



Energy drinks: what's the evidence?

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Summary

The UK, in common with many other countries, has seen a rapid rise in the per capita consumption of energy drinks in the last few years. Energy drinks (soft drinks containing more than 150mg of caffeine per litre) are made up of water, caffeine, sugars and a range of additives and flavourings. Sales of energy drinks in the UK increased by 155% between 2006 and 2014, from 235 to 600 million litres, an average per capita consumption of 9.4 litres in 2014. While the market for soda is declining, the \$50 billion global energy drinks market is projected to grow at an annual rate of 3.5% between 2015 and 2020.

This paper aims to present the latest available evidence on whether this trend is cause for concern, and if so, what could be done about it.

Robust evidence demonstrates that children and teenagers who drink energy drinks are also more likely to consume alcohol, smoke or use drugs. There is also some evidence that youth energy drink consumers are more likely to have unhealthy diets, and experience hyperactivity and a range of other health effects. For example, emergency department visits linked to youth energy drink consumption in the USA doubled between 2007 and 2011, with the most frequently indicated symptoms being vomiting, nausea, feeling jittery or on edge, trouble sleeping, palpitations, dizziness, fainting, abdominal pain and headache.

There is still a lot we do not know about the health impacts of energy drinks, particularly in relation to heavy and long-term consumption by young people. Evidence is also lacking in terms of the effects on younger children and those with existing cardiovascular problems. However, in light of high levels of consumption among young people, a few countries and localities have taken action in an attempt to reduce levels of intake, including banning sales to under-18s, permitting sales only from pharmacies, as well as voluntary measures to reduce consumption. Energy drinks are also captured under many of the soda taxes in place in a range of countries.

Owing to concerns about sugar, some energy drink manufacturers have developed low or no sugar varieties. However, there has been no action on the high caffeine content of energy drinks. There are a range of actions that, however, could be taken to reduce consumption in light of the health concerns, including labelling and limits on marketing and sales.

While there are significant gaps in the evidence base around the health impacts of energy drinks, the evidence that has emerged so far indicates some effects worrying enough for policy makers and civil society to sit up and take note.

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1. Introduction

Energy drinks are typically non-alcoholic beverages⁴ containing high levels of caffeine and sugar in combination with other ingredients known to have stimulant properties. They are marketed explicitly as a way to relieve fatigue and improve mental alertness. It is important to distinguish these drinks from isotonic or sports drinks, which consist primarily of carbohydrates and electrolytes and are intended to help athletes rehydrate after exercise [1]. The British Soft Drinks Association (BSDA) code of practice on energy drinks relates to beverages that contain more than 150 mg of caffeine per litre [2]. It is recommended that children consume caffeine in moderation, in recognition that childhood and adolescence are important periods of rapid growth and brain development. However, up to one in three young people report regular consumption of energy drinks [3]. The ease of access to energy drinks among children and adolescents is growing and is a source of concern, particularly in the UK.

This Briefing Paper presents information to local and national policymakers on the state of evidence in relation to consumption of energy drinks by children and adolescents. It sets out: the key components of commercially available energy drinks; the current market situation; the scientific evidence base, including areas in need of further research; and interventions in place at country, sub-country and industry level. The Paper concludes with a series of recommendations on what could be done to address this issue in order to reduce the short- and long-term harms associated with excessive caffeine and sugar intake. This information is needed now to enable policymakers, health professionals, parents, children and others to make evidence-informed decisions in the face of increasingly prolific, sophisticated and youth-oriented marketing by energy drinks companies.

2. Energy drink ingredients

The recipes for energy drinks include some common ingredients and a wide range of other additives, including preservatives, colourings, acidity regulators, vitamins and flavourings. These are described in turn below, along with their main health effects.

2.1 Caffeine

Caffeine is an alkaloid found naturally in plants, seeds and fruits, such as coffee and cocoa beans, tea leaves, guarana berries and the kola nut. It is an ingredient in many popular foods and drinks, as well as certain medicines, and is consumed worldwide. Caffeine stimulates the nervous system and, at moderate intakes, can enhance endurance performance and concentration in adults [4, 5]. However, larger doses can cause anxiety, agitation, sleeplessness, gastrointestinal problems and arrhythmias [6]. There is no official recommended limit for non-pregnant adults, but the European Food Safety Authority (EFSA) suggests that single doses of caffeine up to 200 mg (about 3 mg/kg body weight for a 70kg adult) and habitual consumption of up to 400mg per day do not give rise to safety concerns [7]. A cup of instant coffee contains around 100mg of caffeine, tea has 50mg and a can of cola has 30mg. Many energy drinks do not clearly label the exact caffeine content per serving, but some products contain as much as two cups of coffee.

