Is internet a missed opportunity? Evaluating radon websites from a stakeholder engagement perspective

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ABSTRACT

Exposure to indoor radon, a naturally occurring radioactive gas, is one of the main causes of lung cancer worldwide. Although radon tests are easily accessible in most countries, and protective actions are effective and relatively easy to apply, the levels of radon testing and subsequent home remediation remain lower than aimed for. Public engagement, particularly through internet, may contribute to addressing this value-action gap. Given their role as common interaction points between citizens and public services, this research analyzed radon websites from a stakeholder engagement perspective. The rich database assembled, of websites in eight European countries with highly radon prone areas, provides for the empirical novelty of the study. The website evaluation relied on internet communication metrics adapted for radon risk mitigation. This included availability of radon information, accessibility, stakeholder interaction, dialogue, responsiveness, content and design, and transparency and openness. Unexpectedly, results show that availability of radon information on the internet in radon prone areas is often limited and poor, as for instance only three internet pages dedicated to radon have been found. Radon websites should be improved with consistent information supported by engaging stories, provide for personalized features, support stakeholder feedback and dialogue, and include the use of social media. We conclude by consolidating the analysis into a list of recommendations for health communication practitioners, which should support radon risk mitigation, and contribute to improving public health, particularly decreasing the numbers of lung cancers. The effect of radon information available on internet pages on changing protective behaviors is suggested for future research.

1. Introduction

Recent studies in Europe, North America and Asia provide strong evidence that indoor radon, a naturally occurring, odorless radioactive gas, causes a large number of lung cancers in the general population. The exposure to radon in homes is - after smoking - one of the most important causes of lung cancer deaths worldwide (WHO, 2009). Radon is responsible for about 9% of deaths from lung cancer and about 2% of all deaths from cancer in Europe (Darby et al., 2005), and is estimated, based on risk factors, to cause about 21,000 lung cancer deaths per year in the USA (EPA, 2016). Several studies demonstrate that there is a substantial problem with radon in houses, public and work spaces, and an urge to protect public health from radon related risks (Darby et al., 2005; Krewski et al., 2006; Lubin et al., 2003; Witte et al., 1998). Reducing exposure to radon, for instance by remediation of buildings, e. g. sealing cracks in the house foundation, or installing a radon venting

system, is a rather cheap and accessible mitigation measure for people at risk, as highlighted in several international guidance documents (ICRP, 2014). The World Health Organization (WHO) recommended in 2005 that comprehensive radon programmes are developed for radon prone areas (WHO, 2009). This policy has also been endorsed in the revised General Safety Requirements of the International Atomic Energy Agency (IAEA, 2014) and the European Basic Safety Standards directive (BSS) (2013/59/EURATOM). European Member States are required to develop National Action Plans to address long-term risks from radon exposures, given the "statistically significant increase of lung cancer risk from prolonged exposure to indoor radon at levels of the order of 100 Becquerel per cubic meter" (EU, 2014). Among others, these legally required plans should include the development of a „*strategy for communication to increase public awareness and inform local decision makers, employers and employees of the risks of radon, including in relation to smoking.*

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However, the implementation of radon action plans faces important challenges. Testing for radon and subsequent home remediation are scientifically and technically straightforward. However, empirical studies indicate that the application of these actions by people at risk is generally low, although the cost of radon mitigation measures for most homes is similar to that of common home repairs and is often an eligible expense covered by national health care programs (Doyle et al., 1991; Hevey, 2017; Lofstedt, 2018b). This indicates that radon risk remediation is not a scientific or technical problem, but may be a socio-political and psychological one, indicating a 'value-action gap'. This refers to a situation where the values or attitudes of an individual do not correlate to his or her actions (Nordgren et al., 2008). Poortinga and colleagues found for instance that people living in high radon affected areas find the risks of radon acceptable, despite being more concerned about these risks. Although they know that radon is bad for their health, they accept living in a house with high radon concentrations and they don't apply any protective actions that are proven to be efficient for cancer prevention (Poortinga et al., 2011; Poortinga et al., 2008). Moreover, the Swedish National Board of Housing and Planning noted in 2004 that only half of the yearly radon subsidy budget dedicated to the application of measures for reducing radon concentration in houses had been used by concerned homeowners (Lofstedt, 2018a). Furthermore, public health campaigns showed that increased awareness about radon risk and the efficiency of the protective actions does not automatically lead to action and health behavioural change. For instance, awareness of radon risk among the public in Ireland has increased after a series of communication campaigns, from 76% in 2004, to 77% in 2010 and 86% in 2013. Despite this increased awareness, concern about radon in their home decreased: from 47% in 2004, 43% in 2010 to 33% in 2013. Moreover, the likelihood of having their home tested was even lower: 36% in 2010 (Long, 2014). In addition, the Environmental Protection Agency in Ireland has found that, of those that test and find elevated radon concentrations in their home, only 1 in 4 apply mitigation actions to reduce radon concentrations (Long, 2014). The Irish 2017 EPA, 2019 survey showed that 75% of the population are aware of radon, but only 22% took up the offer of free tests and about 20% of householders with radon above the reference level carries out remediation (EPA, 2019). When radon measurements are recommended by authorities, for instance in Norway, where "*practically everyone should measure radon in their home*", only small fractions of the population in the affected areas effectively carry out these measurements (Abelshausen et al., 2018).

The studies mentioned above provide evidence that changing health behaviour, in the sense of testing radon concentrations at one's home and applying mitigation actions such as the renovation of one's house, is challenging. The 'information provision approach', i.e. the assumption that individuals will act rationally in relation to the information provided, does not hold. In other words, the idea that "*once you tell people that there is a threat, they will be motivated to test to see if they personally are at risk from the particular threat, and then they will act to remediate if the test indicates a threat, has proved ineffective*" (Hevey, 2017). Knowledge about cancer risk due to radon and the high efficiency of protective actions is uncorrelated with actually doing a radon test at home and taking respective action (Sandman and Eblen, 1994). Opposite to this, stakeholder engagement stimulates changes in health-and protection-behavior and may help address successfully the radon value-action gap (EPA, 2001; Neuhauser and Kreps, 2003). Poortinga et al. (2011) provide empirical evidence in that respect. Their study found that homeowners living in local communities actively engaged in a radon program were more likely to have their home tested for radon than homeowners living in non-engaged communities were. Engagement can be nowadays initiated, facilitated and/or enabled also by internet pages (Karakaya-Polat, 2005; Neuhauser and Kreps, 2003; Park et al., 2016). A complete overview of the importance of internet for political engagement has been conducted by Boulianne (2009). Internet can be more than an information point related to health: it can also serve as an engagement tool for promoting health-related behaviour. Indeed,

e-government has been growing rapidly over the past 17 years, especially since the first attempt of the United Nations to benchmark the state of e-government in 2001 (Bonnar-Kidd et al., 2009; UN, 2001) and there is growing evidence that e-health communication can improve behavioural outcomes (Neuhauser and Kreps, 2003).

The study applies health communication theories to radon communication, proposes a new research method for the evaluation of stakeholder engagement in health related topics through internet, presents new case studies, collects and analyses radon communication data. Our hope is that this study will contribute to more coherent, creative and effective radon related communication which goes beyond increasing awareness, to enhancing protective behaviours in populations exposed to high radon risks. Our primary audience are practitioners in health and radon communication, researchers in the field of risk communication, as well as authorities who wish to improve their internet pages.

