By how much would limiting TV food advertising reduce childhood obesity?

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Background: There is evidence suggesting that food advertising causes childhood obesity. The strength of this effect is unclear. To inform decisions on whether to restrict advertising opportunities, we estimate how much of the childhood obesity prevalence is attributable to food advertising on television (TV). **Methods:** We constructed a mathematical simulation model to estimate the potential effects of reducing the exposure of 6- to 12-year-old US children to TV advertising for food on the prevalence of overweight and obesity. Model input was based on body measurements from NHANES 2003–04, the CDC-2000 cut-offs for weight categories, and literature that relates advertising to consumption levels and consumption to body mass. In an additional analysis we use a Delphi study to obtain experts' estimates of the effect of advertising on consumption. **Results:** Based on literature findings, the model predicts that reducing the exposure to zero would decrease the average BMI by 0.38 kg/m^{-2} and lower the prevalence of obesity from 17.8 to 15.2% (95% uncertainty interval 14.8–15.6) for boys and from 15.9% to 13.5% (13.1–13.8) for girls. When estimates are based on expert opinion, these values are 11.0% (7.7–14.0) and 9.9% (7.2–12.4), respectively. **Conclusion:** This study suggests that from one in seven up to one in three obese children in the USA might not have been obese in the absence of advertising for unhealthy food on TV. Limiting the exposure of children to marketing of energy-dense food could be part of a broader effort to make children's diets healthier.

Keywords: advertising, childhood obesity, nutrition, television.

Introduction

Childhood obesity rates are rising worldwide. This is alarming because once gained, it is very difficult to get rid of extra weight, and obesity is associated with an increased risk of diabetes, cardiovascular disease and cancer, and with a lower life expectancy.[1,2]

Though conclusive direct evidence is lacking, a wealth of indirect evidence suggests that food advertising causes weight gain in children.[3–5] The overwhelming majority of food-product advertisements seen on television (TV) by American children and adolescents are for food of poor nutritional value but high in energy content.[6] Food promotion is having an effect, particularly on children's preferences, purchase behaviour and consumption. This effect is independent of other factors and operates at both a brand and category level.[3] It seems unlikely that a change in consumption towards energy-dense foods would not have any effect on body mass. The real question is no longer whether food advertising causes childhood obesity, but rather how much. Is its impact negligible, as industry representatives argue, or considerable, as health and consumer organizations estimate?[7,8]

A recent study shows that US children aged 2–11 years see an average of 11.5 min of food-related TV advertising per day.[9] How much of the overweight and obesity among US children this explains is unknown and this implies that the potential effectiveness of restrictions on the marketing of energy-dense food to children is not known, either. We aim to give a quantified estimate of the impact of TV food advertising on childhood overweight and obesity.

The effect of advertising is difficult to examine directly. Trials in life-like situations are virtually impossible, and observational studies are complicated by a number of known and suspected confounders. Both exposure to TV food advertising and obesity are highly correlated with time spent watching TV, permissive parenting styles and exposure to other kinds of marketing. No study provides all the required information but elements of the pathway from advertising to overweight and obesity are known. Mathematical models can be used to bring this information together in a logical framework to derive effect estimates of interventions.[10,11]

Data from the published literature was used in a mathematical simulation model of the relationship between exposure to food advertising on TV and the prevalence of childhood overweight and obesity. In this article, we explore the potential effects of a total ban on TV food advertising on 6- to 12-year-old children in the USA.

Methods

The model compares two populations: a reference population that remains unchanged, and an intervention population in which changes in exposure to food advertising are translated into corresponding changes in consumption, body mass (BMI, in kg/m^{-2}) and the prevalence of overweight.

Our analytical framework consists of four steps. First, an intervention or policy lowers exposure to food commercials. At most, the exposure can be reduced to zero, and this is the scenario we present. This is not a realistic scenario, but it indicates the theoretical maximum effect of measures that aim to limit children's exposure.

