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Research methods

Assessing the effect of public health information by incentivised risk estimation: An example on Swedish snus

Daniel Bergsvik[a,b,*], Ole Rogeberg[b]

[a] Norwegian Institute of Public Health, Department of Drug Policy, PO Box 4404, Nydalen, 0403 Oslo, Norway
[b] Ragnar Frisch Centre for Economic Research, Gaustadalléen 21, 0349 Oslo, Norway

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ABSTRACT

Background: The provision of accurate information on health damaging behaviours and products is a widely accepted and widespread governmental task. It is easily mismanaged. This study demonstrates a simple method which can help to evaluate whether such information corrects recipient risk beliefs.

Methods: Participants assess risks numerically, before and after being exposed to a relevant risk communication. Accuracy is incentivised by awarding financial prizes to answers closest to a pursued risk belief. To illustrate this method, 228 students from the University of Oslo, Norway, were asked to estimate the mortality risk of Swedish snus and cigarettes twice, before and after being exposed to one of three risk communications with information on the health dangers of snus.

Results: The data allow us to measure how participants updated their risk beliefs after being exposed to different risk communications. Risk information from the government strongly distorted risk perceptions for snus. A newspaper article discussing the relative risks of cigarettes and snus reduced belief errors regarding snus risks, but increased belief errors regarding smoking. The perceived quality of the risk communication was not associated with decreased belief errors.

Conclusion: Public health information can potentially make the public less informed on risks about harmful products or behaviours. This risk can be reduced by targeting identified, measurable belief errors and empirically assessing how alternative communications affect these. The proposed method of incentivised risk estimation might be helpful in future assessments of risk communications.

Introduction

While risks may be unavoidable, commercial providers have an incentive to downplay, obscure or misinform society and users about the potential risks associated with their products. This is a serious problem in markets for addictive substances, where industries selectively fund research that serves their case, lobby to loosen regulatory burdens, and develop marketing materials to distort risk perceptions – with the tobacco industry being the most well-documented and pernicious case (Glantz, Bero, & Slade, 1998; Ong & Glantz, 2000; Pollay & Dewhirst, 2002).

To counteract these practises, an important government task is to support informed decision making through policies and programs that help consumers accurately perceive and navigate the risk landscape. In addition to reducing industry disinformation (e.g., marketing restrictions), this involves the provision of credible and pragmatically useful information about risks of dependence and harms.

Given its importance, such publicly provided information on risks needs to be accurate, follow established design principles, and be rigorously evaluated, as emphasised in a recent FDA publication (Fischhoff, Brewer, & Downs, 2011). If the goal is to promote informed decision making, we need to identify people's prior beliefs and the belief errors that matter for the decisions involved, correcting these through credible, convincing and understandable communications. The review repeatedly stresses the need for empirical evaluations, as “even the best science cannot guarantee results” but rather “produces the best-informed best guesses about how well communications will work."

While this highlights the difficulties involved in any risk communication, additional issues are raised when the correction of belief errors is seen as potentially harmful to public health concerns. This is well illustrated by the current debate surrounding smokeless nicotine products such as Electronic Nicotine Delivery Systems (ENDS) and Swedish snus, where government information has been strongly criticized for failing to provide relevant information on harm differentials (Kozlowski & Sweanor, 2016, 2017).

Harms from these alternative nicotine-products are not known with

* Corresponding author at: Norwegian Institute of Public Health, Department of Drug Policy, PO Box 4404, Nydalen, 0403, Oslo, Norway.
E-mail addresses: daniel.bergsvik@fhi.no (D. Bergsvik), ole.rogeberg@frisch.uio.no (O. Rogeberg).

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precision, but there are strong reasons to believe that they are substantially lower than the harms from cigarette use (Levy et al., 2004; Lee, 2013; McNeill et al., 2015; Nutt et al., 2014; Royal College of Physicians of London, 2007), and that considerable improvements in public health would be expected if current cigarette smokers could be persuaded to shift to such products (Gartner, Hall, Vos, et al., 2007; Hajek, Etter, Benowitz, Eissenberg, & McRobbie, 2014; Levy et al., 2017; Ramström & Wikmans, 2014).