The research firstly discusses the theoretical background for radon risk communication, continues with an overview of practice in stakeholder engagement on radon issues, and presents the methodology including new metrics for the evaluation of radon internet pages. This is followed by results and discussion, a synthesis of good practices supporting health communication practitioners and conclusions.

2. From health behavior theories to practices in stakeholder engagement

This section summarises main results of health behaviour models. It then substantiates the need for higher levels of stakeholder engagement on radon issues that go beyond simple provision of information. Finally, it argues that engagement through internet may be a valuable opportunity to support behaviour change in terms of radon risk mitigation.

Only one person in five is prepared to take health-related actions at any given time. (J. Prochaska, Butterworth, Redding, Burden and Perrin, 2008; J. O. Prochaska, DiClemente and Norcross, 1992). Several health behaviour models, such as the Theory of Planned Behaviour (Ajzen, 1985), the Health Belief Model (Janz and Becker, 1984), the Protection-Motivation Model (Rogers, 1975), and the Transtheoretical Model of Health Behavior Change (TTM) (J. Prochaska et al., 2008), suggest that knowledge is only one of the health behaviour determinants. Other determinants are attitudes, subjective norms, descriptive norms, moral norms, self-efficacy, risk-perception, protective efficiency of an action, threat, among others. The majority of populations at-risk are not prepared for health-protection actions and will not be served by traditional prevention programs if the objective of the programme is limited to improving risk awareness. For instance, The Transtheoretical Model of Health Behaviour Change which has been applied among others also to the behaviour related to radon exposure, postulates that individuals move through six stages of change: pre-contemplation, contemplation, preparation, action, maintenance, and termination. The model has two major components: change and decisional balance, where the knowledge is not identified as the main health-protection change determinant (J. O. Prochaska, Redding and Evers, 2002). Similarly, the message design theories, such as the Extended Parallel Processing Model (EPPM) which has been used as the theoretical framework for formative and summative analysis of radon communication campaigns, indicate the importance of other factors than knowledge for health-protection behaviour (Witte et al., 1998). These factors are threat and efficacy (for complete exposition of the EPPM, see (Witte, 1992)). Unfortunately the evaluation of radon campaign materials according to EPPM shows that such materials often promote perceptions of threat, but not perceptions of efficacy regarding recommended responses (Witte et al., 1998). For instance, an evaluation of radon brochures in 1993 showed that the US EPA brochures present information in the same general way: first radon is defined, after which exposure processes, effects, detection procedures, and control techniques are discussed (Atman et al., 1994). Effective radon risk communication should therefore seek to trigger other factors influencing behavior change in the target audience and not only to increase

awareness about the radon risks. The most promising outcomes of health-related behavior changes according to TTM is engagement of people at risk (J. Prochaska et al., 2008).

In the past decades, both academic studies and practical experiences have focused on radon risk perceptions and beliefs, as well as on informing stakeholders about risks from living in radon prone areas (Bostrom et al., 1992; Golding et al., 1992; Guimond and Page., 1992; Hampson et al., 1998; IAEA, 2017; Poortinga et al., 2011). However, higher levels of engagement of broader publics are nowadays called for in several areas of radiological protection, including radon risk mitigation. Recent radiation protection events, for instance the Conference on Social Science and Humanities in Ionising Radiation Research 2017) (RICOMET), the Society for Risk Analysis Benelux 2018 (SRA) and the European Radiation Protection Week 2018 confirmed the need for stakeholder engagement in radiological protection, specifically concerning radon protection.

The need for enhanced stakeholder engagement in radon mitigation is supported by both normative considerations, as well as empirical evidence.

Firstly, engagement of stakeholder and wider publics is nowadays widely required in social, political, economic and environmental processes and practices in democratic societies. Scholars and practitioners have proposed general principles for effective engagement, such as representativeness, inclusiveness, fair deliberation, access to resources, transparency, among others, (e.g. Rowe and Frewer, 2000). Environmental authorities in several countries have increased their efforts to involve the public and other stakeholders, by giving citizens, industry, environmental groups, and academics greater opportunities to play key roles in environmental decision-making. These efforts seek to ensure that citizens can have a substantive impact on environmental decisions affecting them at the national, regional, and local levels, including in radon related issues (EPA, 2001).

International and national regulations also call for higher levels of engagement of stakeholders than before in addressing radon exposure situations and the associated risks. The revised European Basic Safety Standard Directive (Art. 102) requires for instance that „*Member States shall provide as appropriate for the involvement of stakeholders in decisions regarding the development and implementation of strategies for managing exposure situations*" (EU, 2014).

Secondly, several studies within the field of communication about radon have shown that stakeholder involvement is beneficial to the implementation of radon risk protection actions (EPA, 2016; Long, 2018; Poortinga et al., 2011). WHO (2009) recognised that key elements for a successful radon national programme include stakeholder engagement and collaboration with other health promotion programmes (e.g. indoor air quality, tobacco control), and training of building professionals and other stakeholders involved in the implementation of radon prevention and mitigation (e.g. local authorities).

Thirdly, engagement of stakeholders is also motivated by a substantive rationale. Local authorities are recognised as an important stakeholder, as they have been found able to bring in specific knowledge and increase the effectiveness of radon action plans. As national campaigns have often proved less effective than campaigns at local level, local initiatives for radon risk reduction are currently being developed (e.g. in France) (Abelshausen et al., 2018, p.9). In some countries, national authorities collaborate with local authorities. For instance in Belgium the Federal Agency for Nuclear Control organises annually the Radon Action campaign with support from the five Walloon provinces and the Brussels Region. It "*negotiates with local governments*" to include radon preventive measures in the building code, trains architects and building professionals from the municipalities, and in relation to new build, it provides detailed scale radon maps, trains local governments to provide radon info, and distributes brochures (Dehandschutter, 2016). In Ireland, the Environmental Protection Agency organises radon related briefings with politicians that represent the target community and organises public meetings related to radon chaired by local politicians

(Long, 2018). Furthermore, responsible national authorities recommended to "*work with local authorities to ensure that information about radon is available on their websites and awareness is raised with environmental awareness officers.*" (EPA, 2019, p. 15). In other countries, for instance in Slovenia, national authorities make official requests for collaboration with local authorities in the radon action project, in particular, *"by informing [… the] local population using internet pages and other communication channels, usually used [by their] local community (*Skrk and Omahen, 2018 *p. 1)."*

Decision making concerning radon issues should ideally include municipalities and local authorities at the frontline to promote activities concerning new build and renovation of houses, alongside other stakeholders directly linked to the local population. "*Communicators need to include a range of radon stakeholders, and representatives of civil society. They need to partner with local/regional authorities, inform people at risk to perform measurements and remediate by themselves if they wish so*" (Bouder et al., 2019, p. 2).

Authorities in several countries are currently seeking to involve stakeholders in various ways, for instance through stakeholder workshops (e.g. in Czech Republic and Estonia), visits to schools (Montenegro), webinars (Serbia), or public hearings (North Macedonia) (IAEA, 2017). In Lithuania and Slovenia, health authorities organise meetings with professionals, publics, health specialists and they involve them in radon mapping.

