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Combating Online Misinformation Regarding Vaccinations

The Influence of a Warning Tool on Information Choice

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DOI

[10.47368/ejhc.2023.205](https://doi.org/10.47368/ejhc.2023.205)

Publication date

2023

Document Version

Final published version

Published in

European Journal of Health Communication

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Citation for published version (APA):

Westerbeek, L., Hendriks, H., Smit, E. S., & Meppelink, C. S. (2023). Combating Online Misinformation Regarding Vaccinations: The Influence of a Warning Tool on Information Choice. *European Journal of Health Communication*, 4(2), 93-112.
<https://doi.org/10.47368/ejhc.2023.205>

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Article

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Regarding Vaccinations**DOI: 10.47368/ejhc.2023.205
2023, Vol. 4(2) 93-112
CC BY 4.0**The Influence of a Warning Tool on
Information Choice****Leonie Westerbeek** 

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Abstract

An increasing number of parents refrain from vaccinating their children. This causes lower immunisation coverage, resulting in disease outbreaks. Online misinformation about early-childhood vaccination is a potential cause of this problem. This study tests whether a warning tool, with the appearance of a traffic light, can influence parents' information choices. An online experiment was conducted with parents and expecting parents ($N = 179$) with varying pre-existing attitudes and in different decision stages. Participants were asked to select three vaccine-related web links on a Google search result page either with or without the warning tool present. Results showed that participants in the warning tool condition (i.e., who saw reliability labels) selected a higher number of links marked as reliable compared to participants in the control group. No significant moderating effect of decision stage and pre-existing attitude were found. As our findings suggest that a warning tool can lead to better-informed vaccination decisions, the implementation of such a warning tool may prove worthwhile.

Keywords

Vaccination, information selection, warning tool, online information, information reliability.

There is much debate about early-childhood vaccinations and, despite the fact that nationwide vaccination programs have been highly effective in decreasing outbreaks of preventable diseases over the last decades, increasing numbers of parents have become wary of vaccines. However, when many parents refrain from vaccinating their children, herd immunity is compromised because for herd immunity, a high percentage of all children needs to be vaccinated (i.e., immunisation coverage; Conyn-van Spaendonck et al., 2012). Recently, immunisation coverage has been gradually decreasing (Van Lier et al., 2019), which increases the likelihood of disease outbreaks (Conyn-van Spaendonck et al., 2012), such as several recent measles outbreaks across Europe: Italy, France, Ukraine, and Romania (RIVM, n.d.; Siani, 2019).

A potential cause of parental vaccination hesitancy might be online misinformation. Anyone can publish anything on the internet for everyone to find and read. Consequently, laypeople can spread content on a large scale, resulting in much online information that has not been checked for accuracy (Flanagin & Metzger, 2000; Meppelink et al., 2019). Part of this can be classified as health misinformation. Health misinformation is defined as “information that is contrary to the epistemic consensus of the scientific community regarding a phenomenon” (Swire-Thompson & Lazer, 2020, p. 434).

An increasing number of individuals use the internet to seek health information (Cotten & Gupta, 2004), thereby increasing the risk of encountering online misinformation (Kata, 2010). Vaccine-related misinformation is widely available, which can influence people’s decision-making (Dubé et al., 2013). For example, a recent study has shown that exposure to online misinformation regarding the Covid-19 vaccine lowered participants’ intention to accept this vaccine (Loomba et al., 2021). It is, therefore, important to investigate how individuals can be assisted in distinguishing reliable from unreliable information. In line with Adams (2010), we define *reliable* as information that is evidence-based and trustworthy. While previous studies have explored how to combat online misinformation (e.g., Nyhan et al., 2014), an effective solution has not yet been found.

Online Misinformation

In 2021, 73% of the Dutch population used the internet to seek out health information (CBS, 2021). Anyone can publish online information regardless of their qualifications (Flanagin & Metzger, 2000), resulting in a considerable amount of misinformation being present on the internet (Shao et al., 2016). When seeking health information online, individuals can experience difficulties in distinguishing between reliable and unreliable information (Diviani et al., 2015). If individuals do not succeed in making this distinction, they run the risk of trusting misinformation and mistrusting reliable information. In the context of online vaccination information, this can lead to decisions that are primarily based on unreliable information.

In the past, decisions to refrain from vaccinating one’s children were often religion-based (Ruijs, 2013). More recently, non-religious parents have also become vaccine-hesitant, because, for example, they incorrectly believe that vaccinations can have harmful side effects or that their children will benefit from going through certain diseases (Vermeulen, 2015). These incorrect beliefs are widespread online, e.g., on blogs or anti-vaccination websites, with online anti-vaccination sources often containing misinformation, such as a suggested link between autism and vaccinations, which has been proven non-existent (Godlee et al., 2011). Previous

research has shown that exposure to anti-vaccination information lowers the intention to vaccinate (Jolley & Douglas, 2014), which is disadvantageous for both children and society.

Online vaccine-related misinformation can thus have severe consequences for public health (Kata, 2010), and effective solutions are hardly available. Some suggested solutions, such as using storytelling (Shelby & Ernst, 2013) or training experts on how to correct misinformation (Smith & MacDonald, 2017), are not supported by empirical evidence. Furthermore, these proposed solutions have in common that they try to counter misinformation after exposure. However, research has shown that countering vaccination misinformation *after* exposure is frequently ineffective and can even backfire (Pluviano et al., 2017). If people are told that earlier distributed information was incorrect, they are often unable to disregard the incorrect information and still tend to fall back on it (Pluviano et al., 2017), a phenomenon called the continued influence effect (Ecker et al., 2010). Nyhan et al. (2014) showed that correcting misinformation regarding a link between vaccination and autism even resulted in a decreased intention to vaccinate among parents with unfavourable vaccination attitudes. A more preventive method against misinformation is therefore necessary as warning people about the unreliability of information *before* they are exposed to it is likely to be more effective (Lewandowsky et al., 2012).