Since a large share of cigarette users remain unaware of the harm differential (Kiviniemi & Kozlowski, 2015; Liu et al., 2015; Lund & Scheffels, 2014), some researchers have called for clear communication of the harm differential (Gartner, Hall, Chapman, & Freeman, 2007; Kozlowski, 2002; Kozlowski & Sweanor, 2017; Lund, 2012). This proposal has met strong opposition from other researchers, who fear that such a harm-reduction strategy might cause non-smokers to initiate consumption of nicotine products, or cause current smokers to switch or co-use rather than quit. (Dutra & Glantz, 2014; Mejia & Ling, 2010; Tomar, Fox, & Severson, 2009). Other researchers have presented evidence to refute those fears (Ramström, Borland, & Wikmans, 2016; Ramström & Foulds, 2006). The result has been a heated and contentious debate, with accusations in both directions of bias and misuse of science (Gartner, Hall, Chapman, et al., 2007; Polosa, 2015; West, 2014).

Considering this potential conflict between public health and political targets on the one hand, and the goal of informed decision making on the other, we designed a study to pilot a new method for assessing the effects of government-provided health information on participant risk beliefs regarding smokeless tobacco (Swedish snus). The study also asked participants to judge the quality of the information to which they were exposed, allowing us to assess whether perceived quality was higher for information materials that measurably reduced belief errors.

Methods

Measuring accuracy of and changes to risk beliefs following exposure to risk communications requires numerical risk estimates. This is complicated by the often low levels of numeracy in the general population, but nonetheless necessary since qualitative measures ('low risk') and information is ineffective. As noted in the FDA risk communication guide, qualitative information fails to provide "the details needed to make an informed decision; it increases risk perceptions, and patients vary in their interpretations of what low and high risks are" (Fischhoff et al., 2011). Rather than avoiding numeric likelihoods, "we should work to make numbers more accessible for all individuals." Based on a review of the literature, the guide recommends constant time-frames to facilitate comparisons, providing absolute risks rather than relative risks, making clear the difference in baseline and treatment risk, and using whole numbers with constant denominators across comparisons (e.g., stating 1 in 10 000 rather than a 0.01%). This is also consistent with the use of a natural frequency format (X of Y individuals) rather than the use of percentages, which has been argued to promote risk reasoning in the general population (Gigerenzer & Edwards, 2003; Hoffrage, Gigerenzer, Krauss, & Martignon, 2002). In our pilot study, numeracy was expected to be above average, as the majority of participants were undergraduate students from STEM disciplines.

Risk estimation was incentivized in order to reduce bias of anchoring to the initial estimate and normative judgements.

Study protocol

As an illustration of the proposed method, we performed a study comparing incentivized risk estimates elicited before and after exposure to risk communications on tobacco products. Risk communications were randomized across participants. Eight prizes of 200 Norwegian kroner, roughly 22 Euro, were awarded for the most accurate beliefs − four prizes based on initial estimates and four prizes based on the post-treatment estimates. In addition, four randomly drawn participation prizes were awarded. Accuracy was defined by the distance to risk estimates drawn from reports of the Norwegian Institute of Public Health (FHI) (Alexander, Schwarze, Becher, & Øya, 2014; Vollset, Selmer, Tverdal, & Gjessing, 2006).

Participants were asked to consider three groups, each consisting of 100 individuals 40 years old. Groups were specified to differ only with regards to their tobacco use, with one group being tobacco-abstainers, one group smoking 10–19 cigarettes per day, and one group using 10 portions of snus per day. For each group separately, participants were asked to give an estimate of the expected number of deaths 30 years later, when the surviving group members would turn 70.