According to the EFSA, there is insufficient information to derive a safe caffeine intake for children and adolescents, and substantial uncertainty regarding the longer-term effects of habitual consumption in adults [7]. They propose 3mg/kg

⁴ Some varieties are available pre-mixed with alcohol.



body weight per day as the level of no safety concern for habitual caffeine consumption by healthy children and adolescents. This means that an average 11-year-old weighing 35kg should consume no more than 105mg of caffeine per day. A single can of popular energy drink brands such as Monster, Relentless or Rockstar contains approximately 160mg. Children may be more susceptible than adults to the stimulant effects of caffeine because of their lower body mass and the fact that they are less likely to have built up a tolerance to these effects. Therefore, the BSDA and others have recommended that highly caffeinated drinks, including energy drinks, should not be consumed by children [8].

2.2 Sugars

Energy drinks tend to contain large quantities of sugars. Action on Sugar surveyed 197 energy drinks in the UK and found that 78% would receive a 'red' (high) label for sugars per serving [9]. The worst offender was Rockstar Punched Energy + Guava Tropical Guava flavour, with a staggering 20 teaspoons of sugar per 500ml can. Regular consumption of high sugar energy drinks can increase the risk of longer-term health implications such as dental erosion, obesity and type 2 diabetes [10]. A US study showed that dental cavities can result from the acidic pH and high-sugar content of products such as energy drinks, and another study showed that consumption of energy drinks can cause erosion and smear-layer removal in the teeth, leading to cervical dentin hypersensitivity [11, 12]. A report by the Scientific Advisory Committee on Nutrition (SACN) cited several studies demonstrating that consumption of sugar-sweetened beverages by children and young people results in greater weight gain and increases body mass index [13].

Whilst certain drinks manufacturers claim their products are a good source of energy, this can be misleading. The body generates energy from any food, such as fruits, vegetables, breads, pasta and rice, and there is no nutritional need for added sugars. Indeed, the European Commission recently banned five glucose claims previously approved by the EFSA due to concerns over encouraging excessive sugar consumption [14]. Energy drinks high in sugars can be reformulated, as there are similar products on the market with much less sugar; for example, Monster Khaos Energy + Juice contains 7.8g/100ml, about 50% less sugar than the highest sugar-containing energy drinks.

2.3 Other additives

Preservatives can be used to inhibit the growth of pathogenic organisms such as bacteria and moulds, but in energy drinks their main function is to extend the shelf-lives of the products [15]. Preservatives commonly used in energy drinks are: sorbic acid (E200), benzoic acid (E210) and sodium benzoate (E211).

Colourings are used for cosmetic purposes. This category includes caramels (E150) and carmoisine (E122), quinolone yellow (E104), and beta-carotene (E160a).

Acidity regulators, such as citric acid (E330), which is often used to control levels of acidity but can also be used as an antioxidant and flavouring, while sodium citrates (E331) can be used to stabilise emulsions.

Vitamins. Several B vitamins are used in energy drinks, such as Niacin (E375), which is a variety of vitamin B₃ that also serves to stabilise some colourings. Vitamins B₂, B₃, B₅, B₆, B₁₂ and B₁₂ are also used, but the amounts are insufficient to have any meaningful effect. Glucuronolactone is an ingredient in several products; it is a precursor for the synthesis of ascorbic acid/vitamin C (E300).

Flavourings are unlike other additives in that they have not been assigned E-numbers, and their identities do not have to be declared on labels. Nonetheless, some ingredients that provide flavour are listed on energy drink packaging, when that information is expected to increase sales. They include a variety of herbs, such as panax ginseng, ginkgo biloba, milk thistle extract and guarana seed. Women who are breastfeeding or pregnant should avoid milk thistle extract [16]. Guarana



contains 3-4% caffeine, which is twice the level in Arabica coffee, in addition to several other related molecules such as theobromine and theophylline [15]. Several of these substances also fall under the next category, namely stimulants.

