



Effect of Formulation, Labelling, and Taxation Policies on the Nutritional Quality of the Food Supply

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Abstract

Purpose of Review Food formulation, labelling, and taxation policies may encourage food (re)formulation. However, most literature focuses on their impact on consumer behaviours. This review summarizes the impact of various nutrition policies on food (re)formulation.

Recent Findings Food (re)formulation targets (particularly mandatory policies) have been associated with positive reformulation of targeted products. Limited evidence (mostly from Health Star Ratings and the Tick) demonstrates that some labelling policies effectively incentivize food reformulation. No peer-reviewed evidence has examined warning labels and taxes on sugar in drinks, but limited grey literature evaluation suggests that those policies have stimulated reformulation to some extent.

Conclusions The effect of nutrition policies on food (re)formulation is insufficiently studied. The impact of such policies on (re)formulation is likely greater when they are mandatory, aligned with other regulations, and thoroughly monitored and evaluated. Policies targeting (re)formulation have important limitations and broader food system policies will additionally be needed to significantly improve diets.

Keywords Food reformulation · Labelling · Taxation · Sugar · Sodium · Food supply

Introduction

Unhealthy population diets are an increasingly important risk factor for obesity and diet-related non-communicable diseases (NCDs) [1, 2], and unhealthy food environments have been shown to play a major role in promoting unhealthy population diets [3, 4]. The food supply, or specifically the nutritional quality of packaged and restaurant foods available for sale, is an important part of the food environment [5]. Over the last decades, there has been a significant shift away from traditional and home-prepared meals towards out-of-home meals and highly processed food products, which are increasingly available, cheap, and heavily marketed [6]. In addition, several studies have shown that there are considerable differences in

the nutritional quality of similar packaged food products and fast food meals across different countries [7–12].

Policy Recommendations to Improve the Nutrition Quality of the Food Supply

Improving the nutritional quality of the food supply is one of the several interventions recommended by the World Health Organization (WHO) to improve population diets [13], and studies have shown that a variety of policies targeting or stimulating (re)formulation of foods are cost-effective [14–19]. Policies targeting (re)formulation of packaged food products may have greater health impacts than those focusing on changing consumer behaviour [20, 21], and food reformulation may have significant health impacts even in the absence of behaviour change [22]. Reformulation can also be performed silently by food retailers or manufacturers without policy changes. A Danish study found that silent reformulation of a retailer's private brands towards lower energy density contributed somewhat to lowering the calorie intake in the population but with some losses in retailer's sales revenues [23].

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Different types of nutrition policies may encourage or drive (re)formulation of food products, such as voluntary or mandatory standards/targets for different food product categories, and various labelling and taxation policies. Recent global policy progress has seen increases in the implementation of front-of-pack labelling policies and taxation of sugar-sweetened beverages [25–27]. Most of the evidence currently available however focuses on the impact of these policies on consumer behaviours rather than the impact on industry behaviour, including food (re)formulation [28, 29].

Nutritional Foci for Product (Re)formulation

This section summarizes the available evidence on the impact of formulation, labelling, and taxation policies on the (re)formulation of food using real-world research, with a focus on the key nutrients of public health concern, such as sodium, trans fat, saturated fat, and added sugar.

According to the latest Global Burden of Disease Study 2017, salt is among the leading dietary risk factors for deaths and disability-adjusted life years globally [2]. A 30% relative reduction in mean population intake of salt is one of the nine global targets within the WHO's global NCD action plan 2013–2020 [13]. It has been established that salt can be reduced by approximately 40% in breads and approximately 70% in processed meats without significantly impacting consumer acceptability [30]. According to the latest WHO NCD progress monitor 2017, 47% of countries reported having some policy in place to reduce population salt intake [31]. Upstream strategies involving various elements (reformulation, in particular mandatory reformulation, labelling, and media campaigns) generally seem to achieve larger reductions in population salt consumption than interventions focused on individual behaviour change [32, 33].

