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Communicating quantitative evidence of policy effectiveness and support for the policy: Three experimental studies☆

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ABSTRACT

Increasing the prices of products that harm health is an effective intervention for changing behaviour to improve health but public support for such interventions is generally low. The current paper investigates whether communicating evidence of a policy's effectiveness at tackling the focal problem could increase support. Across three studies we develop an infographic for communicating quantitative evidence of the effectiveness of a hypothetical tax to tackle childhood obesity. We investigate first, whether communicating evidence of effectiveness increases (a) perceived effectiveness (Studies 1,2,3) and (b) support for the policy, and second, whether any increase in perceived effectiveness mediates an increase in support (Studies 1 & 3). In all three studies (combined $N = 9654$) communicating evidence of effectiveness for the intervention increased perceived effectiveness. In Study 1, communicating evidence did not change support for the policy. Variations of the infographic were developed in Study 2 with one emerging as clearer and easier to comprehend. This infographic was therefore used in Study 3 in which it increased support for the tax from 45% to 49%, an effect that was mediated by perceived effectiveness. The effect sizes were small but probably meaningful at a population level. The results of these three studies suggest the potential for presenting quantitative evidence of intervention effectiveness to increase public support. Much uncertainty remains about the most effective ways of presenting this evidence, whether similar effects are achieved by presenting unquantified evidence and whether larger effects might be achieved by presenting information other than effectiveness.

1. Introduction

Public support for an intervention is often critical for policy-makers considering its implementation through policy (Cairney, 2009; Freudenberg, 2014; Cullerton et al., 2016, 2018). This often leads to partisan groups attempting to sway public opinion one way or another (Elliott-Green et al., 2016). Support for large-scale interventions to change behaviour in health and other contexts is highest for information-based interventions, such as public awareness campaigns, that are of limited effectiveness and lowest for price-based interventions such as taxes, that are of higher effectiveness (Diepeveen et al., 2013; Li et al., 2017). When a proposed intervention is unpopular, yet has the potential to have an impact, policy makers may seek to increase public support. We set out to test one set of promising approaches for doing so, namely communicating the effectiveness of a policy.

We test this approach within the context of childhood obesity policies. As a large number of children are currently overweight or obese (28%) in the UK, with the risk increasing among younger UK generations (NHS Digital, 2017; Johnson et al., 2015), there is a growing demand for government to take action. The UK Government's childhood obesity plan highlights the key role of reducing sugar intake via the associated strategies of taxation and reformulation (HM Government, 2018). While most of the focus has been on taxing sugar-sweetened beverages, we explore the public's support for a tax on confectionary due to recent evidence that it may lead to healthier food selection (Smith et al., 2018).

We use the term public support to refer to a construct that describes how individuals feel and think about the implementation or continued existence of a policy proposed by governmental or supranational organisations (e.g., Sekhon et al., 2017). We use this term synonymously with *public acceptability*.

The predictors of policy support include demographic characteristics, such as gender, age, and ethnicity (Barry et al., 2009), beliefs and values of the individual (Barry et al., 2013), and policy specific beliefs,

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such as the perceived fairness and effectiveness of the policy (Bos et al., 2015; Lam, 2015; Mazzocchi et al., 2015; Petrescu et al., 2016; Storvoll et al., 2015). Amongst these various predictors, numerous studies covering multiple fields have determined the perceived effectiveness of a policy to be one of the strongest predictors (Bos et al., 2015; Lam, 2015; Mazzocchi et al., 2015; Petrescu et al., 2016; Storvoll et al., 2015). Targeting people's perceived effectiveness may therefore be an effective way of increasing support for different policies.

Previous attempts at communicating evidence of intervention effectiveness have increased support for various public health interventions such as vaccines, food labelling and incentive schemes to help people quit smoking (Bigman et al., 2010; Pechey et al., 2014; Promberger et al., 2012). It is unknown whether communicating evidence of its effectiveness would increase support for a tax, one of the least popular public policy interventions (Diepeveen et al., 2013; Somerville et al., 2015). The specific outcome that a policy is effective at reducing is also important, as the public values different outcomes differently (Ipsos MORI, 2017). In particular, the public may not only value overall changes in the key outcome, but also reductions in inequalities related to that outcome (Howarth, Marteau, Coutts, Huppert & Pinto, under review). Communicating evidence of effectiveness confounded with other information has also increased support for policies (Bachhuber et al., 2015; Cornwell and Krantz, 2014; Niederdeppe et al., 2015; Ortiz et al., 2016). For example, Niederdeppe et al. (2015) also included information about the nature of the problem and narratives of people affected by the problem. These studies that use evidence of effectiveness to increase support of a policy may be considered a specific case within the wider research on using evidence to change to beliefs (e.g., Lord et al., 1979; Nyhan et al., 2014; Sunstein et al., 2016). This wider research has found similar results, that under certain circumstances communicating evidence can change some peoples' minds, yet identifying whose mind will change and the best methods for doing so is not always clear.

Communicating evidence takes many forms and these can be evaluated within the context of both risk communication and science communication literature (Logan, 2001; Spiegelhalter, 2017). Evidence of effectiveness can be communicated in different ways including quantitative estimates (e.g., childhood obesity would be reduced by 2%), qualitative estimates (e.g., childhood obesity would be reduced by a lot), and assertions (e.g., childhood obesity would be reduced; Bachhuber et al., 2015; Bigman et al., 2010; Cornwell and Krantz, 2014; Niederdeppe et al., 2015; Promberger et al., 2012). Quantitative estimates are under-used, yet preferable due difficulties in discerning to what qualitative distinctions refer (e.g., what is the difference between very effective and extremely effective?; Spiegelhalter, 2017; Zipkin et al., 2014). The use of visual representations of information such as icon arrays can also be particularly useful for increasing understanding when paired with numerical estimates, including those with low numeracy (i.e. those who struggle to understand numbers; Kreuzmair et al., 2016; Spiegelhalter, 2017). With quantitative communication, the effectiveness must also be framed positively or negatively (10% effective vs 90% ineffective). Positive framing appears to lead to greater support towards the policy (Bigman et al., 2010). Although much is left to be discovered about optimal communication methods, following current guidelines is the best practice (see Spiegelhalter, 2017; p53-54). In the current paper, we primarily used visual representations of the effectiveness using quantitative estimates. These provide specific estimates in a clear way.

The aim of the studies in the current paper is to test whether communicating evidence of effectiveness changes participant's beliefs about the effectiveness of a policy, and whether this then leads to greater support for the policy. It is predicted that communicating evidence that a policy is effective at reducing obesity or reducing inequalities in obesity will lead to greater support for the policies. Values and beliefs were also tested as moderators to see if different participants respond differently to the evidence.