Personal engagement by using internet, for instance through computer-based individualized and interactive interventions including personalized counselors, is one of the promising means to elicit change in health behaviour (J. Prochaska et al., 2008). In particular, radon websites of national and local authorities may therefore play an important role in radon health-protection programs, as they are the most common interaction points between citizens and public services in many countries. It is widely agreed that deploying e-government in support of good governance is essential for building effective, accountable and inclusive institutions at all levels (UN, 2018). Coleman et al. (2008) confirmed that if authorities build a good website, citizens will become engaged. They found that websites designed to conform to users' wishes and needs in content, navigation and appearance foster positive attitudes toward engagement. "*Participants who saw the useable site were significantly more likely to have positive attitudes toward civic engagement than those who saw a site not designed for stability. The site features under the control of website creators, such as story content and site appearance, showed strong correlations with civic engagement attitudes.*" (Coleman et al., 2008, p.179). Studies in health communication also point out the opportunity to engage with people through internet pages and influence in this way people's health behaviour (Katz et al., 2001; Knight-Lapinski, 2006). People may use the internet for health related information, as they may perceive them to offer "*convenience, anonymity, reliability, interactivity, and asynchronicity*" (Rice and Katz, 2001, p. 94). In particular, radon websites can enable collaborative, traceable, searchable, linkable, and open engagement; they can empower stakeholders to contribute their own ideas, suggestions, and requests, by providing 'guides', 'resources' and 'reviews'. In particular, websites with social media links promote transparency, participation, and collaboration (Mergel, 2012). Communication technologies based on the philosophy of Web 2.0, for instance, allow authorities to foster engagement with stakeholders, with "*social media through which individuals are active participants in creating, organizing, editing, combining, sharing, commenting, and rating Web content as well as forming a social network through interacting and linking to each other*" (S.A. Chun, Shulman, Sandoval and Hovy, 2010).

3. Method

This study uses a combination of automated and manual evaluation methods for website analysis.

First, a non-systematic literature review of website evaluation metrics has been conducted. Based on the Karkin and Janssen (2014), the

website evaluation metrics included indicators of stakeholder engagement, as well as other indicators related to availability, accessibility, responsiveness, dialogue, content and transparency or openness as defined by Coleman et al. (2008), Domarkas et al. (2012) and Siar (2005). These indicators have been adapted to health communication and the radon-risk context, for instance interactivity of radon maps has been evaluated and radon stakeholders have been identified. Next, websites of national, regional and local authorities responsible for radon issues have been evaluated in Belgium (n = 88) and from radon prone areas in seven other selected European countries (n = 85).

3.1. Sampling of study cases and websites

Case studies were selected from European Union Member States, in light of the revised European legal requirements (Basic Safety Standards –BSS) stipulating the implementation of national radon communication programs. These requirements had to be transposed into national legislation by February 2018 (2013/59/EURATOM). The selection of the European Member States for analysis took into account the surface of high radon prone areas and the numbers of population at risk from indoor radon: Belgium, Croatia, France, Germany, Italy, Ireland, Slovenia and Spain (Tollefsen et al., 2014).

A number of 173 websites were evaluated, from national, regional and local policy actors (see Annex 1 for a full list). This included national authorities responsible for the radon communication plan according to new the BSS directive (e.g. nuclear safety authority or ministry of health), as well as to regional and local authorities (e.g. municipality websites of communities in radon prone areas). The aim was to include all the relevant websites at national level for each country. In addition, depending on the different administrative contexts in each country at regional and local level, we selected a random sample of relevant websites. This approach is reflected in the different number of selected websites per country.

- For Belgium: website of the federal nuclear safety authority (FANC-AFCN) and the specific Radon Action page, websites from all provinces with increased levels of radon,[1] and from local communities randomly selected in two provinces (in total 3 national, 2 regional, 7 provincial, 76 local community web pages);
- For Croatia: All national websites (specific radon page), and websites of three regions where radon concentrations exceed 300 Bq/m³ according to the radon map published by the national authorities for nuclear and radiological safety (1 national and 3 regional websites);
- For France: the website of the national radiation protection institute (IRSN), websites of provinces with highest radon concentrations (>400 Bq/m³), and of three local towns randomly chosen among those with the highest radon concentrations and located in departments with highest radon concentrations (1 national, 9 provincial, 3 local communities' websites);
- Germany: all national websites, websites from 5 regions where radon concentration is the highest (between 40 kBg/m³ and 100 kBq/m³), and for 5 local communities in the region with the highest radon rate (4 national, 5 regional, 5 local communities);
- Ireland: National website (EPA), websites of all regions, all provinces (all Ireland is a radon prone area), and of 6 local communities within those regions randomly chosen among those where the radon level was the highest (West region) (more than 20% of homes exceed the reference level of 200 Bq/m3) (1 national, 7 regional, 5 provinces, 6 local communities);
- Italy: A national website and the websites of three regions where the radon concentrations were the highest (between 200 and 500 Bq/

m3) have been evaluated. Within those regions, we chose one (Lombardia) and randomly picked 6 communes where more than 20% of homes exceed the reference levels (200 Bq/m3) (2 national, 3 regional, 6 local communities);
- Slovenia: all national websites and websites from all local communities indicated as the highest radon prone areas according to the Ministry of Health (2 national and 12 local communities)
- Spain: websites from the provinces that have the highest surface area of areas with radon concentrations above 400 Bq/m3. Within those provinces, the websites of communities of each province (5) were evaluated. (5 provinces, 5 regions).

The evaluation of websites was done by native speakers (English, Dutch, German, Italian, French and Slovene) or with high proficiency in the respective language (Spanish, Croatian).

3.2. Evaluation criteria for website analysis

The following indicators were used to evaluate webpages from a stakeholder engagement perspective: availability of the radon information on internet, accessibility, personalisation/customization, presence/absence of broken links, stakeholder interaction, dialogue, responsiveness, content and design, transparency/openness (see Annex 2 for a summary). The national, regional or local internet pages are not statistically evaluated separately, since it is recognised that national authorities need to partner with local and regional authorities, not only at the policy level but also at the implementation level (Bouder et al., 2019; EPA, 2019); however stakeholder engagement by different levels of authority has been assessed qualitatively and is also reported in the result section whenever meaningful.

Availability of radon information on the internet page was checked in both an automated and manual way. First, the word "radon" was included as a browser criterion if the search engine existed on the evaluated page. Second, the search was upgraded manually, by looking at all pages, sub-pages related to health, environment, policies and news in order to identify topics related to radon on the evaluated internet page.

Accessibility refers to the capability of making website content accessible to a wide array of possible stakeholders, with equal access to information and functionality, regardless of their technical skills or possible disabilities (Olalere and Lazar, 2011). Accessing information on mobile devices with a good user experience is more and more important, since most of the population accesses the internet via mobile devices (OECD, 2018; Yusuf and Adams, 2014). Accordingly, accessibility by mobile devices was tested. The mobile responsiveness of a website was measured using a smartphone indicating whether the application had a mobile friendly version or not.

Personalized/customizable websites offer tailored content and features to specific stakeholders, so that different stakeholders can see different things on the "same" page. Customization gives control to the stakeholder and personalisation to the website. Both can enhance stakeholder' experience, but only when carefully implemented. The personalized and customizable features were evaluated by looking at the following indicators: possibility to obtain radon information (e.g. % houses exceeding action level) corresponding to a specific address or location (e.g. GPS coordinates in radon prone areas); provision of an interactive radon map (e.g. possibility to get radon information by click on a particular province or commune on the map); provision of a map with radon concentrations (not necessarily interactive) but presenting radon measurements at place. The use of maps as a form of evidence to communicate about the multiple determinants of cancer has been recognised specifically for radon concentrations in dwellings in the U.S., for instance in the states of Alabama and Washington (Parrott et al., 2007).

Broken links on the internet pages were counted since they are a major barrier to engagement, as citizens require consistent, reliable, and accurate access to information from authorities on their websites

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[1] 1.1%–5% of houses have radon concentrations above the action level which is 300 Bq/m³, <5.1%–10% of houses have radon concentrations above the action level which is 300 bq/m³, 10%–5%, above 20%.