Industrially produced trans fats cause an estimated 540,000 deaths each year globally [34]. Their elimination from the global food supply has been identified as one of the priority goals within WHO's latest strategic plan for the period 2019–2023 [34, 35]. The adoption of national policies that virtually eliminate partially hydrogenated vegetable oils and limit saturated fats in the food supply is one of the 25 indicators within the WHO NCD global monitoring framework [36]. According to the latest NCD progress monitor (2017), about 35% of countries adopted policies to eliminate industrially produced trans fats or limit saturated fatty acids in the food supply [31].

While reducing population intake of added or free sugar does not feature among the targets and indicators within the WHO NCD global monitoring framework, the WHO published long anticipated guidelines for sugar intakes among adults and children in 2015, which recommend reducing free sugar intakes to 10% of daily energy intake and to 5% of daily energy intake for additional health benefits [37]. The vast majority of policies to reduce sugar intakes

implemented to date have focused on sugar-sweetened beverage (SSB) taxation [38]. Such policies have shown to effectively reduce sugary drink purchases, especially among lower socio-economic groups [39].

(Re)formulation of Food through Voluntary/Mandatory Targets/Standards

One of the policy options to encourage or drive food (re)formulation is setting targets/standards for nutrients of concern, either through self-regulation by industry, mandatory regulation or co-regulation. A recent systematic review synthesized the results of simulation models estimating the effect of such policies to improve population diets. While all models predicted positive outcomes, most studies did not assess technical/industrial aspects, marketplace dynamics, and consumer reactions in modelling the strategies [40]. The section below summarizes evidence related to actual policies implemented for the different nutrients of concern.

Salt/Sodium

Voluntary standards for sodium in packaged foods, as part of a national salt reduction strategy including a set population intake target and regular monitoring, may contribute to reducing population salt intake, as shown in Brazil and the UK [41, 42]. In Brazil, the national strategy for sodium reduction, although voluntary, was regularly monitored over a 6-year period (2011–2017), and for more than half of the food categories, a significant reduction (8–34%) in average sodium content was found. By 2017, most products across food categories had met the proposed Pan American Health Organization targets [41]. The UK Salt Reduction Programme, also voluntary, included set targets for levels of salt in a wide range of food categories. These targets were progressively lowered on a regular basis allowing for gradual reformulation. A significant 15% reduction in 24-h urinary sodium among the population (from 9.5 to 8.1 g a day) was observed over 7 years [42]. Some modest reductions in sodium content in packaged foods were observed in several other countries through a voluntary co-regulatory or structured voluntary approach [43–47].

Few countries (Argentina, South Africa) have set mandatory targets for sodium in a range of packaged food categories, but no evidence of impact is available as of yet.

An Argentinian study found that sodium content in most of the products assessed during baseline already achieved the target set by legislation, which has important implications for the potential magnitude of changes in the nutritional quality of the food supply over time [48]. In South Africa, monitoring and enforcement have been highlighted as key challenges due to capacity constraints [49].

Trans Fats/Saturated Fats

Policies to reduce trans fats in the food supply are effective and will likely reduce the burden of diet-related disease, particularly among the most vulnerable population groups [50•]. Trans fat bans have been suggested as the most effective, economical, and equitable option to reduce intake of trans fats [50•].

In Denmark, a law introduced in 2003 banned the use of trans fats in all products aimed for sale on the Danish market. After the ban was introduced, cardiovascular disease death rates reduced by 3.2%, which is more than in similar countries that did not implement such restrictions [51]. Following a 25-year-long campaign to effectively ban trans fats from the US food supply, the Food and Drug Administration declared trans fats as *not generally recognized as safe* in 2015 and allowed food manufacturers 3 years (until June 2018) to reformulate their products [52]. Recently in September 2018, Canada similarly announced the introduction of a ban on trans fats. Earlier evidence from Canada showed that voluntary limits on trans fats were successful in reducing trans fat content of food products but foods with the lowest levels of trans fat were found to have the highest levels of saturated fats [53]. A recent systematic review found that product reformulation to reduce trans fats had variable effects on saturated fat contents in these foods; however, the combined amount of trans and saturated fats was found to have declined in most products [50•].

