A Web Search on Environmental Topics: What Is the Role of Ranking?

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Abstract

Background: Although the Internet is easy to use, the mechanisms and logic behind a Web search are often unknown. Reliable information can be obtained, but it may not be visible as the Web site is not located in the first positions of search results. The possible risks of adverse health effects arising from environmental hazards are issues of increasing public interest, and therefore the information about these risks, particularly on topics for which there is no scientific evidence, is very crucial. The aim of this study was to investigate whether the presentation of information on some environmental health topics differed among various search engines, assuming that the most reliable information should come from institutional Web sites. **Materials and Methods:** Five search engines were used: Google, Yahoo!, Bing, Ask, and AOL. The following topics were searched in combination with the word "health": "nuclear energy," "electromagnetic waves," "air pollution," "waste," and "radon." For each topic three key words were used. The first 30 search results for each query were considered. The ranking variability among the search engines and the type of search results were analyzed for each topic and for each key word. The ranking of institutional Web sites was given particular consideration. **Results:** Variable results were obtained when surfing the Internet on different environmental health topics. Multivariate logistic regression analysis showed that, when searching for radon and air pollution topics, it is more likely to find institutional Web sites in the first 10 positions compared with nuclear power (odds ratio=3.4, 95% confidence interval 2.1–5.4 and odds ratio=2.9, 95% confidence interval 1.8–4.7, respectively) and also when using Google compared with Bing (odds ratio=3.1, 95% confidence interval 1.9–5.1). **Conclusions:** The increasing use of online information could play an important role in forming opinions. Web users should become more aware of the importance of finding reliable information, and health institutions should be able to make that information more visible.

Key words: e-health, information management, policy

Introduction

Increasing evidence suggests that various environmental exposures are a cause of or contributing factor to a wide variety of diseases and conditions.^{1–3} Environmental health risks represent hot media topics. Every day, the public faces several types of news in this field from a variety of media channels. The implementation of policies, such as traffic limitations carried out by the local administrations of industrialized areas to reduce air pollution, has rendered environmental risks a generally recognized issue. Then there are events such as the nuclear accident after the 2011 earthquake in Japan and the 2010 waste emergency in Naples, Italy, which, largely debated by the media, trigger public interest in environmental health.

Use of the Internet as a source of information has increased in the last few decades. Recent data have shown that around 80% of American adults search for information on the Internet, and the percentage of European Internet users is increasing rapidly as well.⁴

Even important health institutions such as the Centers for Disease Control and Prevention are using the new communication tools (e.g., mobile phone applications) in order to disseminate information among the population.⁵

It is interesting that a high percentage of people use the Internet to find health information: 83% of American users and 60% of Italian users.^{6,7} Environmental health hazards are included among the most frequently searched health topics.⁸

This should be taken into account when considering the important role that available knowledge plays in the process of shaping risk perception, in addition to scientific communication. This is particularly important in the case of environmental health risks, which are of interest to the entire population.

There is not always a consensus between the scientific evidence and the public risk perception.⁹ For example, risk perception about electromagnetic waves is high, although the actual risk to human health is still controversial.¹⁰ Conversely, it is low about radon, in spite of strong scientific evidence of its carcinogenic effects and high levels of awareness.^{11,12}

The Internet provides information through different channels (institutional Web sites, blogs, news, videos) with no specific rules. We expect institutional Web sites—meaning ones published by a government, college, or university—to contain more reliable information, meaning information evaluated by an expert and supported by scientific evidence. This topic was also taken into account by the National Institutes of Health in a tutorial.¹³

Reliable information may not necessarily be in the first positions of the Web search. A blog, for example, may have more visibility, but this does not mean it contains reliable information.

Because the position of the search result could be strategic, it was necessary to determine how information is shown to the Web user before analyzing Web site content. Imagining ourselves as ordinary Web users, we conducted the study to evaluate whether and how the results related to some environmental health topics differed among various search engines. In particular, we considered environmental topics on which there exists a great deal of variation, at the level of both scientific evidence and public awareness. To our knowledge, no previous studies have performed similar investigations in the environmental field.