(CENDI, 2004; Karkin and Janssen, 2014). It is important that links to information are valid and up to date, as broken links frustrate stakeholders, discourage further website visits and engagement with the issue (e.g. radon). Broken links were evaluated automatically by the open source evaluation tool W3C validator[2] that checks links and anchors in Web pages or full Web sites. The radon internet pages were checked for all linked documents recursively and a recursion depth level 3 was used.

Stakeholder interaction via websites is enacted by tools that stakeholders can use to interact with authorities, such as satisfaction questionnaires, submission of requests (e.g. policy proposals) or feedback on authorities' initiatives. The website evaluation included a range of indicators: existence of feedback forms or satisfaction questionnaires, e.g. "was it helpful" or "like" symbol; existence of tools designed for collecting stakeholders Q&A as an open category on the internet page: e. g. "your comments"; the possibility to propose ideas e.g. related to radon actions or mitigation of radon prone areas; availability of broadcasting related to the radon program or radon related events/meetings, where questions, opinions can be shared on-line (e.g. radio shows, TV broadcasts, documentary movies, public meetings and Webinars); possibility for direct personal communication (e.g. e-mail address) with the person responsible for radon issues; opportunities for stakeholder participation and data transformation, and user-centered design (e.g. Web 2.0 (Buccoliero and Bellio, 2010): Facebook, Twitter, YouTube).

Dialogue with stakeholders was evaluated through the presence or absence of chat areas or message boards. This is an interactive feature, public and open to everyone (e.g. the chat can be followed by any stakeholder) and it should be at least two-way communication. The presence or absence of institutional email addresses and email updates also in the form of a newsletter was evaluated, for instance subscription to email updates, regularly sent out newsletters detailing tasks or activities that community have taken up.

Responsiveness of the authorities was tested by sending an e-mail to each institution dealing with radon issues presented on the website and measuring the time for receiving a response. The following e-mail has been sent: "*Dear Sir, Dear Madam, I recently watched a documentary related to radon on internet and I am worried! I would like to know where I can obtain a Radon Test, how much it would cost, where I would bring the kit and where the results will be published (and when!). Thank you in advance for the attention you will grant to this email.*" This email allows to share factual data, increase the radon awareness, express empathy and address stakeholder's risk perception. Responsiveness was evaluated quantitatively (number of days waiting for response), and qualitatively, to assess whether the answer addressed empathy and risk perception factors. Another indicator was the use of social media plug-ins, since these have become a key tool for authority's responsiveness. For each feature, the number of posts related to radon and the number of comments on posts were counted (e.g. radon related posts on Twitter or Facebook), as well as number of visitors, "likes", followers and shares were counted. For Facebook sites, it was checked whether they gave an opportunity to share the post within a stakeholder's network. Values for the responsiveness indicators were coded as 1 (no) or 2 (yes).

Content and design for different stakeholders groups: the content of the website is an important indicator for engagement. In the research by Coleman et al. (2008) the "story content" and "site appearance" showed strong correlations with engagement attitudes by stakeholders. A clear organization structure with an easy-to-use navigation system and user-centered design is essential. The website should attend to the informational (content) and presentational (design) dimensions with a special attention to different stakeholder groups that have different needs as users of an internet page. The website should also be user-friendly. Usability can be measured by how easy a website is to

learn, how quickly a user can accomplish a task, how error-proof the site is, how satisfied the user is with the experience and how often users return to the site (Coleman et al., 2008; Gould & Lewis, 1985; Nelson et al., 1999). In addition, this study evaluated whether the webpages had a story, for instance jingle/tune and redline. Values of these indicators were clear webpage story (1), some dispersed elements of a story (2), unclear or no story (3); for personalisation of the internet page: not personalized at all (1), somewhat personalized (2), personalized (3). It was also checked whether the internet page has different sub-pages for different stakeholder groups and if yes, the stakeholder groups addressed were listed (open category). Through the number of clicks we measured how easy it is to learn where to get radon test, how much does the measurement kit cost, where to bring the dosimeter and where will the results be published. The value of a reporting variable was the number of clicks from a home page starting with a keyword "radon" in a site search engine.

Transparency and openness in the context of the radon websites can be achieved through dissemination of vital information such as online tenders, live broadcast of meetings, financial statements of government agencies/departments, legislative information, policy strategy, regular reports of government activities and projects, contact information of public officials, and the ability for citizens to submit complaints online (Bertot et al., 2010; Karkin and Janssen, 2014). By publishing legislative drafts online, stakeholder engagement and transparency can be enhanced, as stakeholders will have the chance to participate in policy discussions. This acts as an enabler for deliberative and participatory democracy (Cegarra-Navarro & Garcia-Perez, 2014; Coleman et al., 2008). Transparency and openness was measured by answering the following questions: are tenders for analysis laboratories online; is the (draft) national action radon plan on-line; are financial documents related to radon action plan published; is the new Basic Safety Standards Directive on-line; are other national legislative documents on-line; is the radon mapping plan online; and is it announced where the radon mitigation activities are taking place?

4. Results and discussion

4.1. Availability of radon information on the internet

The results show that radon information is not very present on internet pages of local, regional or national authorities. 60% (n = 103 out of 173) of the websites or expected internet information sources from local and national authorities do not publish any information related to radon on the internet. This is surprising, since the authorities included in the analysis are directly or indirectly responsible for radon mitigation actions, as well as for raising awareness of radon risks among the population.

Radon information is therefore in many cases unavailable or difficult to find. See Fig. 1, Table 1: Availability of radon information of internet pages of authorities at different governance levels (from national to local community levels) (see Table 1)

While it is possible, that some radon information is available on the internet, but not found by evaluators, this indicates that also stakeholders are not able to find this radon information since evaluators used both automatic and manual search methods, as described in the method section.

Three countries among those included in the study have a specific, dedicated internet page for radon on a national level: Belgium has an internet page with the title: "*Radon Action*",[3] Croatia has an internet page with the title: "*Radon, natural gas without smell and taste*", and Ireland has an internet page "*Radon*". 29% of the analyzed national and

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[2] https://validator.w3.org/checklink?uri=http%3A%2F%2Fwww.baelen.be %2Fsearch%3FSearchableText%3Dradon&hide_type=all&recursive=on &depth=3&check=Check.

[3] In Belgium there is also a radon internet page dedicated to radon at work. This page has not been evaluated since is out of the scope of this study, which focused on radon in homes.
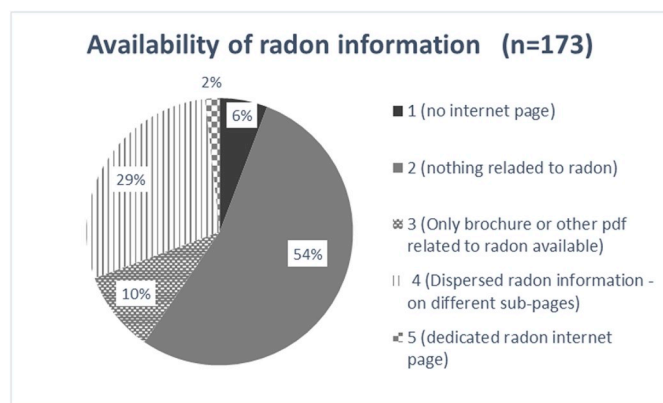
Fig. 1. Availability of radon information of internet pages of authorities at different governance levels (from national to local community levels).

local authorities have information related to radon dispersed and rather unstructured throughout different sub-pages and 10% publish only a radon brochure or another radon related document on the internet. For instance, an internet page in Germany published the minutes of a radon related meeting, whereas a local community internet page in Croatia published the minutes of a question/answer session related to radon mapping at the city council.