Warning Tools

One preventive method for combating misinformation is the use of warning tools. Warning people before initial exposure to vaccine-related misinformation rather than afterwards is expected to reduce the impact of the misinformation (Lewandowsky et al., 2012), and to make individuals more critical of information quality (Ludolph et al., 2016; Pennycook et al., 2020).

Furthermore, the implied truth effect states that adding warnings to headlines with fake news increases the perceived reliability of headlines without a warning, even if these headlines might simply not have been checked (Pennycook et al., 2020). This is important to take into consideration, as it is undesirable for people to simply assume information is reliable if a tag or warning is not present. In the current study, every single link is accompanied by a green or red traffic light, leaving no room for the implied truth effect to occur. Scharrer et al. (2022) found that attaching a warning stating that independent fact-checkers contest the information provided in an online text led to increased scepticism towards this text among laypeople. However, they also found that the warning did not reduce the persuasiveness of online misinformation presented in an easily understandable manner (Scharrer et al., 2022). This is an important pitfall to keep in mind when trying to combat online misinformation using a warning tool.

Ludolph et al. (2016) tested the effects of warning tools by manipulating a Google knowledge graph box to warn about the reliability of any online vaccine-related information they would encounter. They found that a simple warning (i.e., easily comprehensible text) was more effective than a more complicated warning (i.e., hardly comprehensible text; Ludolph et al., 2016). The current study provides a valuable addition to Ludolph et al. (2016) in two ways. First, our study uses an even simpler, visual warning modelled after a traffic light, as using such a tool has proven successful in warning individuals about the credibility of information in other contexts (Idris & Jackson, 2011). This type of warning tool is expected to have a similar desirable effect in the context of vaccination misinformation. Second, individuals in our study received a warning about specific links instead of a general warning message about the topic.

This might help individuals to distinguish reliable from unreliable information (Lewandowsky et al., 2012).

Decision Stage

A first personal characteristic that may influence the effect of the warning tool is whether parents have already made a vaccination decision for their child. For the parents who have already decided, cognitive dissonance is likely to occur during the online information-seeking process when they encounter information that does not support their decision. Cognitive dissonance entails dealing with conflicting ideas, resulting in uncomfortable feelings, which motivate the individual to reduce the dissonant state (McMaster & Lee, 1991). Since research has shown that people tend to avoid certain information if it will cause dissonance (Case et al., 2005), this can also occur during the information-seeking process regarding early childhood vaccination. If, for instance, a parent has decided not to vaccinate their child, and subsequently encounters information stating the benefits of vaccinating, an uncomfortable state of dissonance will occur. In order to prevent this, individuals tend to select information that is in line with their previous actions (Adams, 1961).

The tendency to refute evidence that causes a state of dissonance has also been observed in the process of seeking online vaccination information (Kessler et al., 2019; Moran et al., 2016; Pluviano et al., 2019), meaning that participants might, for instance, tell themselves that the warning tool is not accurate. Dissonance occurs when parents have decided not to vaccinate their child and are confronted with information inconsistent with this decision (e.g., benefits of vaccination). Parents who have already made this vaccination decision will likely try to avoid information inconsistent with their decision and will probably tend to select information that supports their decision. Compared to parents who have not decided yet, they are therefore more likely to disregard the warning tool when choosing information. Practically, this means that both vaccine-supportive and vaccine-opposing parents would choose information marked as unreliable when it presents information that is congruent with their decision over information marked as reliable that is incongruent with their decision. This is because the latter situation would result in increased dissonance.

Pre-Existing Attitude Towards Vaccination

A second personal characteristic that might influence the effect of the warning tool are people's pre-existing attitudes towards vaccination. When seeking online and offline information, individuals tend to seek and interpret evidence in such a way that it is congruent with pre-existing beliefs and expectations; a phenomenon known as confirmation bias (Nickerson, 1998; Klayman, 1995; Ling, 2020).

Research shows that parents tend to select more belief-consistent information than information that disconfirms their own beliefs when it comes to online vaccination information seeking (Meppelink et al., 2019). This process of confirmation bias is powerful and could influence how people's actual information choice is guided by a warning tool. For example, if people hold strong negative beliefs about vaccination and a specific vaccine-critical page is marked as unreliable by the warning tool, they might still select this webpage because it is in line with existing beliefs. This effect likely occurs among parents with rather strong attitudes (both positive and negative), compared to parents with moderate attitudes. Research has shown

confirmation bias occurs in vaccine decision-making, as people tended to seek out information that confirmed their pre-existing beliefs about the topic (Voinson et al., 2015).

Furthermore, research shows that people are more likely to accept information if this falls within their “latitude of acceptance”, meaning it falls within the range of values judged acceptable by the individual (Cordina et al., 2021; Pan et al., 2021; Sherif, 1963). This indicates that people are often unwilling to accept information that deviates too much from their own beliefs (Eagly & Telaak, 1972; Maio et al., 2018). This is also related to belief-strength; a person with weak attitudes is likely more receptive to a broader range of information (Moran et al., 2016). Thus, based on confirmation bias research and latitudes of acceptance, we expect that people with strong pre-existing attitudes are more likely to ignore the warning tool, as the warning might indicate to read information that does not fall within their latitude of acceptance.