Materials and Methods

Five environmental health topics were chosen. For each topic, the word “health” plus three different key words were entered in five search engines. The topics and corresponding key words (in parentheses) were as follows: nuclear power (“nuclear power,” “nuclear energy,” and “nuclear radiation”), electromagnetic waves (“electromagnetic waves,” “electromagnetic fields,” and “electromagnetic radiation”), air pollution (“air pollution,” “air contamination,” and “smog”), waste (“waste,” “rubbish,” and “garbage”), and radon (“radon,” “radon pollution,” and “radon gas”).

The Web search was carried out using Google, Yahoo!, Bing, Ask, and AOL, as they are the most commonly used search engines.¹⁴

The first 30 search results for each query were considered on the basis of previous findings.¹⁵ With regard to type, they were classified as institutional Web sites (e.g., governmental or university), noninstitutional Web sites, news (including Web sites containing a news section), blogs, videos, online encyclopedias, and portals.

The results were excluded if they did not lead to the researched content within three clicks of the first page, they required registration for access, or they were not related to environment and health.

The page rank—namely, the location of the page itself in the search results¹⁶—was evaluated in order to access user visibility of the search results of interest.

The ranking variability among the search engines was analyzed for each topic and for each key word.

The search was conducted three times (July 4, 2011, July 8, 2011, and August 1, 2011) using the same criteria in order to assess possible time variability.

Groups were compared using the chi-squared test or Fisher's exact probability test for categorical data. Two-sided p values <0.05 were considered statistically significant.

Multivariate logistic regression analysis was performed to identify factors significantly associated with a dichotomous variable, taking as a value of 1 for having institutional Web sites in the first 10 rank positions and 0 for having results different from institutional Web sites or having institutional Web sites after the first 10 positions. The topic and search engine with the lowest number of institutional Web sites were considered as references.

The data were analyzed using the StataTM version 12.0 statistical package (Stata Statistical Software release 10.0, 2008; StataCorp, College Station, TX).

Results

The first 10 search results provided by the search engines for each key word and topic are shown in *Figure 1* for the first date (July 4, 2011).

NUCLEAR POWER

An evaluation of the overall search results, arising from all the key words and search engines taken together, showed that the topic of nuclear power was mainly characterized by noninstitutional Web sites (27%), followed by news (16%) and institutional (11%) Web sites. Twenty-six percent of the search results did not fit the inclusion criteria.

With regard to the distribution of results according to the key words, there was a statistically significant difference for noninstitutional Web sites (44% and 41% for “nuclear energy” and “nuclear radiation,” respectively, versus 25% for “nuclear power”; $p=0.007$) and news (29% and 24% for “nuclear power” and “nuclear radiation” versus 11% for “nuclear energy”; $p=0.003$).

The distribution of results according to the search engines showed a statistically significant difference for blogs, which were less frequently provided by Yahoo! and Bing (3% and 6%, respectively, versus 13%, 18%, and 14% for Google, Ask, and AOL, respectively; $p=0.05$).

ELECTROMAGNETIC WAVES

In the case of the topic of electromagnetic waves institutional Web sites were present less frequently than noninstitutional ones (18% versus 36%, respectively). Twenty-three percent of the search results did not fit the inclusion criteria.

With respect to the distribution of results according to the key words, there was a statistically significant difference for institutional Web sites (35% for “electromagnetic field” versus 16% and 20% for “electromagnetic radiation” and “electromagnetic waves,” respectively; $p=0.002$) and blogs (7% and 8% for “electromagnetic radiation” and “electromagnetic waves,” respectively, versus 0% for “electromagnetic field”; $p=0.008$).

Regarding the search engines, there was a statistically significant difference for institutional Web sites only (32%, 29%, and 26% for AOL, Google, and Yahoo!, respectively, versus 10% and 19% for Bing and Ask, respectively; $p=0.033$).