2. Study 1 – Communicating quantitative evidence of effectiveness of the sweet tax

The aim of Study 1 was to estimate the effect on support for a policy of communicating different types of quantitative evidence of that policy's effectiveness and to determine the mechanism for this effect. Specifically, the evidence includes the effects of the sweet tax on overall childhood obesity rates and on inequalities in childhood obesity rates. We predict that reducing inequalities and reducing overall rates by a greater degree will increase support for the sweet tax.

2.1. Method

The study was preregistered with the Open Science Framework (DOI: https://osf.io/nckdj/?view_only=12ee76cb0cd848fc86591ec3163cda51).

2.2. Participants

A power calculation suggested that at least 1566 participants would be needed to provide 80% power to detect small effects $f = 0.10$ with a Bonferroni adjustment ($\alpha = 0.005$) applied to the moderation analyses. Two research agencies (Onepoll; Viga) recruited the participants to be representative of the English population based on age, gender, and socioeconomic status. 2031 participants entered the study, 158 were rejected due to a full quota, 178 were screened-out due to ineligibility (26 were not from England; 152 were using their mobile device to access the survey), 20 did not finish the entire survey (completion rate 98.7%), and 107 participants were removed for failing a quality control question. The relevant quotas were "topped-up" after the quality control exclusions to ensure a representative sample, resulting in $N = 1568$. See Table S1 for the demographic characteristics of the sample.

2.3. Design

The study was conducted online and hosted on www.eu.qualtrics.com. It involved a between-participants design, with seven groups, varying in: Presentation of evidence of distributional impact (population effects only; population effects + reduces inequality; population effects + increases inequality) and Size of effect (small; large), with one control group given no evidence (see Box 1). The Qualtrics randomisation feature randomly assigned participants to one of these seven groups. The control group was weighted to receive three times as many participants as the other individual groups to ensure equal sample sizes for analysis. Before and after the infographics, participants completed a questionnaire.

2.4. Interventions

For all groups the sweet tax was described in a short vignette:

The government is considering a new policy to reduce the number of children who are obese in England.

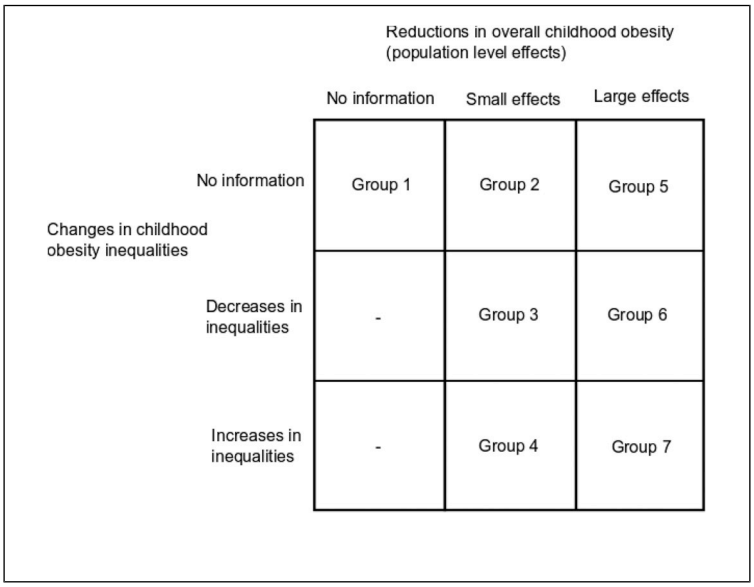
This will increase the price of chocolates and sweets by 20%.

This means that:

a chocolate bar that now costs 50p would cost 60p
a bag of sweets that now costs £1 would cost £1.20

This will not affect the price of biscuits or cakes.

Box 1
Study 1 - Information provided to the experimental groups (Groups 1–7).



Participants were then randomised to a group and received evidence of the policy's effectiveness via infographics, with the exception of the control group (who received nothing). The evidence of the policy's effectiveness was based on data from Briggs et al. (2017). Although Briggs et al. were investigating sugar-sweetened beverages rather than confectionary, this allowed us to estimate a realistic effectiveness. The small effects group was based on the actual predicted effects. The large effects group was based on double the predicted effects. The changes in inequalities was not based on evidence, but kept within realistic ranges derived from Briggs et al. These were developed for the current study based on guidelines for risk communication (Spiegelhalter, 2017) and tested for comprehension in a pilot study (N = 169). Comprehension was high amongst those with less education, although it was highest amongst those with more education (see Supplement for full infographics).

2.5. Measures

All questionnaire items (except demographics) were randomised within their construct.

2.5.1. Demographic measures

Baseline measures included socio-demographic characteristics of age, gender, and occupational classification measured with the NS-SEC (the National Statistics Socio-Economic Classification) (Office for National Statistics, 2005). A single item was used to assess numeracy (Wright et al., 2009). See the supplement for all questionnaire items.

2.5.2. Moderator variables

The beliefs and values variables included the benevolence (α = 0.64) and universalism items (α = 0.62) from the Portrait Values Questionnaire (Schwartz, 2007), assessed on a 1–6 scale with higher scores indicating greater benevolence or caring about the world.

Political orientation was assessed using items reflecting right-wing/left-wing orientation (α = 0.85; Evans et al., 1996).

Two items assessed the desire to reduce childhood obesity (α = 0.86) and two items assessed the desire to reduce towards inequalities in childhood obesity (α = 0.71; both developed by the authors).

2.5.3. Other variables

Two items each were also used to assess causal beliefs about obesity: whether the participant believed that the cause of obesity was due to genetics (α = 0.86), self-control (α = 0.83), and/or the environment (α = 0.81) (adapted from Bos et al., 2015 and Beeken and Wardle, 2013). These items were assessed on a seven point scale (1 = Strongly disagree; 7 = Strongly agree).

Note. The infographics used to communicate this information are provided in supplementary materials. An example from Group 6 is given in Appendix I. In the analysis, the small effects group is 2, 3, and 4 combined. Large group = 5, 6 & 7. Decreases in inequalities = 3 & 6. Increases in inequalities = 4 & 7. Population only = 2 & 5.

2.5.4. Primary outcome

Three items were used to assess support for the sweet tax, the primary outcome for the analysis (α = 0.98; Petrescu et al., 2016). This variable was assessed on a 1–7 response scale with higher values indicating greater support.