Participants were recruited in three separate sessions from the common areas of the University of Oslo in the first two weeks of the fall term 2015. After filling out contact information, participants were given instructions and a risk elicitation survey. As participants finished the first risk survey, they were handed information material and a second risk survey from a block-randomized pile. Participants were free to spend as much time as they wanted on both the first and second survey, the three information texts were randomized across participants within each session, and participants were not told that there was variation in the type of risk information handed out to different participants within their session. Since participants were invited continuously and some groups of recruited participants would likely be similar (having just finished the same lecture, etc.), the materials were randomized within blocks of 21 (with 7 of each of the three texts in each block). This raised the probability that all risk communication groups drew equally from participants recruited at different times.

After completing the post-information risk estimates participants were asked to assess the quality of the information – how comprehensible, new/interesting, credible and clarifying they found it – as well as provide information on gender and own tobacco use.

Subjects

A total of 228 participants were recruited on a total of three separate occasions. Participants were primarily younger students from the faculty of natural sciences and the faculty of social sciences. The distribution of participants by gender and tobacco use across the three information texts is shown in Table 1.

Measures

Baseline and post-information risk estimates are collected and an average change in belief errors is calculated. Belief errors are defined as the absolute difference between a risk estimate and the research-based risk estimate.

Table 1
Distribution of subjects by gender and tobacco status across treatment groups (counts). 4 subjects with some missing values are excluded, N = 224.

Sex	Tobacco status		Treatment group		
			Govt. short	Govt. long	Newspaper
Male	Smoke	Never	12	18	17
		Sometimes	11	6	4
		Daily	1	1	1
	Snus	Never	16	20	16
		Sometimes	2	3	4
		Daily	6	2	2
Female	Smoke	Never	11	9	7
		Sometimes	3	2	7
		Daily	1	1	0
	Snus	Never	13	10	9
		Sometimes	2	1	3
		Daily	0	1	2

Risk communication texts

Three different texts with information on snus risks were randomized across participants. Two were taken from official government websites, whereas the third was a newspaper article on the relative harms of snus and cigarettes. The newspaper article was chosen because its content differed substantially from the governmental texts. More specifically, the newspaper article contained numeric information on relative risks of cigarette and snus, whereas the governmental texts quantified neither absolute nor relative risks. A translation of each text is provided as Supplementary information.

The first text (henceforth «Govt. Long») was taken from a health information web portal (helsenorge.no) run by the Norwegian Health Directorate. The text was four pages long, roughly 750 words, and covered health risks of snus relating to cancer, heart disease, use during pregnancy, diabetes/obesity and dental harms. Snus is compared to cigarettes only with respect to nicotine absorption. Six images are included: a brain image illustrating addiction, an infant's leg illustrating risks during pregnancy, a used portion of snus in an ashtray, two pictures of teeth and gums and one photo of a father and son.

The second text (henceforth «Govt. Short») was taken from the website of the Norwegian Health Directorate, and provided a one-page summary (roughly 450 words) of the health effects of snus. The text covered largely the same risks as those of the longer government text in somewhat less detail. In addition, the text mentions sport injuries and erectile dysfunction. Health risks of snus are not contrasted to the health risks of cigarettes. The text was illustrated with an EKG graph.

The last text (henceforth «Newspaper») was two pages long (roughly 900 words), taken from the website of a national Norwegian newspaper (Aftenposten), and based on interviews with Karl Erik Lund (Research director at the Norwegian Institute for Alcohol and Drug Research), Hilde Skyvulstad (Deputy Director General of the Public Health Division of the Norwegian Health Directorate), and Tom K. Grimsrud (Senior Medical Officer at the Etiological Research Unit of the Cancer Registry of Norway). The article headline translates to "Snus is 90 percent less dangerous than cigarettes", and discusses the communication of risks surrounding snus. Lund argues for a harm reduction approach, claims that the large risk differential between snus and cigarettes needs to be communicated strongly and that some of the evidence regarding cancers is preliminary. Skyvulstad states that the most important thing for the Norwegian Health Directorate is to provide accurate information (pointing to helsenorge.no from which the «Govt. long» text was taken). She states that complete cessation of tobacco use is best, but that snus is preferable, if the alternative is continued cigarette use. The interview with Grimsrud, which closes the article, criticizes Lund and the harm reduction perspective. In his view, snus is not necessary for smoking cessation, comparison of overall risks is misleading, the evidence for the cancer risks of snus is strong, and public information should focus on the dangers of use. The text included two pictures, one of Karl Erik Lund and one of an opened package of snus.