Second, a change in exposure lowers total daily energy consumption [see Equation (1) in the Appendix 1]. We first

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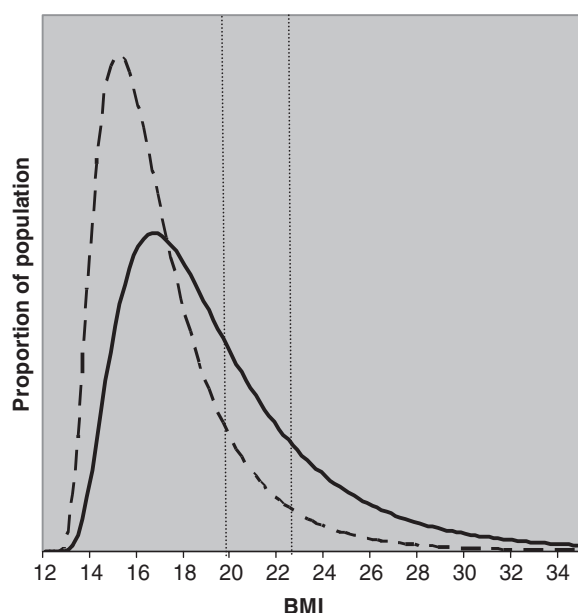
Figure 1 Modelled BMI distribution of 10-year old US boys. The solid line represents the distribution in 2003–04 based on NHANES data, the dashed line is based on the NHES data from 1963 to 1970.[15] The area under the curve represents the total population of 10-year old boys. In 2003–04 a greater proportion of the distribution lies above the age-specific cut-off points for overweight (19.76) and obesity (22.64), reflecting the rising prevalence of overweight and obesity

data, we fixed the lower end of the BMI-distribution in the intervention population. This is consistent with the data and theoretically plausible: below a certain BMI level, no life is possible. We modelled boys and girls separately in 1-year age categories. Children with a BMI between the 85th and 95th percentiles of US reference populations are categorized as overweight, and those above the 95th percentile as obese.[18,19] Because these definitions are based on age by month, we used the mid-year values. The entire BMI distribution can be manipulated by changing its mean value. Shifting the average upwards increases the variance and the rightward skew, which pushes a higher proportion of the population above the 85th and 95th percentile thresholds. The model was implemented in a spreadsheet (MS Excel).

Delphi study

The uncertainty in the above calculation was considerable, particularly in the dose–response relationship between TV advertising and total energy intake. It is based on a single study that was published in 1983 and did not quantify uncertainty. In view of this paucity of evidence, we decided to obtain current expert opinion and conducted a Delphi study to estimate the impact of advertising on consumption.[20] We invited 33 academic experts to complete online questionnaires. Twenty-five were selected via PubMed because of recent publications on the subject, and eight were known by the authors to have expertise on the subject. After briefly presenting the Bolton study we asked for a lower and higher boundary, and for a central estimate of the effect. We used the latter in this analysis.

Uncertainty analysis

The two parameters with the greatest uncertainty are the link from advertising to energy intake and the link from energy intake to BMI. To reflect their potential impact, we calculated 95% uncertainty intervals around the outcomes. We used a parametric bootstrap for the link between the amount of energy consumed and body mass, assuming a normal distribution.[13,21] Since the Bolton study did not present confidence limits, we could not incorporate the uncertainty arising from the relation between advertising and energy intake in our base case scenario. In the scenario based on the Delphi study, we used a non-parametric bootstrap on the central estimates of the experts to model the dose–response relationship between exposure to advertising and energy intake. For all bootstraps, we used the Ersatz programme (Barendregt JJ, Brisbane 2007) and 5000 iterations.

Results

The base case model predicts that reducing the exposure to TV food advertising of US children from 80.5 min/week[9] to zero would decrease total consumption by 4.5%. If every 10% reduction in consumption corresponds to a 4.5% lower body weight, children would weigh about 2.1% less than in the current situation, on average. This translates to a reduction in mean BMI of 0.38 kg m^{-2}, and a decrease in the prevalence of obesity by 2.7 (95% uncertainty interval 2.3–3.1) percent-point for boys and 2.4 (2.1–2.8) for girls. The proportion of children with overweight would also decrease (table 1).