Brochures related to radon were found for a number of internet sources evaluated: 6 (out of 14) in Germany, 2 (out of 10) in France, 5 (out of 10) in Spain, 2 (out of 11) in Italy, 1 (out of 12) in Ireland, 0 (out of 14) in Slovenia, 2 (out of 4) in Croatia, 21 (out of 88) in Belgium. Slovenia is the only country without any brochure or other document related to radon on the analyzed webpages of the local communities in high radon prone areas, as well as at the national level.

4.2. Website accessibility

More than half (57%, n = 40) of the 70 internet pages containing information related to radon have a user-friendly mobile application, enabling stakeholders to access information on mobile devices with a good user experience. For instance, users do not need to zoom in a screen to be able to get readable font sizes and they can easily swipe and browse on their mobile device for radon related information. Radon websites from Ireland and France provide good examples in this respect, since they have user-friendly mobile device applications for all websites, both at the national or the local community level. This ensures radon information can be accessed and read in a user-friendly way (see Fig. 2).

4.3. Customized and personalized content

Specific "Radon Action" and "Radon" internet pages as well as

internet pages with dispersed radon information (n = 53) were analyzed to evaluate whether they provide customized and personalized content and features tailored to specific stakeholders. Results presented in Fig. 3 suggest that more efforts should be made to enhance stakeholder experience on a large majority of the evaluated internet pages. Only four (national) authorities have integrated GPS coordinates linked to radon prone areas on their internet pages, four authorities have integrated interactive radon maps (option where a stakeholder can click on a particular province or commune and he/she gets radon information) and 17 authorities provide information about radiation measurements at place (map with radon concentrations, which is not necessarily interactive, but presents radiation measurements). Most of the stakeholders that will look for the information on provincial, regional or local community levels will therefore not be able to find this customized and personalized option. It is interesting that maps with radon prone areas and radon concentrations are presented differently in each country; visual presentations differ also within the same country. For instance, the colour for the highest concentration in Germany is dark brown at the national level, while on the regional level is flashy red (e.g. Saxony). In Italy brown presents the highest concentration at the national level, while the highest concentration in the region of Lombardy is presented with red, and in the region of Campagna as orange. Also the graphical presentation of radon concentrations differs from a country to country, and from authority to authority. Radon concentration and measurements are most frequently presented as coloured dots or squares. Sometimes the size of these dots and squares corresponds to the number of radon measurements in the region, while in the most cases the size of dots and squares is the same. In many cases the complete administrative boundary of a community is coloured, while on some maps only a radon prone area is coloured regardless of the administrative boundary. While most maps present two dimensions, there are also a few maps (for instance in Slovenia) presenting the radon concentration as the third dimension with the 3D graphics over a whole radon prone area.

4.4. Broken links

The analysis of internet pages containing radon information (n = 53) shows that only the internet pages from Ireland do not have any broken links, whereas webpages from Germany have one broken link on average, Croatia, Italy, Slovenia and Spain between two to three broken links per internet page and Belgium has, on average, more than five broken links per internet page. The problem of broken links is specific for radon related internet pages in ownership of national authorities in Croatia and France; these websites have 4, respectively 5 broken links. Websites of national authorities in three of the countries analyzed (Belgium, Ireland, Spain) provide good practice in this respect, as they do not have any broken links, for instance the specific radon internet page "Radon Action" from Belgium. The internet page "Radon" from Croatia had two broken links, as did the website of the national authority Italy (ISS).

Table 1
Availability of the radon information on internet per country.

Country[a]	No regional or community internet page	Nothing related to radon (% of the internet pages evaluated per country)	Only brochure or other pdf related to radon available	Dispersed radon information (on different sub-pages)	Dedicated radon internet page	Total
Belgium	0	49 (55.7%)	10	28	1[a]	88
Croatia	0	2 (50%)	1	0	1	4
France	3	7 (53.8%)	1	2	0	13
Germany	0	5 (35.7%)	0	9	0	14
Ireland	7	10 (52.6%)	0	1	1	19
Italy	0	6 (54.5%)	1	4	0	11
Slovenia	0	10 (71.4%)	0	4	0	14
Spain	0	4 (40%)	4	2	0	10
Total	10	93 (53.8%)	17	50	3	173
Total webpages evaluated: 163 (10 communities did not have a web page)						

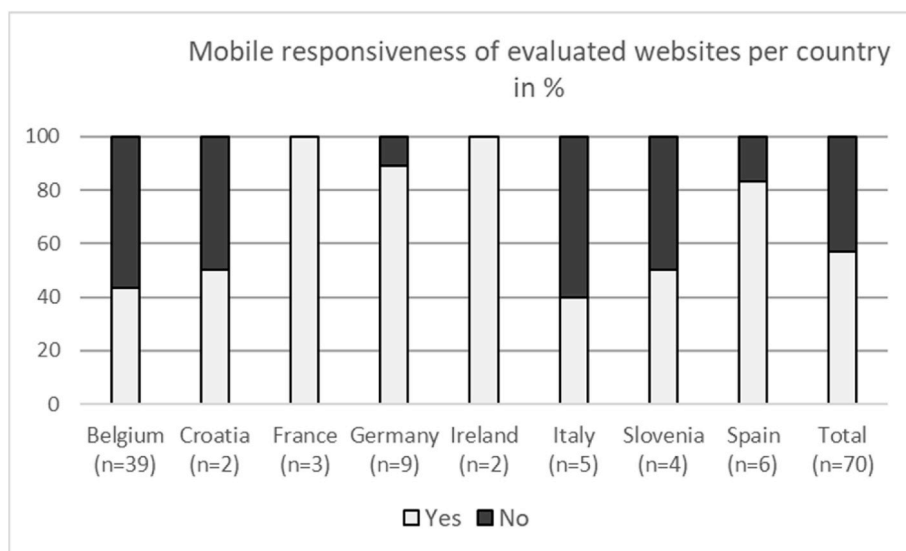[a] For information on the sampling see the Method section.

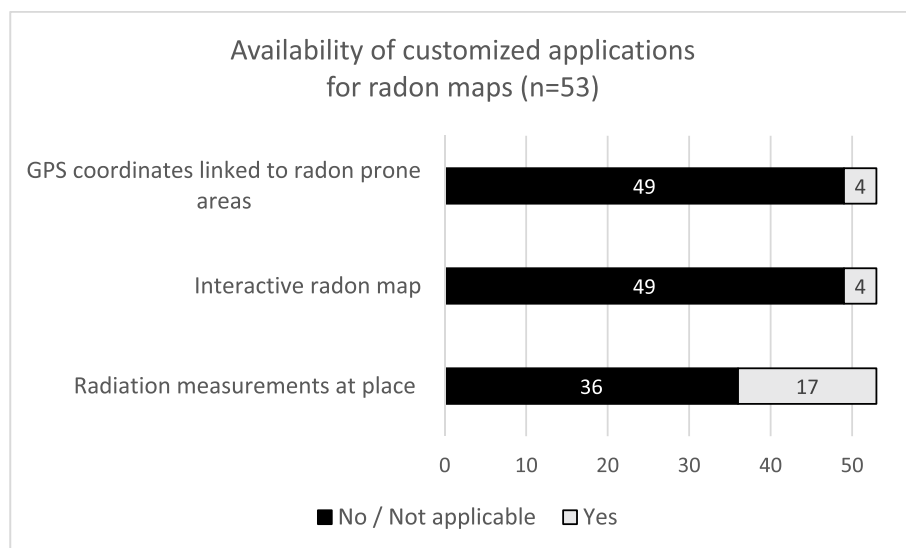**Fig. 2.** Mobile responsiveness of web pages containing radon information per country in % (n = 70).