Research-based risk estimates

Belief errors are defined here as the distance between a participant's risk estimate and research-based risk estimates from the FHI, which we took to be the risk estimate towards which the government wished to shift the recipient.

The research-based estimates were derived from reports published by FHI. The mortality risks of cigarette smoking were taken from a report stating that some 11% of women and 21% of men smoking 10–19 cigarettes daily will die as a result of smoking between the ages of 40 and 70 (Vollset et al., 2006). According to the tobacco habit survey of Statistics Norway, some 52% of daily smokers in 2014 were male, giving a weighted mean of 16.2% (Statistics Norway, 2015).

The mortality risks of snus were based on a recent FHI review of the evidence on the health harms of snus (Alexander et al., 2014). While the review chooses not to provide numeric estimates of the risk of death, the evidence is judged to be substantial for a causal role of snus in three types of cancers: pancreatic cancer, cancer of the oesophagus and oral cancer. For these cancer forms, the review points to relative risks from *meta*-studies of 1.6–1.8. Using the upper estimate of 1.8 for all three and estimating the mortality risks of these cancers using baseline prevalence estimates and five-year survival rates, it we calculate that around 2.3% of snus users would die between the ages of 40 and 70 as a result of snus use. While these estimates are arguably the ones on which the belief error impact of Norwegian governmental health information should be judged at the time of the experiment, it is worth noting that the implied risk difference between cigarettes and snus may be higher (Boffetta, Hecht, Gray, Gupta, & Straif, 2008; Nutt et al., 2014). Recent summaries even contest the increased cancer risks (Araghi et al., 2017; Gakidou et al., 2017).

Statistical analysis

The distribution of pre-exposure beliefs is illustrated by histograms and means of belief errors.

Risk estimates are by necessity bounded (0–100). This implies that pre-exposure differences across treatment groups also generates differences in mean changes across groups. Since randomization did not succeed in making pre-exposure risk beliefs entirely similar across groups, a balanced subset of the data was drawn by matching observations across treatment groups on the first digit of both pre-exposure snus and cigarette risk estimates. As an example, the number of individuals in the three treatment groups with initial beliefs of snus risks in the 0–10 percentage point range AND initial beliefs of smoking risks in the 20–30 percentage point range could be 5, 8 and 7. The balanced data would then contain all observations from the first group, and a randomly drawn set of 5 observations from each of the two others. This matching process created comparable distributions of initial risk estimates in the three groups. Results based on the non-matched samples were qualitatively similar (See Supplementary material for more details).

Post-treatment changes in risk estimates are displayed in scatterplots, while changes to belief errors are analysed by comparing changes in means using a paired *t*-test on the matched subsample. Belief error changes concerning the risk difference (smoking vs. snus) implied by individual responses are calculated for different relative weightings of over- and under-estimates.

Participant judgments of information texts were done by scoring disagree/neutral/agree as $-1/0/1$ respectively, taking the mean of individual judgments across the four dimensions of quality, and comparing the mean score across treatment groups using linear regression with dummy variables for information text.

Results

Baseline risk estimates

The distribution of initial risk estimates for all participants pooled are shown in Fig. 1. The «excess mortality risk» for snus users had an average estimate of 17.3%, for smokers 31.7%, and the absolute risk difference estimate implied was on average 14.4 percentage points. While average risks are exaggerated for both snus and smoking, the average absolute risk difference implied by responses was accurate on average. The distributions are strongly skewed with a long right-hand tail.

