions are found (ranging from -38.1 to 12.4 kcal). However, results from their meta-analysis show no overall effect on purchases among consumers who noticed the calorie labelling. A third review by Mayne et al. [158] did not find any impact on food purchasing based on six studies assessing the impact soon after implementation (1-9 months). However, in two studies assessing the impact at least one year post implementation, results show a decrease in calories purchased and an increase in the purchase of foods and beverages with high nutritional quality.

Atanasova et al. [148] also report no general effect of information labels (e.g., menu calorie labelling, FOP traffic light, numeric and warning signs) on purchases, except for three studies where information was displayed either through a warning sign, a tailored front of pack labelling or a health-prime (a recipe flyer covering health and diet-related words). The review by Sarink et al. [153] also mainly reports null results on purchases since the introduction of the menu board legislation in NYC and the labelling legislation in King County, except for one study reporting significant decreases in calories purchased at coffee chains.

The mixed evidence is also highlighted in the grey literature on menu labelling. Again, it is emphasised that evidence from real-world settings is limited, but three publications suggest that menu labelling can lead to healthier purchases in some settings [87, 91, 163, 172]. The European Heart Network [93] reports that evidence on menu calorie labelling from real-life settings is mixed, but some evidence shows that the calorie content of the chosen meals is reduced. Furthermore, evidence shows that menu labelling might be more effective in certain settings (e.g., full-service restaurants, cafes, and sandwich shops) and among specific groups of individuals (e.g., children and adolescents) [154, 173, 174].

Consumption/dietary intake

Six reviews examine the effect of labelling on dietary intake/consumption [120, 151, 153, 155, 156, 159], and two find positive effects [151, 155], two find mixed results [120, 153], and two find null effects [156, 159].

In a meta-analysis, Shangguan et al. [151] find that food labelling reduces dietary intake of certain nutrients, such as total energy and total fat. Results from the meta-analysis show that food labelling decreases energy intake by 6.6% (CI95% -8.8% to -4.4%, n=31 studies), total fat by 10.6% (CI95% -17.7% to -3.5%, n=13 studies), and other unhealthy dietary options by 13% (CI95% -25.7% to -0.2%, n=16 studies), while increasing vegetable consumption by 13.5% (CI95% 2.4% to 24.6%, n=5 studies). Littlewood et al. [155] also find positive effects of menu labelling in their meta-analysis on energy consumption and energy ordered. Based on all types of studies, a meta-analysis was done for energy consumption, and results showed an overall effect of menu labelling with a mean reduction of 419.50 kJ (CI95% -613.25 to -225.76, p<0,001). A meta-analysis was also made for energy ordered, only among studies conducted in real-world settings, showing that menu labelling decreases energy ordered by a mean of 325.66 kJ (CI95% -508.60 to -142.71 kJ, p=0.0005, n=5 studies).

The grey literature concludes that there is too little evidence from real-life studies to evaluate the impact of FOPNL on dietary intake. Nevertheless, evidence from experimental and

modelling studies suggests that FOPNL, especially evaluative schemes, can reduce the consumption of energy and nutrients such as saturated fatty acids, sugars, and sodium, while increasing the consumption of protein and dietary fibre [161]. For example, an evaluation of the traffic light label in Ecuador shows that people consume fewer products with 'high' labels (high in fat, salt, and/or sugar) and more often choose products with 'medium' or 'low' labels [166, 167]. Overall, the World Health Organization [168] and the European Commission [91] emphasise a lack of evaluations on the dietary impact of FOPL, and that current evidence is still mixed and limited.

This is also highlighted by the findings of the CAPOC umbrella review. In a systematic review by Pereira et al. [120], the authors include findings from another systematic review by Anastasiou et al. [175] on the effect of food labelling on dietary intake. Anastasiou et al. [175] report that food labelling may affect consumers' dietary intake, but that the evidence is insufficient. The results from Sarink et al. [153] are, however, limited and mixed. Meanwhile, one of the studies included finds a significant increase in calories purchased since the introduction of a mandatory menu energy labelling policy in NYC (increase of 32 calories compared to 14 in control city, Newark). Another study based on the same data find no change in the energy content of the meals purchased by adults visiting stores in low-income neighbourhoods. However, the differences can be explained by the fact that the 2011 study uses a sub-sample of the original sample. Finally, a third original study also do not find any changes in the calorie content of lunchtime purchases in low-income neighbourhoods of NYC.

Furthermore, two reviews report no significant results on consumption [156, 159], and even though Cechinni et al. [156] report that food labelling can potentially decrease calorie intake/choice by 3.59%, the results of their meta-analysis are not statistically significant, and thus mostly account for null effects.

b. Effects of food and beverage labelling on anthropometry

Weight

Two reviews examine the effects of labelling on weight [148, 151]. Only one original study in the review by Atanasnova et al. [148], examine the effect of labelling and BMI and report a significant decrease in BMI among 145 adults after an 'intervention' consisting of 14-month shelf labelling exposure in local stores. The other review, Shangguan et al. [151], could not perform a meta-analysis on adiposity and metabolic risk factors because the included studies reporting on these outcomes were too few and very heterogeneous. Thus, evidence included in the CAPOC umbrella review on the effectiveness of labelling on weight is very limited.

The European Commission [91] also highlights that knowledge of nutritional information and awareness do not always influence consumer choice and, in the end, anthropometry. However, the European Commission concludes that there is suggestive (albeit limited) evidence linking food labelling to changes in BMI [91].

c. Effects of food and beverage labelling on industry level

Reformulation

One review (n=6) [151] evaluates the effects of labelling on industry responses and finds desirable effects on the reformulation of food products. Results from the meta-analysis show that food labelling reduce the content of sodium by 8.9% (CI95% -17.3% to -0.6 %, n=4 studies) and trans-fat by 64.3% (CI95% -91.1% to -37.5%, n=3 studies).

Six grey literature publications also address the effects of FOPNL on the reformulation of food and beverage products. While all these publications acknowledge the limited availability of real-life data, they also report potential benefits on reformulation resulting from the evaluation of already existing FOPNL measures [93, 161, 164, 166-168].

FOPNL has the potential to drive the reformulation of products in the direction of a more

nutritious food supply and improved nutritional content [161]. Studies from both New Zealand and Australia find that manufacturers are reformulating selected products in response to the FOPNL Health Star Rating system. In New Zealand, it is observed that products such as cereals, breakfast drinks, convenience foods, sauces, and spreads, are reformulated to some extent. This is also seen in Australia, where the average energy density of food products carrying this type of labelling is lower than before [164, 167].

Furthermore, evaluations of the warning labels implemented in Chile also reveal results suggestive of product reformulation [166]. Evaluations of the voluntary Choices Logo in the Netherlands demonstrate that the labelling system results in the reformulation of existing products and the development of new products with healthier compositions. Soups are the most frequently reformulated category that carry the logo, and the highest level of new product development is observed in the snack category. Sodium is the most adjusted ingredient across various product groups, and dietary fibre is significantly higher in new products compared to reference products in these categories [166, 168].

The World Health Organization [168] also reports that studies conducted among representatives from the food industry show that the Choices logo and the Keyhole logo had influenced product development, and nutrient criteria for the logos is mentioned as a relevant consideration for product development by the manufacturers.

In alignment with the evidence concerning FOPNL, evidence also suggests that mandatory menu labelling can encourage restaurants to reformulate their menus by offering more lower-calorie options [87].

d. Characteristics of an effective labelling initiative

While there is limited evidence on the link between FOPNL and real-life behaviour and anthropometric outcomes, some of the grey literature publications (n=8) explore which types or characteristics of different labelling initiatives are preferred and most well-understood by the population [87, 91, 93, 160-162, 167, 171].

An interpretive front-of-pack-nutrition label

All evidence suggest that an interpretive FOPNL system, when compared to a non-interpretive system[f] , is the most favourable approach for ensuring the best consumer understanding of nutritional content and declarations across all subgroups [87, 91, 93, 160-162, 167, 171]. When a front-of-pack label (FOPL) is compared to a back-of-pack label, it is found that an FOPL is easier to understand by consumers [143, 156]. For FOPLs to be most well-understood, evidence also indicates that simple, evaluative, directive, and colour-coded labels are more effective compared to complex, reductive, and monochrome labels [87, 91, 93, 161, 162, 167, 171].

Additionally, evidence from the European Union [161] suggests that consumers from groups of lower socioeconomic status tend to prefer simple, evaluative, and directive labels, which have the greatest potential to assist both children and people from lower socioeconomic groups in making healthier choices. Here, traffic lights and the Nutri-Score schemes are highlighted as particularly effective in increasing healthier choices among consumers of lower socioeconomic status.

Mandatory versus voluntary labelling

Six of the grey literature publications discuss the advantages of implementing mandatory FOPNL schemes compared to voluntary labelling schemes [87, 160, 161, 164, 165, 169]. Three publications highlight that mandatory labels ensure better adoption rates and compliance among the industry [160, 164, 165]. Here, it is reported that when a label is voluntarily and contains negative information about products, e.g., summary indicators, the industry tends to use the labelling scheme selectively.

An example of this is the voluntary Health Star system in Australia/New Zealand. In 2018, it was reported that only 31% of the eligible products displayed the label, and only certain product categories, such as convenience foods, cereals, fruit, and vegetables, displayed the label. This inconsistency with respect to certain product categories underscores how manufacturers are applying the voluntary labelling scheme unevenly and selectively [160, 164].

[f] An interpretive FOPNL system is a system that refers to the actual or relative healthiness of a food or beverage product. Interpretive systems can be visualized by using graphics, symbols, and colours. In contrast, a non-interpretive system provides nutritional information without indicating how the nutrition content relates to a healthy/unhealthy diet.

Meanwhile, the European Union [161] reports that evidence on the health effects of voluntary claims is mixed and find an overall tendency for voluntary claims and marketing images to interfere with the effectiveness of FOPNL. Experiences from other countries also suggest that mandatory FOPNL regulations could have more significant health effects. The mandatory labelling system in Chile is highlighted as having greater compliance among the industry and health effects on consumers' purchase and consumption [87, 160, 165].

Finally, the European Union [161] reports that mandatory labelling is viewed as more beneficial in terms of what consumers understand, trust, and prefer, while voluntary schemes are sometimes found to be confusing and difficult to interpret [169].

7.5. Conclusion

From a total of 13 systematic reviews, including six meta-analyses, and 16 grey literature publications, it can be concluded that current evidence on implemented labelling policies is limited to a few positive results highlighted through experiences from individual countries. Existing evidence on anthropometric outcomes, such as weight, is currently too limited to draw conclusions. Overall, there is also a need for additional systematic evidence of the effects of, e.g., front-of-pack nutrition labelling (FOPNL) and menu labelling on real-life consumption, purchases, sales, and dietary quality, for both children and families with children.

Existing evidence is more consistent regarding the positive effects of FOPNL on increased consumer awareness, and it is found that FOPNL is the easiest label type to understand for all socioeconomic groups, compared to a standard back-of-pack label. This emphasises that FOPNL can contribute to consumers health literacy and lead to more well-informed food and beverage choices. Furthermore, existing evidence suggests that manufacturers are aware when new labelling initiatives are implemented, and that some products are reformulated into healthier nutrient compositions. Evidence shows that FOPNL has a higher impact, is understood most correctly, and found most trustworthy by the population when it is designed as an interpretive, simple, colour-coded, and evaluative label. Most importantly,

it must be implemented through legislation, as it ensures higher compliance, and preferably be combined with other policies, such as marketing restrictions and taxes, to enhance possible health effects.

8 School Health

8.1. Definition of subject-specific terms

Free fruit and vegetable scheme: The provision of free fruit and/or vegetables during the school day.

Nutrition standards: A set of standards aiming to improve the nutritional quality. These standards can, e.g., inform and determine which food and beverage products that are offered and served at schools in general or in school meals.

Active transport: Transportation forms that replaces still transportation such as driving a car or taking the bus or metro. Active transport can be, e.g., walking or bicycling.

8.2. Background: Schools as an arena for overweight and obesity prevention among children

When children begin school, typically around the age of 5-6 years, they spend most of their weekdays in school until they finish primary school. Subsequently, the majority continue in some form of youth education. School is therefore a unique setting for preventing overweight and obesity.

Current literature suggests that certain policies within schools are beneficial to children's health, economic, and socioeconomic outcomes [40, 176]. In a historical study examining the long-term benefits of a universal school lunch policy (free school lunches introduced in all primary schools in Sweden between 1959-1969), the authors conclude that the school lunch programme generates substantial long-term benefits such as higher lifetime income, reduced socioeconomic inequalities in adulthood, increased number of years of schooling, increased number of pupils attending university, and increased height in adulthood [176]. Other school food environment policies are also reported to have beneficial effects on reducing the intake and availability of sugar-sweetened beverages, as well as increasing the

availability of water [40].

Furthermore, evidence shows that both positive and negative health effects can be found depending on the food and physical activity/movement environment surrounding schools and school children [177-181]. The built surroundings, the availability of healthy and unhealthy foods and beverages, the amount of time dedicated to nutrition education, physical activity education and movement, and the existence of gym facilities in schools are all examples of environmental influences associated with overweight or obesity among children. School nurses are also highlighted as a central resource for improving different health parameters of school children, but evidence regarding effects on anthropometric outcomes is mixed [182, 183].

Overall, the evidence highlights the school as a central period and environment where health policies can be effective in leading to health benefits among school children. The next section covers results from the NCU-CAPOC umbrella review and grey literature searches on the effects of school health policies as a way of contributing to the prevention of childhood overweight and obesity.