Stimulants. The most widely used stimulant, after caffeine, is taurine. Taurine occurs naturally in meat, fish and breast milk, and synthetic versions may be used as a dietary supplement. L-Carnitine is another ingredient that some claim can help the body turn fat into energy.

3. The market situation for energy drinks

3.1 Consumption levels

In 2011, the EFSA commissioned a study that for the first time collated data on self-reported consumption of energy drinks at a European level for specific population groups, including children and adolescents [17]. Questionnaire data were gathered for 16 European Union countries – involving more than 52,000 participants – and the key findings were as follows:

- Across the study population, 30% of adults, 68% of adolescents (10-18 years) and 18% of children (3-10 years) reported consuming energy drinks
- Prevalence of energy drink consumption by adolescents ranged from 48% in Greece to 82% in the Czech Republic
- Prevalence of energy drink consumption by children ranged from 6% in Hungary to 40% in the Czech Republic
- 12% of adults were categorised as high chronic consumers (regularly consuming energy drinks on 4-5 days a week or more), with an average intake of 4.5 litres per month
- 12% of adolescents and 16% of children were high chronic consumers, with an average intake of 7 litres and almost 4 litres per month respectively
- 11% of adults and 12% of adolescents were categorised as high acute consumers (drinking at least 1 litre of energy drinks in a single session)
- In terms of the contribution of energy drinks to total caffeine exposure, the figures were 8% for adult consumers, 13% for adolescents and 43% for children.

The EFSA study found that young people in the UK consumed more energy drinks on average than their counterparts across the other EU countries (3.1 litres per month, compared with 2 litres). The 2015 WHO Health Behaviour in School Aged Children Survey (HBSC) also found that 14% of young people aged 11-15 years in England reported consuming energy drinks 2-4 times per week [18]. Overall, 5% of these young people reported drinking energy drinks daily. Consumption was linked to being male, being in the older age groups and receiving free school meals.

3.2 Current market situation

The global energy drinks market was \$50 billion in 2014 and projected to grow at an annual rate of 3.5% between 2015 and 2020 [19]. This is despite an overall decline in sales of soft drinks [20]. Consumer concerns over the sugar and caffeine contents of energy drinks are contributing to slower growth amongst 15-24 year olds, the core users [21]. However, the 10-14 age group is set to see an 11% increase in numbers over 2014-19 to 3.8 million which could boost sales from 2019 amongst the core user group.

In the UK, sales of energy drinks increased by 155% between 2006 and 2014, from 235 to 600 million litres [22]. This equated to a per capita consumption of 9.4 litres



across 2014 and a total value of £1.48 million. The leading brands' shares in the UK energy drinks market, by value in 2013/14, were Red Bull (25%), own-label (12%), Monster (10%), Relentless (6%), Rockstar (5%), Mountain Dew (2%), Boost (2%) and Emerge (2%) [21].

4. The scientific evidence

4.1 Health-related behaviours and risks

Robust evidence, largely from North America, Europe and the Middle East, demonstrates that consumption of energy drinks by children and adolescents is strongly and consistently associated with three clusters of risky behaviours: use of alcohol and/or binge drinking; smoking or susceptibility to smoking; and illicit drug use [23-33]. In the aforementioned EFSA study, 53% of adolescent energy drink consumers reported co-consumption with alcohol [17]. A longitudinal study involving 144 sixth and seventh graders (11-12 and 12-13 year olds) in the USA found that frequency of energy drink use at baseline predicted frequency of alcohol use 16 months later [34]. This relationship was partially related to levels of parental monitoring but not to sensation-seeking tendencies. Other studies have identified associations between consumption of energy drinks and sensation-seeking, particularly amongst frequent users, as well as links with self-destructive behaviours and problems with behavioural regulation [27, 35, 36]. One in four high school students in a US study involving a nationally representative sample of 6,498 participants had consumed alcohol mixed with energy drinks in the previous 12 months [37]. These students were more likely to report binge drinking, marijuana and other illicit drug use, and alcohol-related unsafe driving. The latter is particularly worrying given that road injuries are the leading cause of death amongst adolescents globally [38].