2.5.5. Mediator variables

Two items were used to assess the perceived effectiveness of the tax at reducing obesity (α = 0.88), two to assess the perceived effectiveness of the tax at reducing inequalities in obesity (α = 0.84), two to assess the perceived fairness of the tax for consumers; (α = 0.85), and two to assess the perceived fairness of the tax for businesses; (α = 0.80). These items were assessed on a seven point scale and were developed by the authors (1 = Strongly disagree; 7 = Strongly agree).

Participants were then given a chance to provide any additional comments and were then debriefed.

2.6. Analyses

The main analyses used linear regressions, with bias corrected accelerated (BCa) bootstrapped (1000 samples) standard errors. The interactions and mediation analyses were tested using Hayes Process models (Hayes, 2017). Outliers (> 3SD) were removed before analysis (however none of the primary or secondary outcome measures met this criteria). Residuals were checked for the regression models and assumptions were satisfied.

Potential confounding variables (numeracy, SES, gender, age, and

Table 1
Study 1 - Public support and perceived effectiveness (mean (SD)) by group.

	1. Control	2. Population effects only; small effects	3. Inequalities decrease; small effects	4. Inequalities increase; small effects	5. Population effects only; large effects	6. Inequalities decrease; large effects	7. Inequalities increase; large effects
Public support	4.00 (2.04)	4.14 (1.94)	4.35 (1.97)	3.98 (1.83)	4.16 (1.72)	4.14 (1.84)	4.14 (1.93)
Perceived effectiveness at reducing childhood obesity	2.84 (1.57)	3.35 (1.62)	3.53 (1.73)	3.32 (1.57)	3.30 (1.54)	3.44 (1.48)	3.53 (1.61)
Perceived effectiveness at reducing inequalities	2.91 (1.57)	3.44 (1.54)	3.69 (1.72)	3.06 (1.52)	3.29 (1.47)	3.51 (1.48)	3.29 (1.53)

educational attainment) were judged to be matched across groups using a percentage method to assess chance imbalances following the randomisation (Moher et al., 2010). The largest imbalance was 4.4% points (30.6% of participants in the control group had low numeracy compared to 35.0% in the small effects group), equivalent to just 24 participants. Therefore, none of these variables was entered as a covariate in the models.

2.7. Results

2.7.1. Perceived effectiveness

Providing evidence that the sweet tax reduces childhood obesity from 14% to 13% increased the perceived degree of effectiveness of the tax (control vs small effects). Providing evidence that the sweet tax reduces obesity from 14% to 12% had no further effect on perceived effectiveness (small effects vs large effects). Providing evidence that the tax would reduce inequalities increased the perceived degree of effectiveness of the tax at reducing inequalities (population only vs population and reduces inequalities). In contrast, providing evidence that that tax would *increase* inequalities had no effect on the perceived effectiveness of the tax (population only vs population and increases inequalities) (see Tables 1 and 2). These analyses that tested the role of condition on perceived effectiveness were planned only as part of the mediation analyses, but were not planned as standalone results in the preregistration, and were therefore exploratory.

2.7.2. Support for the sweet tax

There were no significant effects of any of the interventions on support for the sweet tax. (see Tables 1 and 2).

2.7.3. Moderation analyses

There were no significant interactions between communicating any of the infographics and any of the five values and beliefs (see Supplemental Table S2 & S3).

2.7.4. Mediation analyses

As there was no main effect of any intervention on public support, the mediation analyses are reported in the supplement (Figure S1 and S2).

2.8. Discussion

Study 1 showed that communicating evidence of the sweet tax's effectiveness increased participants' perceived effectiveness of the tax at reducing childhood obesity. Not all forms of evidence had an impact on perceived effectiveness. Although providing evidence that the sweet tax would reduce childhood obesity from 14% to 13% had an effect on perceived effectiveness, communicating evidence that it would reduce obesity from 14% to 12% had no further impact. Communicating evidence that the sweet tax would reduce inequalities increased perceived effectiveness at reducing inequalities. However, communicating evidence that it would increase inequalities had no significant effect. Despite these effects, none of the interventions increased public support for the tax.

The main effects of communicating evidence of effectiveness on perceived effectiveness replicate the limited research in this area (Bigman et al., 2010). Bigman et al. found that giving people evidence that vaccines were effective increased perceptions of effectiveness among the participants. Communicating evidence of effectiveness did not influence public support for the policy in the current study. This finding contradicts previous research, which has shown increased support for policies as a result of communicating evidence purely on their effectiveness (Bigman et al., 2010; Pechey et al., 2014; Promberger et al., 2012) as well as along with other information (Bachhuber et al., 2015; Cornwell and Krantz, 2014; Niederdeppe et al., 2015; Ortiz et al., 2016).

Table 2
Study 1 - Bootstrapped linear regressions of communicating evidence on perceived effectiveness and public support.

Dependent variable	Predictor	*B*	CIlower	CIupper	t (df)	*p*	Cohen's *d*
Perceived effectiveness at reducing childhood obesity	Communicating evidence (Reference: Control group)						
	Small effects	.56	.36	.76	5.68 (1053)	< .001	.35
	Size of the effect (Reference: Small effects)						
	Large effects	.02	-.16	.21	0.22 (1039)	.839	.01
Perceived effectiveness at reducing inequalities	Distribution of the effect (Reference: Population only)						
	Inequalities decrease	.24	.02	.46	2.01 (1038)	.050	.13
	Inequalities increase	-.19	-.43	.07	−1.62 (1038)	.110	.10
Public support	Communicating evidence (Reference: Control group)						
	Small effects	.16	-.08	.38	1.29 (1053)	.194	.08
	Size of the effect (Reference: Small effects)						
	Large effects	-.02	-.25	.20	−0.13 (1039)	.898	.01
	Distribution of the effect (Reference: Population only)						
	Inequalities decrease	.09	-.21	.40	0.66 (1038)	.507	.04
	Inequalities increase	-.09	-.39	.20	−0.64 (1038)	.517	.04

There are several possible explanations for the lack of change in public support following increased perceived effectiveness for the policy in the present study. First, the communication of evidence of effectiveness could have been suboptimal. In Bigman et al.'s (2010) study, the effect was clear and large: "*The vaccine is effective against HPV strains that cause 70% of cervical cancers*". In the current study, the effect was small - a reduction in childhood obesity from 14% to 12% - in the largest case. Although the information increased perceived effectiveness, approximately 70% of the participants that received this information still perceived the tax to be ineffective. From a population health perspective this effect would be a notable achievement in reducing the problem. Reframing the level of effectiveness in other ways may make the impact of this reduction more vivid to participants. This vividness, in turn, has the potential to increase engagement with the material and increase the likelihood of attitude change (Ophir et al., 2017; Smith and Shaffer, 2000). If the effect is perceived to be small, a larger sample size may be needed to adequately power the study to detect the smaller statistical effects on policy support. Furthermore, comments made by participants indicated that educating people about weight gain was an effective way of reducing childhood obesity, rendering the tax unnecessary. Before people support other solutions to the problem, it may first be necessary to challenge the erroneous belief that education is sufficient in tackling childhood obesity.