Research Objectives and Hypotheses

The present study tests the effectiveness of a warning tool; a method which has been applied successfully in other contexts to help people distinguish reliable from unreliable information (e.g., Hwang & Jeong, 2016; Pennycook et al., 2020). Our tool resembles a traffic light, and its colour indicates the reliability of the information (i.e., green for reliable and red for unreliable). We test whether the tool can effectively guide people towards choosing information marked as reliable over information marked as unreliable. We also assess whether 1) there are differences between individuals who have already made a vaccination decision for their child versus those who have not yet and 2) between those with varying pre-existing attitudes towards vaccination. This leads to the following three hypotheses:

H1: Participants in the warning tool condition will choose to read information marked as reliable as opposed to unreliable more often than participants in the control condition.

H2: The effect of the warning tool on the information choice is stronger for participants who are yet to make a vaccination decision than for participants who have already decided.

H3: The effect of the warning tool on information choice is weaker for participants with a (very) negative or (very) positive pre-existing attitude towards vaccination compared to participants with a moderate attitude.

Materials and Methods

Participants and Design

The online experiment was conducted in 2019 (i.e., before the start of the Covid-19 pandemic) among parents who were expecting a child and/or had a child of nine years or younger. The age of nine was chosen as children receive vaccinations until this age according to the national program in Netherlands (RIVM, 2019). Qualtrics was used to create the online questionnaire and the experimental manipulation. Participants were approached through several channels. Five obstetricians, two primary schools and an association with five childcare facilities in the Netherlands cooperated by distributing the questionnaire. Furthermore, the questionnaire was shared on a Facebook page for pregnant women. Before starting the experiment, ethical approval was obtained by the Ethics Review Board of the Faculty of Social and Behavioral Sciences, University of Amsterdam (2019-PC-10412).

Table 1. Participant Characteristics

Variable	<i>n</i>	%	<i>M</i>	<i>SD</i>
Gender				
<i>Male</i>	22	12.3		
<i>Female</i>	155	86.6		
<i>Prefer not to answer</i>	2	1.1		
Age			33.35	7.46
Level of Education				
<i>Low</i>	7	3.9		
<i>Middle</i>	62	34.6		
<i>High</i>	110	61.5		
Pregnant or Child Younger than 6 Weeks				
<i>Yes</i>	65	36.3		
<i>No</i>	114	63.7		
Vaccinating Children According to National Immunization Program				
<i>Yes, National Program</i>	150	83.8		
<i>No, Alternative Scheme</i>	5	2.8		
<i>No, not at all</i>	15	8.4		
<i>Other</i>	9	5.0		
Role of Religion During Vaccination Decision (1 = <i>not at all</i> , 7 = <i>very much</i>)			2.09	2.55
Searching for Online Information about Vaccination (1 = <i>very little</i> , 7 = <i>very much</i>)			4.15	2.18
Doubt about Vaccination Decision (1 = <i>very little</i> , 7 = <i>very much</i>)			2.07	1.71
E-Health Literacy (1 = <i>low</i> , 5 = <i>high</i>)			4.04	0.52

In total, 394 participants started the experiment, of whom 191 participants completed it. Responses of individuals who indicated not having any children and who were also not expecting ($n = 4$), or who looked at the information on the web pages for less than 10 seconds ($n = 8$) were excluded. This resulted in a final sample of 179 participants ($M_{age} = 33.35$, $SD_{age} = 7.46$). Table 1 provides insight into the characteristics of the participants. The sample included mainly female participants ($n = 155$; 86.6%). Slightly over one-third ($n = 65$; 36.3%) had yet to make a vaccination decision. Most of the participants ($n = 150$; 83.8%) vaccinated or were planning to vaccinate their child according to the Dutch national immunisation program. Participants had overall high e-health literacy scores, measured using the eHEALS measure (Norman & Skinner, 2006) on a 5-point-scale ($M = 4.04$, $SD = 0.52$, see measures).

Procedure

Participants received an invitation to participate including a link to the questionnaire. Here, the topic of the study was introduced and people provided informed consent. The questionnaire first assessed pre-existing vaccination attitudes. Then, participants were randomly assigned to one of the two conditions. All participants were exposed to a fictitious Google results page

showing 10 search results. In the warning tool condition, each result was accompanied by a traffic light. Participants in this condition were told that the traffic light next to each result reflected its reliability, with green meaning more reliable (i.e., defined as evidence-based and trustworthy) and red meaning less reliable. The control condition showed the same Google search results, without traffic lights. All participants were asked to choose three search results from the Google page and click the links that would subsequently lead them to the corresponding webpage. They were asked to choose links they would normally click when searching for vaccine-related information and were told that they could choose whichever link they would like to see.

After exposure, potential covariates were assessed in the questionnaire, such as the age of the participant's child(ren), their vaccination status and how this decision was made. Participants' age, gender, level of education and e-health literacy were assessed at the end of the questionnaire. In the debriefing, we informed the participants that the Google page had been simulated and explained the important fact that the traffic light did not represent the actual reliability (or accuracy) of the information (see pre-test). Participants were referred to the RIVM for reliable information. Lastly, participants were thanked for their participation. The procedure is visualised in Figure 1, and the questionnaire (translated from Dutch to English) can be found in Appendix A.