8.3. Search results

A total of 21 systematic reviews [120, 122, 184-202], four of which included meta-analyses [186, 187, 189, 198], were included in the CAPOC umbrella review, which was supplemented with 21 grey literature publications [25, 87, 91, 203-220]. A depiction of the selection of relevant articles for the CAPOC umbrella review can be seen in Figure 5.

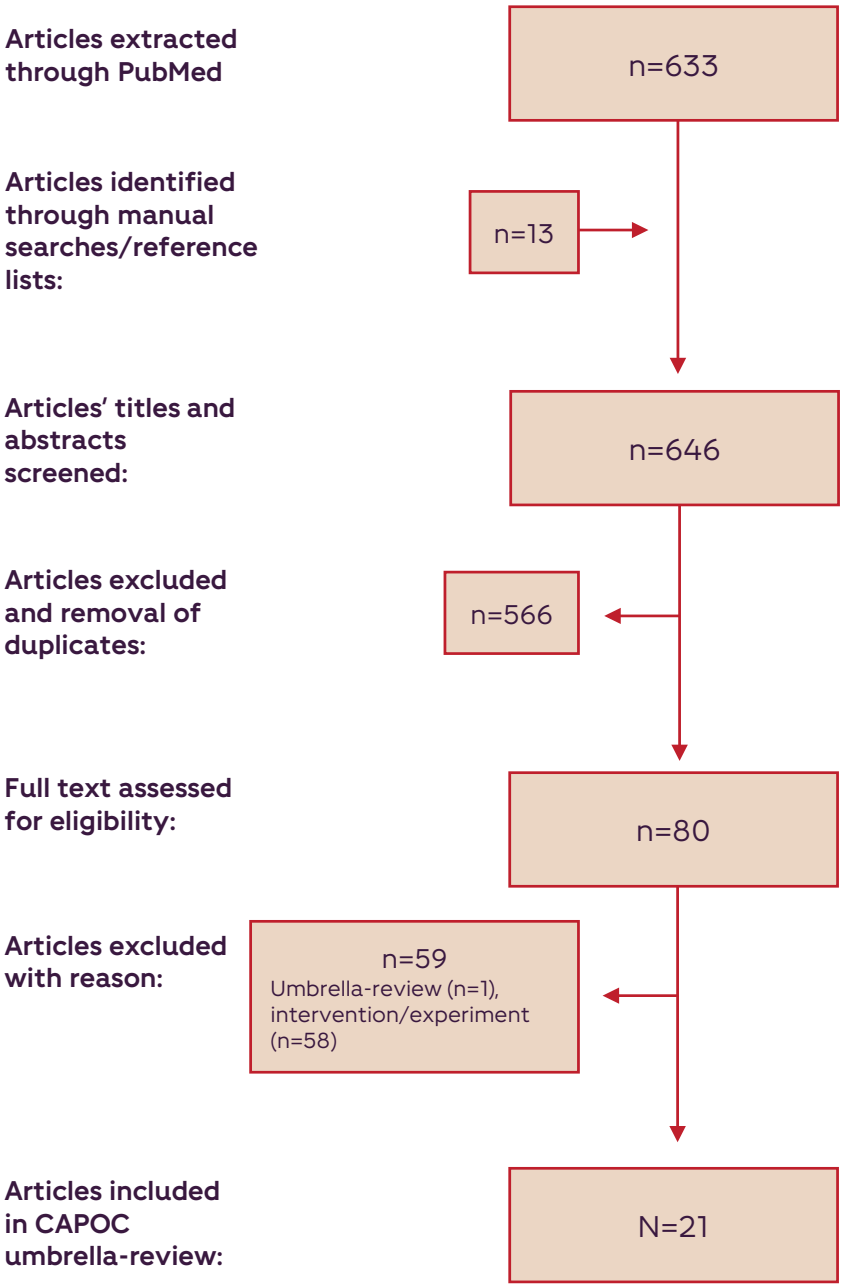


Fig. 5: Flowchart of the selection of relevant studies pertaining to the school health section

Two systematic reviews were rated as having high quality [186, 189], seven as moderate quality [187, 188, 190-192, 195, 199], five were rated low [193, 196-198, 200], and seven systematic reviews were rated as having critically low quality [120, 122, 184, 185, 194, 201, 202].

The included reviews encompass a broad range of study designs ranging from experimental to modelling studies, including random controlled trials, cluster randomised controlled trials, laboratory studies, simulation studies, quasi-experimental studies, and non-controlled

trials (n=15) [122, 185-187, 189, 191-193, 195, 196, 198-202]. Furthermore, most included studies (n=18) contain observational studies like natural experiments, quasi-natural experiments, observational cluster studies, surveys, comparisons between pre- and post-policy implementation, with study designs like longitudinal studies, cross-sectional studies, cohort studies and prospective studies [120, 184, 186-198, 200-202]. One review also includes qualitative interviews with school stakeholders [187].

The number of original studies included in the reviews range from 1 to 91, and sample sizes range from 48 to 1,065,562 participants. In 16 out of 21 reviews, not all included studies were relevant, either because they investigate more topics/settings than school policies alone, or because the reviews include both intervention and policy studies, whereas only policy studies are included in this umbrella review [120, 122, 184-188, 190-194, 196, 199, 200, 202].

The data in the included reviews stem primarily from high-income countries, such as the United States, the United Kingdom, France, Denmark, Norway, the Netherlands, Canada, Ireland, Germany, New Zealand, Australia, Spain, Italy, Sweden, Switzerland, and South Korea (n=20 reviews), whereas two of the reviews [120, 199] are based on local data from states in the United States (Pennsylvania and Delaware). Some data (n=3 reviews) stem from middle-income countries, such as China, Tonga, Mexico, India, and Brazil. None of the included studies are based on data from low-income countries. Information about country of origin of the included studies is not reported in one review, not even in the supplemental file [122].

The reviews are all based on data regarding children between 0-18 years of age. All reviews (n=21) examine effects on school-aged children and adolescents [120, 122, 184-202], and three reviews also examine the perspectives of adult stakeholders, e.g., school nurses, school employees, and parents [187, 192, 193]. One review focuses on disadvantaged children [192].

The type of school policies examined varies greatly between reviews, encompassing either nutrition policies, physical activity/physical education policies, or both. 16 reviews include

studies that examine different types of nutrition policies, such as free fruit and vegetable schemes, universal school-food programmes (breakfast and lunch), nutrition standards for school meals, guidelines for the availability of unhealthy food, beverages sold inside or nearby schools, provision of healthful foods/beverages, or competitive food/beverage standards [120, 122, 184, 185, 187-191, 194, 196-198, 200-202]. Six reviews include studies that examine the effect of physical activity/physical education policies, e.g., incorporating physical activity into physical education class time, promotion of physical activity outside PE classes, active transportation to school, increasing the amount of and access to physical activity equipment, physical activity in the curriculum, or meeting national guidelines for physical activity [122, 185, 187, 188, 193, 198]. Two reviews also include studies that examine the effect of a broader legislation/strategy focused on combatting obesity among children and containing both nutrition and physical activity elements [191, 199].

The effects of different school policies are investigated in relation to the health of school children and adolescents. However, these outcomes vary and cover both anthropometric outcomes (e.g., body weight, BMI, BMIz, adiposity, overweight/obesity), health behaviour (e.g., physical activity, dietary intake, consumption, selection/preference, purchasing, use of physical activity facilities), and availability of unhealthy/healthy foods/beverages. Finally, two reviews examine the cost-benefit and/or cost-effectiveness of school policies [122, 185].

8.4. Results for policy effectiveness

In general, many of the included reviews lack a detailed descriptions of the contents of the examined school policies. Some authors also note this problem, and that data is missing from the original studies. However, only two reviews are so limited in the descriptions on the included policies that they only describe the included policies as 'school-based', 'multi-component', 'organisational', or 'community and school based', without any more information on the specific elements [186, 192]. Furthermore, the reviews differ as to whether they report on the effectiveness of one type of school policy, or whether different types of school policies are grouped in the reviews.

Due to this heterogeneity, we chose to pool all relevant original studies included in the reviews and perform a narrative analysis. The narrative analysis includes 157 original studies. 12 sub-themes were identified, and these were further grouped under three main headings, focusing on school policies aimed at either improving diet or improving physical activity levels and multicomponent policies that included both a diet and a physical activity component.

Sub-themes identified for policies aimed at improving diet include:

- Fruit and vegetables policy/programmes (free/subsidised/increased availability)
- School meals (breakfast and lunch)
- Provision of healthy foods and beverages (FB), limiting access to unhealthy FB, or competitive food laws
- Nutrition standards/guidelines
- Multicomponent nutrition policy (including several nutrition components)
- Unspecified/broader nutrition policy

Sub-themes identified for policies aimed at improving physical activity/physical education (PA/PE) include:

- Standards/guidelines/policies for PE classes/PA in the curriculum/during the school day
- Provision of increased PA opportunities/environmental changes within and near schools
- Active transport
- Multicomponent PA/PE policy (including several PA/PE components)
- Unspecified/broader PA/PE policies

Since the contents of multicomponent policies that both include a diet and a PA/PE component are so heterogeneous, all relevant studies were grouped under the broader category 'multicomponent policies'.

Results for each policy are presented in relation to either direct or by-proxy health outcomes, including consumption, purchase/sales, nutritional quality, physical activity behaviour, anthropometry, cost-effectiveness, and environmental change. An overview of the categorisation of the results can be seen in Appendix A8.

In this section, results of the CAPOC umbrella review, supplemented by findings from the grey literature, are presented in three sections regarding a) school policies aimed at improving diet, b) school policies aimed at improving physical activity levels or physical education, and c) multicomponent school policies that include both a diet and a physical activity/education component.

a. School policies aimed at improving diet

Fruit and vegetable policies/programmes

26 studies report on the effects of fruit and vegetable (FV) policies/programmes (free, subsidised, or increased availability). Seven studies describe the effects of the Norwegian free fruit and vegetables policy, and the remainder describe policies such as the UK fresh fruit and vegetable programme, fruit truck shops, and other types of policies aimed at increasing fruit and vegetable consumption through free or subsidised provision of either fruit and/or vegetables to school children.

Most studies (n=22) report effects on consumption, and 17 of them report significant positive results on fruit and vegetable consumption, four report mixed results, and one study reports non-significant findings. This suggests that free fruit and vegetable programmes are beneficial towards increasing school children's fruit and vegetable consumption. One study reports mixed effects on purchase/sales, and one study reports a positive significant change on anthropometric outcomes (lower BMIz and BMI percentile). One study reports mixed results (non-significant BMI change for boys and girls overall, and significantly lower BMI for certain groups of girls). One study reports that two national interventions to promote fruit and vegetables are cost-effective.

The European Commission [219] also identifies free distribution of fruit and vegetables and the subscription to fruit and vegetables programmes as effective policy actions to improve health among school pupils. Based on the results of a systematic literature search, these actions are reported as statistically significant measures to increase fruit and vegetable consumption among 3–18-year-old children. Furthermore, increasing the variety, choice, and attractiveness of fruit and vegetables along with increasing the fruit and vegetable content of meals is also reported to increase fruit and vegetable intake among 3–18 year-olds [219].

The Norwegian Directorate of Health [217] also examines the socioeconomic effects of a free fruit and vegetable programme for all grades in elementary schools in Norway. It reports that this initiative can lead to an extra 100,000-250,000 quality-adjusted life years (QALYs). This underlines that economically, a free fruit and vegetable supply in schools can be financially more beneficial than treating future overweight- and obesity-related consequences.

Universal school meals

15 studies report on the effects of universal school meals (breakfast and lunch), such as The National School Lunch Program and School Breakfast Program in the US. Four studies measured consumption, and all report significant positive changes, such as improvement of breakfast habits and overall food intake. Most studies (n=12) report anthropometric outcomes (BMI, mean BMI-SDS, prevalence/probability of overweight/obesity), with two studies reporting significant positive changes, one study reporting significant negative changes, two reporting mixed findings, and seven studies reporting non-significant findings.

Some of the grey literature also covers the effects of free/subsidised school meals [203, 207, 209, 217, 219], and three publications cover evidence regarding other types of school nutrition policies [209, 213, 215].

Two publications report beneficial effects on dietary consumption among school children. The Norwegian Institute of Public Health [203] reports an overall positive effect of free school

meals on outcomes such as participation in school meals and diet. Furthermore, universal free school meals are reported to reduce social differences in diet, depending on the quality and content of the school meal and participation rates. The European Commission [207] also reports that evidence on school meal programmes shows a potential impact on dietary consumption, such as decreased consumption of calories among students, in the short term. However, the authors note that evidence is limited regarding general and long-term changes in dietary intake. Besides positive effects on diet, free school meals have positive effects on learning, school absence, and weight development (no development/less overweight) among school children [203]. However, evidence on the effects on weight development, academic performance, learning, and school absence is more uncertain than on the effects on participation and diet. The Danish Health Authority [209] also reports that mandatory breakfast programmes are successful in keeping students enrolled in vocational schools, as these programmes strengthen social bonds.

Even though evidence is limited on the long-term effects of free school meals, the European Commission [207] reports results from an original study that investigates the long-term impact of the Swedish free school meal programme. The results show significant benefits, such as greater lifetime earnings, longer educational attainment, and increased height. However, no effects are reported on the risk of being overweight/obese, cognitive skills, lifestyle changes, or the likelihood of health shocks (morbidity and mortality). Furthermore, limited, although promising, evidence is reported to suggest that school meals can contribute to the elimination of household food insecurity.