Variation in risk estimates was substantial. Some 64% of the participants estimated a mortality risk for snus users that was 5 percentage points or more above the research-based value, 64% did the same for smoking. Underestimates of smoking and snus risks were less common. The share of individuals with at least one percentage point lower risk

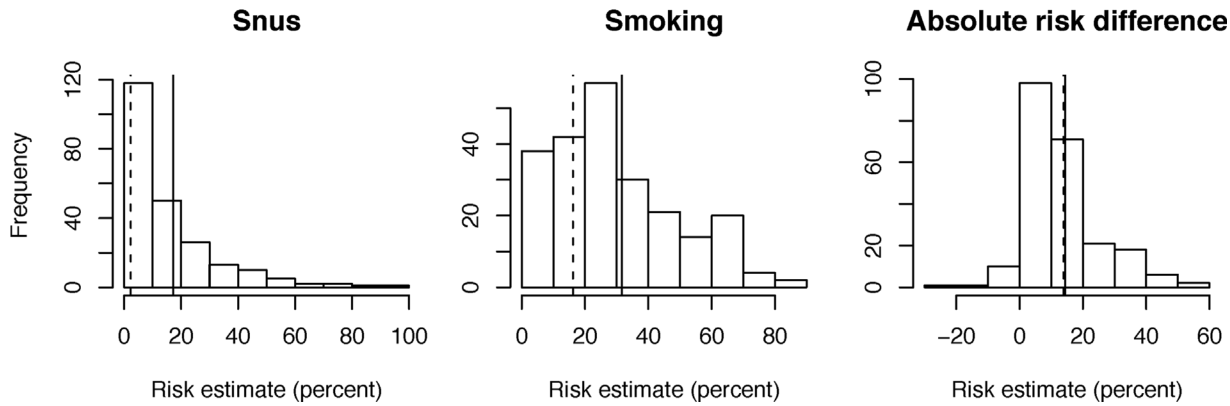

Fig. 1. Distribution of initial risk estimates for snus and smoking, and implied difference in absolute risk. Mean estimate (solid line) and research-based estimate (dashed line).

estimates were 5% for snus and 26% for smoking.

The results imply initial average belief errors of 15.1 percentage points for snus and 18.9 percentage points for smoking.

Changes in risk estimates

The raw data in the form of a scatterplot show the change in individual (log) risk estimates from the pre-exposure to post-exposure period, see Fig. 2. The points can be evaluated relative to the "no change" and "perfect correction" benchmarks, indicated by the 45° line and the dashed line respectively.

A pre-post comparison of unlogged risk errors using paired *t*-tests finds substantial and statistically significant changes in snus belief errors within all information groups. Results are summarised in Table 2.

For snus, the long and short government text increased belief errors by 44% and 52%, respectively, while the newspaper article decreased them by 37%. Evaluated in percentage points, the increase in belief error from reading a government text was larger than the actual risk.

Table 2
Comparison of belief errors, pre- and post-exposure to snus risk information.

Substance	Treatment group	Pre. error mean	Post. error mean	Diff. error mean	p. value	Percent change
Snus	Govt. long	10.25	14.79	4.54	0.01	44.3
	Govt. short	10.03	15.22	5.19	0.00	51.7
	Newspaper	9.60	6.07	−3.53	0.01	−36.7
Smoking	Govt. long	12.19	14.90	2.71	0.07	22.2
	Govt. short	12.63	13.96	1.34	0.04	10.5
	Newspaper	12.88	19.57	6.70	0.00	51.9
Absolute risk difference	Govt. long	6.43	7.38	0.95	0.28	14.8
	Govt. short	7.44	9.83	2.40	0.04	32.2
	Newspaper	7.21	14.25	7.04	0.00	97.6