Of the 33 experts invited to join the Delphi study, eight completed the two rounds of questions (24% response). When asked for a most likely value, the panel estimated that reducing the exposure of children to food advertising on TV by 10 min/week would reduce the total energy intake by 1.4% (95% uncertainty interval: 0.8–2.1). Using the experts'

searched the literature for studies that quantified the effect of advertising on body weight in a realistic setting, but found none. We then decided on total energy intake as an intermediate outcome measure and found only a single suitable study. Based on cross-sectional data and a structural equation model Bolton estimates that an increase in TV food advertising exposure by an additional 25 min/week would cause a child to consume one additional snack per week, which would increase the child's energy intake by ∼1.4%.[12] Hastings *et al.*[3] describe the study as a complex, high-quality study which found a small but significant association between TV viewing and frequency of snacking. In a separate analysis, we replaced this value with one based on current expert opinion, as described below.

Third, lower consumption leads to a lower average body weight [see Equations (2) and (3) in the Appendix 1]. For this step, we applied the results of a study by Swinburn and colleagues[13]. They analysed cross-sectional data in which total energy expenditure is precisely measured and assumed to be equal to total energy intake ('EnFlux'), and validated the outcomes with longitudinal data. The study showed that a higher total energy expenditure is associated with a higher body mass; the authors estimate that two populations with a 10% difference in mean EnFlux would have a 4.5% (95% confidence interval: 3.8–5.1%) difference in mean weight.

Finally, we applied Rose's theorem that the mean predicts the number of deviant individuals[14] and assumed that the average BMI predicts the number of overweight and obese. The development of the obesity epidemic can be conceptualized as a shifting population distribution of BMI.[11] Over the years, the BMI-curve has shifted to higher values with increased skew to the right (figure 1).[15] This is reflected in the mean BMI, which has also steadily increased.[16] We fitted the measured BMI-data of the NHANES 2003–04 study, using the proper sample weights, to a lognormal curve using the least squares method.[17] To mimic the historic changes observed in the

Table 1 Obesity and overweight among US children aged 6–12 years

	NHANES 2003–04	2003–04, no TV commercials for food (counterfactual)	
		Base case (Bolton)	Delphi panel
Boys			
Obesity	17.8%	15.2% (14.8–15.6)	11.0% (7.7–14.0)
Overweight	16.3%	15.0% (14.7–15.2)	12.3% (9.7–14.3)
Girls			
Obesity	15.9%	13.5% (13.1–13.8)	9.9% (7.2–12.4)
Overweight	18.4%	16.8% (16.5–17.1)	13.8% (11.1–16.0)

95% Uncertainty intervals are in brackets. Those around the base case express uncertainty in the relationship between energy intake and body weight only, while those around the 'Delphi panel' scenario also include the uncertainty in the effect of advertising on consumption

estimates as input, the model predicts that reducing the exposure of US children to zero would result in a 12% decrease in total consumption, a lowering of weight by 5.6% and mean BMI by $1\,kg\,m^{-2}$ and a reduction in the prevalence of obesity by 6.8 (3.9–10.1) percent-point for boys and 6.0 (3.5–8.7) for girls. The proportion of children with overweight would be reduced with 4.0% (2.0–6.6) and 4.6% (2.4–7.4), respectively (table 1).

Discussion

A complete ban on food advertising on TV may reduce the prevalence of obesity among US children by about 2.5 percentage points. Based on expert opinion, this could be as much as 6.5 percentage points. In other words, given a baseline prevalence of about 17%, possibly as many as one in seven—or even one in three—obese children would not have been obese in the absence of food advertising on TV. Comparable numbers of overweight children might have had a normal weight.