Improved/limited provision of healthy/unhealthy foods and beverages and competitive food laws

44 studies report on the effect of policies that include either the provision of healthy foods and beverages (FB) or limiting the access to unhealthy FB, including competitive food laws. Policies covered include, e.g., the provision of healthy foods, elimination of sales and availability of SSBs and junk food, the reduction of portion sizes, district and state school com-

petitive food and beverage policies, and changes to the availability of beverages in vending machines.

Most studies (n=23) report on the consumption of healthy/unhealthy FB, eight of which report significant positive results on consumption, either reflecting an increase in the consumption of healthy products or a reduction in the consumption of unhealthy products. 10 studies report mixed findings on consumption, and five studies report non-significant results. Two of the mixed results derive from pooled results from a meta-analysis [189] where competitive FB standards are reported to significantly reduce the intake of SSBs and unhealthy snacks, but no effect is reported on total calories (pooled results, n=29 studies). The meta-analysis (n=39 studies) also shows that a direct provision of healthy FB (mainly fruit and vegetables) increases the consumption of fruits and combined fruit and vegetable intake, with a slight increase in vegetable intake, but no effect is reported on total calories consumed.

Five studies report a significant positive effect caused by this type of policy, which is reflected as an increase in purchases/sales of healthy products or a reduction of purchases/sales of unhealthy products, and five studies report mixed results. One study reports that the nutritional quality of the food served is improved (lower energy density).

Mixed results are reported on anthropometry (BMI, BMI percentile, BMIz score, % of overweight/obese) with six studies reporting significant positive effects, one study reporting a significant negative effect, four studies reporting mixed results, and three studies reporting non-significant results. Furthermore, this policy type is also reported to cause positive environmental changes in 11 studies, with two studies reporting mixed results. The positive results on environmental changes cover, e.g., a greater access and availability of healthy foods and/or beverages.

Some of the grey literature publications also support the conclusion that policy actions

should include the promotion of healthy eating habits by increasing the availability of fruit and vegetables and other healthier FB alternatives [25, 91, 208, 212]. Furthermore, it is recommended to ban certain unhealthy products or forms of retail (e.g., vending machines) that promote an unhealthy diet along with the marketing of HFSS products within and around schools [25, 212, 214, 220]. (See Section 6 for results on marketing restriction policies).

Nutrition standards/guidelines

15 studies report on the effect of nutrition standards/guidelines. These cover, e.g., nutrition guidelines on and standards for all foods served in schools, guidelines on increasing the availability of healthy foods and beverages, and guidelines on limiting the fat and saturated fat content in the foods served.

Most studies (n=10) measure food consumption, with three studies reporting significant positive results, one study reporting mixed findings, and six studies reporting non-significant findings. The mixed results stem from a meta-analysis [189] where school meal standards (mainly for lunches) increased fruit consumption and reduced total fat, saturated fat, and sodium content, but had no effect on total calories consumed (pooled results, n=39 studies). One study reports significant positive results on purchases/sales, and one study reports a significant positive impact on nutritional quality (lower energy, carbohydrate sugar, fat, saturated fat, sodium, vitamin C, folate and more protein, fibre, vitamin A, and calcium in foods provided in schools), while two studies report non-significant findings.

One study reports mixed findings for anthropometric measures, and one study reports that nutrition standards for school meals and all foods and beverages sold in schools are cost-effective. Lastly, one study reports mixed findings on environmental changes.

Some of the grey literature publications also support implementing nutrition standards for school meals and beverages available at school, and restricting access to HFSS products [91, 212, 220]. Furthermore, several organisations report that school nutrition policies (e.g., the imple-

mentation of nutrition standards for the production and availability of food and beverages in schools) as well as price interventions (e.g., price reductions on healthy foods) are effective in improving dietary behaviour and achieving an adequate energy intake among school children [209, 213, 215]. Also, it is highlighted that school nutrition policies must be implemented and aligned with national dietary guidelines [208, 214].

Multicomponent nutrition policies

13 studies report on the effect of multicomponent nutrition policies, covering policies that include several nutrition components. These components include, e.g., nutrition education, provision of healthy food and beverages in vending machines, modifications of school food services, reduced portion sizes, provision of free fruits, and ensuring that foods and beverages sold meet nutritional standards.

Most studies (n=9) measured consumption, with six reporting significant positive results, two reporting mixed findings, and one study reporting non-significant findings. One study reports significant positive results on purchases/sales, and three studies measured anthropometric outcomes (BMIz score, % of overweight/obesity), with one study reporting mixed results and two studies reporting non-significant findings. Finally, one study reports positive findings on environmental changes (increased overall servings of fruit and vegetables per student per day).

Unspecified/broader nutrition policies

44 studies focused on unspecified and broader nutrition policies, e.g., The Healthy, Hunger-Free Kids Act in the US, school wellness policies, and school nutrition policies.

The majority (n=29) of studies measured food consumption, with 20 studies reporting a significant positive effect, two studies reporting a significant negative effect, three reporting mixed results, and four studies reporting non-significant findings. Three studies measured anthropometric outcomes (BMI-SDS, overweight/obesity), with two studies reporting mixed

findings and one study reporting non-significant findings. Lastly, four studies report positive environmental changes, and 12 report no environmental changes (e.g., majority of unmet nutrition standards).

b. School policies aimed at improving physical activity (PA) or physical education (PE)

Standards/guidelines for physical education classes and physical activity as part of the school curriculum and/or the school day

27 studies analysed the effects of policies covering standards/guidelines for PE classes/PA as part of the school curriculum and/or the school day. These policies cover, e.g., minimum requirements for physical activity during the school day, physical activity across the curriculum, or modifications of the existing PE curriculum. Only one study reports on the consumption of total fat, saturated fat, carbohydrates, protein, fibre, and total calories with non-significant results. Seven studies report the effects on physical activity behaviour, such as number of steps, moderate to vigorous physical activities (MVPA), and physical activity level. Two studies have significant positive findings, one reports mixed findings, and four studies report non-significant findings. Most studies (n=20) measure anthropometric outcomes (BMI, BMI-SDS, BMIz score, BMI percentile, % of overweight/obese), with three studies reporting significant positive findings, six studies reporting mixed findings, and 11 studies reporting non-significant findings. One study reports that a policy of physical education in public elementary schools and ≥ 50 % of PE class time allocated to moderate and vigorous physical activity is cost-effective. Lastly, one study reports positive environmental changes, reflected as a modified physical education program.

Some of the grey literature also supports implementing a mandatory minimum time allotted for physical education (incl. physical activity and movement) during the school day, securing compliance [205, 210], and introducing standards for frequency, time, and physical activity content during recess [204, 205]. Furthermore, it is highlighted that regulating the quality of physical education as part of the formal curriculum, e.g., setting standards for PE

teachers [204, 205], as well as embedding an active classroom through the school curriculum [204], are recommended policy actions for increasing physical activity.

Increasing physical activity opportunities and environmental changes

Only four studies report on the effect of policies that provide increased physical activity opportunities or environmental changes within and near schools. These policies cover the renovation of school grounds, the local construction of a neighbourhood park, a national sporting playground initiative (UK), and the provision of access to buildings after school hours. One study reports a non-significant finding on physical activity behaviour, and one study reports mixed findings on anthropometry (BMIz). Two studies report positive environmental changes, reflected as a significant positive change on the overall utilisation of school yards in one study, and the opening of schools for a community walking programme in another study. Hence, evidence for the effects of this type of policy is scarce.

Aligned with this, a grey literature publication from the Policy Evaluation Network [205] also recommends providing access to physical activity spaces in the school environment as an effective policy option based on current evidence.

Active transport

Two studies about active transport school policies are included in the CAPOC umbrella review. These cover a walking bus scheme and a national programme for active transportation (walking) to school. One study reports significant positive effects on physical activity behaviour, such as walking and more physical activity, and the other reports mixed findings on anthropometry (BMI). The national programme is reported not to be cost-effective.

The World Health Organization [204] also highlights creating and enhancing opportunities for active travel to and from school as an effective way to increase physical activity levels among school children.

Multicomponent physical activity/physical education policies

17 studies report on the effects of multicomponent PA/PE policies, covering policies that include several PA/PE components. These components include requirements of PA/PE in schools, enhancement of the school environment and opportunities for PA/PE, PA breaks, sports clubs, and enhancement of infrastructure to support active transport.

Two out of seven studies report significant positive physical activity behaviour effects in the form of an increase in steps per day and higher odds of participating in organised sports. Two studies report mixed findings on physical activity behaviour, and three report non-significant findings. Most studies (n=11) report effects on anthropometric measures (BMI, BMIz score, waist and hip circumference, odds of obesity) with three studies reporting significant positive effects, one reporting significant negative effects, one reporting mixed findings, and six studies reporting non-significant findings. Seven studies report positive environmental changes, namely changes to playgrounds, walking trails, class walks, and active breaks, and two studies report mixed results on environmental changes.

Unspecified/broader physical activity/physical education policies

Unspecified and broader PA/PE policies were analysed in 12 studies. The studies report the effects of promoting physical activity outside of PE classes, the promotion of a physical activity and obesity policies, national sports and physical education guidelines, and physical activity after school. Eight studies analyse physical activity behaviour, with three studies reporting significant positive effects, one study reporting significant negative effects, one study reporting mixed results, and three studies reporting non-significant findings. 10 studies report on anthropometric measures, with two studies reporting significant positive findings, one study reporting mixed findings, and seven studies reporting non-significant findings. One study reports that a national programme on physical activity after school is cost-effective.

Benefits of promoting physical activity in schools

Overall, the grey literature on policy actions supporting physical activity in schools reports that physical activity in schools has positive effects on both educational, social, well-being and health outcomes [204-206, 210, 218]. The World Health Organization [204] reports beneficial effects on both educational and social outcomes, such as better cognitive function, concentration, attention, memory, planning, and social skills. Evidence also shows that school activities promoting children's physical activity have a positive effect on health, school performance, and well-being [218].

Overall, there is strong evidence suggesting that physical exercise, sports classes, free play, class-integrated movement, and active transport have positive effects on school children's health [206]. Furthermore, some of the grey literature puts forward generic evidence-based recommendations on the promotion of physical activity to, in, and from schools, promoting, e.g., active play, active transport, active recess, and active classrooms as policy options [25, 204, 208, 212].

c. Multicomponent school policies - including both a diet and physical activity/physical education component

106 studies cover multicomponent policies that include both a diet and a physical activity/physical education component, a comprehensive school health approach, a variety of diet and physical activity policies, PE sessions and nutrition education, nutrition education and gardening programs, and school wellness policies.

22 studies report consumption outcomes (e.g., fruit and vegetable intake), with four studies showing significant positive results, eight studies reporting mixed results, and 10 studies obtaining non-significant findings. One study reports significant positive results on purchases/sales. 24 studies report physical activity behaviour outcomes, with nine studies showing significant positive effects, such as, e.g., lower sedentary behaviour, higher levels of physical activity in schools, and increases in PACER test performances. Three studies report mixed

findings for physical activity behaviour, and 12 studies report non-significant findings.

Most of the studies report anthropometric measures (n=86) (BMI, BMIz score, BMI SDS, % of overweight/obesity), with 25 studies showing a significant positive effect (either a decrease in anthropometric outcomes or a lower increase compared to controls). One study reports a significant negative effect on anthropometry, 17 studies report mixed findings, and 43 studies report non-significant findings. Six studies analysed the cost-effectiveness of multi-component policies, and all report the policies to be cost-effective. Lastly, six studies report positive environmental changes, such as increased availability of fruit and vegetables in school cafeterias, and one study reports no changes in school environments.

Seven grey literature publications also cover the evidence on the effects of multicomponent interventions in schools (including both a nutrition and physical activity element) [91, 204, 208, 211, 213, 215, 216]. The World Health Organization [204] recommends assessing children's and adolescents' health in schools using a whole-of-school approach to be most effective. Along these lines, the World Obesity Federation [208] recommends implementing multi-component interventions focusing on both physical activity and diet for greater effectiveness. Furthermore, they suggest including a family/home component since evidence suggests this has a significant effect on weight reduction.

Evidence on multicomponent actions in schools shows positive effects on both school children's consumption behaviour (e.g., increased fruit and vegetable consumption, decreased consumption of unhealthy foods) and physical activity (increased physical activity level), while evidence for anthropometric outcomes is scarcer, with some studies, however, suggesting positive effects [91, 204, 208, 213, 215, 216].

A systematic review by the European Commission [91] reports that overall research suggests that multi-setting, multi-component programmes in schools focusing on nutrition and physical activity, taking place across home and school environments and including an educa-

tional component and environmental changes, are especially effective in driving positive behavioural change (e.g., decreased consumption of unhealthy foods, increased physical activity) and potentially reducing BMI. The Danish Council for Health Promotion and Disease Prevention [213] also reports that complex school initiatives combined with competence development and structural initiatives (e.g., supply, availability, and price), as well as parents' involvement [215], have the greatest effect on school children's health behaviour.

Furthermore, studies combining both educational and environmental components (e.g., reduced price and increased availability of water and fruit) show positive effects on obesity outcomes among adolescent girls in Europe. However, in some studies, environmental changes such as decreasing the availability of some unhealthy food and beverages have had unintended consequences, with school children ending up buying more ice cream as a substitute [215].

Furthermore, some of the grey literature publications recommend allocating sufficient resources to promote school health, both locally and nationally [208], and to put healthy diet, physical activity, and health literacy on the school curriculum, as well as optimising the quality of the existing physical education [204, 208, 214].