In low- and middle-income countries, however, key challenges have been identified in relation to implementation of trans fat restrictions which include a lack of trans fat awareness, the largely unorganized retail sector, a need for suitable alternative products that are both acceptable to consumers and affordable, and a need to build capacity [54, 55]. Thus, actions to reduce the content of trans fat in food products remain an important objective in many settings.

Added/Free Sugars

There are very few examples of policies setting targets or standards for added/free sugar reduction in packaged foods. A recent example is the structured reformulation approach by Public Health England [56•]. The overall aim is to reduce the amount of sugar in the foods that contribute most to children's intakes by 20% by 2020, with a 5% reduction in the first year [56•]. A report on the first year's target showed it was not met, although a very modest overall reduction of 2% for retailers own brand and manufacturer branded products was achieved and 5 out of 8 measured food categories showed some reductions in sugar content [57].

In France, since 2008, 37 food manufacturers and retailers have signed the government's Charters of Voluntary Engagement to reduce sugar and other unhealthful ingredients in their products in France. Based on the first 15 signed charters, up to 13,000 tonnes of sugar were removed from the French food market between 2008 and 2010 [58].

(Re)formulation of Food through Back-of-Pack or Menu Labelling

Many countries, particularly high-income countries, require mandatory nutrient lists on packaged foods, while some countries only require such labelling when nutrition or health claims are made. About 10 countries additionally require mandatory declaration of trans fats and the USA is the first country requiring labelling of added sugars [59]. While there is no post-implementation research available, a recent study estimated that between 2018 and 2037, the added sugar label in the USA would prevent 354 400 cardiovascular disease and 599 300 diabetes mellitus cases by encouraging behaviour change (or 708,800 and 1.2 million taking into account reformulation), gain 727 000 quality-adjusted life years (1.3 million taking into account reformulation), and save \$31 billion in net healthcare costs or \$61.9 billion societal costs (or \$57.6 billion and \$113.2 billion taking into account reformulation) [60].

Calorie labelling of menu boards has been regulated in a few countries like the USA and some states in Australia and Canada [59]. A few studies have examined changes in the calories of restaurant meals after implementation of local menu labelling regulations. A systematic review [61], including five relevant studies [62–66], suggests that calorie labelling regulations (either implemented or anticipated) may be associated with healthier restaurant meals, but because of the low number of studies, differences in design, and lack of comparison sites, it is hard to draw conclusions [61]. In addition, the lack of national-level implementation of menu labelling policies may have reduced incentive for (re)formulation.

A recent meta-analysis found that a range of food labelling initiatives (including back of pack and menu labelling) were associated with significantly reduced trans fat (−64.3%, 95% CI = −91.1%, −37.5%, $n = 3$ studies) and sodium (−8.9%, 95% CI = −17.3%, −0.6%, $n = 4$ studies) content in foods. Significant effects were not identified for total energy, saturated fat, total sugar, dietary fibre, or other healthy or unhealthy dietary components [29•].

(Re)formulation of Food through Front-of-Pack Labelling

A synthesis of front-of-pack labelling schemes implemented globally has previously been published [28]. While an increasing number of governments implement FOP labelling schemes, there are important differences in the regulatory approaches that likely influence their impact on product (re)formulation. Summary systems (i.e. the Health Star Ratings and the Nutriscore), warning labels, and traffic light labels are the most commonly implemented FOP systems [28]. Implementation of summary systems has generally favoured a voluntary approach, warning labels are typically mandatory,

and a combination of voluntary or mandatory approaches have been used for traffic light systems. In addition, a variety of government-endorsed nutrient profile models underpin these front-of-pack labelling systems to inform how the labelling system is applied to products [67]. Most of the studies conducted to date have focused on impact of these labels on consumer purchases or dietary behaviour, while evidence for impact on (re)formulation is very scarce [29•].