Limitations

The uncertainty in the size of these effects is considerable and reflects the paucity of quantified data in this field of inquiry. The most uncertain factor in our model is the dose–response relation between advertising and total energy intake. We based our estimate of the number of calories/day that is attributable to TV food advertising on the Bolton study and, in a separate analysis, on expert opinion obtained with the Delphi method. The Bolton study is rather old and based on cross-sectional data. The effect of advertising may be confounded with 'snacking-while-watching', because the time children were exposed to TV advertising was not adjusted for the time spent watching TV. On the other hand, the study may underestimate the effect of commercials because it corrects for parental influence. This assumes parents are not influenced by advertising, but longstanding exposure to advertising may have shifted parents' idea of what constitutes a 'normal' diet for children, even if there is no evidence of an influence on their understanding of a healthy diet.[3] The Delphi study had a rather low response of 24% and self-selection bias cannot be excluded. This bias would probably lead to overestimation of the effects of restrictions on advertising, since people who are passionate about the subject will be more likely to respond. The respondents found the questions difficult to answer. The resulting effect estimate is more than twice the Bolton effect estimate, which was justified by referring to (indirect) evidence from other studies, perceived limitations of the Bolton study

and the notion that marketing is probably more effective now than it was in 1977 when the Bolton data were collected.

The model itself also has its limitations. The modelled prevalence of obesity is about 1.4% lower than that reported by the CDC,[22] though our value falls within their 95% confidence range. This may result from a less than ideal fit of our lognormal curve to children's BMI and from the use of mid-year cut-off points for overweight and obesity, rather than the monthly values. As did Bolton, our model assumes that the relationship between advertising exposure and consumption is linear. This may not be accurate, but since we only estimate the mean effect this is unlikely to lead to significant bias.

Other studies

Few studies give a quantified estimate of the effect of food advertising on childhood obesity, or of the effectiveness of measures to limit the exposure of children to advertising. In an ecological study, Lobstein and Dibb[5] conclude that advertising could explain up to half of the variation between countries' overweight prevalence figures. This suggests a larger effect than we found. Possibly their exposure parameter, the number of obesogenic advertisements per hour, acts as proxy for marketing pressure more in general and the attitude of the public (including parents) towards advertising. A recent econometric study estimates that a ban on TV advertising for fast food would reduce the number of overweight children ages 3–11 years in the USA by 18%,[23] which falls between our high- and low-estimates and suggests an effect for all energy-dense foods that is in the higher ranges of our results.

An Australian study estimates that reductions in TV food advertising may lower mean BMI by $0.17\,kg/m^{-2}$ which is about half to a quarter of the effect we find for a total ban.[24] A strong point is that this effect is based on a randomized controlled trial,[25] but the setting of a summer camp makes extrapolating to total consumption during ordinary life difficult.

Although few other studies estimate the magnitude of the effect of food advertising, TV watching as such has been firmly linked to obesity. In a 4-year longitudinal study Dietz and Gortmaker found a dose–response relationship of about 0.6% increase in obesity prevalence per extra hour of TV, after correcting for past obesity and several socio-economic characteristics.[26] In a later study they conclude that more than 60% of overweight incidence in a representative sample of US children could be linked to excess TV viewing time.[27] Robinson et al. conducted an experiment that reduced the time 9-year-old children spent watching TV from about 15–9 h/week. After 7 months the BMI of the intervention group was 0.45 lower than that of the control group.[28] The mechanism by which TV viewing causes weight gain remains less clear. Besides the influence of advertising, two more pathways have been postulated: the sedentary nature of watching TV and a tendency to snack while watching TV. A recent randomized controlled trial by Epstein at al showed that reducing time spent watching TV or using a computer resulted in a decrease in energy intake, while physical activity levels (measured by accelerometer) remained largely unaffected.[29] This contradicts the widely held belief that physical inactivity explains most of the link between TV viewing and obesity, but does not indicate whether the culprit is advertising or 'snacking-while-watching'. A rough estimate shows that in the Epstein study, a 70% reduction of TV and computer time was associated with a decrease in net energy intake of 10%. In comparison, our model predicts that a similar reduction in TV advertising exposure may decrease consumption by about 3–8%, an estimate that remains under the ceiling implied by the Epstein study.