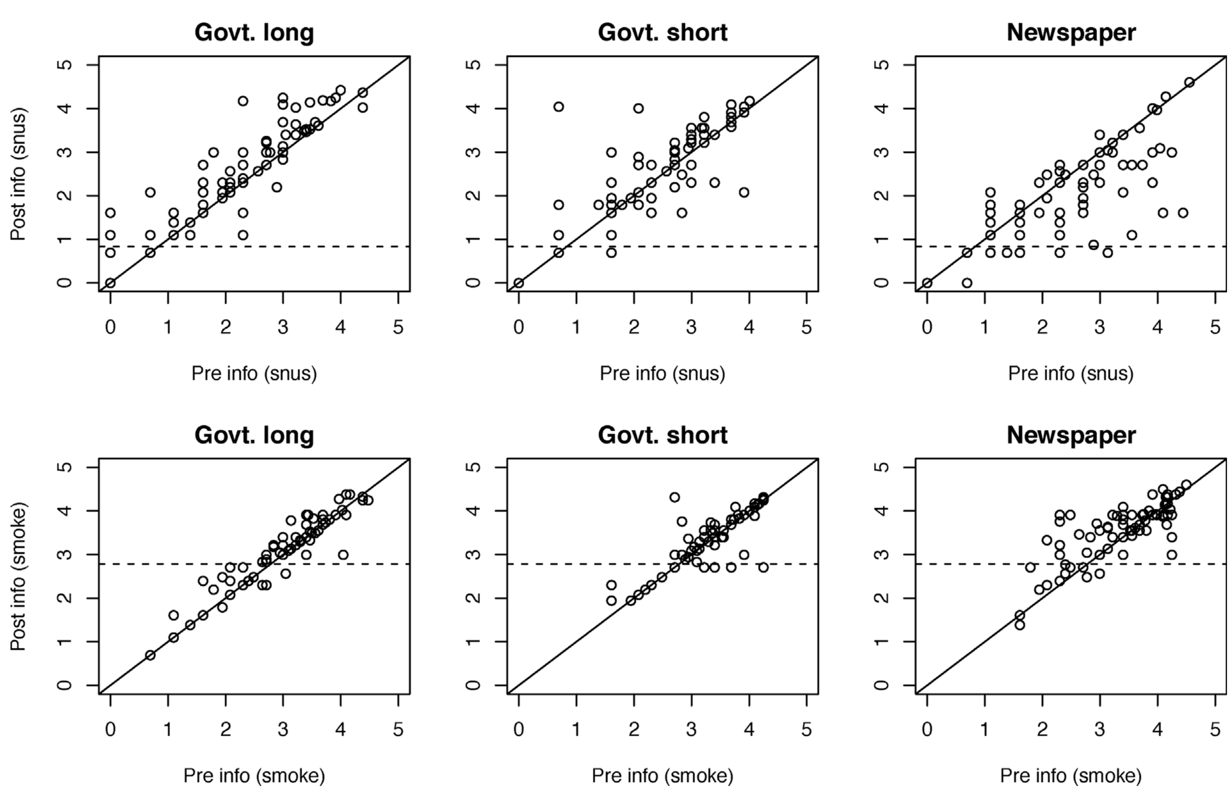

Fig. 2. Pre- vs post-exposure estimates of (log) snus and smoking mortality risk. Individuals with unchanged estimates lie on the solid 45°. The dashed lines indicate where points should lie if the risk information fully removed belief errors.

For smoking, the long government text and the newspaper article both led to statistically significant changes in risk estimates, increasing belief errors by 22% and 52%, respectively

Turning to the absolute difference in risk beliefs regarding snus and smoking, the analysis displayed in Table 2 shows that the difference in belief errors implicit in the responses increased significantly and substantially for the short government text and the newspaper article, increasing by 32% and 98%, respectively.

Our measure of belief error adds underestimates and overestimates as though these were equally problematic, but this may not be appropriate in all contexts. Underestimates, unlike overestimates, may lead individuals to expose themselves to excessive risks, which may be seen as a particularly undesirable outcome of a public information campaign. As a result, we may wish to examine what the overall effect of an information text on belief errors would be if overestimates counted less than underestimates. If overestimates were weighted as some X% of an underestimate. This may alter the relative scores of communication texts substantially, as it indeed does in the present study. With low weights given to over-estimates, the newspaper article does best, reducing the weighted belief errors by 3 percentage points, while the two government texts do not. With zero weight on overestimates belief errors increase by more than 1 and 3 percentage points after exposure to Govt. long and Govt. short, respectively.