Summary Systems

The Health Star Rating (HSR) system is a voluntary front-of-pack labelling initiative endorsed by the Australian and New Zealand governments in 2014. In 2017, the HSR was found on about one third of eligible packaged foods in Australia, more frequently on healthier than less healthy foods [68]. To date, two studies have examined the short-term impact of the HSR on food reformulation. The first study from New Zealand used annual representative surveys of composition and labelling of packaged food before and after adoption of HSR, i.e. 2014 to 2016 [69•]. After 2 years of implementation, packaged foods carrying the HSR (5.3% of packaged foods) had significantly lower mean saturated fat, total sugar, and sodium content compared with products without the HSR. Small but significant changes were observed in mean energy density (−29 KJ/100 g), sodium (−49 mg/100 g), and fibre (+0.5 g/100 g) contents of products with HSR compared with their nutritional quality prior to HSR adoption. Energy reduction in HSR products was greater than in non-HSR products (−1.5% versus −0.4%), and sodium content of HSR products decreased by 4.6% while that of non-HSR products increased by 3.1% over the same period. The vast majority (83%) of products displaying the HSR in 2016 had been reformulated since 2014 [69•]. An Australian study examined children’s packaged food products ($N = 252$, of which 53.6% were classified as “less healthy” according to the Food Standards Australia New Zealand Nutrient Profiling Scoring Criterion) from three major supermarkets between 2013 and 2016 [70]. About 28.5% of products displayed the HSR, and of those, 73.8% were classified as “healthy”. Positive reformulation of products that were available in 2013 had occurred in 100% of HSR-labelled products in comparison with 61.3% of non-HSR labelled products [70]. Both studies indicate that the HSR is likely driving healthier reformulation of some products.

The Nutriscore, a similar FOP labelling system more recently implemented in France, Belgium, and Spain, has not yet been evaluated to examine the impact on food (re)formulation. A modelling study which examined breakfast cereals in France showed that theoretical reformulation scenarios allowed for significant changes in Nutriscore allocation: 5% reduction in sugar would lead to a modification of the label for 4.2% of products while a 10% reduction in sugar, saturated fat, and sodium would lead to a modification of the label for 19.2% of products [71].

Warning Labels

Warning labels indicate foods that are high in certain nutrients of concern. Finland was the first country introducing a warning label for excessive sodium content for some food categories in the early 1990s. In 2016, Chile was the first country to require “high in” warning labels for products that exceed limits for three nutrients of concern (sodium, saturated fats, total sugars) as well as total energy (kilocalories). Several other Latin American countries, as well as Israel and Canada, are currently in the process of developing and/or implementing similar warning labels [28, 59]. As of 2019, only 17% of packaged food products in Chile will not carry any warning label, under the most strict limits for the nutrients of concern [72]. However, anticipatory effects of the implementation of the Chilean Law of Food Labelling in June 2016 on food and beverage product reformulation have been analyzed and found to be minimal. A study of the nutritional composition of the food supply in Chile between February 2015 and February 2016 found that only a few products (< 2%) would have avoided at least one warning label as a result of product reformulation [73].

In contrast, the Chilean Ministry of Health recently published a report indicating that about 7–8 months after the implementation of the law, significant reductions (between 20 and 35% of initial content) were found in the average content of sugar in best-selling beverages, dairy products, and breakfast cereals, as well as significant reductions in sodium in bestselling cheeses and meat products (between 5 and 10% of the initial content) [74].

Warning labels can also be implemented on menu boards. For example, New York City adopted a mandatory policy requiring sodium warning labels on restaurant menus for meals with more than 2300 mg of sodium. The majority of restaurants are complying with the policy [75] but evidence on whether they drive a reduction in sodium content of meals is not yet available.

Other Systems

‘The Tick’ was a voluntary FOP logo developed by the Heart Foundation of New Zealand, but was discontinued due to the implementation of the HSR. Several studies evaluated the impact of the Tick on food reformulation [76–78]. It was estimated that 33 tonnes of salt were removed from breakfast cereals, breads, and margarine products over a 1-year period through reformulation to meet the Tick criteria [78]. Another study calculated that over 2 years, food companies removed approximately 16 tonnes of salt through the reformulation of 52 breakfast cereals, edible oil spreads, cooking sauces, and processed poultry products to meet the Tick criteria [76]. In addition, around 4.1 million MJ of energy, 156.0 tonnes of saturated fat, 15.4 tonnes of trans-fat, and 4.0 tonnes of