Fig. 3. Frequency of customized applications for radon on internet (n = 53). Only internet pages with dispersed radon information (on different sub-pages) and specific radon internet pages are included in this analysis.
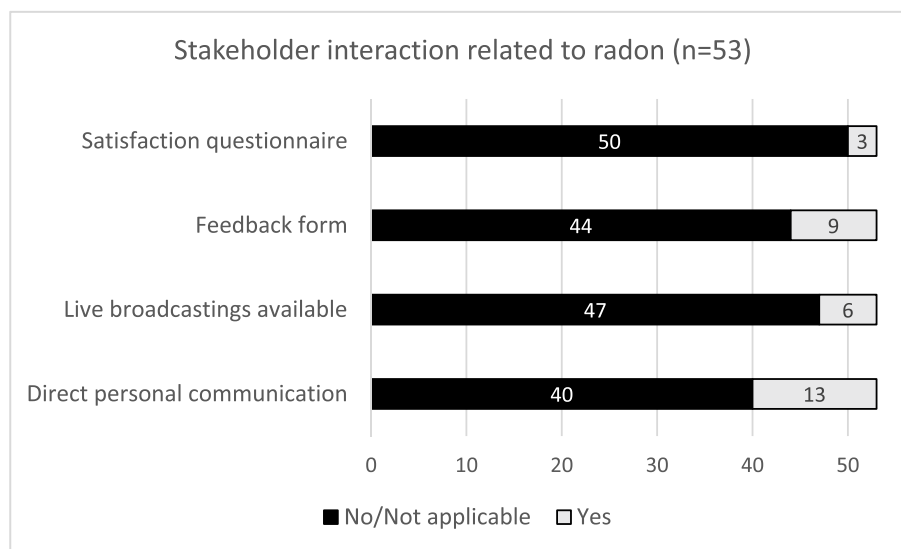
4.5. Stakeholder interaction

Although internet provides an opportunity for stakeholder interaction in activities related to radon issues through the use of new communication tools, this is not fully exploited yet. Stakeholder interaction possibilities via websites include for instance satisfaction questionnaires and tools for submitting requests, such as policy proposals and stakeholder feedback on authorities initiatives. Results presented in Fig. 4

Fig. 4 show that the feedback forms, as well as satisfaction questionnaires are not often present on the internet pages containing radon information. In addition, only few internet pages have been found to contain broadcastings or audio/video material related to radon available for stakeholders. In such cases, this material is limited to provision of information about radon rather than an interaction opportunity for stakeholders. Such broadcasts are published for instance by national

authorities in Slovenia or Germany, where it is possible to re-listen to a radio broadcast about radon issues or watch a TV public science program related to radon. The IAEA Webinars[4] related to radon have proved to be an effective way of engagement with stakeholders; however, the Webinars are not used on the analyzed webpages, nor has any link to the existing IAEA Webinars been identified.

As social media have become a key tool for authorities' responsiveness, most authorities integrate social media plug-ins into their websites. During the last few years, several authors and projects related to radiological risks have addressed the potential of social media for the innovation of public sector organizations (Gehner and Oughton, 2016; Mays et al., 2016). Authorities are expected nowadays to have social media accounts, as a means interacting with the public. Results showed that sixteen web pages from Belgium integrate some of the following social media plug-ins: Facebook, Twitter, Google+, Viadeo, Gmail, Pinterest, LinkedIn. The most used is Facebook (14 web pages have a

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[4] https://www.iaea.org/topics/radiation-protection/radon/webinars.

Fig. 4. Stakeholder interaction opportunities related to radon issues on internet pages (n = 53). Only internet pages with dispersed radon information (on different sub-pages) and specific radon internet pages are included in this analysis.

Facebook), followed by Twitter (13 web pages have twitter account) and LinkedIn (6 webpages have LinkedIn). While Facebook is followed by many local users, for instance one Facebook has 309, 858 followers, radon related posts are very rare. Only three Facebooks from the analyzed web pages from Belgium published posts related to radon (in one case there were 14 posts related to radon, 8 shares and 5 likes). Among the websites analyzed, four websites with social media plug-ins were found in Germany, two in France and Ireland, three in Spain and Italy, one in Slovenia and no media plug-ins on any of the Croatian webpages.

4.6. Dialogue

Health communication research shows that people often use internet chat rooms and discussion boards to learn about diseases and symptoms, for instance related to cancer. Lamberg (1997) found already at the end of 20th century that discussion groups and chat rooms were among the most widely visited websites on the internet. Chat rooms and dialogue boxes on the internet are clearly important sources of information and emotional support, also related to medical treatments and drugs (Macias

et al., 2005). The same importance of chat areas is found also in marketing research. Firuta (2014) showed that chat areas on webpages engage visitors and turn them into customers (Firuta, 2014); for instance, visitors invited to chat are 6 times more likely to become customers than the ones who do not chat; and 61% who become customers do so after the first chat (Firuta, 2014). However, results of this research show that opportunities offered by chat areas, message boards and forums are rarely used for radon related topics. Illustrative examples of good practice related to dialogue have been found for two local communities in Slovenia and Germany, where stakeholders can ask a question related to radon publicly and the answer is published and visible to all internet page visitors. One way information in the form of subscription to email updates, regularly sent out newsletters detailing tasks and activities is somewhat more present on the internet pages evaluated, but still scarce. Most internet pages evaluated publish an institutional email address to enable stakeholders to address their question or opinion. It is worth mentioning that there are only a few internet pages where the e-mail address of an expert or responsible person related to radon issues is published. Results presented in Fig. 5 show that the internet pages should provide more opportunities for
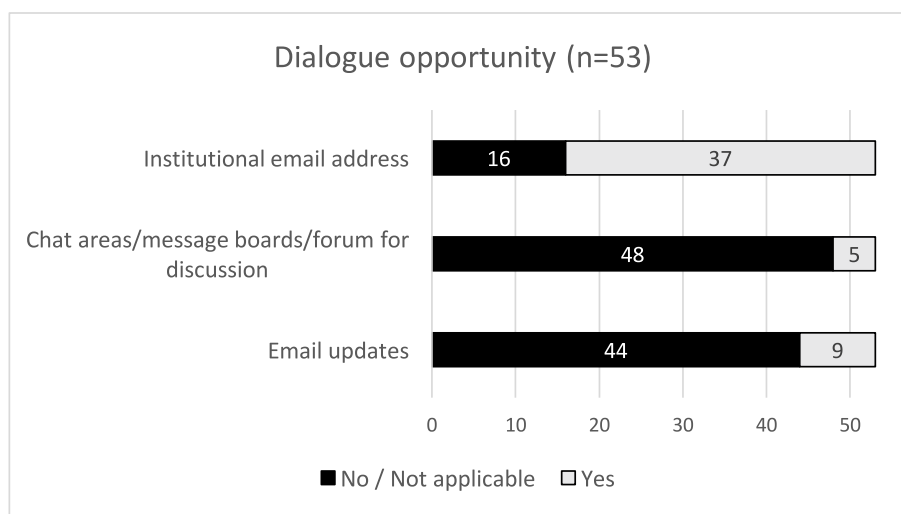
Fig. 5. Dialogue opportunities related to radon on internet pages (n = 53). Only internet pages with dispersed radon information (on different sub-pages) and specific radon internet pages are included in this analysis.

stakeholders to start a dialogue related to radon with national or local authorities. When present, opportunities for dialogue were often blocked or limitations were imposed on the participants in a chat area, forum or e-mail updates to the permanent residents of the community or the country (e.g. persons holding a citizen's certificate in Spain, or a permanent address in Slovenia). This prohibits non-residents, visitors of the area, tourists and other temporary residents to engage in a dialogue related to radon. To participate in a chat section, for instance, a stakeholder needs a citizens certificate linked to a browser in the local community of Ayuntamiento de la Coruna, in Spain, whereas in the local community Pivka, in Slovenia, a permanent address in the community is required in order to post an opinion or question on the local authorities' internet page (see Fig. 6).