Finally, the grey literature publications highlight positive benefits regarding health, economy, and human rights as a result of implementing school-based prevention initiatives overall. Existing evidence shows that school-based prevention initiatives improve eating behaviour among all school children and may have positive effects in terms of either decreased or maintained BMI and/or overweight/obesity prevalence among 6-12 year-olds [25, 208]. Furthermore, the OECD [87] reports that school-based programmes can help prevent the health burden of overweight and obesity by preventing approximately 50,000 cases of cardiovascular diseases and 140,000 cases of type 2 diabetes in OECD countries.

Besides positive health effects among school children, the grey literature also notes that

the health of other people, e.g., school staff, families, and other community members, can be improved, and that school policies can be used as an opportunity for achieving human rights by ensuring the right to adequate food and safeguarding the rights of the child [208, 214].

8.5. Conclusion

Schools are, in general, highlighted as an obvious setting to implement policy actions since every child under 18 years of age spends a significant amount of time in school every day, and previous health initiatives and interventions have shown positive health effects.
A total of 157 original studies extracted from 21 systematic reviews, four of which included meta-analyses, and 21 grey publications were included. The included evidence covers school policies aimed at improving diet, physical activity/physical education and multicomponent policies for improving both. Overall evidence on anthropometric outcomes is either limited or mixed for all types of school policies.

The evidence is most clear on the positive effects of fruit and vegetable programmes/policies in schools and increased consumption of fruit and vegetables. Findings from the grey literature also suggests a positive effect of free school meals, yet evidence is limited regarding long-term effects and effects on weight development. Moreover, overall evidence suggests that nutrition standards, increased availability, and reduced prices of healthy foods and beverages are effective measures to improve school children's diets.

Multicomponent policies, which include both a diet and a physical activity component, have the greatest impact on physical activity levels among school children. Furthermore, evidence from the grey literature suggests that effective policy actions to increase physical activity levels include implementing mandated physical education as part of the formal curriculum, creating school environments that promote active travel, providing access to physical activity during break times, and incorporating more movement into the classroom via the curriculum.

The grey literature further notes that multicomponent policies, which include a diet and

physical activity component, are the most effective in increasing the consumption of healthy food and beverages as well as physical activity levels among school children. These publications underline the importance of incorporating educational, environmental, and family components for these actions to achieve the greatest health effects. Hence, prevention in schools requires a multifaceted approach, spanning local, communal, and national levels.

In conclusion, policy actions that promote both healthier diets and physical activity in schools show positive effects in improving diets and physical activity behaviour, which has the potential to prevent overweight and obesity among children.

9 Availability, accessibility, and affordability

9.1. Definition of subject-specific terms

Availability: refers to the physical presence of healthy food options and opportunities for physical activity within an environment. Examples of this are the physical presence of, e.g., fruit and vegetables within a home, in schools, and in supermarkets; playgrounds in schools, and walking and bicycling trails within a neighbourhood. Vice versa, low availability of these options can hinder the prevention of childhood overweight and obesity, and the same applies to a higher availability of unhealthy food options (e.g., unhealthy foods and beverages provided in school cafeterias or fast food restaurants near schools) and opportunities for sedentary behaviour (e.g., lack of physical spaces that promote physical activity, screen-based education instead of active learning, and neighbourhood infrastructure that promotes driving instead of active transportation), as opposed to the availability of healthy food options and opportunities for physical activity.

Accessibility: refers to the ease with which individuals can obtain and use available resources. It concerns factors such as proximity, convenience, and transportation. It is necessary to ensure not only the physical presence (availability) of healthy food options and opportunities for physical activity, but also provide easy access to these opportunities to be able to incorporate them into daily lives. This can involve factors such as geographical proximity (e.g., short distances to supermarkets with a high presence of healthy food options or short distances within a supermarket to fruit and vegetables) and transportation options (e.g., easy access to public transportation). Furthermore, this concept refers to whether it is generally easy and convenient for an individual to access healthy food options and spaces for physical activity, or whether barriers make it difficult to make use of these opportunities (e.g., the lack of sidewalks or safe walking routes).

Affordability: refers to the financial possibility of obtaining and maintaining a healthy lifestyle. This includes, e.g., the cost of nutritious foods and organised sports. It also concerns whether an individual, regardless of socioeconomic status, can afford healthy food and physical activity options. Furthermore, the concept of affordability also concerns the relative price of healthy food options compared to unhealthy food options, e.g., whether water vs. soft drinks or fruit and vegetables vs. fast food are more affordable for all children and families.

9.2. Background: Three important aspects of preventing childhood overweight and obesity

The concepts of availability, accessibility, and affordability (AAA) are relevant when preventing overweight and obesity among children since dietary habits and physical activity behaviour are not contingent on rational, individual, and free choices alone. Several social and structural aspects influence the possibilities of healthy food choices and physical activity habits among children and their families.

Specifically, the food environment - translated into the availability and access to foods and beverages - has the potential to promote healthy dietary choices when it promotes the availability, accessibility, and affordability of healthy foods. On the other hand, it can have a negative impact if the availability, accessibility, and affordability of unhealthy foods like sugar-sweetened beverages or fast food outweigh that of healthy products. The literature shows that lower density, reduced availability, and lower proximity to unhealthy foods and beverages are associated with a reduction in energy intake and selection of products [39, 148, 221-223]. The opposite counts for healthy foods, and especially a higher availability of fruit and vegetables are associated with a higher consumption of these products [121, 224]. Mixed findings are reported when it comes to the association between the food environment and anthropometric outcomes, since anthropometric outcomes are not regulated by dietary intake alone [39, 121, 223, 225-227].

Furthermore, the literature reports an association between the built environment and increased opportunities for movement, physical activity, play, and active travel, which can promote physical activity among children and adults [139, 228-230]. The literature also highlights the unfavourable effects of socioeconomic vulnerabilities throughout life, including food insecurity and famine exposure, on increased risk of overweight and obesity in adulthood [221, 231]. Finally, evidence suggests that regulation on what is served, sold, and its sizes has positive effects on sales, intake, and availability towards a healthier dietary pattern [39, 232], while evidence of the effects on anthropometric measures is, again, mixed [232, 233].

Thus, these aspects are important to consider when implementing structural initiatives that can support healthier choices and physical activity among children. The next section covers results from the NCU-CAPOC umbrella review and grey literature searches on AAA policies as a way of contributing to the prevention of childhood overweight and obesity.

9.3. Search results

A total of 15 systematic reviews [122, 150, 158, 192, 194, 234-243] were included in the NCU-CAPOC umbrella review, supplemented with 16 grey literature publications [12, 52, 87, 91, 92, 98, 206, 212, 244-251]. A depiction of the selection of relevant articles for the NCU-CAPOC umbrella review can be seen in Figure 6.

Five systematic reviews were rated as having moderate quality [150, 192, 239-241], three rated low [234, 237, 243] and seven rated critically low [122, 158, 194, 235, 236, 238, 242].

The included reviews encompass a broad range of study designs. Most included reviews contain observational studies (n=12), such as natural experiments, quasi-natural experiments, interrupted time-series, controlled before and after case studies, comparisons between pre- and post-policy implementation, with study designs like longitudinal studies, cross-sectional studies, cohort studies, time series comparisons, and prospective studies [122, 150, 158, 194, 234, 236, 237, 239-243]. Seven reviews also include experimental studies like random controlled trials and quasi-experimental studies [122, 150, 158, 192, 240-242]. Two reviews include modelling studies like economic evaluations [235, 238], and one review also includes qualitative studies [236].

The number of relevant studies in the included reviews ranges from 2 to 23. In 13 out of 15 of the reviews, not all included studies are relevant, either because 1) the review investigates more topics/settings than only availability/accessibility/affordability policies, 2) the review includes both intervention and policy studies, whereas only policy studies are included in the NCU-CAPOC umbrella review, or 3) some included studies are grey literature [122, 150, 158, 192, 194, 235, 236, 238-243].

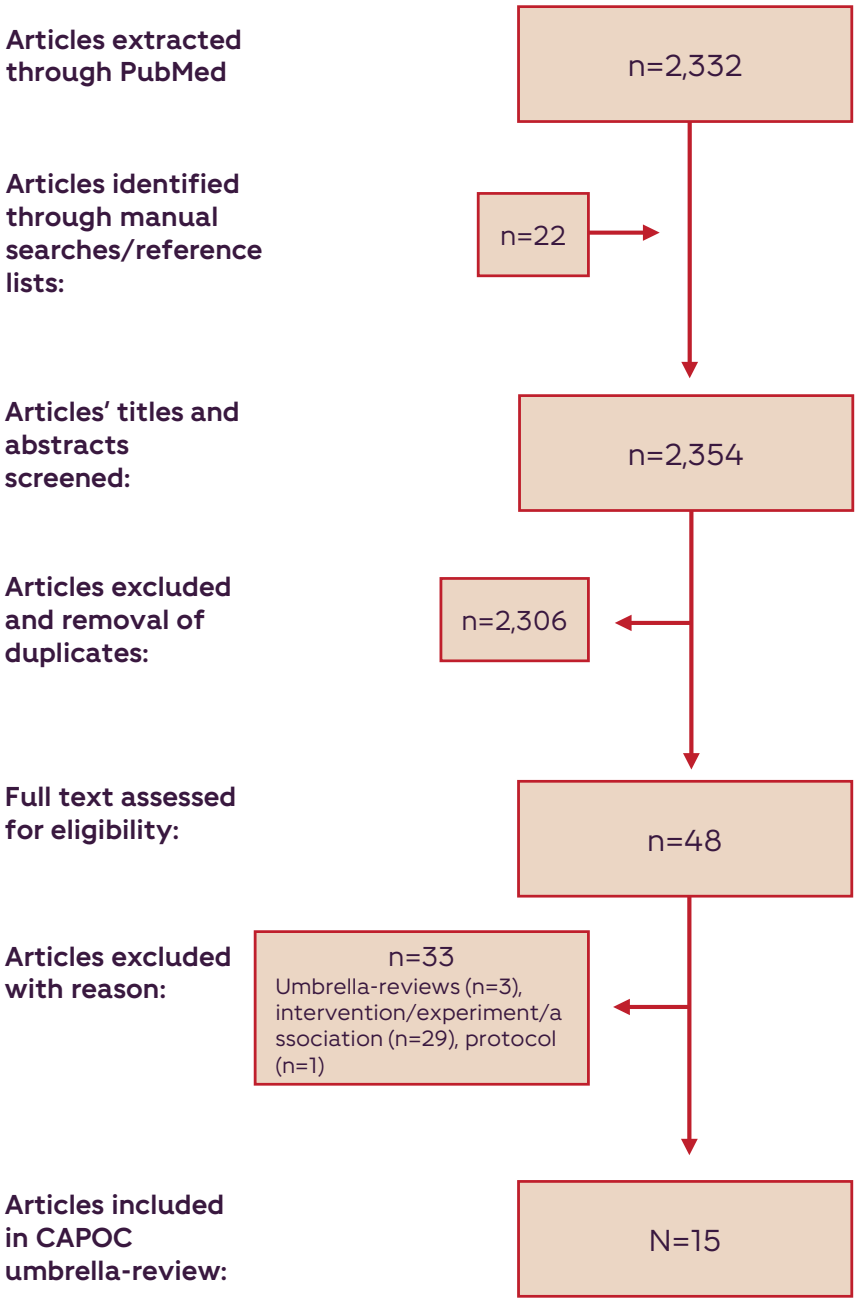


Fig. 6: Flowchart of the selection of relevant studies pertaining to the availability, accessibility, and affordability section

The data in the included reviews stem primarily from high-income countries, such as the United States, the United Kingdom, England, Scotland, New Zealand, Denmark, Ireland, Norway, the Netherlands, Canada, Australia, Sweden, and Chile (n=14 reviews) [150, 158, 192, 194, 234-243]. Some data (n=3 reviews) stem from middle-income countries such as Peru, Mexico, Brazil, and South Africa [194, 234, 241]. Two reviews include data from specific US states and cities such as NYC, LA, Arizona, North Carolina, and Boston [194, 239]. None of the included studies are based

on data from low-income countries. Information about the country of origin of the included studies is not available in one review [122].

The reviews are either based on data for children/adolescents only (n=1) [237], both children and adults (n=9) [150, 158, 192, 194, 234, 235, 238, 242, 243], or only adults (n=4) [236, 239-241]. Sample sizes range from 16 to 275,215 participants. Four reviews do not provide information on sample sizes [122, 235, 238, 242], and McKinnon et al. 2016 [122] do not provide information on the age of the participants.

The type of policies examined varies greatly between the included reviews, which encompass studies on either cash transfer/food benefit programmes (e.g., SNAP, WIC[g]) (n=5 reviews) [122, 150, 234, 237, 241], price incentives for healthy foods and beverages (n=3 reviews) [150, 192, 236], healthy food procurement/food schemes (n=5 reviews) [150, 235, 236, 239, 242], in-store promotions (n=3 reviews) [150, 158, 241], restricting or improving availability of healthy/unhealthy foods and beverages (n=6 reviews) [150, 158, 192, 194, 239, 241], physical activity on referral (n=1 review) [238], multi-component policies, either including both a physical activity and diet component or several of each (n=5 reviews) [122, 192, 238, 240, 241], improvement of walking and bicycling infrastructure (n=3 reviews) [122, 158, 243], and improvement of the built environment and access to increased physical activity equipment, settings, and opportunities (n=3 reviews) [122, 158, 192].

The effect of the different policies is investigated in relation to health in children and adults in all reviews. The health outcomes under investigation vary and cover both anthropometric measures (body weight, BMI, BMIz, adiposity, overweight/obesity), physical activity outcomes, dietary intake, consumption, selection/preference, purchasing behaviour, use of physical activity facilities, and availability of unhealthy/healthy foods/beverages, as well as nutrient composition. Finally, three reviews examine the cost-benefit, cost-utility and/or cost-effectiveness of policies [122, 235, 238].