sodium were removed from 45 food products within the Tick program over the same 2 years [77]. These Tick products were, on average, 14–76% lower in energy, saturated fat, trans fat, and sodium than non-Tick products, indicating they were now healthier options [77]. A similar analysis in Australia found that an average 40% reduction in sodium for 12 breakfast cereals made to meet the Tick criteria led to removal of an estimated 235 tonnes of salt annually from the national food supply [79]. A study on the Choices logo introduced in the Netherlands in 2007 and terminated in 2018 which included 47 manufacturers also indicated the program motivated food manufacturers to reformulate existing products and develop new products with a healthier product composition, especially for sodium and dietary fibre [80].

(Re)formulation of Food through Taxation

A number of overviews of the impact of taxation policies on food consumption and composition, particularly in relation to sugar-sweetened beverages, have previously been published [25–27]. There is strong evidence that such taxes can change consumer behaviour [39], but evidence for impact on reformulation is scarce. Four types of food and beverage taxes are generally distinguished: (1) content taxes (i.e. *x cents/100 g of sugar in SSBs*), (2) tiered volumetric taxes (i.e. *x cents/litre on SSBs with sugar content < 8 g/100 mL; x cents/litre on SSBs with sugar content > 8 g/100 mL*), (3) volumetric taxes (i.e. *x cents/litre on SSBs*), and (4) ad valorem excise taxes (i.e. *x per cent tax on the retail value of SSBs*) [81]. Reformulation, where possible, can stimulate manufacturers reduce the effect of the tax on the price of the product, and it is likely that these different types of taxes may differentially influence the amount or extent of reformulation that occurs after implementation.

Taxes on Sugar

In March, 2016, the UK Government proposed a tiered levy on sugar-sweetened beverages (SSBs; high tax for drinks with > 8 g of sugar per 100 mL, moderate tax for 5–8 g, and no tax for < 5 g), which was implemented in 2018. Six months into the tax, the Treasury revealed it collected £150million in revenue from the tax, less than half of the amount expected, due to reformulation efforts by industry to reduce sugar and avoid the tax [82, 83]. This was driven as well by Public Health England's co-regulatory approach that encouraged companies to cut the sugar in their products by 20% by 2020 [56•]. Empirical studies on product (re)formulation are limited, given the recent implementation of the policy. One study reported a 10% reduction in the average sugar content of energy drinks in the UK in anticipation of the levy [84].

According to Euromonitor market research data, while the majority of soft drink producers reformulated their drinks ahead of implementation of the UK tax, some manufacturers reduced pack sizes or introduced new zero sugar or low calorie variants (i.e. different flavours) in their product portfolios [85]. The potential effect of possible industry responses to the levy on rates of obesity, diabetes, and dental caries was recently estimated. Out of the three scenarios modelled (reformulation to reduce sugar concentration, an increase of product price, and a change of the market share of high-sugar, mid-sugar, and low-sugar drinks), the best scenario for health was found to be reformulation [86•]. Other countries have also implemented tiered taxes or levies on sugar in SSBs (Ireland, Portugal, Chile, France, Thailand) or graded taxes that increase over time, such as in Thailand [38]. No evaluations of the impact of these taxes have been published to date.

Taxes on Other Nutrients of Concern

The Hungary Public Health Product Tax is a hybrid of a specific and ad valorem tax as the rate is levied based on volume/weight of the total product, but the rates only apply after certain ingredients (e.g. salt, sugar) exceed a minimum threshold level. Industry representatives confirmed that the tax has, to a certain extent, contributed to the reformulation of taxed products. Through a survey, 40% of manufacturers reported to have changed their recipe, 30% reported to have completely removed the targeted ingredient, and 70% reported to have reduced the amount of the targeted ingredient [87].

In October 2011 Denmark introduced a tax of 2.7dollars per kilogram of saturated fat for products exceeding 2.3 g saturated fat per 100 g fat. The tax was abolished as of 1 January 2013 [88].