Studies 2 and 3 address some of the key uncertainties identified in Study 1. Methods to effectively communicate evidence is addressed in Study 2 first, by making the size of the reduction in obesity that could be achieved by the tax more vivid and second, by refuting the belief that education is the most effective option. The most effective method of communicating evidence to emerge from Study 2 will inform Study 3 that will have a sample size sufficient to detect a smaller effect than was possible in Study 1.

3. Study 2 – Developing the infographic communicating quantitative evidence the effectiveness of the sweet tax

Study 1 found that communicating evidence of a policy's effectiveness had no main effect on public support. Study 2 assessed the possibility that this lack of effect was due to the evidence being communicated sub-optimally. Specifically, we tested whether the evidence could be simplified to increase comprehension, and whether including images could increase engagement with the content, which then could facilitate belief change (Petty and Cacioppo, 1986).

3.1. Method

3.1.1. Participants

A research agency, YouGov, recruited $N = 597$ participants to be representative of the UK population based age, gender, socioeconomic status, region, and education. Unlike Study 1, all subsequent analyses were weighted using the sample weights that YouGov provided. See Supplemental Table S4 for the demographic characteristics of the sample. Recruitment was driven by practical constraints rather than powered for a certain effect size. With the number of participants that were recruited, the study was powered to detect an effect size of at $d = 0.32$ for the 4-group independent variable and $d = 0.23$ for the 2-group independent variable.

3.1.2. Design

The study involved an online experiment, using a between-participants 4 (type of infographic) x 2 (refutation against rival policy) design with eight groups (see Box 2). YouGov's software, used to host the survey, randomly assign participants to one of the eight study groups. After participants viewed the experimental interventions they completed a questionnaire.

3.1.3. Interventions

All participants received the same vignette describing the tax, as in Study 1.

3.1.3.1. Infographics. The "population only, small effects" infographic used in Study 1 formed the basis for Study 2. This infographic is referred to here as the *basic infographic*, with variants of this created in collaboration with the Winton Centre for Risk and Evidence communication and referred to as the *enhanced infographics*. In the enhanced infographics, the text information was simplified and also included a source credibility statement "*The following evidence comes from the University of Oxford*". This was chosen as the evidence was generated by researchers at the University of Oxford. Two of the enhanced infographics also included an image to highlight the magnitude of the reduction in childhood obesity: 1) an image of Wembley stadium with text stating that 100,000 would more than fill Wembley stadium and 2) an image of multiple schools with text stating that 100,000 would fill 400 primary schools. In the refutation condition, the infographics were preceded by a refutation against a rival policy's effectiveness, an educational campaign on poor diets.

3.1.3.2. Refutation. The refutation stimuli include the statement "*You may think [have heard, read] that simply educating children about poor diets is enough to tackle obesity in children. However, the weight of evidence is now clear – this does not work. Although education about poor diets may raise awareness of the problem, it does not actually change behaviour.*" This refutation aimed to challenge the preexisting belief that education on healthy eating is sufficient to combat childhood obesity.

3.1.4. Measures

3.1.4.1. Comprehension. Two items on a 7-point scale were used to assess participants' subjective comprehension of the infographic ($\alpha = 0.95$; 1 = strongly disagree to 7 = strongly agree) and three items were used to assess their objective comprehension. Each objective comprehension item was scored as correct or incorrect, meaning scores range from 0 to 3.

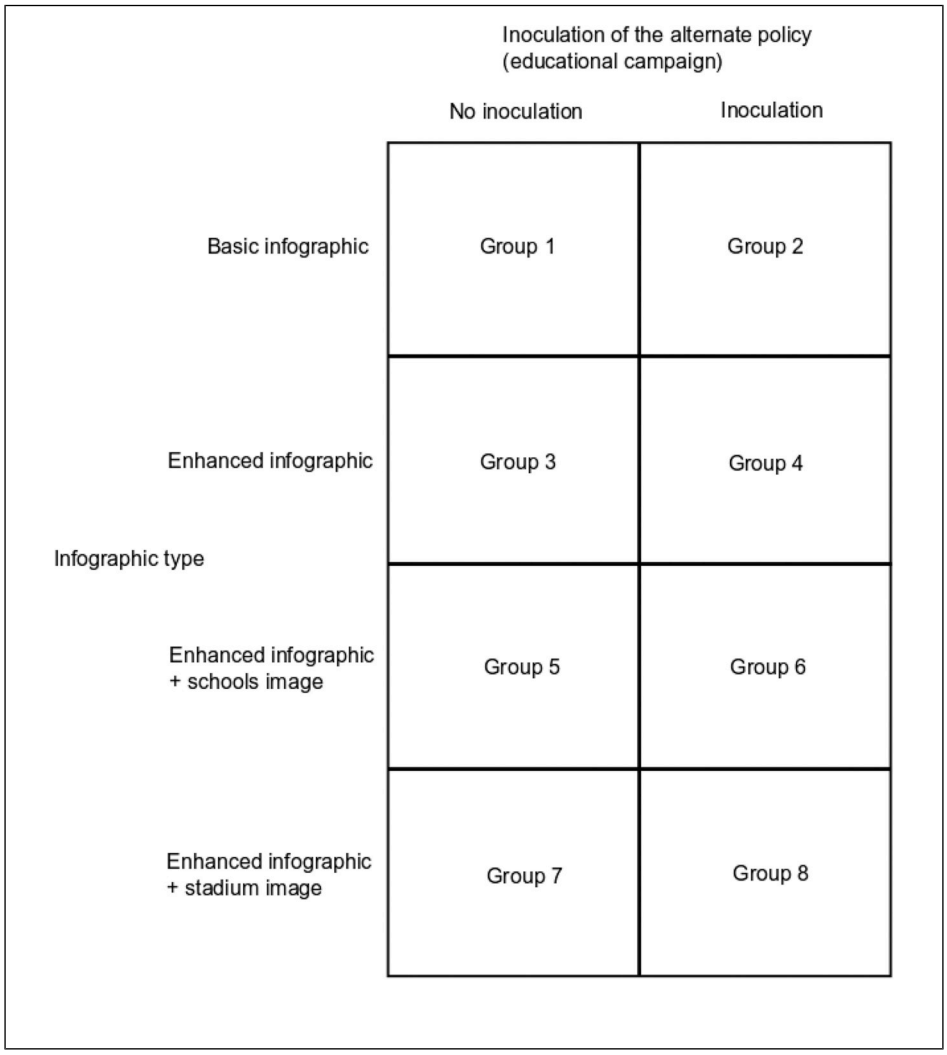
3.1.4.2. Perceived effectiveness and public support. Two items were used to assess the perceived effectiveness of an educational campaign on healthy eating at reducing childhood obesity ($\alpha = 0.89$), two to assess the perceived effectiveness of the tax at reducing childhood obesity ($\alpha = 0.86$), and three items were used to assess the public support for the tax ($\alpha = 0.97$). These items were developed by the authors. See the supplement for all questionnaire items.