AIR POLLUTION

Institutional Web sites represented the 30% of the search results concerning the topic of air pollution, followed by noninstitutional Web sites (19%), news (14%), and online encyclopedias (11%). Sixteen percent of the search results did not fit the inclusion criteria.

There were no statistically significant differences with regard to the distribution of the results according to the key words selected. The distribution of results according to the search engines showed a statistically significant difference for blogs (0% for Google and AOL versus 7%, 6%, and 4% for Yahoo!, Bing, and Ask, respectively; $p=0.042$).

	G	Y	b	A	Ao
Rank	NUCLEAR POWER				
1	I	I	I	NI	I
2	N	OE	B	B	I
3	*	N	NI	N	B
4	I	N	B	*	I
5	B	I	N	*	N
6	NI	N	NI	NI	P
7	B	OE	I	*	B
8	N	*	N	NI	N
9	N	I	NI	N	B
10	N	*	OE	*	P
	ELECTROMAGNETIC FIELDS				
1	NI	OE	NI	I	NI
2	OE	*	NI	N	OE
3	OE	I	NI	I	*
4	*	*	*	I	*
5	*	NI	NI	NI	*
6	*	NI	I	I	*
7	I	NI	*	P	I
8	*	*	*	I	NI
9	NI	OE	NI	NI	I
10	I	NI	NI	I	NI
	AIR POLLUTION				
1	I	OE	V	I	I
2	I	N	NI	NI	NI
3	NI	I	NI	*	*
4	I	*	OE	P	I
5	I	B	P	OE	I
6	I	I	NI	P	I
7	I	N	I	NI	I
8	N	N	NI	OE	I
9	I	I	NI	I	NI
10	I	NI	*	P	*
	WASTE				
1	NI	N	B	I	NI
2	I	NI	B	N	I
3	NI	*	I	NI	NI
4	I	*	P	NI	P
5	P	I	*	*	B
6	B	NI	I	P	P
7	P	I	NI	I	N
8	N	*	I	I	B
9	B	I	I	NI	I
10	I	I	N	NI	*
	RADON				
1	I	I	NI	NI	I
2	I	OE	OE	I	I
3	I	I	*	I	I
4	I	OE	*	I	OE
5	I	*	NI	NI	I
6	I	NI	P	I	I
7	I	I	I	I	I
8	NI	I	*	I	NI
9	I	I	NI	NI	I
10	NI	NI	I	*	NI
	NUCLEAR ENERGY				
1	I	P	I	*	I
2	I	NI	*	P	I
3	P	I	NI	NI	P
4	NI	NI	*	P	NI
5	I	NI	NI	NI	NI
6	NI	OE	*	B	I
7	B	*	P	P	N
8	N	OE	NI	I	B
9	N	NI	*	V	NI
10	NI	*	OE	I	NI
	ELECTROMAGNETIC RADIATION				
1	OE	OE	OE	OE	OE
2	NI	OE	B	I	NI
3	NI	*	NI	NI	NI
4	N	NI	*	OE	I
5	I	I	OE	*	I
6	NI	NI	*	I	*
7	I	N	*	NI	NI
8	N	I	B	NI	N
9	I	NI	NI	B	NI
10	*	NI	NI	B	N
	ELECTROMAGNETIC WAVES				
1	OE	OE	*	OE	OE
2	OE	NI	*	NI	OE
3	B	I	NI	NI	P
4	P	OE	P	NI	NI
5	NI	NI	*	P	NI
6	I	NI	*	N	B
7	NI	NI	P	I	I
8	NI	I	*	P	N
9	N	*	*	B	NI
10	I	V	*	*	N
	AIR CONTAMINATION				
1	I	OE	I	I	I
2	I	I	P	NI	NI
3	NI	I	NI	I	*
4	*	N	I	N	I
5	I	*	NI	OE	I
6	I	*	*	OE	I
7	I	I	I	I	I
8	OE	N	*	*	OE
9	NI	N	I	*	N
10	I	OE	I	I	NI
	SMOG				
1	I	I	NI	I	I
2	I	OE	N	*	I
3	NI	*	*	N	I
4	*	I	OE	NI	OE
5	I	NI	I	OE	*
6	I	OE	I	N	N
7	I	P	*	I	NI
8	OE	B	NI	N	*
9	NI	I	N	I	V
10	I	N	V	OE	N
	RUBBISH				
1	N	N	*	*	N
2	P	N	N	N	P
3	*	I	N	I	*
4	N	I	*	*	N
5	P	I	*	*	N
6	I	N	*	NI	P
7	I	NI	N	I	*
8	NI	*	*	N	*
9	*	N	*	N	*
10	I	N	B	I	N
	GARBAGE				
1	*	N	*	I	*
2	I	I	N	*	I
3	OE	*	*	I	I
4	I	NI	*	*	N
5	N	*	*	P	I
6	I	I	*	I	*
7	*	NI	*	I	I
8	I	I	*	*	N
9	*	N	*	N	I
10	N	I	*	N	N
	RADON POLLUTION				
1	I	I	*	I	I
2	I	I	I	OE	I
3	I	P	N	I	OE
4	I	I	NI	NI	I
5	OE	*	*	I	*
6	I	I	I	I	*
7	*	NI	B	*	I
8	*	I	NI	NI	I
9	I	OE	OE	I	I
10	I	I	I	I	NI
	RADON GAS				
1	I	I	NI	I	I
2	I	I	OE	*	I
3	I	OE	*	NI	I
4	NI	OE	*	NI	OE
5	OE	NI	NI	I	I
6	N	I	P	NI	I
7	B	I	I	I	I
8	NI	NI	*	I	NI
9	*	NI	NI	I	I
10	P	NI	NI	NI	NI