In terms of diet-related behaviours, studies have found that those who report consuming energy drinks are less likely to eat breakfast on a school day [18] and more likely to report regular consumption of fast food [39]. The picture is less clear-cut in relation to physical activity and sedentary behaviours, where there is some evidence of a U-shaped association [40]. Research shows that reported use of energy drinks is correlated with hours spent watching TV or playing video games, as well as with higher levels of physical activity and participation in team sports [28, 39, 41]. Although much of what is currently known about young people's use of energy drinks comes from school-based surveys, there is a lack of evidence relating to their impact on classroom behaviour. Schwartz et al [42] set out to examine associations between sweetened beverage consumption and self-reported hyperactivity or inattention amongst 1,649 middle students in a single urban school district in the USA. They found that students in the normal range for hyperactivity/inattention symptoms consumed fewer sweetened beverages per day (2.17 vs 2.72 beverages, volumes not specified) and were less likely to consume energy drinks (13.4% vs 21.1%), compared to those who were at risk for these symptoms. Energy drinks were the only type of beverage found to have an independent association with risk of hyperactivity/inattention, even after adjusting for potential confounders. Although the cross-sectional study design makes it impossible to rule out reverse causality, the authors suggest that their findings support recommendations to prohibit consumption of energy drinks by young children [43].

4.2 Health and performance outcomes

Few studies have been able to demonstrate clear positive or negative health effects attributable to use of energy drinks, largely due to the ethical implications of administering a substance to children that may be harmful. Instead, we rely on cross-sectional as well as retrospective study designs, including analyses of routinely collected emergency department or poison centre data. In Australia, 62 children (mean age 36 months) who accidentally consumed energy drinks were reported to the New South Wales Poisons Information Centre between 2004 and 2010 [44].

Fourteen had symptoms probably related to energy drink consumption – most commonly hyperactivity – and nine required assessment in hospital. In the USA, 4854 calls (0.2%) received by the National Poison Data System in 2010-11 related to energy drink exposure cases [45]. Almost half (46%) were under six years old, but older children reported the largest proportion of moderate or major effects, such as cardiac rhythm disturbances, hypertension and hyperthermia. These numbers may be small but they appear to be increasing; emergency department visits linked to energy drink consumption in the USA doubled between 2007 and 2011 [46]. The most frequently indicated symptoms include vomiting, nausea, feeling jittery or on edge, trouble sleeping, palpitations, dizziness, fainting, abdominal pain and headache [33, 44, 46-48].

Evidence from small-scale trials involving elite junior athletes in Spain suggests that consumption of energy drinks in controlled doses may have beneficial effects on specific aspects of sports performance [49, 50]. However, in one of these trials, sweat rate was slightly higher in the intervention group, producing significantly higher dehydration and potentially resulting in reduced performance [50]. Data from a population-based survey of 10,272 students aged 11 to 20 years in Canada found that adolescents who sustained a recent traumatic brain injury (TBI) while playing sports had higher odds of recent energy drink consumption than abstainers [51]. The odds of sustaining a TBI were greater for those consuming alcohol, energy drinks, and alcohol mixed with energy drinks, than for abstainers. Use of energy drinks may be a coping mechanism to deal with the effects of TBI or they may predispose adolescents to TBI, or both. Surveys involving representative samples of adolescents in Iceland (10-12 years) and Finland (12-18 years) indicated that frequent use of energy drinks was associated with common health complaints such as headaches, stomach aches and sleeping problems [52, 53]. In the Icelandic study, the prevalence of these complaints generally increased with greater energy drink use for boys and girls, although their frequency was less common amongst boys [52]. In the Finnish study, adolescents who used energy drinks several times a day were 4.5 times as likely to experience headaches and 3.5 times as likely to experience sleeping problems, in comparison with those who did not consume energy drinks, providing evidence of a potential dose-response effect [53].

4.3 Evidence gaps

There are a number of gaps in the evidence base in relation to the consumption of energy drinks by children and adolescents. The majority of published studies involve cross-sectional study designs and rely on self-report data, often gathered in North American high school settings. There is a need for further research involving younger children, as well as parents and teachers, including longitudinal and cross-sectional studies to examine a wider range of outcomes (educational, behavioural, social and emotional). More research is also needed to explore the health impacts of heavy and long-term energy drink consumption, given that we know childhood and adolescence are critical yet understudied periods in the development of health-related behaviours. Robust, ethically sound experimental studies are required to establish cause-and-effect, in terms of the strong associations identified in previous observational studies between use of energy drinks and various health effects. This evidence is essential to enable children, parents and others to make evidence-informed health decisions.