3.1.5. Analyses

Given that SPSS does not allow bootstrapping with non-integer sample weights, we used R.3.4.2. with survey and boot packages to weight then bootstrap the data (Canty and Ripley, 2017; Lumley, 2017; Oberski, 2014; Rosseel, 2012). The plan was to remove outliers (> 3SD) however none met this criteria. The main analyses used linear regressions, with bootstrapped (1000 samples) bias corrected standard errors. Residuals were checked and assumptions were satisfied.

The descriptive statistics for perceived effectiveness and comprehension variables are shown in Table 3.

Box 2
Study 2 - Information provided in the eight experimental groups.



3.2. Results

3.2.1. Perceived effectiveness

All three enhanced infographics increased the perception that the sweet tax could reduce childhood obesity when compared to the basic infographic. The refutation had no effect on the perceived effectiveness of the sweet tax. See Tables 3 and 4 for full results.

The refutation against the education campaign reduced perceptions that the educational campaign would effectively reduce childhood obesity. This was tested by comparing the four groups that received the refutation against the four groups that did not. There were no effects of infographic type on the perceived effectiveness of the educational campaign.

3.2.2. Comprehension

All three enhanced infographics were reported as being clearer and easier to understand than the basic infographic. The refutation did not increase the subjective comprehension of the infographics further.

Participants who viewed the three enhanced infographics accurately reported more information from the infographic than those who viewed the basic infographic, indicating higher objective comprehension. The refutation did not increase this further.

Table 3
Study 2 - Public support and perceived effectiveness of the sweet tax by group.

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
Perceived effectiveness of the sweet tax	2.98 (1.49)	3.12 (1.52)	3.34 (1.42)	3.45 (1.73)	3.68 (1.69)	3.06 (1.47)	3.37 (1.62)	3.41 (1.55)
Perceived effectiveness of an education campaign	5.07 (1.41)	4.37 (1.39)	5.46 (1.10)	4.27 (1.50)	5.25 (1.30)	4.53 (1.56)	4.96 (1.43)	4.53 (1.49)
Subjective comprehension	3.95 (1.60)	4.41 (1.73)	5.39 (1.66)	5.52 (1.28)	5.39 (1.65)	5.24 (1.42)	5.39 (1.71)	5.96 (1.16)
Objective comprehension	1.96 (.83)	1.84 (.98)	2.30 (1.01)	2.17 (1.04)	2.18 (1.06)	2.33 (.90)	2.24 (1.11)	2.64 (.74)

Table 4
Study 2 - Bootstrapped linear regressions of communicating different forms of evidence on four outcomes.

Dependent variable	Predictor	*B*	CIlower	CIupper	t (df)	*p*	Cohen's *d*
Perceived effectiveness of the tax at reducing childhood obesity	Refutation against a rival policy (reference: no refutation)						
	Refutation	-.11	-.42	.17	−0.76 (592)	.460	.06
	Infographic content (reference: basic infographic)						
	Enhanced infographic	.35	-.03	.75	1.75 (592)	.090	.20
	Enhanced infographic + image of schools	.34	-.05	.70	1.80 (592)	.068	.20
	Enhanced infographic + image of stadium	.34	-.04	.73	1.73 (592)	.082	.21
Perceived effectiveness of an educational campaign (the rival policy option)	Refutation against a rival policy (reference: no refutation)						
	Refutation	-.77	−1.04	-.52	−5.90 (592)	< .001	.48
	Infographic content (reference: basic infographic)						
	Enhanced infographic	.15	-.26	.49	0.79 (592)	.416	.09
	Enhanced infographic + image of schools	.17	-.21	.54	0.93 (592)	.314	.22
	Enhanced infographic + image of stadium	.00	-.45	.38	0.00 (592)	.942	.00
Subjective comprehension	Refutation against a rival policy (reference: no refutation)						
	Refutation	.22	-.06	.57	1.46 (592)	.158	.12
	Infographic content (reference: basic infographic)						
	Enhanced infographic	1.28	.87	1.69	6.26 (592)	< .001	.73
	Enhanced infographic + image of schools	1.15	.78	1.58	5.84 (592)	< .001	.66
	Enhanced infographic + image of stadium	1.48	.86	1.91	5.90 (592)	< .001	.72
Objective comprehension	Refutation against a rival policy (reference: no refutation)						
	Refutation	.07	-.10	.28	0.69 (592)	.476	.06
	Infographic content (reference: basic infographic)						
	Enhanced infographic	.34	.06	.58	2.63 (592)	.014	.31
	Enhanced infographic + image of schools	.35	.14	.57	3.23 (592)	< .001	.36
	Enhanced infographic + image of stadium	.52	.04	.75	3.15 (592)	.004	.38

3.3. Discussion

Study 2 tested different interventions for communicating evidence and measured how comprehension and perceptions of effectiveness are affected by altering content and visualisation. Participants rated the enhanced infographics as being easier to understand compared to the basic infographic taken from Study 1 (see Supplement – Full questionnaire, p25-32). This was reflected in both subjective and objective comprehension. The three enhanced infographics were unsurprisingly similar in terms of comprehension as they had similar content, and were distinct from the basic infographic which had marginally lower levels of comprehension. The basic infographics had information presented in three ways: percentages, frequencies, and absolute numbers, whereas the enhanced infographics only displayed this information in percentages and absolute numbers. It appears to be this change in content that explains the difference in comprehension between the basic infographic and the three enhanced infographics, rather than the addition of an image.