Strengthening the evidence base

The best design to obtain more accurate estimates of the effect of TV food advertising on childhood obesity would probably be a randomized controlled trial that reduces TV exposure, distinguishes between exposure to advertising and time spent watching TV and also measures physical activity (using accelerometers). Such a study is technically difficult, though in some settings it might be possible to randomize access to channels with a high density of advertising. Given the low feasibility of intervention studies, carefully designed longitudinal and cross-sectional observational studies could make very useful contributions to this field. More quantitative evidence on the effect of marketing on childhood obesity might strengthen the case for policy measures that limit (commercial) freedom and go against powerful vested interests. However, given the complexities of this field of research, the ultimate proof is unlikely to be attainable.

Policy options

The present study suggests that if food advertising on TV were banned, significant reductions in the prevalence of childhood obesity are possible. Reducing marketing of energy-dense foods via any channel might have an even greater effect. A study into the effect of tobacco advertising concluded that a comprehensive set of advertising bans can reduce tobacco consumption but that a limited set of advertising bans will have little or no effect.[30] This might be true for food advertising as well. If only TV advertising were restricted, marketing budgets might not be reduced in size, but instead used to deliver the same message via different media. For example, the internet opens new ways to reach children with marketing messages (e.g. via 'advergaming'). Therefore, even though exposure to TV advertising seems to have stabilized in the US,[9] the total commercial pressure on children's diets is likely to be increasing. Around the year 2000 about 75% of the marketing budgets for food and drink in European countries were spent on TV advertising, but the market share of TV seems to be diminishing.[8] However, it seems unlikely that the use of other marketing channels would fully compensate the loss of TV as an advertising medium. Marketers use a mix of strategies and media to influence their target audience, and it seems reasonable to assume that if the opportunities to reach children diminish, some of its power will be lost.

How much evidence justifies action will always be a matter of judgment.[31] In view of the likely costs of inaction, many obesity experts would argue that the scientific evidence is strong enough to proceed to action.[3,19] The International Obesity Task Force (IOTF) recently formulated the 'Sydney Principles', which call for statutory actions to reduce marketing to children.[32] The American Academy of Paediatrics advocates a ban on junk-food advertising during programming that is viewed predominantly by young children.[33] Several countries (Sweden, Norway, Greece and the province of Quebec) have already restricted advertising to children.

In conclusion, a considerable proportion of overweight children in the USA might have had a normal weight in the absence of advertising for unhealthy food on TV. Though more comprehensive measures are likely to be more effective, restrictions on TV food advertising may reduce the prevalence of overweight and obesity among children. Limiting the advertising of energy-dense foods could well be an element in a broader effort to make children's diets healthier.

Key points

- There is evidence to suggest that advertising for energy-dense food increases children's' body mass index, but it is not well-know how much advertising contributes to the prevalence of childhood obesity.
- This study uses data from various sources in a logical framework to quantify the effect of TV food advertising on childhood obesity in the USA, 2003.
- TV food advertising may be responsible for 15–40% of the obesity prevalence among 6- to 12-year-old US children, with a wide margin of uncertainty.
- Limiting the advertising of high-calorie foods could well be an element in a broader effort to make children's diets healthier.

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Appendix 1: Calculation of hypothetical mean BMI after a change in exposure to TV food advertising

$$\overline{\mathrm{d}I} = \left((1 + S)^{\overline{\mathrm{d}XIT}}\right) - 1 \qquad (1)$$

where $\mathrm{d}I$ = Proportional change in total energy intake due to a change in exposure to TV food advertising; S = Strength of effect, i.e. proportional increase in energy intake/T min/week exposure to TV food advertising; $\mathrm{d}X$ = change in average exposure to TV food advertising (min/week).

$$\overline{\mathrm{dWt}} = \left(1 + \overline{\mathrm{d}I}\right)^{C} \qquad (2)$$

where dWt = proportional change in weight; $\mathrm{d}I$ = proportional change in total energy intake; C = correlation coefficient of body weight with total energy intake.

$$\overline{\mathrm{BMI}_\mathrm{h}} = \frac{\overline{\mathrm{WtdWt}}}{\overline{\mathrm{H}}^2} \qquad (3)$$

where BMI_h = hypothetical BMI after a change in total energy consumption; Wt = weight (kg); H = height (meters).