4.7. Responsiveness

Most of the webpages with radon information publish an institutional e-mail address in order to enable a stakeholder to establish a personal conversation with a representative of an authority. "*While it is important to have e-mail addresses available on websites, they serve no purpose unless someone actually reads and responds to the messages that are received*" (West, 2004), p.22). A response should be given in a reasonable time, be meaningful and provide at least the requested information. The answer should also address risk characteristics (Perko, 2014) for instance dread, controllability and familiarity (Slovic, 1996) and show empathy with the concerns expressed. In our study the following information was asked: where to obtain a radon test, how much would that cost, where would the kit need to be brought (for reading the measurement), and where and when would the results be published. The gateway for a response addressing risk perception characteristics and expressing empathy was the sentence included in the e-mail: "*I recently watched a documentary related to radon on internet and I am worried.*" The e-mail was sent to all available e-mail addresses published and found on the analyzed webpages with radon information. For Belgium, 53 responses were received for 88 websites, with ten out of 14 internet pages in Germany, four responses from 14 internet pages in Slovenia, three responses from 12 internet pages in Ireland, two responses for ten

webpages in Spain, and only one response for eleven internet pages in Italy, one response from four internet pages in Croatia and one response for ten internet pages in France.

Most of the responses from Belgium and Germany were received within a few working days. In general the responses were similar to the following: "*You can order a radon test (detector) via the website* www.actionradon.be. *The test (20 EUR) takes place over* 3 months *in the room you spend the most time in on the ground floor. The results will be communicated to you via post a few weeks after you have sent the detector back to the lab.*" Some responses took the question as an opportunity for outreach and offered more information, for instance "*there is going to be an article on this topic in the next local newsletter (the distribution will take place during the week of the 10th of September). If you want, here is the text that will be published*", while others closed down the discussion with one sentence "*Everything is written on Facebook …*" not taking into account, that Facebook may not be used by the stakeholder. Only few responses addressed the concerns expressed in the e-mail, gave extended information and offered a possibility for dialogue: "*I am well aware of the fact that you are unsettled by the topic of radon, because the information in the public domain is still very scarce on this topic. In any case, it is welcome that you want to approach this problem. To answer your questions, while giving you some additional information that I hope will help explain the Radon problem a bit better, I would like to allow me to send you the attached information document. Of course, if you have any further questions you can always contact me by phone or e-mail. Some things can be better represented and explained in direct conversation.*" Most of the responses offered a partial, basic information or only redirected the stakeholder to some other institution e.g. Ministry of Health ("*In order to obtain the information you are talking about in your e-mail, you should contact the Ministry of Health.*").

4.8. Content and design for different stakeholders groups

Research related to internet use showed that if people cannot figure out where they can find the information, and what kind of information is available on the internet, they become frustrated and quickly leave (Krug, 2000). A clear organization structure with an
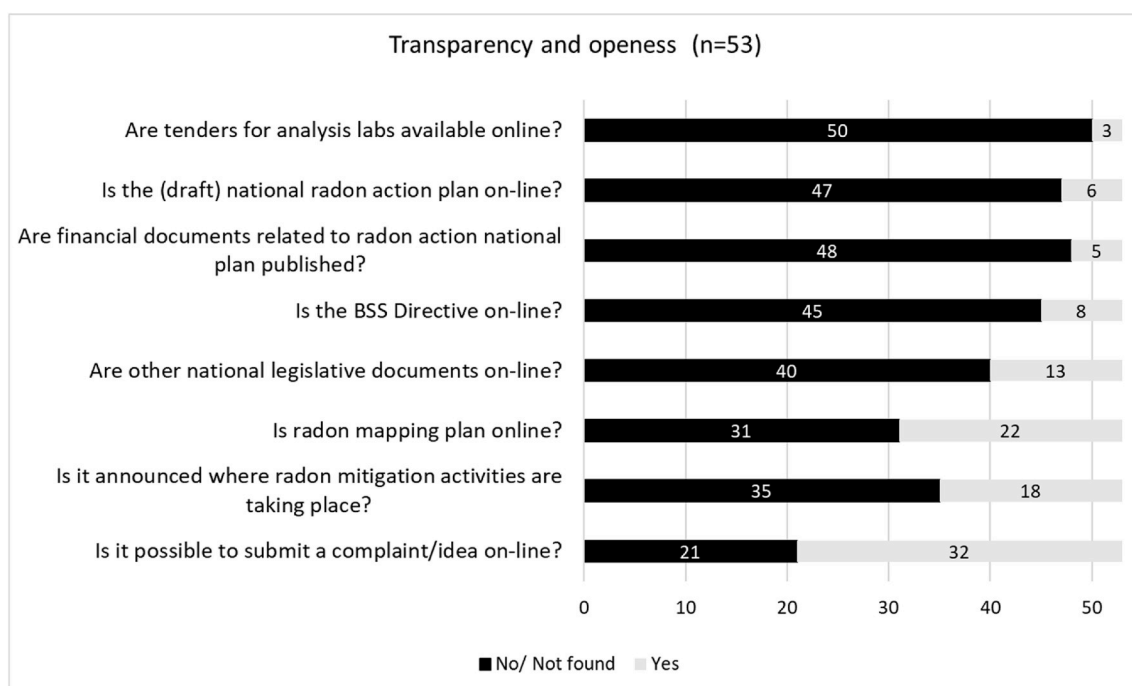

Fig. 6. Transparency and openness on the websites with the radon information (n = 53). Only internet pages with dispersed radon information (on different sub-pages) and specific radon internet pages are included in this analysis.

easy-to-use navigation system and user-centered design is essential for the engagement of a website user. An engaging website should be user-friendly and have a content that has both informational value and a professional design attentive to the needs, capacities, interests of different stakeholder groups. Usability is measured by how easy a website is to learn, how quickly a user can accomplish a task, how error-proof the site is, how satisfied the user is with the experience and how often users return to the site (Gould and Lewis, 1985; Hale et al., 1995; Nelson et al., 1999).

The analysis of the webpage story showed that only three internet pages have a content completed with an engaging and clear story, design and messages, and five webpages have a clear radon story on a sub-page or even more sub-pages dedicated to radon. For instance an internet page from the national authority in Germany has nine sub-pages about radon: Radon, What is Radon, Radon in the ground, Radon in buildings, Effect on health, Further information, Measures for protection from radon, Home and a pdf brochure. Brochures in pdf format are common to the internet pages dedicated to radon and the internet pages with dispersed radon information. A small and not engaging summary of what is in the pdf and pdf itself are often found on a webpage, for instance "Radon gas brochure", or "Renovation incentives". Only in few cases the link to the pdf document is presented with an introduction text that invites and engages a stakeholder to open the document and to build awareness around the simple and affordable steps they can take to protect their loved ones from radon risks. A good example of inviting, engaging and motivating introduction text for a brochure is: "*Are you going to build? Protect against radon*".