Participants in the three groups that were provided with enhanced evidence, compared with those provided with basic evidence, also perceived the sweet tax as marginally more effective at reducing childhood obesity. This could be due to their higher comprehension, which was correlated with perceived effectiveness. However, it also could be due to the addition of the image which would encourage greater engagement with the content, thus increase likelihood of belief change (Petty and Cacioppo, 1986). Although the study was not designed to specifically test the effectiveness of the source credibility statement, it is probable that the inclusion of this also explained part of the difference in beliefs between the basic and enhanced groups (Pornpitakpan, 2004). The refutation also decreased the perceived effectiveness of the alternate policy option: educational about poor diets.

The aim of Study 2 was to assess methods for communicating quantitative evidence of a policy's effectiveness more effectively than in Study 1 for use in Study 3. Although the three enhanced infographics performed similarly, participants who viewed the enhanced infographic with the stadium image reported the highest mean levels of comprehension and comparable levels of perceived effectiveness. The refutation also effectively weakened beliefs that an educational strategy would tackle the problem of childhood obesity. For Study 3 we therefore selected the enhanced infographic and stadium image with the refutation.

4. Study 3 – Communicating quantitative evidence of effectiveness and refutation against ineffective interventions to increase policy support

The aim of Study 3 was to test whether communicating evidence of effectiveness can increase public support of the sweet tax first, by powering the study to detect smaller effects than did Study 1 and, second, presenting enhanced evidence with the potential to increase the perceived effectiveness, as found in Study 2.

The secondary aims of Study 3 were to test whether perceived effectiveness mediates the effects on public acceptability, and to examine whether beliefs and values moderate the impact of evidence, as examined in Study 1.

4.1. Method

The current study was preregistered with the Open Science Framework (DOI: https://osf.io/8nfj9/?view_only=ac8166121e8d4c23b409fe6bb8aee874).

4.1.1. Participants

A power calculation suggested that at least 7362 participants would

be needed to provide 80% power to detect an effect size of $d = 0.08$, that was derived from Study 1. A research agency, YouGov, recruited 7596 participants of which 107 did not complete the survey, leaving a total of $N = 7489$ (98.7% completion rate). Participants were recruited to be representative of the UK population based on age, gender, socioeconomic status, region, and education. All analyses were weighted using the sample weights that YouGov provided. See Table S7 for the demographic characteristics of the sample.

4.1.2. Design

An online study using a between-participants design with three groups: control (no evidence provided), basic evidence of the impact of the tax on childhood obesity (the infographic from Group 2 in Study 1), and enhanced evidence of the impact of the tax of childhood obesity (using the same effectiveness information from the basic evidence group but presented according to the findings from Study 2). YouGov's software, which hosted the study, randomly assigned participants to one of the three groups. Before and after the infographics, participants completed a questionnaire.

4.1.3. Intervention

All participants received the same vignette describing the tax as in Study 1. The intervention groups then received information on the effectiveness of the tax.

4.1.3.1. Infographics. The two intervention groups received infographics to communicate the effectiveness of the tax at reducing childhood obesity, whereas the control group received no information. The basic infographic group received the small effects, population only infographic from Study 1 and 2. The enhanced evidence group received the enhanced infographic with the image of the stadium from Study 2.

4.1.3.2. Refutation. The refutation from Study 2 was provided to the enhanced infographic group before seeing the infographic.

4.1.4. Measures

4.1.4.1. Demographic measures. Baseline measures were largely the same as used in Study 1 and included sociodemographics (age, gender, socio-economic status measured with the National Readership Survey social grade questionnaire) and a single item measure to assess numeracy (Wright et al., 2009).

4.1.4.2. Beliefs and values. The same items from Study 1 were used, including benevolence ($\alpha = 0.86$), and universalism items ($\alpha = 0.87$), which were assessed on six point scales.

Additional values and beliefs included political orientation ($\alpha = 0.86$), the belief that something should be done to reduce childhood obesity ($\alpha = 0.88$), and causal beliefs about obesity, namely attributions to genetics ($\alpha = 0.87$), self-control ($\alpha = 0.87$), and the environment ($\alpha = 0.83$). These items were assessed on seven point scale (1 = Strongly disagree, 7 = Strongly agree).

4.1.4.3. Primary outcome. The same three items from Study 1 were used to assess support for the tax ($\alpha = 0.97$). These were scored on a seven point scale, with higher values indicating greater support for the tax.

4.1.4.4. Perceived effectiveness and fairness. The same items from Study 1 were used, including two items assessing the perceived effectiveness of the tax at reducing childhood obesity ($\alpha = 0.90$), two assessing the perceived fairness of the tax for consumers; ($\alpha = 0.84$), and two assessing the perceived fairness of the tax for businesses; ($\alpha = 0.82$). These items were assessed on seven point scale (1 = Strongly disagree, 7 = Strongly agree).

4.1.5. Analyses

The same analysis procedure used in Study 2 was used here. Potential confounding variables (numeracy, SES, gender, age and educational attainment) were judged to be matched across groups using a percentage method to assess chance imbalances following the randomisation (Moher et al., 2010). The largest imbalance was 4.5% points (39.7% of the control group were aged 25–34 compared to 44.2% of the enhanced infographic group). Further examination put the difference in means for age across these groups at only 1.3 years suggesting the groups are well balanced. Therefore, none of these variables were added as covariates into the models.

4.2. Results

4.2.1. Perceived effectiveness

Communicating evidence that the tax reduces obesity (control vs basic infographic) increased perceived effectiveness. As predicted, the enhanced infographic had a larger effect than the basic infographic (see Tables 5 and 6).

4.2.2. Support for the sweet tax

Support for the tax did not increase in the basic infographic group but did increase in the enhanced group when compared to both other groups (see Tables 5 and 6).

4.2.3. Moderation analyses

There were no significant interactions between communicating either infographic and any of the five values and beliefs (see Supplemental Table S9).

4.2.4. Mediation analyses

A mediation model showed that perceived effectiveness mediated the effect of communicating enhanced evidence on public support, (indirect effect: $B = 0.18$, Bootstrapped 95% CI [0.13, 0.24]). There also was a significant indirect effect via perceived fairness for consumers ($B = 0.07$, Bootstrapped 95% CI [0.03, 0.14]), but not via perceived fairness for businesses ($B = -0.00$, Bootstrapped 95% CI [-0.01, 0.01]). However, after controlling for these three mediators, communicating enhanced evidence appears to have a negative effect on public support. See Fig. 1.

As there were no main effects of communicating basic evidence on public support, those mediation analyses are presented in the supplement. While indirect effects can exist in the absence of a main effect (e.g., Hayes, 2009) this does not serve our purpose of identifying mechanisms behind a main effect. For the basic evidence mediation model see the supplement (Figure S3).