Materials

For the purpose of this study, we simulated a Google page with 10 links related to childhood vaccinations (Figure 2). The results (links) were selected based on a pre-test described below. During the experiment, participants were asked to click on three links, leading to screenshots of the corresponding webpage. The links and corresponding webpages were identical for the two conditions except that for the experimental condition, the warning tool (i.e., traffic light) was added to the Google page (Figure 2). The warning tool consisted of a red or green traffic light placed next to each link, indicating the reliability of the information. Participants were told that green links could be interpreted as reliable and red links as unreliable. As we wanted to test the sole effect of the warning tool, we controlled for the potential influence of information valence in the following way: The Google page included four vaccine-supportive, four vaccine-opposing and two links of neutral valence, and we evenly and randomly assigned the reliability indicators (red/green light) to those links. That is, half of the positive links (2) randomly received a green light and the other half (2) a red light. The same procedure was followed for the negative and neutral links. It is important to note that, due to this procedure, the colour of the traffic light is not based on the actual reliability of the link.

Pre-Test

A pre-test was conducted to select the hyperlinks for the simulated Google page. All participants (22 women, 7 men; $M_{age} = 43.34$, $SD_{age} = 6.43$) in the pre-test had children. During the pre-test, participants were exposed to 20 links (not the corresponding web pages) in a random order. As we planned to randomly assign the label *reliable/unreliable* to each link, the sources of the hyperlinks had to be unfamiliar to participants. We did not want participants to become suspicious when, for instance, seeing a well-known and respected source marked as unreliable. Thus, for the pre-test, links were selected that originated from sources that we expected to be fairly unfamiliar and would also score fairly neutral on perceived reliability.

This would allow for randomly allocating reliability to the links with positive, negative, and neutral valence.

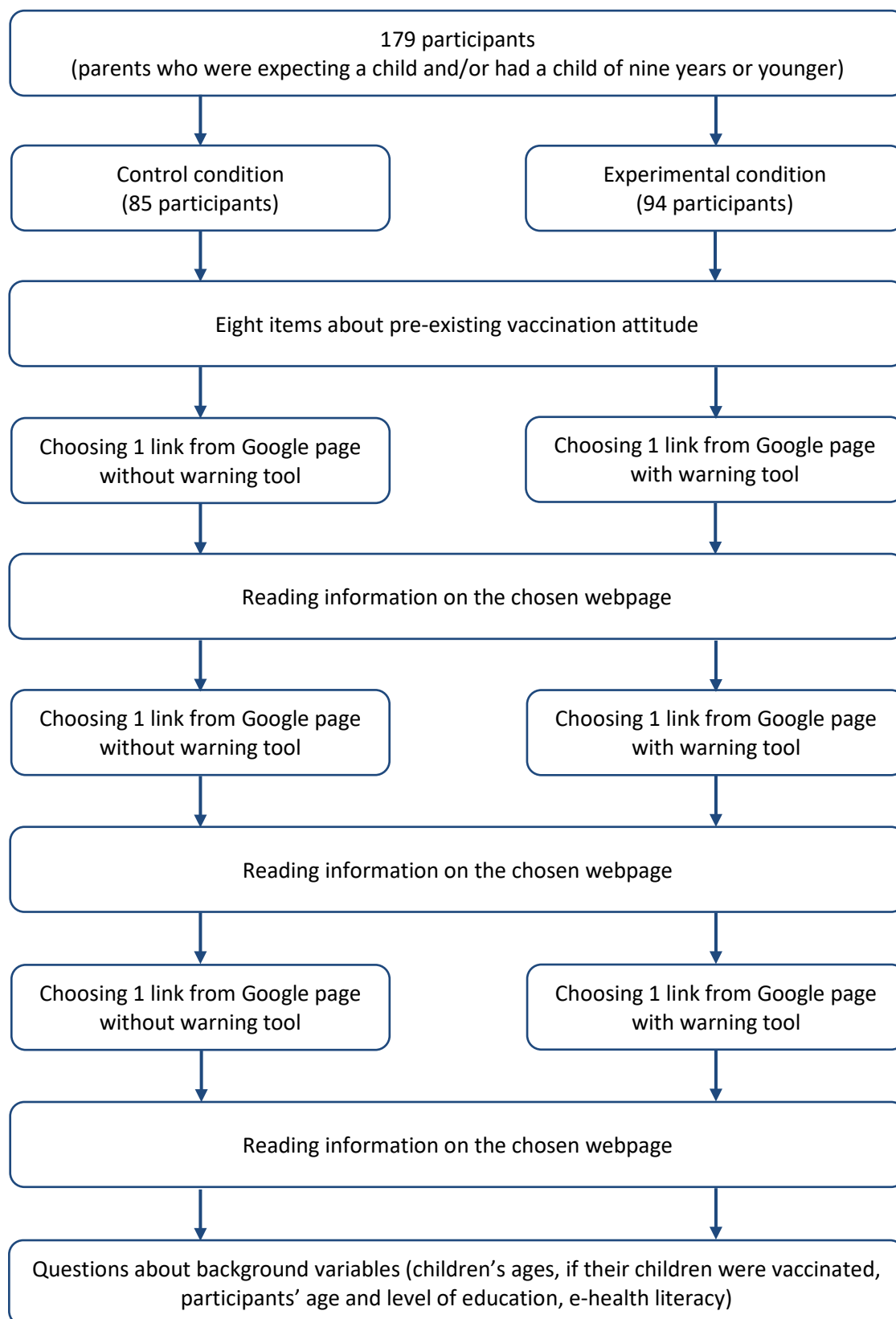


Figure 1. Visualised Procedure

Google Kinderen vaccineren

Alle Afbeeldingen Nieuws Video's Shopping Meer Instellingen Tools

Ongeveer 1.670.000 resultaten (0,41 seconden)

1 **Waarom verplicht vaccineren een goed idee is - Blogs - Skipr**
<https://www.skipr.nl/blogs/id1512-waarom-verplicht-vaccineren-een-goed-idee-is.html>
 9 jul. 2013 - Ouders die hun kinderen niet laten vaccineren krijgen niet te maken met Zeer belangrijk omdat deze gegevens door een onverdachte bron, ...