There is no literature on product reformulation in relation to the Danish saturated fat tax; however, it is unlikely to have been significant, as low fat versions of the taxed products already existed prior to introduction of the tax, and a lot of the taxed products (e.g. meat, butter, cooking oils, and margarine) are difficult to reformulate as they require a fixed fat content.

Discussion

Summary

While real-world evidence of the impact of nutrition policies on (re)formulation of the food supply is limited, most of the evidence suggests some modest, positive improvements to the food supply via formulation policies, FOP labelling policies, and taxes. Most of the policies targeting the healthiness of the food supply have focused on sodium reduction and reduction or elimination of industrially produced trans fats, largely via policies that purposefully target product (re)formulation. Less

progress is evident for the other nutrients of concern (saturated fat, added/free sugar), which have not been traditionally targeted in governmental (re)formulation policies.

The recent proliferation of countries implementing taxation and front-of-pack labelling policies may also stimulate reformulation; however, the vast majority of these new policies have not yet been evaluated for their effectiveness in influencing the nutritional quality of the food supply. The Health Star Ratings and some of the previously employed FOP labelling systems such as the Tick have shown some promise in encouraging food reformulation. There is no peer-reviewed evidence available yet for warning labels and content and tiered volumetric taxation policies, but the limited grey literature evaluations available suggests that those policies stimulated some reformulation.

Limits of Reformulation to Improve Nutritional Health

Although reformulation may contribute to effecting dietary changes across populations, like any policy, it is unlikely by itself to solve the complex problem of poor diet quality. There are limits to the impact that can be achieved by narrowly defined reformulation policies. Some researchers argue that such policies may even legitimize current high levels of consumption of ultra-processed products, which contain a range of other potentially harmful processed and industrially produced ingredients that are not removed during reformulation [89]. The sources of nutrients of concern in these products may be replaced with other highly processed ingredients and additives, rather than shifting diets towards whole or minimally processed foods [89]. Nutrient profiling is currently the dominant approach used to determine the healthiness of foods in nutrition policies or regulations [67]. This contrasts with food-based classification schemas, such as NOVA [90], that are currently informing nutrition science and guidelines but no policy actions (yet) in some countries.

In addition, the lack of mandatory reformulation targets has precluded evaluation of the effectiveness of mandatory compared with structured, voluntary, or co-regulatory approaches. Co-regulatory approaches using voluntary targets have shown that reformulation is possible, but the magnitude of the impact of mandatory reduction targets is likely to drastically increase the effectiveness of formulation policies. Research from other areas has shown that weaker policies, such as voluntary reformulation, are often used by companies to prevent or resist more effective policies in other domains, like taxation and marketing restrictions [91]. It has been suggested that weak reformulation policies that are limited in scope and application are used as a mechanism of corporate political strategy to shape public health policies to fit commercial needs [92]. Industry responses to a 2014 US government consultation on product reformulation, often claimed that reformulation is “part of the solution” to obesity and NCDs, and that progress has been made despite reformulation posing significant technical challenges [92].

Research Recommendations

The effect of various composition, labelling, and taxation policies on food reformulation is insufficiently studied, as well as unintended negative consequences like the impact of reformulation on price of foods [93]. This is likely a reflection of some of the complexities faced in monitoring and evaluating the nutritional composition of food products and the impact on population health. The continuous reformulation and introductions and removals of packaged and restaurant foods make the maintenance of food composition databases an ongoing challenge [94]. In addition, few countries have branded food composition databases that are comprehensive and regularly updated, although some groups are making concerted efforts in this area [95]. Access to detailed, brand-specific food consumption surveys or sales data is needed but at present is prohibitively expensive to many researchers. New methods, like weekly extractions of nutrition and availability data of food products from the webpages of supermarkets, have therefore been proposed and tested [96].

Research assessing the reformulation of food, particularly at the company and brand-level, can act to hold the food industry to account for their action or inaction. A recent report from Australia has measured the state of the food supply and ranking manufacturers according to the healthiness of their product portfolios, thus identifying action required to improve the quality of their products [97].