At present, it is not known how caffeine interacts with other stimulants, including those found within energy drinks, or how it affects particular sub-groups who may be at increased risk, such as those with existing cardiovascular problems. Research on the potential dangers associated with consuming energy drinks before, during or after taking part in sport is also needed to counter marketing claims of enhanced performance. Systematic assessment of energy drink and overall caffeine intake at population-level requires improved assessment methods. School-based health behaviour surveys tend to include one or two specific questions on this topic; for example, whether the respondent consumed any energy drinks in the past week or year. It is generally not possible to quantify the types of beverages consumed or the frequency of consumption. Improved survey designs would provide valuable

information on patterns of energy drink use, specific products consumed, contexts and consequences of consumption. These should be supplemented by well-designed qualitative studies to explore the complex relationships between behaviours and health outcomes in children, as well as the feasibility and acceptability of proposed interventions.

5. Interventions

5.1 Country level

In spite of the need for further robust evidence, a small number of countries have taken action to regulate sales of energy drinks from a cautionary viewpoint. A law banning the sale of energy drinks to under-18s in Lithuania was introduced in November 2014. The law applies to non-alcoholic drinks that contain at least 150mg of caffeine per litre. Retailers who sell the drinks to minors face a fine of up to US\$144, while underage buyers have to pay up to US\$72. In Sweden, sales of some types of energy drinks are restricted to pharmacies and sales to children are also banned [54]. Many other countries have established, or are in the process of establishing, levies on high sugar food and/or beverages, including energy drinks [55]. For example, in Hungary, a 'public health tax' adopted in 2012 is applied on the salt, sugar and caffeine content of various categories of ready-to-eat foods and drinks. Since 1 September 2015, the Dominican Republic has applied a 10% excise tax to food and drinks with high sugar content, which includes candy, chocolate bars and soft drinks. Revenues contribute to a national 'Get Healthy' campaign.

In Mexico, a 10% tax has been applied to sugary drinks (including energy drinks) since January 2014. In the 12 months following the introduction of this tax, an average of 4.2 litres fewer sugary drinks were purchased per person [56]. Purchases decreased at an increasing rate up to a 12% decline in monthly purchases by December 2014. This was coupled with a 4% rise in sales of untaxed drinks, primarily bottled water. In 2018, the UK government will implement its own tax on soft drinks with more than 5g of sugar per 100ml, with a higher rate for drinks with more than 8g per 100ml. Fruit juice and milk-based drinks will be exempt. The impact of these types of levies on sales of energy drinks specifically remains to be seen.

5.2 Sub-national level

There are also examples of interventions and campaigns implemented at the sub-national level. The city of Berkeley, California, passed a law taxing sugary drinks that came into effect on 1 January 2015 [57]. An excise duty of \$0.01 per fluid ounce of a sugar-sweetened beverage applies to soda, energy drinks and heavily pre-sweetened tea, as well as to the 'added caloric sweeteners' used to produce them. Suffolk County, a suburban area of New York state, was the first community to regulate marketing of energy drinks in 2013, prohibiting distribution of coupons and free samples to minors and sales in county parks and beaches [58].

In Scotland the campaign for the Responsible Retail of Energy Drinks (RRED) was started in Edinburgh in 2013. RRED seeks to persuade retailers to adopt a voluntary code of good practice by refusing sales of energy drinks to those under 16 years of age. It also campaigns for legislation to ban sales of energy drinks to children, improve labelling and direct marketing away from children.

Many schools have banned energy drinks as a result of reported hyperactivity amongst pupils and disciplinary problems in classrooms [59]. Others have collaborated with students and others on developing campaigns and educational activities to promote healthy choices. For example, Abbey School in Faversham worked in partnership with Kent Community Health NHS Foundation Trust to reduce consumption of energy drinks and promote alternatives through their 'Just Water' campaign. The Magna Carta School worked with Runnymede Borough Council and a local film-maker (and former student) to develop a short film to raise awareness



about the dangers of energy drinks for young people. The film is available via YouTube⁵ and will be shown in schools across Runnymede.