G, Google; Y, Yahoo!; b, Bing; A, Ask; Ao, AOL.

I=Institutional website; NI=Non Institutional; N=News; B=Blog; V=Video; OE=Online Encyclopedia; P=Portal; *=Not eligible.

Institutional websites are evidenced in gray in order to better show their distribution.

Fig. 1. Distribution of the first 10 search results of the Web search carried out on July 4, 2011.

WASTE

The topic of waste was mainly characterized by institutional Web sites (22%), followed by news (20%) and non-institutional Web sites (10%). Thirty-six percent of the search results did not fit the inclusion criteria.

The distribution of results according to the key words showed a statistically significant difference for noninstitutional Web sites (22% for “waste” versus 10% and 12% for “rubbish” and “garbage,” respectively; $p=0.037$), news (48% and 40% for “rubbish” and “garbage,” respectively, versus 15% for “waste”; $p<0.001$), and blogs (12% for “waste” versus 1% and 6% for “rubbish” and “garbage,” respectively; $p=0.012$).

There were no statistically significant differences with regard to the distribution of the results according to the search engines.

RADON

Institutional Web sites were predominant in the case of the topic of radon (44%), followed by noninstitutional Web sites (24%). Fourteen percent of the search results did not fit the inclusion criteria.

With regard to the distribution of the results according to key words, there was a statistically significant difference only for institutional Web sites (60% for “radon” versus 47% and 45% for “radon pollution” and “radon gas,” respectively; $p=0.028$).

With respect to the distribution of results according to the search engines, there was a statistically significant difference for institutional Web sites (22% for Bing versus 76%, 61%, 51%, and 43% for AOL, Google, Yahoo!, and Ask, respectively; $p<0.01$), noninstitutional Web sites (46% and 35% for Bing and Ask, respectively, versus 26%, 22%, and 13% for Yahoo!, Google, and AOL, respectively; $p=0.000$), and news (16% for Bing versus 7% for Google and Yahoo!, 3% for Ask, and 1% for AOL).