2 **Petities pleiten voor verbod op kindervaccinaties. Zal Big Pharma nu ...**
<https://www.ninefornews.nl/Gezondheid>
 7 aug. 2017 - Zal Big Pharma nu eindelijk een halt toegeroepen worden? Petities pleiten voor verbod op kindervaccinaties. Gaat dit onze kinderen redden?

3 **Kinderarts bevestigt baby-vaccinatieschade..! - WantToKnow.nl**
<https://www.wanttoknow.nl/gezondheid/.../kinderarts-bevestigt-baby-vaccinatieschade...>
 29 okt. 2016 - Er lijkt een eeuwige welles/nietes-strijd te zijn, inzake de aanwezigheid van kansen op vaccinatie-schade bij baby's, tussen de realisten en de ...

4 **Stop de claim van gezondheidsautoriteiten dat vaccineren veilig is ...**
<https://stichtingvaccinrij.nl/stop-claim-gezondheidsautoriteiten-vaccineren-veilig-is/>
 22 feb. 2018 - Deze petitie is niet voor of tegen vaccineren. Het wil laten zien dat burger hulpverleners, gezondheidsautoriteiten en regeringen oproepen om ...

5 **Dit wil je weten over de vaccinatie-discussie | 10 belangrijke vragen ...**
<https://gezondnu.nl/Immuun-en-afweer-systeem/Allergie>
 13 sep. 2018 - Vaccineren blijft een heet hangijzer. Moet je je kinderen laten inenten, of niet? We praten je bij over de discussie rondom vaccineren.

6 **Waarom je je kinderen wél moet laten vaccineren: dit zijn de feiten en ...**
<https://www.bedrock.nl/Body/Care>
 8 nov. 2016 - Wel of niet vaccineren tegen kinderziekten is zo'n onderwerp waar menig ... En als de voordelen (bescherming tegen dodelijke infectieziekten) ...

7 **Vaccinatie: voordelen, risico's en bijwerkingen | Mens en Gezondheid ...**
<https://mens-en-gezondheid.infonu.nl/.../190987-vaccinatie-voordelen-risicos-en-bijw...>
 Vaccinatie: voordelen, risico's en bijwerkingen. Ter-info in Diversen (Mens en Gezondheid), 21-09-2018 (laatste update) FacebookGoogle+TwitterWhatsapp/ ...

8 **Autisme door Vaccinaties inclusief wetenschappelijk bewijs (RIVM ...**
<https://www.larsvanhemmen.nl/Vaccinatie-RIVM/autisme-vaccinatie/index.html>
 Autisme door Vaccinaties Wetenschappelijk aangetoond. Lees hier alles en download opzienbarend bewijs. Vaccinatie gevaren van het RIVM ...

9 **Laat je kind vaccineren tegen infectieziekten | Dokterdokter.nl**
<https://www.dokterdokter.nl/Gezond-leven/Kind>
 Als ouder is het soms moeilijk: je kind laten inenten. Kinderen worden namelijk vaak ziek van vaccinaties en zijn een paar dagen uit hun doen. Toch zijn ...

10 **Hoe vaak moet de wetenschap aantonen dat vaccinatie veilig is - Joop**
<https://joop.bnnvara.nl/.../hoe-vaak-moet-de-wetenschap-aantonen-dat-vaccinatie-veilig...>
 2 jul. 2014 - Hoe vaak moet de wetenschap aantonen dat vaccinatie veilig is ... Hoe vaak is er al niet aangetoond dat vaccinatie levens redt, ziekte voorkomt ...

Googoooooogoo >
 1 2 3 4 5 6 7 8 9 10 Volgende

Figure 2. The Google Page with the Warning Tool

Note. The translations of the hyperlinks in the stimulus material are as follows: (1) “Why compulsory vaccination is a good idea - Blogs – Skipr”, (2) “Petitions calling for prohibition of childhood vaccinations. Will Big Pharma ...”, (3) “Pediatrician confirms baby-vaccination damage..! - WantToKnow.nl”, (4) “Stop health authorities' claim that vaccination is safe ...”, (5) “This is what you want to know about the vaccination discussion | 10 important questions ...”, (6) “Why you should vaccinate your children: these are the facts and ...”, (7) “Vaccination: advantages, risks and side effects | Human and Health ...”, (8) “Autism because of vaccinations including scientific evidence (RIVM ...”, (9) “Get your child vaccinated against infectious diseases | Doctordoctor.nl”, (10) “How often does science have to prove that vaccination is safe – Joop.”

Participants in the pre-test were asked to rate the valence of each link, its reliability and their familiarity with the source on a 7-point scale (ranging from 1 = *very negative* to 7 = *very positive*, 1 = *very unreliable* to 7 = *very reliable*, and 1 = *very unfamiliar* to 7 = *very familiar* respectively). At the start, participants were told that we define reliable as evidence-based and trustworthy. The links were real hyperlinks, collected by Googling several search terms about vaccinations such as “importance childhood vaccinations” and “danger childhood vaccinations”. In total eight links with positive valence, eight links with negative valence and four links with neutral valence were presented. The results of the pre-test showed that all 20 pretested links scored low on familiarity and moderate on reliability; with no significant differences between the mean scores on these two variables. Based on this, the four links with the most positively evaluated valence, four links with the most negatively evaluated valence, and two links with the most neutrally evaluated valence were selected for the Google page. Thus, the selected positive and negative links scored equal in terms of perceived reliability. The neutral reliability score was necessary, as the links for the final stimulus material would be randomly marked green or red and participants should not become suspicious. The low familiarity score ensured that participants were most likely not influenced by any impressions of the links they may have formed based on prior encounters.