4.3. Discussion

Study 3 showed that communicating evidence of the sweet tax's effectiveness in reducing childhood obesity increased its perceived effectiveness, whether using a basic or enhanced set of information. The enhanced evidence also increased support for the tax relative to both control and basic evidence groups.

These results are in line with our hypotheses for the lack of an

Table 5
Study 3 - Public support and perceived effectiveness of the sweet tax by group.

	Control group ($n = 2544$)	Basic evidence ($n = 2436$)	Enhanced evidence ($n = 2509$)
Public support	3.87 (1.88)	3.79 (1.82)	4.02 (1.87)
Perceived effectiveness at reducing childhood obesity	2.74 (1.45)	2.88 (1.50)	3.04 (1.49)

Table 6
Study 3 – Bootstrapped linear regressions testing the role of communicating evidence of effectiveness on perceived effectiveness and public support.

Dependent variable	Predictor	*B*	CIlower	CIupper	t (df)	*p*	Cohen's *d*
Perceived effectiveness at reducing childhood obesity	Communicating evidence (Reference: Control group)						
	Basic evidence	.14	.04	.23	2.83 (4982)	.004	.08
	Communicating enhanced evidence (Reference: Control group)						
	Enhanced evidence	.30	.21	.40	6.43 (5083)	< .001	.18
	Comparing evidence formats (Reference: Basic evidence)						
	Enhanced evidence	.16	.07	.26	3.21 (4907)	.001	.09
Public support	Communicating evidence (Reference: Control group)						
	Basic evidence	-.07	-.18	.03	−1.22 (4982)	.212	.04
	Communicating enhanced evidence (Reference: Control group)						
	Enhanced evidence	.15	.03	.27	2.52 (5083)	.013	.07
	Comparing evidence formats (Reference: Basic evidence)						
	Enhanced evidence	.23	.11	.34	3.66 (4907)	< .001	.10

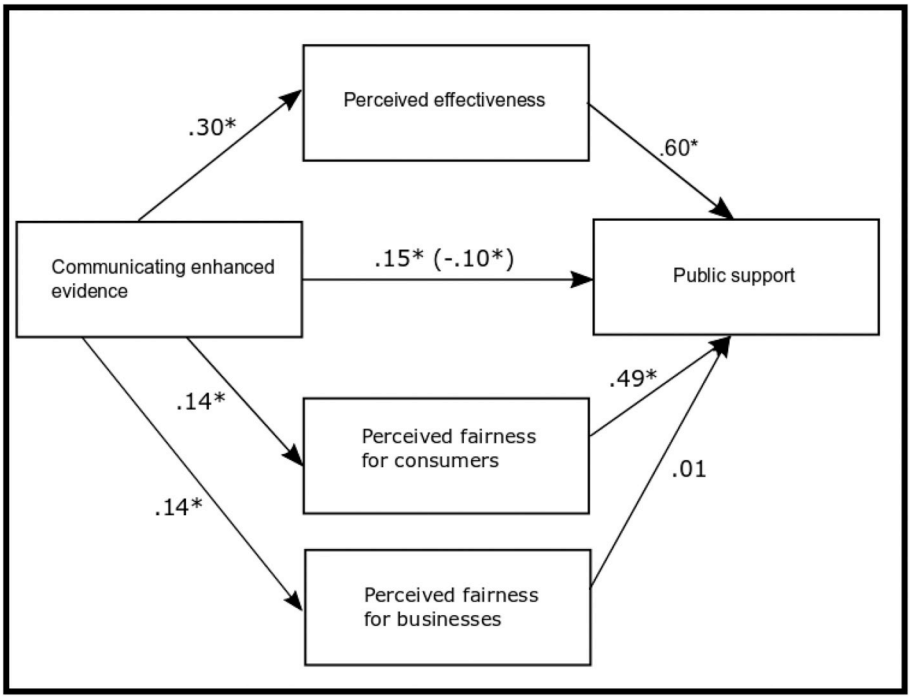


Fig. 1. Study 3 - A mediation model describing the total and direct effects of presenting evidence on public support. The effect of communicating enhanced evidence on public support after including three mediators in the model is reported in brackets (i.e. the direct effect). The indirect effects are reported in the text. ***$p < .001$. **$p < .01$.

impact of communicating evidence on public support found in Study 1. Given that the enhanced evidence group reported greater levels of perceived effectiveness, and only the enhanced group reported greater levels of public support, this highlights the importance of the method of communicating quantitative evidence. These effects would not have been detected without sample sizes of approximately 2500 per group, which supports our other explanation for why no effect was detected in Study 1. Importantly, none of the moderation analyses involving values and beliefs were significant, suggesting that communicating evidence - at least in the current policy area - can increase policy support equally among those with different values and beliefs.

The mediation analysis also confirmed the mechanism for the main effect of communicating evidence on support for the sweet tax: communicating evidence of effectiveness leads to participants believing that the policy is more effective at reducing the focal problem, which then increases support for the policy. Perceived fairness for consumers partly mediated this effect, although this was a weaker effect than that observed for perceived effectiveness. Communicating evidence of effectiveness therefore appears to increase perceived fairness as well as perceived effectiveness which then increases public support. The enhanced evidence infographic that increased participants' perceptions of the effectiveness and support for the tax had several additional characteristics as well as the evidence of effectiveness. It included information about the provenance of the information to add source credibility (Pornpitakpan, 2004), simplified language, a refutation against a rival policy, and an image of a football stadium to convey the magnitude of the effect more vividly. However, as the current study was not designed to tease apart these effects, further research would be needed the relative contribution of each of these features to belief change. The results of Study 3 are in keeping with previous studies reporting that policy support can be increased by communicating evidence of effectiveness (Bigman et al., 2010; Pechey et al., 2014; Promberger et al., 2012). The current study also builds on these studies by confirming the primary mechanism, namely changes in perceived effectiveness.

5. General discussion

The main goal of the current research was to test whether communicating quantitative evidence of a policy's effectiveness can

increase support for that policy. Using the context of a tax on confectionary to reduce childhood obesity, Study 3 showed that support for the tax can be increased by communicating evidence of the tax's effectiveness. Although, in Study 1, support was not increased by communicating evidence, this lack of effect appears to have been due to power issues and use of suboptimal methods of evidence communication. The increases in support observed in Study 3 were small, equivalent to increasing the number who support the tax from 45% to 49%. This increase, however, is likely meaningful when considered on the population level. In addition to increasing support for the tax in Study 3, both Studies 1 and 3 demonstrated an increase in its perceived effectiveness at reducing childhood obesity and related inequalities (only tested in Study 1), an effect that appears to be driving the increase in support. The impact of communicating quantitative evidence of effectiveness was unrelated to participants' beliefs or values, including values of benevolence and universalism, desire to reduce childhood obesity, belief that the environment plays a role in childhood obesity, and political orientation. No previous research has investigated how these first four variables interact with the communication of evidence. However, political orientation has also been found to affect the response to evidence in multiple studies (Nyhan and Reifler, 2010; Nyhan et al., 2013; van der Linden et al., 2015). One explanation for the null finding in the current study is that a tax on sweets and chocolate to decrease childhood obesity is less politically salient than, for example, weapons of mass destruction (Nyhan and Reifler, 2010).