As we consider higher weightings of over-estimates, the newspaper article does worse on our overall score, and when over- and underestimates are treated symmetrically it actually does worst, increasing belief errors by 7 percentage points (See Supplementary material for more details).

Assessment of information

With Govt. long as the reference text, quality (averaged across the four dimensions of «credible», «new and interesting», «understandable» and «clarifying») was perceived as significantly lower ($\beta = -0{,}17$, $P = 0.02$), for the newspaper text, whereas the shorter government text was rated as being of similar quality to the long government text.

Discussion

Using a sample of Norwegian university students, the study measured the quality of information on mortality risks of tobacco products in two ways. First, in terms of how it affected belief-errors expressed by participants who were incentivized to improve their risk estimates using the information. It should be noted that this may not accurately assess how subjectively believed risk beliefs were altered. Since participants were incentivized to estimate the mortality risk estimates of FHI, participants who disagree with or distrust these official estimates would have an incentive to misrepresent their true beliefs. It does, however, estimate the extent to which government health information successfully communicated these risk estimates. Given that the convenience sample was drawn from a student population, numerical and text comprehension should be expected to be higher than in the general population of Norwegian smokers. We conclude that the government texts communicate net health risks poorly and substantially increase misperceptions of snus-related risks.

Second, we also measured how the quality of the information texts were subjectively scored by the participants. These two measures did not correlate for snus risk estimates. Although belief errors substantially increased (44–52%) for those exposed to government information and reduced (−37%) for those reading the newspaper article, the participants themselves scored the newspaper article as being of significantly lower informational quality. This suggests that participants are unable to judge the extent to which a piece of information is useful in improving risk estimates, and that researchers should be cautious in judging the quality of risk communications based on participant judgments.

Although the information provided was primarily concerned with snus, one of the three texts («Newspaper») discussed snus risks by contrasting them with smoking. This text highlighted the large difference in mortality risks of smoking and snus, but without anchoring either the snus or cigarette risks in specific numbers. The text reduced risk estimates for snus, but also caused a substantial increase in the (already overestimated) risks of smoking.

This result highlights the importance of being clear on which specific risk misperception we are concerned with and what other risk perceptions our communication may inadvertently influence. As we have seen, all three texts appeared to influence the perceived risks of smoking in addition to that of snus use. The newspaper article was mainly focused on explaining the risk differential between snus and smoking, but this was led to large changes in both the perceived risks of snus (more correct) and smoking (more incorrect).

More importantly, the results highlight the need to be explicit on what it is we want the risk communication to achieve. Our framing of the issue assumes that the goal is to present accurate information in a way that effectively corrects risk beliefs. This is the conventional view emphasised in much of the research on risk communication strategies (Fischhoff et al., 2011). It is also the stated aim of the government information used in this experiment. The newspaper article we used interviews a Norwegian Health Directorate director stating that it is most important for the government to provide correct information. An alternative view, however, might hold that people are poor decision-makers who will fail to adjust their behaviour in the "appropriate" way, even if they had a correct understanding of the risks in question. Coupled with a belief that the "right" behaviour is known, this could lead to an emphasis on "persuasion" over "information". The goal may then be to maximize the probability that recipients cease all use of tobacco and nicotine-containing products (abstinence), or that recipients switch to a lower-harm alternative (harm-reduction).

From our chosen perspective, both government texts were misleading and substantially increased errors in snus risk estimates. The newspaper reduced errors in snus risk estimates substantially, while strongly increasing smoking risk errors. From a "persuasion frame," the government texts were effective in promoting nicotine abstinence by, in practice, leading to exaggerated risk perceptions of snus use, while also (slightly) increasing the perceived risks of smoking. By correcting exaggerated perceptions of snus risks, however, the newspaper article would be viewed as ineffective or counterproductive. Moreover, a persuasion frame may also target a harm reduction message, in which case, the newspaper article was clearly superior in that it raised perceived risks of smoking, while also reducing perceived risks of snus. In this case, the government texts were counterproductive, in that they magnified risk perceptions of snus and decreased the perceived benefit of switching to a less harmful alternative.