[g] SNAP refers to the Supplemental Nutrition Assistance Program, and WIC refers to the Special Supplemental Nutrition Program for Women.

9.4. Results for policy effectiveness

In general, the reviews show a great variety of included studies, as well as their content. Due to this heterogeneity, we chose to pool all relevant original studies included in the selected reviews and perform a narrative analysis. The narrative thematic analysis includes 156 original studies.

Nine sub-themes were identified, and these were further grouped under three main headings focusing on policies aimed at either improving diet, improving physical activity levels, and multicomponent policies that included either several diet and/or physical activity components.

Sub-themes identified for policies aimed at improving diet include:

- Cash transfers/food benefit programmes
- Price incentives for healthy foods and beverages
- Healthy food procurement/food schemes
- Restricting or improving availability of unhealthy/healthy foods and beverages
- In-store promotions

Sub-themes identified for policies aimed at improving physical activity levels include:

- Physical activity on referral
- Improvement of walking and bicycling infrastructure
- Improvement of the built environment and access to increased PA equipment, settings, and opportunities

Because the content of the multicomponent policies is so diverse, all relevant studies were grouped under the sub-theme 'multicomponent policies/broader policies'.

Results for each policy type are presented in relation to either direct or by-proxy health outcomes, such as consumption, purchases/sales, nutritional quality, physical activity behaviour, anthropometric measures, availability (of healthy foods and/or beverages or physical

spaces), and measures of health/economic savings. An overview of the categorisation of these results can be seen in Appendix A7.

In this section, the results of the NCU-CAPOC umbrella review, supplemented by findings from the grey literature, are presented in three sections regarding policies aimed at either a) improving diet or b) improving physical activity levels, and c) multicomponent policies.

a. Policies aimed at improving diet

Cash transfers/food benefit programmes

49 studies report the effects of cash transfers/food benefit programmes that aim to improve the consumption and nutritional quality of foods and beverages by making healthier foods and beverages more affordable/accessible. These programmes include, e.g., the Supplemental Nutrition Program (SNAP), the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) in the US, and programmes such as Juntos, Opportunitas and Bolsa Familia in Latin America. Some studies concern programmes that are conditional (you must qualify within certain criteria to be able to join the programme, e.g., by having an income under a certain level), while other programmes are unconditional and available to a larger group of people (e.g., families with children).

Only a few studies (n=3) measure effects on consumption, with two studies reporting significant positive changes (increased consumption of healthy food and fruit and vegetables), and one study reporting significant negative changes (increased SSB intake). One study reports a significant positive increase in purchases of fruit and vegetables among low-income women. Another study reports a significant positive change in the availability of healthy foods/beverages in family homes.

Most studies (n=42) measure anthropometric outcomes (e.g., weight, likelihood/odds of overweight/obesity, odds of treatment of overweight/obesity), with 10 studies reporting significant positive results (e.g., decreases in weight). Two studies report significant negative

results (e.g., increases in weight), 15 report mixed findings, and 15 studies report non-significant results. One study also reports that the SNAP programme is economically beneficial in preventing purchases of SSBs.

Price incentives for healthy foods and beverages and restrictions on price offers on unhealthy products

18 studies evaluate the effect of price incentives for healthy foods and beverages, such as price deductions/discounts on water and low-calorie beverages, the NYC Healthy Bucks programme (containing a benefit transfer for spending at farmers' markets), and food vouchers/grants/price reductions on fruit and vegetables.

Most studies (n=10) report effects on consumption, with four studies showing significant increases in fruit and/or vegetable intake, two reporting mixed results, and four reporting non-significant results. Nine studies measure purchases/sales, with six studies reporting significant increases in purchases/sales of fruit and/or vegetables, two reporting mixed results, and one reporting non-significant results. One study reports no significant changes in nutritional quality.

Three studies measure anthropometric outcomes, with one study reporting significant increases in BMI, and two reporting non-significant results. One study reports a greater availability of healthy foods and beverages in stores. Two modelling studies report that a $0.77 coupon for redeeming against fruit and vegetables and a 20% price reduction on all fruit, vegetables, diet drinks, and water could all save DALYs. Another study reports that a 20% price reduction on fruit and vegetables, diet drink, and water for 24 weeks is not cost-effective.

In the grey literature, six publications also recommend the use of financial incentives on healthy products, including restricting multi-buy offers and other price promotions on unhealthy products, to increase the affordability of healthy foods and decrease the availability of

unhealthy foods and beverages [12, 87, 91, 92, 212, 248]. The results of a systematic review conducted by the European Commission [92] show that financial incentives can affect consumption in both short and medium term, while evidence on long-term effects is limited [87, 92]. The OECD [87] also reports, based on the findings of a systematic review, that price discounts and vouchers can encourage healthier food purchases, increase sales and consumption of fruit, vegetables, and low-fat and low-calorie foods in settings such as supermarkets, universities/schools, markets, and restaurants.

Evidence on the effects of policies that restrict multi-buy offers and other price promotions on unhealthy products, as well as product placement, is currently limited. However, some of the grey literature publications from the UK cover the effects of price promotions (e.g., multi-buys, discounts) on consumption and health, since this is a political focus area in the country, where national restrictions on the matter are planned for implementation in 2025 [98, 244, 245]. The publications show that high-sugar products and less healthy foods are more likely to be promoted than other food and beverage items in the UK. Furthermore, these items are more frequently purchased on price promotions than other items. Even though buying products on promotion may be perceived as cost saving, evidence shows that price promotions make consumers buy more and spend more, thereby increasing the number of less healthy foods and beverages consumed in households [252, 253].

Thus, restrictions on price promotions can be considered a relevant policy tool for the prevention of overweight and obesity. However, evaluations of these policies are not found in the literature included in the NCU-CAPOC umbrella review.

Healthy food procurement/food schemes

26 studies measure the effects of healthy food procurement/food scheme policies that determine which foods are provided, can be purchased, and are available. These have been implemented at workplaces, hospitals, industries, and state and governmental levels. They cover procurements such as the Healthier Catering Commitment, Healthy Beverage

Executive Order for City Agencies in Boston, Choose Health LA, the Healthier Oils Initiative, the National Salt Reduction Initiative, and the Healthy Food and Beverage Sales scheme.

Six studies report significant increases in the intake of healthy foods/beverages. Out of five studies reporting effects on purchases/sales, three report significant increases in the purchases/sales of fruit. One study reports mixed results, and one study reports non-significant results. One study reports a significant positive change in nutritional quality, and one study reports a significant positive change in availability - seen as a significant decrease in beverages classified as red, and an increase in beverages classified as yellow[h].

15 out of 26 studies do not report relevant health outcomes but describe instead business engagement or qualitative perspectives from retailers/farm owners adopting healthy food procurement schemes. Among these studies, qualitative results are reported on the uptake of healthy food procurement schemes in businesses (ranging from 27-82 %), and facilitators and barriers for uptake.

Findings from the grey literature highlight the implementation of public healthy food procurements, especially in schools, as an important tool for the creation of a healthy food environment for children and the general population[i]. Findings from several reviews in a publication from the Danish Institute of Public Health [52] report that healthy food procurements increase availability, purchases, and consumption of healthy foods and decrease purchases of unhealthy foods in different settings.

Restriction or improvement of the availability of unhealthy/healthy foods and beverages

12 studies report the effect of policies that either restrict or improve the availability of unhealthy/healthy foods and beverages, such as bans on trans-fatty acids in restaurants in the US, the Healthy Bodegas initiative (which stock and promote more healthful foods), the NYC Green Cart Initiative (food trucks that bring fresh fruit and vegetables to neighbourhoods

[h] Beverages were either classified as red, yellow, or green based on nutrient data, including calorie and sugar content, following the Healthy Beverage Executive Order (HBEO), which was introduced to eliminate the sale of sugar-sweetened beverages.

[i] Results on the effects of school health policies can be found in Chapter 8.

with lower availability), the removal of SSBs in stores, and providing healthy defaults on kids menus at Walt Disney World.

Three studies report effects on consumption, with one study reporting a significant increase in fruit and vegetable consumption, and two studies reporting non-significant results. Three studies report effects on purchase/sales, with two studies reporting significant reductions in mean trans-fat content per purchase and decreases in SSB sales, and one study reporting non-significant results. Two studies report significant positive changes in nutritional quality, and two studies report significant positive changes in the availability of healthy foods/beverages, such as an improved healthy food inventory. One modelling study anticipates that a ban on trans-fatty acids in restaurants will lead to more QALYs, health care savings, averted productivity loss, and informal care savings. 4 out of 12 studies do not report the relevant health outcomes but report on qualitative perspectives from retailers/farm owners.

In the grey literature, six organisations also recommend increasing the availability of healthy foods and beverages in the food retail environment and/or regulating where and how food outlets can operate - with a special focus on schools [12, 52, 87, 91, 92, 212, 246]. Here, the evidence suggests that access and proximity to fresh and healthy foods could increase consumption of these products [246]. Furthermore, fast food outlet density and placement is reported to have possible impacts on health behaviour. Even though the association between a high concentration of fast-food outlets and consumption is not yet conclusive, evidence suggests a negative relationship. For example, a systematic review by the Obesity Policy Coalition reports a positive correlation between higher obesity prevalence for residents in areas with higher access to fast food [246].

In-store promotion

Three studies report the effects of policies on in-store promotion, covering a food environment policy in supermarkets in a city in Scotland, point-of-purchase promotion of healthier

beverages in supermarkets, and a food environment policy in supermarkets in the US.

Two studies report non-significant results on consumption, and one study reports non-significant results on purchases/sales. One study also reports non-significant results on the availability of healthy foods/beverages.

The European Union [92] recommends using product placement to influence costumers' purchasing behaviour, which also includes the selection of available products at the point of purchase in retail stores. Based on the findings of a systematic review, product placement could influence consumer purchasing behaviour positively, especially combined with point-of-purchase labelling [92].

A concrete example of a similar policy, implemented in October 2022 in the UK, is the ban on the sale of unhealthy foods at checkouts and shop entrances [12, 251]. Economic predictions by the UK Department of Health and Social Care [251] show considerable future health and economic benefits of restricting checkout, end-of-aisle, and store entrance sales of food and drinks high in fat, salt, and sugar (HFSS), from lowered calorie consumption among people living with overweight and obesity, social care savings, and reduced premature mortality. Thus, restricting prominent placing of unhealthy foods and beverages could also be considered as a policy option. However, real-world evaluations of this type of policy are lacking, and the evidence from the NCU-CAPOC umbrella review does not cover this aspect either, since no reviews on this policy was found.

Limiting portion and package size and restricting/banning trans-fat and salt

Grey literature publications from four organisations recommend limiting portion and package sizes and/or restricting/banning trans-fat and salt as a policy tool [12, 52, 87, 91, 92]. A systematic umbrella review conducted by the Danish Institute of Public Health [52] reports that limiting portion sizes is effective in reducing the consumption of unhealthy foods. The same is reported in a systematic review by the European Commission [92], where evidence suggests

that reducing portion sizes may reduce the consumption of unhealthy foods.

Furthermore, evidence shows that bans/regulations of specific nutrients, such as trans-fat, sugar, etc., effectively improves diet at the population level and decreases the consumption of calories, salt, and sugar [52, 92]. Evidence of the effectiveness of this policy type is limited, but grey literature suggests that salt reformulation initiatives could be cost-effective.

b. Policies aimed at improving physical activity

Physical activity on referral

Two studies report the effects of physical activity on referral. One is based on the National Exercise Referral Scheme in Wales and reports mixed results and no cost-effectiveness.
The second is a modelling study examining the effects of a public health exercise referral scheme. This study predicts that such a policy will lead to approximately 800 QALYs gained for an incremental cost of £20,876. Furthermore, it is reported that the scheme can cause people to become active, preventing cases of CHD, strokes, and diabetes.

Two grey literature publications also address prescribing physical activity [87, 212]. Prescribing physical activity is outlined by the OECD [87] as a policy initiative that could lead to an increase in minutes of leisure physical activity (e.g., sports), and some evidence suggests that it can increase levels of leisure physical activity. The OECD also estimates that prescribing physical activity to individuals at high risk for chronic diseases between 2020-2050 could prevent around 240,000 CVDs, 90,000 type 2 diabetes cases, and around 20,000 cancer cases in the OECD countries. However, existing evidence primarily consists of data collected among 50–75 year-old adults, and results for children and adolescents are limited.

Improving access to and infrastructure of walking and bicycle paths/lanes

18 studies report the effects of policies that aim to improve access to and infrastructure of walking and bicycle paths/lanes. These policies cover, e.g., city policies on active transport

in the US, light rail stop and paths/trails, a city policy on active transport and bicycle sharing in Canada, a city policy on infrastructure development in the US, open streets, bike lanes, and an Australian policy promoting a shift from cars to environmentally friendly modes of transport.

12 studies report effects on physical activity outcomes, with nine showing significant positive changes on physical activity outcomes such as increases in daily bicycle trips, greater odds of cycling, increases in walking, and moderate physical activity. One study reports mixed findings on physical activity outcomes, and two reach non-significant results. One study reports significant reductions in BMI and odds of obesity, and six studies report active transport policies to be economically beneficial.