TIME TREND ANALYSIS

The analysis was carried out separately for the Web searches conducted on July 8, 2011 and August 1, 2011. The findings were substantially confirmed, with no statistically significant differences (data not shown), except for air pollution. More specifically, on the first date the distribution of results among the key words showed a statistically significant difference for noninstitutional Web sites (27% for “air pollution” and “air contamination” versus 14% for “smog”; $p=0.019$) and news (25% for “smog” versus 14% and 13% for “air pollution” and “air contamination,” respectively; $p=0.023$). The distribution of results among the search engines showed a statistically significant difference for institutional Web sites (46%, 45%, 39%, and 33% for Yahoo!, Google, AOL, and Bing, respectively, versus 19% for Ask; $p=0.003$) but not for blogs. This situation was confirmed on

the second date (data not shown). No statistically significant differences were found when comparing the findings of the Web search on July 4, 2011 with those conducted on the other two dates.

OVERALL ANALYSIS

For each topic, the first 10 search results resulted from each key word and each search engine (3 key words $\times$ 5 search engines = 150 results) were grouped according to type. As shown in *Figure 2*, the distribution of results type was not the same according to the different topics, with a considerably higher number of institutional Web sites found for radon and air pollution than for waste ($p=0.01$), nuclear power ($p<0.001$), and electromagnetic waves ($p<0.001$).

Taking the first topic (nuclear power) and the first search engine (Bing) as the references, multivariate logistic regression analysis showed that when searching for radon and air pollution topics, institutional Web sites were more likely to be found in the first 10 positions compared with nuclear power (odds ratio = 3.4 and 2.9, respectively). With regard to search engines, institutional Web sites were more likely to be found in the first positions when using Google compared with other search engines (odds ratio = 3.1) (*Table 1*).

The searches and the analysis of the results were repeated on July 8 and August 1, 2011, giving similar results.

Discussion

Variable results were obtained when surfing the Internet on different environmental health topics. When considering a single topic, especially nuclear power, electromagnetic waves, and radon, a certain variability in the type of search results was found when both the key word and search engine were changed. A definitely higher prevalence of institutional Web sites was found for radon and air

Table 1. Probability of Finding Institutional Web Sites in the First 10 Positions According to Topic and Search Engine

	OR	95%CI
Topic		
Nuclear power	Reference	
Electromagnetic waves	1.0	0.6–1.8
Waste	1.8	1.1–3.0
Air pollution	2.9	1.8–4.7
Radon	3.4	2.1–5.4
Search engine		
Bing	Reference	
Yahoo	2.1	1.3–3.6
Ask	2.2	1.3–3.8
AOL	2.5	1.5–4.2
Google	3.1	1.9–5.1

CI, confidence interval; OR, odds ratio.

pollution, whereas searches on nuclear power and electromagnetic waves revealed the predominance of noninstitutional Web sites and news, with a good rank position for online encyclopedias in the second case. The predominance of news was also observed for searches concerning the topic of waste.

If we assume that the most reliable information can be obtained from institutional Web sites, the topics of radon and air pollution appear to provide the best information. For the same reason, if we look at search engines, Bing can be considered as associated with lower-quality information because it provided a significantly lower number of institutional Web sites compared with the other search engines, on all three research dates.

According to the so-called “Internet paradox,” although the Web contains virtually unlimited information, it has been observed that users generally do not go beyond the first page of search engine results and have a “low tolerance of going in depth through what is retrieved.”¹⁵ From this perspective, there is the risk of obtaining only partial information.

In addition, the general population often ignores the mechanism of page rank algorithms. It follows that an ordinary Web user, in the absence of

Fig. 2. Distribution of Web search results type according to environmental topics.

mediators, may read the first-ranked results as the best, rather than the most clicked or sponsored, ones.¹⁷ When a topic is popular many news Web sites or blogs are likely to deal with it, probably because they are easier to understand or more interesting features, which institutional Web sites often lack.

It should be noted that in the case of news or blogs the source of information is often doubtful or possibly influenced by for-profit organizations in the case of noninstitutional Web sites.