The current study yields small effect sizes that are broadly similar to those found using various approaches to increasing support for obesity policies (Gollust et al., 2017; McGlynn & McGlone, 2018; Niederdeppe et al., 2015). These effect sizes would typically be considered very small in the context of many interventions (Cohen, 1992). The extent to which such effects may be instrumental in achieving policy change is difficult to estimate using traditional scientific methods given the complex processes that characterise policy-making (Cairney, 2009; Cullerton et al., 2018). It should also be noted that the current study only tested this idea on one policy in the health domain. The generalisability of these findings to other policies and domains is unclear.

In developing the infographics, we drew on best practices on risk communication (Spiegelhalter, 2017) and supplemented this with insights from source credibility research (e.g., Pornpitakpan, 2004). Much uncertainty remains about the optimal methods of communicating risk and quantitative evidence (Brick et al., 2018). In particular, Study 2 and 3 found that different interventions that communicated the same core information had disparate effects on the comprehension of the information, the perceptions of how effective the tax was, and support for the tax. Future research would benefit from evaluating different formats for communicating quantitative evidence from the perspective of both comprehension and belief change. However, it should be noted that even if such belief change is accomplished this does not guarantee translation into policy. While public support may be linked with policy implementation it does not ensure it.

While effective communication of evidence may increase its impact, the size of effect that could be achieved is likely to be limited by a number of factors. First, it would not be expected for all participants to support the tax even if they were convinced of its effectiveness, as effectiveness is only one of the many predictors of support, albeit a strong one. Creating larger changes in support will likely require multiple interventions targeting different beliefs and attitudes such as perceived fairness, problem awareness, social norms, and others, in addition to perceived effectiveness (Bos et al., 2015; Lam, 2015; Mazzocchi et al., 2015; Petrescu et al., 2016; Storvoll et al., 2015; van der Linden et al., 2015). Second, the communication of evidence may fail to affect certain people due to cognitive biases. Confirmation bias is one such bias that may explain why evidence is insufficiently effective at changing beliefs (Nickerson, 1998).

In summary, across three studies, communicating quantitative evidence of the effectiveness of a policy increased participants' perceived effectiveness of the policy at tackling the focal problem. There was also some evidence that communicating quantitative evidence of policy effectiveness increased support for it. The effect size was small yet potentially meaningful at a population level. While communicating quantitative evidence of policy effectiveness may increase public support for effective policies, other strategies are also likely to be needed to align public support more closely with effective policies.

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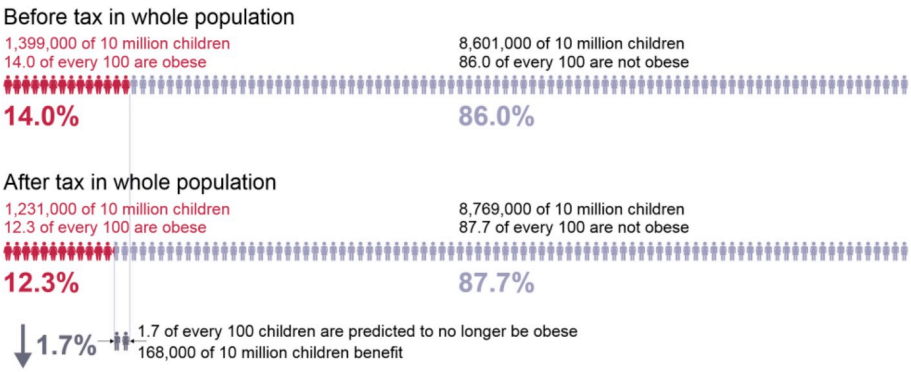
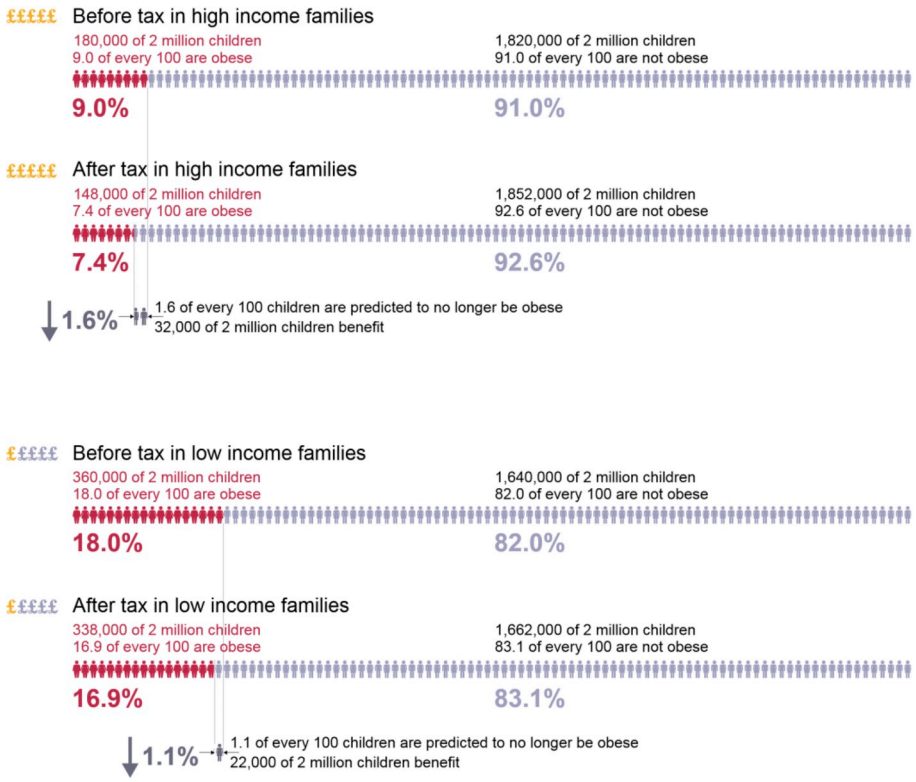
Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2018.09.037.

Appendix I. The infographics from Group 6 [Study 1].





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