Most of the grey literature also recommends enhancing active transport infrastructure and safety measures that support walking and cycling [12. 52, 87, 91, 92, 212, 247-250]. It is reported that cycling interventions, walking interventions within the built environment, walking programmes, improved cycling infrastructure, as well as travel/transport-related policies can have positive effects on PA levels and be cost-effective [92]. Research published in The Lancet, for example, shows that cities with improved cycling infrastructure and restricted car access have been successful in increasing cycling levels [12].

Improving the built environment and creating better access and opportunities to physical activity equipment and settings

Eight studies report the effect of policies that aim to improve the built environment and create better access to and opportunities for using physical activity equipment and settings. Examples include a city policy on the built environment in Australia, playgrounds and other park improvements, construction/refurbishment of parks in a municipality on gymnasiums, fields, paths, picnics, a city policy on park outdoor exercise equipment in the US, and a city policy on park playgrounds in New Zealand.

Seven studies report effects on physical activity outcomes, with three showing significant increases in physical activity, walking, and vigorous activity, one study reaching mixed findings, and three studies attaining non-significant results. Two studies report policies that improve the built environment to be economically beneficial.

Some grey literature publications also highlight improving the urban and built environment and/or improving access to indoor and outdoor physical activity facilities and amenities, with a special focus on the built environment of schools [12, 52, 87, 91, 92, 206, 212, 248, 249]. The WHO [12] reports that features of the built environment, like greater land use mix, intersection density, residential density[j], and access to public transport and recreation facilities have been shown to increase physical activity levels and active transport. Furthermore, research shows that residents (adults, adolescents, and children alike) in physical activity-friendly neighbourhoods accumulate more minutes of physical activity compared to people living in the least activity-friendly neighbourhoods.

Increasing access to and affordability of public transport

The grey literature also covers how increasing access to public transport increases physical activity levels [12, 87], and seven organisations recommend this as a policy option for increasing physical activity levels [12, 52, 87, 91, 92, 212, 247, 248].

A systematic review and meta-analysis included in a publication by the OECD [87] reports that each person exposed to a new public transport option increases transport-related physical activity by around 35 minutes of walking per week. When adjusting for the fact that people will potentially reduce other types of physical activity, the total increase in walking per week is estimated at 20 minutes among both children and adults. Especially children could benefit from public transport when they travel with their parents and to their school. The OECD also argues that between 2020-2050, increased access to public transport in the OECD countries can prevent around 115,000 cases of CVDs, 40,000 type 2 diabetes cases, and a small

[j] Greater land use mix refers to the integration of various land uses (residential, commercial, industrial, recreational) within an area, promoting accessibility and walkability. Intersection density is a measure of the number of street intersections; higher density indicates more connected streets, improving walkability, and connectivity. Residential density refers to the number of housing units or people living in an area.

number of dementia and cancer cases (approx. 10,000 and 15,000).

Enhancing natural environments

A few of the grey literature publications recommend enhancing natural environments like green and blue spaces [12, 87, 206]. Several reviews report a positive association between distance and access to natural environments like green and blue spaces (e.g., publicly available lawns, lakes, rivers, canals) and physical activity, but the association with obesity is inconsistent [12].

Furthermore, evidence from the OECD [87] shows that constructing new green spaces could increase physical activity levels. Some evidence (from the US) suggests that better access to parks and green space areas could lead to a significant reduction in childhood obesity. However, based on a systematic review by the US National Collaborating Centre for Methods and Tools [206], it is reported that conclusive evidence on the effects of natural environments on physical activity levels is currently limited to adults.

Financial incentives to support physical activity participation

Two grey literature publications address using financial incentives to support physical activity participation [52, 212]. Based on the results of a systematic umbrella review, the Danish Institute of Public Health [52] reports that evidence is limited when it comes to financial incentives to increase physical activity. However, evidence from an umbrella review suggests that financial interventions and transport policies can affect the choice of transport, hence also physical activity levels. Higher taxes on private motor vehicles, road taxes, and higher parking fees, as well as cheaper public transport are highlighted in the study as political initiatives that can support physical activity [52].

Some evidence suggests that individual tax deductions for memberships of fitness centres and sports clubs, as well as for the purchase of exercise equipment can be effective in increasing physical activity levels, but changes are only short-term and not sustained once

subsidies are removed [212].

c. Multicomponent policies: including either several diet and/or physical activity components

20 studies report the effect of multicomponent policies that either include several diet and/or physical activity components, such as both mobile fruit and vegetable carts and SNAP[k] benefits; expanded food and nutrition education programs, and nutrition education and incentives for the production and procurement of healthy foods from local farms; or broader multicomponent policies such as the Colorado Healthy People 2010 Obesity prevention initiative, the Baltimore Healthy Stores programme (a multicomponent programme that transforms the retail food environment), Live for Life Sweden, and Health Inequalities in Finmark, Norway.

Two studies report effects on consumption, with one study showing significant increases in fruit and vegetable consumption, and one study reporting mixed effects. Four studies report effects on purchases/sales, with three studies showing significant increases in healthy food purchasing scores and increases in sales of some foods that promote healthy diets, while one study reached non-significant results.

One study reports mixed findings on physical activity outcomes. Five studies report effects on anthropometric outcomes, with one study showing significant decreases in BMI among both males and females. One study shows significant increases in weight, two studies report mixed findings, and one study reports non-significant results. Finally, five studies report state policies on expanded Food and Nutrition programmes to be economically beneficial.

9.5. Conclusion

A total of 156 original studies extracted from 15 systematic reviews and 16 grey publications were included, and the evidence covers policies aimed at improving the availability, accessi-

[k] Supplemental Nutrition Program (SNAP), a food benefit program in the US.

bility, and affordability of either 1) a healthy diet or 2) physical activity opportunities. Overall, across all included studies, results on anthropometry are either limited or mixed.

Results from both the NCU-CAPOC umbrella review and the grey literature suggest that healthy food procurement policies and financial incentives (e.g., price incentives on healthy foods/beverages or restricting multi-buy offers/price promotions on unhealthy foods/beverages) have positive impacts on consumption, purchases, and sales among all age groups. Most of the evidence gathered through the NCU-CAPOC umbrella review covers cash transfers/food benefit programs, and most of the studies report on anthropometry, but results are mixed. Furthermore, evidence from the grey literature suggests that policies that increase the availability of healthy foods and/or decrease the availability of unhealthy foods, regulations of in-store promotion, as well as policies that limit portion package sizes and restrict or ban trans-fats and reduce salt content in products can likewise have positive effects on consumption, purchases, and sales.

Results from both the NCU-CAPOC umbrella review and the grey literature suggest that policies on active transport (e.g., improving walking and bicycle paths) have positive effects on physical activity levels among all age groups. Evidence from the grey literature also shows positive effects on physical activity among all age groups when policies that increase access and affordability to public transport are implemented. Evidence included in the umbrella review regarding policies that improve the built environment is mixed. However, no studies report a negative impact of such policies, and findings from the grey literature also suggest that policies that improve the built environment and/or access to physical activity facilities can improve physical activity. Furthermore, it can be concluded from both the NCU-CAPOC umbrella review and the grey literature that policies that prescribe physical activity, enhance natural environments, and provide financial incentives to support physical activity participation is currently too limited to evaluate the effects of these on children's health.

The NCU-CAPOC umbrella review shows that evidence concerning multicomponent policies increasing the availability, accessibility, and affordability of a healthy diet and physical activity is currently mixed, since the content of the included policies is too heterogeneous.

In conclusion, a broad range of policies focusing on the aspects of availability, accessibility, and affordability have the potential to cause positive health effects among whole populations, on both diet and physical activity outcomes, which can help prevent overweight and obesity among children.

10 Early childhood prevention

10.1. Background: Risk and preventive factors in early childhood

The early childhood period, encompassing the first years of a child's life, is highlighted in the literature as crucial for preventing overweight and obesity in later childhood and adulthood. Factors arising before children are even born can play a significant role in understanding the risk of childhood overweight and obesity. For instance, a clear association between epigenetic changes[I] and childhood obesity has been identified [254].

The literature also underscores the importance of considering various familial and individual factors when preventing childhood overweight and obesity in early childhood. Factors such as being a male child and maternal smoking during pregnancy increase the risk of rapid weight gain among children, while a higher birth weight, higher total gestational age in weeks, and having siblings are associated with a lower risk [255]. Furthermore, families with low socioeconomic status face strong risk factors of childhood overweight and obesity, such as parental obesity and maternal depressive symptoms [256]. Evidence on the effects of maternal stress during and post pregnancy, as well as the influence of food insecurity on child weight outcomes, is more unclear [257, 258].

A well-established preventive factor is breastfeeding [255, 259, 260]. The evidence strongly underscores that breastfeeding is inversely associated with the risk of early childhood overweight and obesity, and for example children who were breastfed at least once in their life have a 27% lower risk of overweight and obesity compared to children who were never breastfed [259].

Thus, the evidence marks pregnancy and early childhood as a crucial period for prevention policies with a shared focus on both the individual child and the whole family. The next section covers the results of the NCU-CAPOC umbrella review and grey literature searches on the effects of early childhood policies and their potential to contribute to the prevention of childhood overweight and obesity.

[I] Children inherit genes from their parents, but experiences surrounding children can influence how and which genes dominate. Epigenetic changes can be understood in relation to how the environmental and social circumstances surrounding a child, e.g., supportive relationships or stressful surroundings, can influence the expression of genes in a child, which can have temporary or permanent effects.

10.2. Search results

A total of two systematic reviews [261, 262] were included in the NCU-CAPOC umbrella review, which was supplemented with six grey literature publications [263-268]. A depiction of the selection of relevant articles for the umbrella review can be seen in Figure 7.

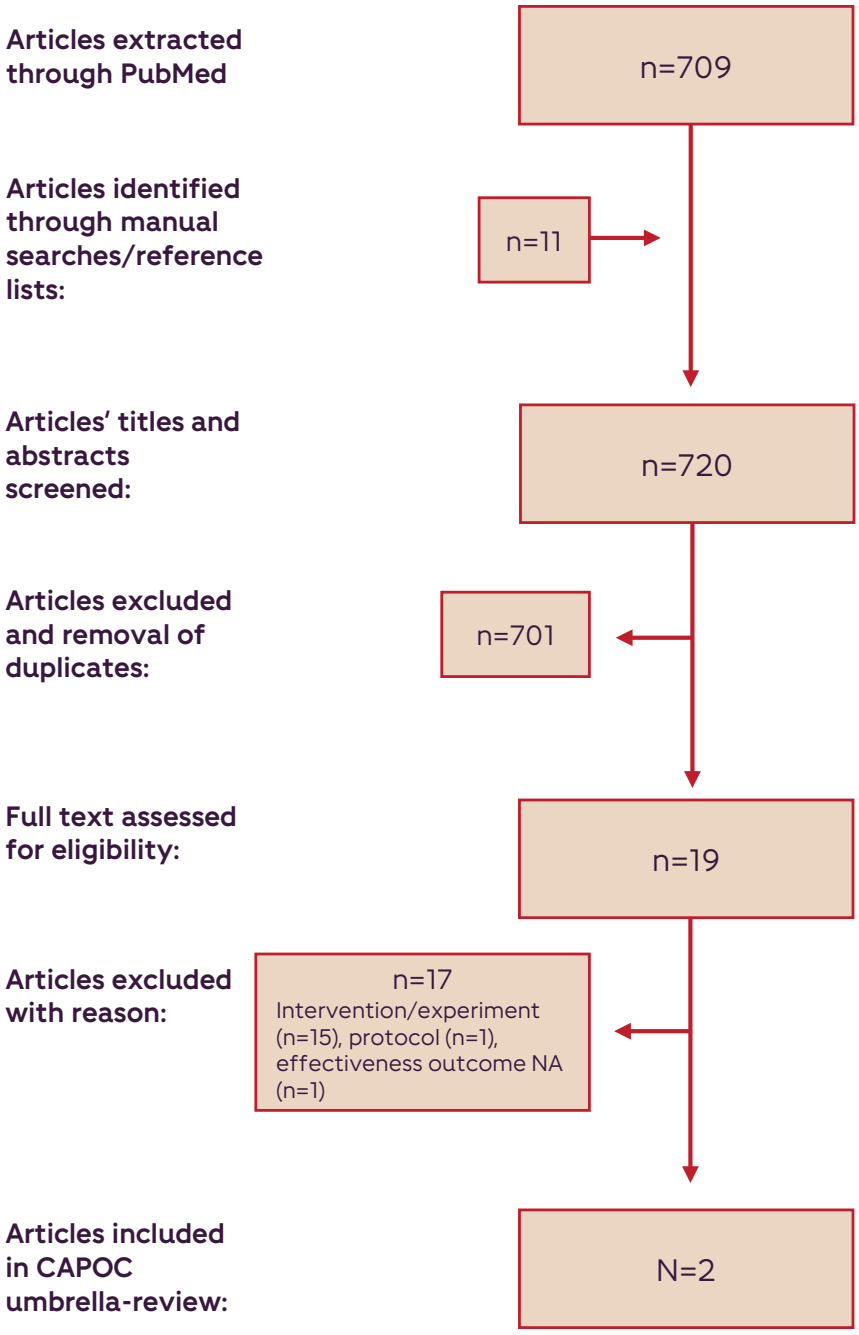


Fig. 7: Flowchart of the selection of relevant studies pertaining to the early childhood section

Martin et al. [262] was deemed of high quality and Rossiter et al. [261] was rated as having mo-

derate quality. However, the quality assessment of Martin et al. [262] was made according to the authors' description of what they would have done if relevant studies were found, since no relevant studies were included.