Measures¹

Information Choice. This dependent variable was calculated based on participants’ three information choices. For each chosen green link (i.e., reliable according to the warning tool), a point was added to their score. This resulted in an information choice score varying between 0 and 3, where 0 indicated choosing zero green links and 3 indicated choosing three green links ($M = 1.80$, $SD = 0.78$). This was done both for participants in the experimental condition and for participants in the control condition (even though participants in the control condition could not see this traffic light). If the warning tool would not affect participants’ information choice, the links selected in each condition would not significantly differ from each other. However, if the warning tool would influence participants’ information choice, we would see a significant difference between the number of green links chosen in the experimental condition compared to the control condition.

Decision Stage. A distinction was made between participants who still had to decide about vaccinating their child and participants who had already made this decision. Therefore, we asked the age of the participants’ youngest child. If the child was not born yet or younger than six weeks, the participant could still make or alter the vaccination decision, as children receive their first vaccine at six weeks old, according to the Dutch national vaccination program (RIVM, 2019). If the participant’s youngest child was older than six weeks, a vaccination decision had already been made.

Pre-Existing Vaccination Attitude. The second personal characteristic, vaccination attitude, was measured with the Vaccination Confidence Scale (Gilkey et al., 2014). The scale consisted of eight items, e.g., “Vaccines are safe” and “Children receive too many vaccines” measured on a 7-point Likert scale (1 = *completely disagree*, 7 = *completely agree*; $\alpha = .89$, $M = 5.51$, $SD = 1.20$). Based on participants’ mean scores on this scale, they were equally divided into four groups. The first group consisted of the most negative 25% of the sample, sample, scoring between 1.00 and 5.14. The second group contained 25% of the sample who were somewhat

positive, scoring between 5.15 and 5.87. The third group was positive towards vaccination, scoring between 5.88 and 6.25. Lastly, the final group was very positive and scored between 6.26 and 7.00.

Control Variables. Next to gender, age and level of education, the vaccination status of participants' children was assessed. We also asked whether religion played a role in the decision to vaccinate or not, with whom this decision was made and if participants searched for information online before deciding. Level of education was measured by asking the participants to select their highest completed form of education from a standard list of options. These options were subsequently converted into three levels: low (primary education, prevocational education, the first three years of higher general secondary education or junior college level 1), middle (finished higher general secondary education, junior college level 2-4), or high (university of applied sciences, or university). Participants' e-health literacy was assessed using the eHEALS measure (Norman & Skinner, 2006). This measure consisted of eight items (e.g., "I know which health information can be found on the internet" and "I know where I can find health information on the internet") measured on a 5-point scale (1 = *completely disagree*, 5 = *completely agree*; $\alpha = .89$, $M = 4.04$, $SD = 0.52$).

Statistical Analysis

Pearson's correlations between the control variables and all main variables were checked before testing the hypotheses. As the dependent variable in this study, information choice, (i.e., number of green links clicked) is a count variable, Poisson regression analyses were performed to test all three hypotheses. For H1 the Poisson regression analysis was performed to test a direct effect, for H2 and H3 the moderators for each of these hypotheses were added to the Poisson regression analyses accordingly. All analyses were conducted with IBM SPSS Statistics 25.0.

Results

Age of the participant significantly correlated with one of the moderators, decision stage ($r = .28$, $p < .001$). None of the other control variables significantly correlated with any of the main variables (i.e., outcome measures and moderator variables) in this study. Therefore, none of the control variables were included in the analyses. It was, however, checked if the results of H2 (concerning decision stage) changed if age was included as a control variable. This was not the case. Including the other control variables in the analyses also did not result in any confounding effects. Therefore, results presented here are based on analyses performed without the control variables.

According to H1, participants in the warning tool condition would choose to read more links marked as reliable (i.e., green links), as opposed to unreliable links (i.e., red links) than participants in the control condition. To test this hypothesis, a Poisson regression analysis was performed. The results showed a significant main effect of the warning tool on participants' information choice. In the warning tool condition 1.697 (95% CI [1.032, 2.792]) times more green links were selected than in the control condition, $p = .037$. This indicates that participants who were exposed to the warning tool were more likely to choose a webpage when marked as reliable by the warning tool than when no such warning was present, confirming H1.

Frequencies of the information choice scores in each condition can be found in Table 2 and the effect has been visualised in Figure 3.

H2 predicted that the effect of the warning tool on the information choice would be stronger for participants who still had to make a vaccination decision than for participants who had already decided. To test this hypothesis, another Poisson regression analysis with an interaction effect between the warning tool condition and decision stage was performed. The analysis showed no significant interaction effect between the warning tool condition and the decision stage of participants ($p = .325$).² This means that the effect of the warning tool was not stronger for participants who still had to make a vaccination decision compared to participants who had already decided, rejecting H2.

H3 predicted that the effect of the warning tool on information choice would be stronger among people who have moderate pre-existing attitudes towards vaccinations compared to people who have very positive or negative attitudes towards the topic. To test this hypothesis, participants were equally divided into three groups based on their pre-existing attitude (i.e., strong negative, moderate, strong positive). This variable was used as a dummy variable to compare the moderate group with the strong positive and negative group. Another Poisson regression analysis was performed with an interaction effect between the warning tool condition and this dummy variable. The results showed no significant interaction effect between the warning tool condition and the pre-existing attitude of participants ($p = 0.563$). This indicates that the effect of the warning tool on participants' information choice is not stronger for people with a moderate pre-existing attitude towards vaccination compared to people with (very) positive or negative attitudes, rejecting H3.