It is known that the attention of an ordinary newsreader is first drawn by the title of a newspaper or magazine, so it is reasonable to assume that an ordinary Web user looks at the Internet in the same way. Because interaction with the Web is very limited,¹⁸ it is important to attract the attention of the user in order to guide him or her toward correct information. The information provided should therefore be clear and easy to find.¹⁹ A well-designed Web site probably increases its visibility, as has been shown for an educational institution in the United States, where a well-designed learning Web site met the satisfaction of the students and was found to be very usable as a learning tool.²⁰ It has also been shown that Web design can influence information-finding performance.²¹ An analysis of Web user preferences regarding different Web pages found that beauty—rather than text, for example—was the best predictor of the overall impression of Web pages.²² It has also been shown that the culture of the Web designer can influence information-seeking skills; Web users tend to find information more quickly when using Web sites created by designers from their own cultures.²³

Another interesting consideration is that the topic of radon was chosen by virtue of its limited popularity, despite strong scientific evidence that it is dangerous to human health. It may be no coincidence that there is a predominance of institutional Web sites in the case of the radon topic over other topics, particularly waste and electromagnetic waves, which are highly debated as to their health risks, despite the current lack of scientific evidence. The risk perception among the population seems to be high, nevertheless. There seems to be a sort of inverse correlation between risk perception and scientific evidence that reflects the sometimes lacking consensus between the scientific evidence and the public risk perception.^{9,24}

As highlighted by previous studies, information is more likely to be distorted by people when there is a lack of scientific evidence about health risks.¹⁷

Risk perception has major implications in terms of public health. Such a complex phenomenon has been found to affect people's behavior, leading sometimes to conclusions that can be far from the scientific evidence,²⁵ and even to influence the effectiveness of communication strategies for environmental health risks.²⁶ Considering the spread of the Internet and its increasing use as a source of information, especially through Web 2.0 tools, it should not be ruled out that online information could play an important role in forming opinions and influencing risk perception as well.²⁷

The increase of information channels spreads the idea that the acquisition of knowledge renders people more able to perform decision-making actions that are beneficial for the enhancement of their own health.²⁸ However, the provision of health information is

not sufficient to render people “empowered.” As discussed in previous studies,^{29,30} it is crucial that people acquire the ability to select the right information and evaluate it critically in order to use it appropriately. Another aspect to take into account is that the vast amount of information available can lead to confusion on the part of the user, in addition to difficulty finding reliable information. For this reason it is also important that Internet users learn to find the information. At the same time there is a need to work toward new solutions that help users to find trustworthy information, as highlighted by a recent survey³¹ in which the majority of respondents reported their difficulties in finding answers to their health queries when surfing the Web and underlined the need for an accessible and efficient search engine for health content.

Some limitations should be pointed out. First of all, this study merely aimed to provide a “snapshot” of what is available in the Internet, not an analysis of the results provided by the search engines. Another limitation could be that the choice of key words for each topic was necessarily arbitrary but based on the most commonly used terms. This does not, however, influence the general interpretation of the results of the study.

Finally, the analysis was based on the assumption that institutional Web sites provide more reliable information because they are usually not supported by for-profit companies, as highlighted by the National Institutes of Health¹³ and the American Academy of Family Physicians.³²

Considering that reliable information means information of which the source is clear and for which there is scientific evidence, it is reasonable to think that an institutional Web site meets these requirements.

Conclusions

In an era in which the Internet is rapidly infiltrating the population, it is important not to underestimate its possible influence on users. The Internet is unlikely to be regulated, but it could be easier and more effective to educate the population in order to promote a more critical and conscious use of the new communication tools. Health institutions need to learn how to use these new tools in order to reach out to the population better, for example, by making their Web sites more interesting, as well as easier to understand. In other words, a Web user needs to be able to find reliable information easily, and health institutions should become “good designers” and make that information more visible and hence more accessible and usable.

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