Such a low number of included reviews (n=2) clearly show that evaluations of implemented policies in early childhood are lacking. In one of the included reviews [261], only 3 out of 49 studies meet the NCU-CAPOC umbrella review's inclusion criteria (studies evaluating policies), while the remainder report effects of different interventions.

The other review [262] assesses the evidence regarding adherence to all WHO infant feeding recommendations and the effects on the risk of later developing overweight and/or obesity among children, but it found no relevant studies that met their inclusion criteria. The lack of relevant studies underlines a major gap in terms of quality and quantity of evidence on the long-term health impact of compliance with all WHO infant feeding recommendations. The WHO recommendations state that 1) infants shall be breastfed exclusively to the age of six months, and 2) that appropriate complementary feeding shall be introduced at six months with continued breastfeeding up to two years of age.

However, even though no relevant studies are included, this does not necessarily mean that the WHO-recommended breastfeeding praxis is not implemented in several countries, but rather that evaluations and monitoring of this praxis are lacking and/or insufficient. This is seen, for example, by the fact that the authors find eight studies where groups of infants were breastfed exclusively for six months, but the studies do not report measurements of the other aspects of this WHO recommendation. Finally, the authors note that compliance with WHO infant feeding recommendations may have important implications for global obesity and NCD prevention, and therefore, more studies are required.

10.3. Results for policy effectiveness

In this section, results of the NCU-CAPOC umbrella review, supplemented by findings from the grey literature, are presented in two sections: a) health effects of the WIC programme (USA), and b) policy recommendations for early childhood prevention.

a. Health effects from the WIC programme (USA)

The systematic review by Rossiter et al. [261] is the one that includes studies relevant to the NCU-CAPOC umbrella review. These studies (n=3) encompass one cross-sectional study and two longitudinal studies.

All studies cover the effects of changes to the nutritional content of the WIC[m] programme's supplemental food packages in the USA and are based on data from Los Angeles County. The WIC programme is a federal programme available for low-income families, implemented in over 50 states, and consisting of vouchers for food packages available from pregnancy up to a child's first five years[n]. The studies all compare children who participated in the WIC programme before and after 2009, where the content of the packages was changed, and effects on obesity risk or other weight outcomes are examined. The new packages contain more fruit, vegetables, and whole grains, and less juice and whole milk. Furthermore, the amount of formula to fully formula-fed infants was reduced to encourage and support breastfeeding. Sample sizes in the studies range from 8117 to 53,072 children aged 0-5 years and are based on data collected between 2003-2016.

The results of the three studies show positive effects on weight outcomes and obesity risk among children after the implementation of the new WIC food package. One study finds that one year-old children participating in the WIC programme and receiving the new food package have a significantly lower mean zWFH (z-score weight for age) than other children at the same age who received the old WIC, regardless of gender or initial weight status. Another study finds that among exclusively formula-fed infants, those who receive the new

[m] The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC).

[n] USDA Food and Nutrition Service. U.S. Department of Agriculture 2023. "Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). WIC Food Packages".

food package have significantly lower zWFH at age four than those receiving food packages before the programme change. The third study finds a significantly lower relative risk of obesity at 4 years among certain sub-groups that received the new food packages. This is valid for children who are mostly breastfed (not among those who were fully breastfed) and boys who are mostly or fully formula-fed, compared to children born before the change of the WIC programme took place.

Together, these studies show that the change of the food package in the WIC programme has led to a lower age-corrected relative risk of obesity and weight for certain groups of children that received the new food package, compared to those who did not. Furthermore, the authors point to the importance of easy accessibility and availability of healthy nutrition among low-income families that the WIC programme contributes to.

One of the grey literature publications also touches upon the effects of the WIC program. A systematic review by the Agency for Healthcare Research and Quality [264] provides additional information on the WIC programme in general, and not just results based on the 2009 change of the food package. The review examines how participation in the WIC programme is associated with maternal and child health outcomes. 82 observational studies are included, 49 of which provide direct evidence regarding WIC participation, and 34 of which present indirect evidence based on the evaluation of the 2009 food package change among WIC participants.

There is moderate evidence that maternal WIC programme participation during pregnancy is likely to be associated with reductions in infant mortality. Furthermore, maternal WIC programme participation is likely to be associated with no difference in initiation rates of breastfeeding. For children, WIC participation is likely to be associated with better child diet quality, a greater intake of 100% fruit juice and whole grain cereals, and age-appropriate shifts from whole milk to lower-fat milk. Finally, household participation in WIC is likely to be associated with increased purchases of healthy food groups and reduced purchases of less

healthy foods and beverages.

b. Policy recommendations for early childhood prevention

In line with the results of the NCU-CAPOC umbrella review, findings from the grey literature on the effectiveness of prevention policies in early childhood are also very limited. The included publications mainly focus on recommendations for infant feeding, including breastfeeding practices, means to end inappropriate marketing of breastmilk substitutes, and strategies to mitigate the double burden of malnutrition.

However, across all included publications, early childhood (age 0-6) is emphasised as a crucial period for preventing overweight and obesity among children. Recommendations in the grey literature span interventions from the prenatal stages to pre-school years. These recommendations encompass protecting breastfeeding, promoting healthy complementary foods, and providing support to new families through institutions such as nurseries, kindergartens, and the healthcare sector [263-268].

Policy recommendations on pregnancy and breastfeeding

The World Obesity Federation [267] highlights the importance of pregnancy as a window of opportunity to prevent childhood obesity. Evidence indicates that maternal obesity is associated with significant complications for both mother and child, such as the risk of developing gestational diabetes, cardiovascular diseases, and higher rates of caesarean delivery and stillbirths. Maternal obesity is also linked to increased healthcare costs. A study from the UK reveals that women with overweight or obesity spent 30% more days in the hospital compared to women of healthy weight, and they had a 10% higher usage of general practitioner services. Furthermore, evidence suggests that maternal obesity can affect the unborn child's health by delaying mental development, causing macrosomia, increasing the risk of cardiovascular diseases, and predisposing the child to overweight or obesity in adolescence and adulthood.

These risk factors underscore that pregnancy presents an opportunity for policymakers to support health professionals in engaging with women regarding their health and weight. Aligned with this evidence, the World Obesity Federation [267] recommends that governments develop and update national standards, guidelines, and recommendations for maternal care, invest in maternal health, enhance data collection on child and maternal health, address women's nutrition before, during, and after pregnancy, and promote breastfeeding.

The WHO [263, 265, 266] and UNICEF [268] also highlight the importance of breastfeeding and the obstacles to successful breastfeeding. UNICEF [268] stresses the importance of an early start to breastfeeding. Results from a meta-analysis from four countries, including more than 130,000 breastfed newborns, show that children who were breastfed between 2 and 23 hours after birth have a 33% greater risk of dying compared to newborns put to their mother's breast within the first hour of life. Furthermore, results of this meta-analysis show that the protective effect of early breastfeeding works independently of whether the child is exclusively breastfed. This underscores the importance of early breastfeeding.

It is also emphasised that the rise of institutional deliveries, specifically in high-income countries, is an important step towards creating opportunities for supporting mothers in bringing infants to the breast quickly. However, no available data on the status of early initiation of breastfeeding for any of the Nordic countries is found, which highlights a need for monitoring [268].

Policy restrictions on marketing of breast-milk substitutes

Both UNICEF [268] and WHO [263, 265, 266] highlight the potential harms to breastfeeding caused by the marketing of breast-milk substitutes. The International Code of Marketing of Breast-milk Substitutes (BMS) is emphasised as an important tool to support parents in achieving successful breastfeeding. Both organisations recommend that countries fully implement the Code.

A publication from the WHO [265] examines the implementation status of the Code and concludes that, as of April 2020, 136 (70%) member countries have enacted legal measures with provisions to implement the Code. The legal status of the Nordic countries (Denmark, Finland, Iceland, Norway, and Sweden) is labelled as 'Some provision of the Code Included' in the report, but the effects of this status are not reported. Thus, despite well-established breastfeeding practices and recommendations, and a partial implementation of the Code in the Nordic countries, there is a further need for monitoring and evaluating these initiatives.

The double burden of malnutrition

The WHO [266] also approaches the double burden of malnutrition and priority actions for ending childhood obesity. The double burden of malnutrition describes the coexistence of overnutrition, such as overweight and obesity, and undernutrition. Again, no specific policies are evaluated concerning this issue, but the WHO puts forward recommendations for preventing it in early childhood.

These recommendations are to 1) develop and implement appropriate and context-specific nutrition information and dietary guidelines for children, 2) enforce the International Code of Marketing of Breast-Milk Substitutes, 3) pass legislation and formulate policies on maternity leave and protection (including maternity benefits, leave, and breaks for breastfeeding for women working outside the home), 4) establish dietary standards to create a healthy food environment in preschools and schools, considering the double burden of malnutrition, and 5) establish regulations and standards for social support programmes based on national dietary guidelines.

10.4. Conclusion

Early childhood is, in general, highlighted in the literature as an important period for establishing obesity prevention policies through institutions that families meet, such as healthcare centres, nurseries, or preschools.

A total of two systematic reviews and six grey publications were included. Overall, evidence is greatly lacking regarding evaluations of national or global policies focusing on preventing overweight and obesity in early childhood. Besides the WIC program, which suggests positive associations between participation and some maternal and child health outcomes, there is a great lack of monitoring and evaluation of established policies and recommendations. Furthermore, the grey literature on early childhood prevention policies mainly covers policy recommendations on various topics such as breastfeeding, the International Code of Marketing of Breast-milk Substitutes, and the double burden of malnutrition.

Thus, the lack of evidence on policies makes it difficult to draw firm conclusions as to which policies the Nordic cancer societies should endorse. To be sure, this does not mean that policies in early childhood are not highly relevant for preventing overweight and obesity among children, but it shows that current evidence is limited. Instead, results of local interventions could help indicate how national policies in this area should unfold. We can conclude that there is a need for existing policies to be better monitored in order to assess their potential health effects.

11 Discussion

Overweight and obesity are complex and multifaceted metabolic conditions [10, 11]. Evidence suggests that preventing these conditions could be achieved through multifaceted interventions and holistic strategies at individual, communal, environmental, societal, and political levels [11, 12]. Research evaluating the effects of real-world policies implemented in different national and global contexts is scarce, but steadily increasing. The NCU-CAPOC umbrella review aims to describe and summarise current evidence of the effects of prevention policies that might contribute to the prevention of childhood overweight and obesity.

The results of the NCU-CAPOC umbrella review illustrate that beneficial health-related outcomes among children and the general population can be gained from all policy tools reviewed. These results are generally reflected as positive effects on health behaviour outcomes or outcomes affecting health behaviour, such as consumption, purchases/sales, physical activity, or improved environmental surroundings, for policy tools such as fiscal policies, marketing restriction policies, school health policies, and actions promoting the availability, accessibility, and affordability of healthy (instead of unhealthy) products. Evidence on food labelling and early childhood prevention policies is scarce when it comes to effects on health behaviour outcomes. Instead, the evidence shows improved consumer awareness for labelling policies. When it comes to early childhood prevention policies, evidence shows that existing actions are poorly monitored and, in some cases, not monitored at all.

These results are well in line with reports and recommendations from the World Health Organization, the European Commission, the World Cancer Research Fund, and several other actors in the obesity prevention arena [84, 90, 92, 104, 133, 160, 165, 167, 269, 270]. Once more, the evidence underlines the importance of multifaceted political approaches for the prevention of overweight and obesity among children, and it highlights significant differences between the impact of voluntary against legislative actions, leaving no doubt that the latter will greatly enhance the potential for the evaluated policies to be successful.

The NCU-CAPOC umbrella review has certain methodological strengths and limitations. One

limitation posed by the current evidence is the broad heterogeneity in terms of study population, study designs, and outcomes examined. Particularly, the evidence for school health policies and policies for the improvement of the availability, accessibility, and affordability of healthy products is very heterogeneous. This was seen in the variety of policy content or the lack of descriptions of the policy initiatives, as well as a broad range of different outcomes reported in the original studies. Due to the extreme heterogeneity within these two topics, we chose to analyse and make a new categorisation of original studies to get a more detailed overview of the evidence. This introduces a minor methodological inconsistency to this work since we did not conduct two classic, systematic reviews instead. However, even though our approach differed slightly from the umbrella review method, it gave us a somewhat similar overview and more detailed insight into the direction of the effectiveness for the relevant outcomes, just like in the chapters regarding other policy topics. Hence, the narrative results of these two topic analyses still provided comparable results.

Another limitation is that most of the included systematic reviews and meta-analyses either rate critically low (n=35), low (n=16), or moderate (n=22) with respect to quality, and only five reviews have a high-quality rating. The main reasons for these low-quality ratings are a lack of detailed methodological descriptions, as well as a lacking risk-of-bias or heterogeneity assessment in the original studies. Furthermore, only few of the systematic reviews contain meta-analyses, and most of the included reviews base their findings on non-randomised controlled trials, such as observational studies. Still, methodological limitations do not necessarily translate to invalid results. The methodological limitations might be the product of a lack of data from implemented real-world policies. This is known to be a general issue for policy studies. Not only can policies be difficult to assess and measure due to variation in intensity, duration, and adherence, but several unstable variables interacting in a complex social system affect the effectiveness of a policy and cannot be controlled for. This often leads to inconsistent method choices and outcomes examined making it difficult to standardise and compare the results in, e.g., meta-analyses. Furthermore, the effectiveness of policies can vary over time and across different contexts, making it difficult to draw conclu-

sions while the evidence base is relatively small, and some policies have not been implemented and monitored long enough to yield definitive results.