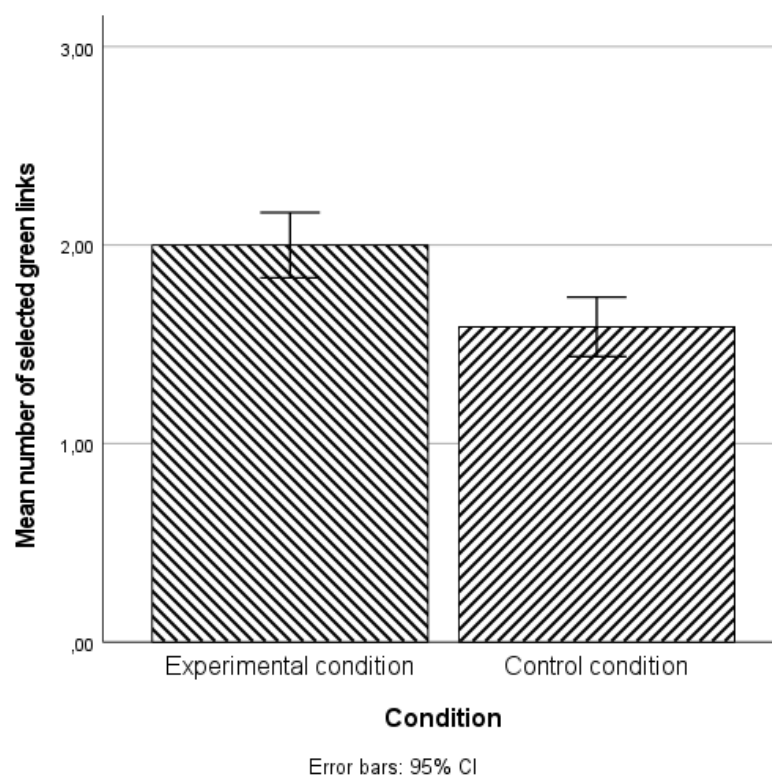


Figure 3. Bar Chart of the Main Effect

Table 2. Frequencies for the Information Choice Score

Reliability of Information Choice	Control Condition		Warning Tool Condition	
	<i>n</i>	%	<i>n</i>	%
0 green links	3	3.5	3	3.2
1 green link	36	42.4	21	22.3
2 green links	39	45.9	43	45.7
3 green links	7	8.2	27	28.7

Change in Warning Tool Trust

Besides testing the three hypotheses, an additional analysis was also performed. It is possible that participants' trust in the warning tool declines over time. That is, perhaps a participant does not agree with the green or red label after seeing the information behind each link, which then might influence the subsequent selection of green (or red) links. To assess this, the data of participants in the experimental condition was analysed in some more detail. The data shows a gradual decline in number of green links chosen. During the first moment of choice the number of green links chosen is highest ($n = 74$, 78.7%), this number declines for the second ($n = 64$, 68.1%) and third ($n = 50$, 53.2%) moment of choice. Paired-samples t-tests were performed to assess whether the moments of choice differ from each other significantly. Results show that the number of green links at the first moment of choice does not differ significantly from the number of green links at the second moment of choice, $t(93) = 1.59$, $p = .114$. Both the first moment of choice ($t(93) = 3.88$, $p < .001$) and the second moment of choice ($t(93) = 2.15$, $p = .034$) do, however, differ significantly from the third moment of choice, suggesting a possible decrease in effectiveness of the warning tool over time.

Discussion

This study investigated the effects of a warning tool on participants' online (mis)information choice concerning vaccinations. Effects were studied for individuals in different decision stages and for people with varying pre-existing attitudes towards vaccinations. The main findings show a significant effect of the warning tool on participants' information choice: the warning tool encouraged participants to choose more links marked as reliable (as opposed to unreliable), leading to the conclusion that the warning tool has the potential to effectively guide individuals in choosing reliable over unreliable information about vaccinations. These findings are in line with previous findings that warning tools can be used effectively in numerous fields (Lewandowsky et al., 2012), and that simple warning tools can effectively influence individuals' information choices (Hwang & Jeong, 2016; Ludolph et al., 2016). This study extends these findings by confirming the effectiveness of a simple warning tool in the context of online vaccination information. While Ludolph et al. (2016) already established that a general warning can affect people's attitudes and criticism towards the reliability of information, the current study builds upon these findings by showing that a specific warning for each web link can influence actual behaviour and direct people towards making more reliable information choices. As implementation of the warning tool can potentially contribute to protecting the immunisation coverage, future research should explore how successful implementation of the tool can best be reached.

This study also unexpectedly showed that the effect of the warning tool was not different for participants who had yet to make a vaccination decision and for participants who had already decided. This contradicts the claim that individuals who have already decided would avoid any information that contradicts their choice and might ignore the warning tool to prevent a state of dissonance (McMaster & Lee, 1991). Of course, it is not necessarily a problem that the warning tool works equally well for both groups, as the most important goal is to help people make informed decisions in general. However, some potential reasons for not finding this effect should be considered. It is possible that this hypothesised difference would only be present for parents making a vaccination decision for the very first time, i.e., for their first child. However, in this study, we did not distinguish between parents who did and did not already have older children, as we argued that with each new child a new decision is to be made. Future research may want to further explore this possibility.