5.3 Industry

Due to growing concerns about the sugar content of energy drinks, a number of low and sugar-free varieties have been launched. Rockstar's Pure Zero grew from a £40k to a £2m brand in the first year after its launch in January 2014 [60]. Red Bull Zero, launched in February 2014, generated £6.4m in sales in the past year. Sales of Coca-Cola Enterprises (CCE) Monster Absolute Zero have surged by 66.5% to £11.2m since relaunch in February 2014. CCE also added a mango flavour to its Relentless Ultra range of zero calorie drinks. Tenzing, created by an ex-Red Bull executive, claims to half the amount of sugar of a can of Red Bull and contains all natural ingredients, including 13g of natural beet sugar [60]. Nevertheless, standard energy drinks still sell well and remain one of the main sectors driving growth for the soft drinks industry as a whole [20].

Members of the BSDA are currently subject to a voluntary code of practice relating to the labelling and responsible marketing of drinks containing more than 150mg caffeine per litre, which has been in effect since April 2015 [2]. Restrictions include no marketing communications placed in any media with an audience of which more than 35% is under 16 years of age, and no commercial activity of any sort undertaken in primary or secondary schools. Many large retailers and supermarkets in the UK have also come out in favour of reducing the sugar content of high sugar foods and soft drinks, which would include energy drinks [61]. There have been calls for mandatory controls on sugar to be the centrepiece of the Government's childhood obesity strategy. However, these measures will not address the high caffeine content of energy drinks and may actually contribute to increased caffeine consumption if low- or no-sugar versions are perceived as 'healthy' options.

6. What could be done?

In light of the growing evidence base on the potentially harmful effects of energy drink consumption and increasing calls for action from teachers, parents and others, policy-makers and industry could consider the following options:

- Schools play a central role in the development of healthy young people. Each education authority could have a named official with a central role in implementing an energy drinks strategy (either a standalone strategy or a core element of existing school food policy) across all schools. Each school in turn could have a named member of staff with responsibility for adopting a code of good practice and implementing the local authority's strategy within their school.
- Definitive information about the safety of youth energy drink consumption could be provided by teachers and health professionals, who may in turn need access to training, resources and guidance, for example, from the National Institute of Health and Care Excellence (NICE).
- In-school interventions could be used to raise awareness of the potential effects of energy drinks on children. In previous research, teachers and students have highlighted curriculum areas, such as science, citizenship and PSHE (personal, social and health education), where energy drinks could be used as an engaging 'real life' case study in terms of health education [62].
- Every local authority and health authority could have a shared policy and strategy on energy drinks and children. This could be overseen by a

⁵ 'Energy drinks: what's the harm': https://www.youtube.com/watch?v=dVZ2A_8NuAc



champion who is empowered to monitor and scrutinise the implementation of the policy. This could cover: sale and consumption of energy drinks on council and NHS property; health awareness and education; authority-wide projects to raise awareness in shops and other retail outlets; and research and evaluation activities.

- Local authorities could consider using existing powers in licensing, trading standards and planning, which could be used to limit the sale and consumption of energy drinks by children. For example, many councils offer training courses to licensees in breach of the alcohol license. These courses could encourage each licensee to adopt a voluntary code which would restrict sales of energy drinks to those under 16 years of age.
- The legislation on the labelling of energy drinks could be reinforced to improve the communication about the risks of caffeine and sugar consumption for children. Information about sugar and caffeine content could be presented in ways that are easier for children to understand; for example, as 'teaspoons' of sugar. The information on each can should be in large font and easily legible.
- Energy drinks being marketed favourably to children by manufacturers and retailers could be made illegal. This might include restrictions on the use and language of cartoons and child-friendly graphics and images. It could also include restrictions on energy drink manufacturers being allowed to sponsor or hold sports events and competitions aimed at children. There is strong support among parents for restricting advertising and marketing of energy drinks to children [63].
- The government could consider setting strict limits on the caffeine and sugars content of energy drinks, similar to the salt targets set in the UK.
- Legislation could be introduced to ban the sale of energy drinks to under-16s, similar to that which is already in place for tobacco and alcohol.

This Briefing Paper has acknowledged that there are significant gaps in the evidence base around the health impacts of energy drinks. However, the evidence that has emerged so far indicates some effects worrying enough for policy makers and civil society in the UK to take notice and to develop a plan for action.

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