Across results for all six policy topics, evidence on anthropometric improvements (e.g., a decrease in the prevalence of overweight and obesity) is either mixed or limited. This might tempt one to draw an immediate conclusion that these policies have no effect, but caution is needed when interpreting such results. On the one hand, policies do not influence anthropometry directly, but changes in the prevalence of overweight and obesity are usually highlighted as expected outcomes of many diet- or physical activity-related policy actions. However, significant changes in anthropometric outcomes at the population level can only be expected as a long-term endpoint of several mediating factors. These can range from more immediate changes in health behaviour (e.g., reduced purchases and consequent reduced consumption of unhealthy products), changes in our surroundings (e.g., improved infrastructure for active transport), or even adjustments on the part of the industry (e.g., reductions of the sugar content in sugar-sweetened beverages). Together, these and other relevant changes (e.g., improved consumer awareness of the healthiness of products) might slowly but steadily result in more balanced diets and increased physical activity levels at the population level. And in the long run, such changes might indeed contribute to changes in the prevalence of overweight and obesity, even though these conditions are complex and multifactorial, highly influenced by several factors of different natures (e.g., socioeconomic, psychological, and genetic aspects, to name a few).

It is important to consider that the limitations of the existing evidence may, in part, be caused by evidence building over time. The prevention policies evaluated here have not been implemented and monitored over several decades, but that might be the time necessary for these policies to have an impact on anthropometric outcomes. However, this does not mean that such policies will have no effect on these outcomes.

An example that illustrates well the importance of time-lag for building an extensive and

strong evidence base comes from the field of skin cancer prevention (melanoma). Countries like Australia, New Zealand, and Denmark have worked towards the prevention of melanoma over long time periods through both communication campaigns on sun protection and structural prevention policies on sunbed regulations. Here, the time-lag also influences the order of effects becoming detectable. First, changes were detected in people's sun/sunbed behaviour, with more people protecting themselves from the sun, and a decrease in the share of people using sunbeds was seen. Later, effects such as a stable or decreasing number of melanoma cases were shown in these three countries. In all countries, the effects are attributed to multi-component prevention programmes adopted much earlier (e.g., Australia began their prevention campaigns in the early 1980s). In contrast, rising melanoma rates are now being detected in North America and some countries in Northern Europe, where such programmes were either implemented decades later or do not exist yet [271]. The same assumption can be applied to an understanding of how the evidence base for mediating behaviours like dietary patterns and physical activity will accumulate before it is possible to detect effects on the end outcome, i.e. stable or decreasing overweight and obesity prevalence rates.

As previously highlighted, overweight and obesity are multifactorial conditions, and ergo, overweight and obesity prevention actions need to be multifaceted as well. The beneficial effects found on health behaviour outcomes from the policies examined in this review concern important and central components that are part of this multifactorial condition. Greater and more beneficial health effects can be expected if more than just one policy is introduced. Policies aimed at preventing overweight and obesity will always operate within a complex system of multiple stakeholders, interventions, other policies, and contextual factors surrounding societies and individuals, which makes it very difficult to attribute population-level changes in anthropometry to one policy alone. Hence, causality might generally be impossible to establish when it comes to examining the effectiveness of prevention policies, due to the complexity of social systems, factors, stakeholders, and time affecting overweight and obesity prevalence, which we are unable to control for. Instead, it is impor-

tant to recognise the importance of using several interventions and policies at different levels, which all support and optimise children's possibilities for a healthy life and contribute to the prevention of overweight and obesity.

An important aspect to be aware of when examining implemented prevention policies is that researchers are not able to control for all surrounding conditions that a population is exposed to (e.g., other policies, economy, genetics, cultural differences, etc.). Randomised controlled trials are often called the "golden standard of evidence" in broad terms, and the appeal of the power of randomisation is easy to understand, since it allows for the establishment of a causal relationship between "exposure" and "outcome", while all other conditions are strictly controlled for. However, in evaluating real-world policies, we must bear in mind that the surrounding conditions will always be dynamic and act within complex systems, and these allow neither easy randomisation nor total control of mediating factors. Hence, policy evaluations most often cannot include a control group, since the whole population is exposed to the policy (except when a policy is implemented in some states in the same country, as sometimes seen in the US). Besides, it could be argued that this would be unethical and create inequity in some cases, e.g., if providing free school meals only to children from families of low socioeconomic status, and not to all school children in one country. Thus, even though most of the included reviews do not base their data on research that matches the gold standard of research designs, the existing evidence also reflects the most valid, ethical, and best-practice ways of reporting evidence on real-world policies.

The main strength of the NCU-CAPOC umbrella review is the extensive research of a vast body of evidence, and the provision of a broader picture on a wide range of prevention policies. This methodological approach has been helpful in uncovering that the effectiveness of some policy types (e.g., fiscal policies, food labelling) is better monitored and studied in the existing evidence than others (e.g., marketing restriction policies and early childhood prevention). Furthermore, this approach also makes it possible to determine whether there is consistency in the existing evidence on each policy type, and in which direction it points

regarding health behaviour outcomes. For example, consistent evidence is found on the beneficial effects of regulating prices through taxes by reducing sales, purchases, and consumption of the targeted products. On the other hand, evidence on marketing restrictions shows that reduced exposure to marketing is not a consistent outcome. However, evidence also shows that this might be mediated by the design of marketing-restriction policies: the evidence in fact uncovers that mandatory/legislative actions consistently lead to reduced marketing exposure, while voluntary agreements show mixed results. Also, evidence on labelling shows a consistent lack of real-world studies examining their effectiveness on health behaviour outcomes, but there is consistent evidence showing that labelling increases consumer awareness of the nutritional quality of products.

Finally, an added strength to this work is the inclusion of grey literature to support or challenge the findings of the NCU-CAPOC umbrella review, since policies are often evaluated in grey literature, and to ensure the broadest possible coverage of the available literature.

Implications for future research aiming to cover the effects of national and global prevention policies that contribute to the prevention of childhood overweight and obesity should be the awareness of the methodological limitations of current policy studies. The major methodological heterogeneity and the limited evidence base must be addressed through more monitoring of existing policies and studies that include more homogeneous study designs, outcomes, and study populations. This will enable more accurate comparisons of results across the literature (e.g., through meta-analyses) and building a stronger evidence base within this field. Furthermore, future studies should report their methods in greater detail, as well as conduct thorough risk-of-bias and heterogeneity assessments to improve their quality. It would also be beneficial to include wider outcomes that could potentially be improved by prevention policies as well, e.g., mental health, loneliness, educational attainment, and economic savings on healthcare costs and within the workforce.

Still, current literature already provides valuable insights on the effectiveness of prevention

policies on different outcomes as well as study populations. The existing evidence draws a clear picture of consistent effects and policy tools that need closer evaluation. Lastly, current evidence also exposes the importance of monitoring existing policy tools to understand their effectiveness.

12 Conclusion

This review report aims to synthesise the evidence on prevention policies addressing childhood overweight and obesity. Through the NCU-CAPOC umbrella review and a systematic search of grey literature, the report explores the effectiveness of six distinct policy areas on health behaviour and anthropometry: Fiscal policies; Marketing-restriction policies; Labelling; School health; Availability, accessibility, and affordability; and Early childhood prevention.

The findings on fiscal policies emphasise their effectiveness on changing prices, sales, purchases, and consumption, particularly in the context of taxing sugar-sweetened beverages (SSBs). Evidence indicates that fiscal measures, such as taxes and subsidies, not only affect retail prices but also purchases and consumption of other targeted food and beverage products, not SSBs alone. Moreover, findings suggest that broader nutrient profiling[o] can enhance health outcomes, and that taxing can lead to industry reformulation of the targeted products into improved nutritional compositions. Despite limited evidence for anthropometric outcomes, the evidence shows that both taxes and subsidies are cost-effective measures and that they are especially beneficial for improving health behaviour and social conditions among low-income populations. Evidence shows that taxes are most effective in reducing purchases and consumption among low-income groups, and that targeted subsidies (e.g., fruit and vegetables) can also improve opportunities for households of lower socioeconomic status to buy and consume healthier products. These results are well-aligned with WHO's (2024) Best buys[p] [269], which highlights taxing of sugar-sweetened beverages as cost-effective measures to reduce unhealthy diets, while subsidies on healthy foods and beverages are recommended for achieving the same goal.

The evidence on marketing restriction policies is overall limited, but existing studies report positive effects on reduced purchases of targeted products, and in some cases reduced exposure to targeted products among children. Furthermore, evidence suggests that marketing restrictions can lead to reductions in the marketing budgets of the food industry for

[o] Using a broader nutrient profiling means taxing an overall composition of nutrients in foods and beverages, such as foods that are high in fat, salt, and/or sugar, whereas the opposite means taxing of single nutrients, e.g., sugar.

[p] WHO's Best buys encompass a range of cost-effective interventions as well as other recommendations for the prevention and control of noncommunicable diseases.

the targeted products, and that it can be cost-effective. Most noticeable is the evidence showing that mandatory restrictions, grounded in legal frameworks such as the Convention on the Rights of the Child, are more effective in reducing children's exposure to the marketing of unhealthy products than voluntary industry codes. Furthermore, evidence shows that restrictions encompassing all children and marketing channels are crucial for maximum health impact. Again, these findings are aligned with WHO's (2024) Best buys, which underline policies that protect children from the harmful impact of food marketing as a best-buy, cost-effective way to reduce unhealthy diets.

The evidence on the effects of food labelling policies on real-life health behaviours and anthropometry is limited. Nevertheless, the literature is certain on the positive effects of front-of-pack nutrition labelling (FOPNL) on improved consumer awareness, and some evidence reports the reformulation of products towards healthier profiles by the food industry. Reformulation can help improve the nutrient composition of food and beverage products that people consume, but evidence also shows that reformulation occurs more consistently if the labelling scheme is mandatory. Mandatory labelling, coupled with other policies like fiscal measures and marketing restrictions, are also reported as important for optimising health impacts. Furthermore, the design elements of FOPNL, such as interpretive, simple, colour-coded labels, are reported as essential for efficacy and better understanding. These results are, once more, aligned with WHO's (2024) Best buys, which deem front-of-pack labelling as a best-buy, cost-effective policy to facilitate consumers' understanding and choice of food for healthy diets. The WHO also recommends the implementation of menu labelling in the food service industry to support healthy diets.

School policies are reported as a crucial tool for overweight and obesity prevention among children. Fruit and vegetable programmes, nutritional standards, and increased availability of healthy foods and free school meals are reported to improve school children's diets and increase their consumption of healthy foods. Furthermore, multicomponent policies, incorporating both diet and physical activity initiatives, are the most effective in enhancing

physical activity levels and increasing the consumption of healthy foods among school children. This aligns with WHO's (2024) recommendation of implementing whole-of-school programmes that include quality physical education, adequate facilities, as well as programmes that support active travel and physical activity during and after school.

The chapter on availability, accessibility, and affordability (AAA) policies reports a positive impact of healthy food procurement policies and financial incentives on reducing sales, purchases, and consumption of unhealthy foods and beverages, while increasing sales, purchases, and consumption of healthy products across all age groups. Active transportation policies, improved walking and bicycle opportunities, and increased access to physical activity facilities are associated with increased physical activity levels. Furthermore, evidence shows that these types of policies have health benefits not only for children, but for whole populations. The WHO (2024) also name public food procurement and service policies as best-buy, cost-effective ways to improve healthy diets., while also recommending the implementation of urban and transport planning to improve walking and cycling infrastructure as effective ways to reduce physical inactivity.

Finally, the chapter on early childhood prevention policies exposes a significant research gap, with limited evidence on their effects, which might be due to the lack of monitoring tools for this type of evidence. The findings emphasise the importance of establishing monitoring systems on existing policies that target early childhood, covering existing evidence-based recommendations on, e.g., breastfeeding practices. The WHO (2024) considers the protection, promotion and support of optimal breastfeeding practices to be cost-effective best-buys to improve healthy diets.

In summary, the findings of this umbrella review and grey literature analysis provide valuable insights that can serve as a foundation for evidence-based recommendations on how Nordic politicians can help counteract the increasing prevalence of childhood overweight and obesity.

While acknowledging certain limitations and gaps in the existing evidence on prevention policies, this review underscores their beneficial health behaviour and social effects upon both children and the general population. Even though it is important to be cautious regarding the methodological quality of the included studies, this work also argues that the evidence gaps often reflect the limited time span that certain prevention policies have been implemented, as well as the fact that the policies are implemented in a complex social system, which cannot be controlled for. Thus, to approach and prevent multifactorial conditions such as childhood overweight and obesity, the evidence speaks in favour of introducing a multifaceted political approach, including complementing policies of different types to fully address this challenge.

Besides the health, social, and environmental benefits of the policies explored in this review, it is also important to recognise aspects such as economics, health equity, ethics, and overall well-being, which can be improved through prevention policies. These aspects are important outcomes that governments must consider when introducing structural prevention policies as ways of contributing to the prevention of childhood overweight and obesity. It is well established that overweight and obesity among children, as well as adults, are heavily affected by socioeconomic status. Structural prevention policies can change the default, challenge commercial determinants, and create supportive environments for a healthy diet and physical activity – for all children. This can both benefit the health of and reduce the social inequality in the Nordic populations, but it also has the potential to avoid future financial costs related to the disease burden caused by overweight and obesity.

Contact:

Any questions about the report, data, results and method ect. can be directed to:

Pernille Boukaïdi Lundgaard at pebl@cancer.dk

Cand.scient.soc, Analysis Consultant, Danish Cancer Society

Design and layout:

Karoline Huber Pedersen, Stud.Scient.San.Publ..

Student Assistant, Danish Cancer Soceity

Photo references:

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