Finally, it is worth noting that the large heterogeneity in risk perceptions implies that even information that is error-correcting *on average* may be error-*increasing* for some subgroups. If some belief errors (e.g., underestimated risks) are seen as more harmful than others (e.g., overestimated risks), this could also result in a different ranking of alternative risk communications. This can be addressed by changing the relative weight (importance) assigned to over- and underestimates. This is most easily shown by the beliefs regarding "switching benefit" (i.e., the absolute risk difference of smoking and snus use). The government texts primarily led to exaggerated risk beliefs for snus, causing larger belief errors regarding switching benefits irrespective of weighting. Since the newspaper article reduced snus risk estimates, while strongly increasing smoking risk estimates, this text led respondents to exaggerate the benefits from switching. If over- and underestimates are treated symmetrically, this is a negative outcome. If we are place less weight on over-estimates of switching benefits, however, the text could be seen as reducing belief errors (see Table 1 in Supplementary material).

It is important to note that opinions differ as to whether accurate numerical estimates of risk are an appropriate focus for health communications, since numerically specified risks may fail to reflect the cognitive or affective coding of risks by participants. Without numerical likelihoods, however, it is hard to see how accuracy of risk perceptions can be measured or even defined: what is the "correct" feeling or qualitative word (e.g., very risky, low risk, negligible risk) a well-informed individual should have?

This also relates to the information materials chosen. As noted, the newspaper article was the only one containing numerical information, making it arguably "unfair" to contrast the impact of this article with non-numerical government risk information. This, however, illustrates exactly why numerical information matters in information as well as effect-analysis. While the information in the government materials may have been technically correct at the time they were written, the choice to avoid numerical information may explain why participant beliefs shifted away from research based estimates. And without the elicitation of numerical estimates from participants, it is difficult to see how this negative impact could have been identified.

Conclusion

In a study of how information texts influenced the assessment of tobacco product mortality risks, a new method of incentivised risk estimation was applied. This method is motivated by the idea that the extent to which a risk communication actually informs the recipient is an empirical question that cannot be answered in the abstract. It requires us to be clear on what an informed individual should know and how important we consider different types of belief errors to be.

Using snus risk information as an example, it was shown how Individuals varied in how they updated their risk beliefs with respect to which information text they were exposed to. The two government texts strongly increased belief errors and raised already exaggerated risk beliefs. Furthermore, the sample of university students were unable to effectively distinguish between error-correcting and error-inflating texts. If risk information is intended to effectively convey defendable estimates of real-world risk, the government texts were poorly designed and counterproductive.

The observed error-inflating effect of government information may have different explanations. The government texts were not designed specifically to help their readers making numerical estimates on mortality risks. Various health risks of snus were summarised comprehensively, but the texts lacked information on risk magnitudes and differentials, and were not aligned with established guidelines for risk communication (Fischhoff et al., 2011). This may reflect poor awareness of risk communication strategies, or it may reflect health authorities operating from a different framing of the issue where "persuasion" rather than "information" is the goal.

It is important to be clear on what our study does and does not measure. The current study measured how motivated (incentivized) individuals from a convenience sample updated their expressed beliefs in the moment based on the information in a text. The effect measured on belief-errors, however, is likely to differ from the effects the same texts would have on a sample drawn from another population, from the effects the same texts would have on individuals not incentivized to improve quantitative estimates, and from the longer term effects on participant belief-errors.

These caveats limit the inference that can be drawn from our particular study, but should not be seen as fundamental limitations of the proposed method. The core idea of the method used is to identify specific and measurable beliefs that are important to correct, of being explicit on the criteria used to score belief errors, to expose different samples to different texts or information materials, and to measure the error-correcting effect of the information on participant beliefs. By altering details in the design and implementation, the method could be adapted to measure longer-term effects, effects on non-incentivized readers, and effects on the general public or specific targeted sub-populations. The pilot study shows that the method works, and is able to identify differences in the effect of different risk communicating texts.

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Declaration of interests

None.

Appendix A. Supplementary data

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