Research is also required around a range of approaches that were not addressed in the present paper, such as restrictions on food marketing to children or restrictions on foods able to be sold in public sector settings that could stimulate food reformulation, but may also result in unintended negative consequences. For example, in 2014, the USDA established “Smart Snack” standards for snacks sold in schools. While some food companies reformulated their products to meet the standards, they packaged them to look similar to the less healthy versions sold in stores. Selling these “look-alike” products could lead parents and children to assume that the brands sold in store meet the same nutrition standards as the school product, which may promote greater acceptance and consumption of inappropriate snack items [98].

Policy Recommendations

Food reformulation is challenging and requires a multi-sectorial approach that embraces four disciplines: nutrition and health, food technology, legislation, and consumer perspectives [99]. Aligning nutrition policies with other policies and regulations improves the likelihood for success. Chile aligns FOP warning labels, marketing and school nutrition policies, and regulations, and the mandatory application of the labels across the food supply reinforces other regulatory measures (i.e. restrictions on marketing to children and sale in schools of foods with

warning labels). This encourages reformulation of the nutrients of public health concern and reduces their likelihood of misuse as a marketing tool by the food industry [100].

In addition, FOP labelling policies and taxation policies should include reformulation as a specific objective of the policy in order to increase overall impact and to ensure that comprehensive monitoring is undertaken. For example, content or tiered volumetric taxes, such as applied in the UK, may encourage businesses to reformulate products or introduce products with lower content of the targeted nutrient of concern, although they add a layer of complexity for implementation. A recent US study found that taxing SSBs based on a tiered tax, followed by grams of sugar content, would be a more effective strategy than a volume tax to generate health and economic benefits [101].

Evidence suggests that voluntary approaches to reformulation may be less effective and may replace the implementation of more effective approaches. Co-regulation or quasi-regulation may be a better alternative if there are political barriers to direct, statutory regulation of the food industry. Co-regulation builds on industry's willingness to participate in efforts to create healthier products, but uses "legislative scaffolding" to drive companies towards meeting government-set or government-endorsed goals and targets, with the threat of mandatory regulation in the absence of meaningful action [102].

Regulatory "scaffolds" can be used to progressively increase levels of government oversight and control in response to inaction [103] but sanctions may be required to drive compliance among industry stakeholders and increase the effectiveness of these policies. An approach that incorporates strong government leadership, adequate funding, clear targets and timelines, management of conflict of interest, comprehensive monitoring and evaluation, and a plan for responsive regulation in the event of missed milestones has been suggested to be an effective co-regulatory approach [104].

Most policies targeting reformulation have been implemented in high- or upper middle-income countries [38, 59, 105]. To reduce health inequalities, product reformulation should occur globally, especially in low- and middle-income countries (LMICs), which are increasingly targeted as emerging markets for soda and junk food and are disproportionately impacted by NCDs [106].

Lastly, broader food system policies will also be needed to meaningfully decrease consumption levels for certain nutrients of concern towards the recommended upper intake levels [37]. Such approaches are being considered by governments across the globe: a report from the UK recommends reduction of the sugar it produces and imports through trade and agricultural policy, for example, by re-establishing quotas on sugar beet production. Year-on-year, these quotas could be tightened and the wholesale price of sugar sold to large industrial buyers could be raised incrementally [107]. In addition, wider food system

policies that make fruits and vegetables more available, affordable, and accessible will be equally important to reductions in the nutrients of public health concern in the food supply in order to address the important contribution that low intake of fruits and whole grains makes to global NCD risks [2].

Conclusion

The effect of various nutrition policies on food reformulation is insufficiently studied. While (re)formulation targets appear to have some effect, it is anticipated the impact of such policies on (re)formulation will be greater when they are mandatory, aligned with other regulations, and thoroughly monitored and evaluated.

The FOP Health Star Ratings and previously employed FOP labels like the Tick have shown some promise to encourage reformulation. There is currently no peer-reviewed evidence around warning labels and taxes on sugar in drinks, but the limited grey literature evaluations available suggest that these policies have stimulated some reformulation in the food supply. Policies targeting reformulation have important limitations and broader food system policies will additionally be needed to significantly improve population diets.

Compliance with Ethical Standards

Conflict of Interest Stefanie Vandevijvere and Lana Vanderlee declare they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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