Furthermore, the effect of the warning tool on participants' information choice was similar for people with a moderate pre-existing attitude towards vaccination and for people with a strong pre-existing attitude. While earlier literature suggested that people with strong pre-existing attitudes are likely to select belief-consistent information, causing them to ignore the warning tool (Meppelink et al., 2019; Nickerson, 1998), this is an interesting and perhaps even desirable outcome. The aim of this study was to create a warning tool that is effective for people with varying pre-existing attitudes towards vaccination. It should be noted, however, that the number of people in our sample that held (strong) negative attitudes towards vaccinations was very small; most people had moderate to very positive attitudes. Individuals with a negative attitude towards vaccination might be harder to reach. Also in our study, only 22 participants (12.3%) with a vaccination attitude scored below 4 on a 7-point scale were included. To understand the potentially moderating role of vaccination attitude, future research needs to specifically target people with a negative attitude towards vaccinations, especially as this group might particularly benefit from receiving warnings when encountering misinformation.

Limitations and Future Research

The current study has a rather low completion rate: while 394 individuals started the online experiment, only 191 completed it (48.5%). Answers to an open-ended question in the survey indicated that many participants found it too much work or too repetitive to choose three links and view three web pages. As a consequence, many participants left the online experiment when making their second or third information choice. Although the number of three decision moments was consciously chosen to have enough variance to get meaningful results, and this was valued as more important than the completion rate, future studies should consider how to make the experiment more user-friendly, without losing the validity of having multiple choices.

Moreover, the current study tested the warning tool with an equal number of green and red positive, negative and neutral links, i.e., we randomly marked half of the positive, negative, and neutral links as green versus red (thus marked reliable and unreliable respectively), irrespective of the actual accuracy of the link. This is the cleanest way of testing if people's information choices are influenced by the warning tool at all. If the links had been labelled based on actual reliability, this would probably have resulted in vaccine-supportive links being marked green more often than vaccine-opposing links, and as a result, valence would have become a confound. Moreover, not only the valence of the links but also their familiarity could have caused biased results. To facilitate the random allocation of red and green labels without

causing too much suspicion among participants, relatively unknown web pages were used. As a consequence, it is still unknown what the effects of the warning tool are when it is used on more well-known sources.

Now that this study has shown desirable responses to the warning tool, future research should test the warning tool using the actual reliability of webpages, meaning that links are only labelled with a green traffic light if they are truly considered reliable based on certain pre-set criteria. This will allow us to see how the perceived reliability of the links might interact with the effect of the warning tool. To inform these pre-set criteria, a measure such as DISCERN, which objectively assesses the reliability and quality of online health information, could be used (Khazaal et al., 2011). Implementing the true reliability of the links would also allow for using more well-known sources to see how this affects the effectiveness of the tool.

Regardless of the measure used to decide upon reliability, however, there is debate about the term *reliability* because it is hard to assess who decides which information is considered (un)reliable (Vedder & Wachbroit, 2003). In this study, the term *reliable* was used and defined as evidence-based and trustworthy (Adams, 2010), yet, in the future, the term evidence-based may be considered more suitable and objective (Vedder & Wachbroit, 2013). Most importantly, researchers in this field should be aware of the difficulties that come with the term reliability and future research should continue to evaluate and potentially evolve its use.

Furthermore, as mentioned earlier, Scharrer et al. (2022) found that the usage of warning tools might not reduce the persuasiveness of online misinformation presented in an easily understandable manner. Our study has shown the potential of the warning tool to prevent people from clicking on online misinformation to a certain extent, meaning a person is not exposed to the misinformation at all. However, sometimes even after seeing the warning people still choose to read the misinformation. Therefore, it is important for future research to look into ways to diminish the persuasiveness of online misinformation even after a warning was already presented.

The additional analysis shows a gradual decrease of the number of green links chosen by the participants in the experimental condition. This could mean that people start to trust the warning tool less over time, for instance because they do not agree with the colour of the tool after seeing the content behind each of the links. This is an interesting finding to further explore in future research, to see how the effectiveness of the warning tool develops over time. Furthermore, it would also be interesting to see if this finding will still be present when testing the tool with actual reliability implemented.

Lastly, it is important to note that the data collection for this study took place in 2019, i.e., before the start of the Covid-19 pandemic. In the meantime, a lot has happened and changed in relation to vaccine hesitancy, which might also influence hesitancy regarding early childhood vaccines. Even though the findings of this study were not influenced by the pandemic, it would be interesting to explore the impact of the Covid-19 pandemic on the effectiveness of the warning tool. Perhaps people have become more sceptical towards tools like these, or maybe there is a stronger need for them to help distinguish reliable from unreliable information on the internet. Furthermore, the effectiveness of the warning tool could even be explored specifically for a Covid-19 vaccines context instead of the context of early-childhood vaccines.

Conclusion

This study found that a warning tool can effectively increase the number of green web pages chosen by participants. Implementation of the warning tool in practice has great potential in combatting exposure to online misinformation regarding vaccinations and, as a result, to increasing immunisation coverage. As the current study was exploratory, further research is necessary, including testing the tool with the actual reliability of the links implemented, and among more people with negative pre-existing attitudes towards vaccination.

Notes

1. For exploratory purposes, we also assessed participants' attitude towards the information, i.e., the full texts of the webpages that people had selected from the search results. However, in hindsight, this variable was not measured in an optimal manner, preventing us from drawing clear and reliable conclusions. Therefore, we chose to not include this variable in the analyses.
2. This analysis was also performed with age as a control variable. Results remained non-significant.

Ethical Approval

Ethical approval was obtained by the Ethics Review Board of the Faculty of Social and Behavioral Sciences, University of Amsterdam (2019-PC-10412).

Funding

This research received no specific grants from any funding agency, in the public, commercial, or not-for-profit sectors.

Conflict of Interest

The authors declare that they have no conflict of interest.

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<https://doi.org/10.1371/journal.pone.0142990>

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Funding acquisition: Not applicable

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