The webpages with a website story had various messages, jingles or customized messages: "*Radon in your home? Take the test to protect yourself*", "*Action radon 2015: an enemy in your house*"; "*Action Radon: order your detector from the province of Liège!*"; "*RADON: Bassenge commune is not concerned*"; "*Detecting radon*"; "*Action Radon: order your kit*"; "*Order your kit with the Province of Liège and save 10 EUR!*"; "*Radon in your home? Take the test to protect yourself*"; "*Action Radon: order a radon detector*"; "*Radon, an enemy in your home?*"; "*Improve your home thanks to the Ecopack*"; "*Advance nuclear safety*"; "*The radon risk*"; "*Radon*" and "*Natural, radioactive gas without smell and taste*". In general, a customized message should engage with the website visitors and turn them into an active stakeholder. An example of a good message is: "*Test. Fix. Save a Life.*", developed and used by U.S. Environmental Protection Agency. In the analyzed countries a similar, but less engaging example is "*Radon in your home? Take the test to protect yourself*", developed and used by the Belgian authorities. A webpage design with a clear and engaging website story is informative and engaging. Yet, most of the webpages with radon information have another redline throughout the page and there is no commonality in message, design or content. Some examples of dispersed, weak or unclear website story are "*Health*", "*Mission Sami*", "*Radon day*", "*Ecopack & Renopack*", "*Radioactivity*". It is worth to mention that most of the messages do not address either "threat", nor "efficacy", which are the most important factors for health-protection behavior according to the message design theory, and the Extended Parallel Processing Model, developed by (Witte et al., 1998). These results show that, in general, the quality of radon messages has not improved since the evaluation of radon campaign materials was done by Witte and colleagues few decades ago according to EPPM (Witte et al., 1998).

In general, on most internet pages one needs to search intensively in order to find some information about radon, while on most others the webpage story is lost in dispersed information. For instance on one of the Belgian pages from local communities radon is mentioned only once, in a section about financial incentives if locals renovate buildings to lower the radon concentration in said buildings. Contrary to a rather poor radon story on the analyzed internet pages, an engaging story is present in radon related brochures found on internet pages. These brochures have a clear, attractive and appealing story related to radon, for instance "*Protect from radon: regulate your risks*" from the Badden-Wuerttenbeg

region in Germany.

Personalized content, for instance a greeting, is for a webpage visitor of extreme importance. A research shows, that correctly set up greeting reaches a visitor at the right moment with a contextual message (Firuta, 2014). They have a much greater rate of success than non-contextual, quantity-oriented invitations to chat. Customized greetings engage visitors on a personal level, as they are much more organic and targeted (Firuta, 2014 p. 3). Out of the webpages analyzed, only three have personalized content: a national webpage from Croatia, a national webpage from Ireland and a national webpage from France. As an example of a good practice is the webpage from Croatia which greets the visitors with "*Welcome to radon pages in the Republic of Croatia. These pages are designed to provide basic and relevant information on radon and radon values in the Republic of Croatia to all interested individuals and institutions.*" Moreover, the content of the webpage should be adapted for different stakeholder groups. While most webpages target a "general population" instead of specific stakeholder groups, the Croatian webpage of the national authorities has a specific content designed for particular stakeholder groups: local communities, local residents, house owners, kindergartens, primary schools and secondary schools. The webpage of the Irish national authorities is another example of good practice, as it has dedicated content for householders, employers, radon services, homebuyers & sellers, health specialists, housing authorities, builders and schools. The French webpage addresses inhabitants, companies and owners of public places. The Table 2 below presents radon stakeholders specifically addressed on the webpages analyzed, grouped in three categories: potentially affected radon stakeholders, regulators and opinion makers, and radon mitigation stakeholders. (see Table 2) This list can serve as a stakeholder mapping for a good practice in stakeholders engagement with radon issues.

A webpage should be easy to learn in order to get information fast and to engage if decided to. It is important to note, that most of the internet pages did not have any information related to radon self-test. However, results show that in general, on those pages that have some information about radon self-test, is relatively easy to learn where to find this information: e.g. in Spain 7 clicks needed from the home page starting with a keyword "radon" in a site search engine to find this information, in Belgium 5, in Italy, Ireland and Germany 3, in Slovenia 2

Table 2
Radon stakeholder addressed by the analyses webpages.

Radon stakeholders addressed by the webpages, analyzed (exact wording from www and grouped in three categories)		
Potentially affected stakeholders	Regulators and opinion-makers	Radon mitigation stakeholders
• local resident, • inhabitant, • parent, • child, • senior, • person with a handicap, • new inhabitant, • workplace, • houses, • house holder, • house owner, • company, • employee, • employer, • home buyer, • home seller, • owner of a public place, • local community, • school, • kindergarten, • primary school, • secondary school, • interested in radon testing	• health specialist, • housing authority, • mayor, • local politician, • city council	• professional • radon service • builder • architect

clicks. Similar results were obtained for other indicators (see Table in Annex 2).

4.9. Transparency and openness

Transparency and openness related to radon issues were measured with several indicators. Tenders for labs for the radon analysis were available online only on three webpages: one from France, one from Spain and one from Slovenia, while the national (draft) action radon plan is published online on six webpages (from France, Germany, Ireland, Italy, and Spain). Financial documents related to the radon action plan, such as incentives offered to inhabitants that reduce the radon concentration in their homes were found on five radon webpages from France, Ireland and Spain. However, information about financial aspects is published in some countries on social media, rather than the internet page. For instance, costs related to the remediation of a school in Slovenia were published on Facebook. The new Basic Safety Standards Directive is published on-line on eight internet pages. Surprisingly, none of the webpages from Germany and Italy made the new legal requirements available on-line. However, other national legislative documents are published online on 13 webpages. Some websites from France include for instance a special brochure which reports on all the legislative documents related to radon, while a brochure published on a webpage from Spain summarises the measures put in place under the form of legislative documents. A radon-mapping plan was found online on 22 webpages, while eighteen webpages contained announcements about locations where radon mitigation activities are taking place. For instance, a local community in France explains on its webpage what has been done by the region over the past year for radon risk reduction, and mentions a radon test organized in a local school.

Another challenging area related to openness and transparency in engagement of stakeholders in radon management are requirements from the General Data Protection Regulation (GDPR), which is focused on personal data, and the ePrivacy Directive which is focused on electronic communications, confidentiality, and includes non-personal data as well. Although pertinent, these issues are out of scope of this article.

5. Recommendations for effective and efficient radon websites

We conclude by consolidating the analysis into a list of recommendations which support stakeholder engagement in radon issues as well as in e-health campaigns more generally (see Table 3).

6. Conclusions

Research has shown that evaluating health-communication materials facilitates the development of effective public health-campaigns, as one learns what is available, how it is communicated, and what are the ways to adapt the communication material and channels in order to improve health behaviour in the target publics. Through the analysis of websites from national, regional and local authorities in eight European countries, this research allowed identifying good practices that can enhance stakeholder engagement and potentially address the value-action gap observed in radon risk mitigation. At the same time, it showed that the potential of internet is insufficiently exploited. Actionable and engaging information related to radon is still scarce, and finding it is often time-consuming. In most cases, information related to radon is dispersed, and sometimes placed under the general context of health, environment, spatial planning or other issues. This evaluation offers recommendations for health communicators that should help them overcome the limitations of internet pages related to radon. Attending to considerations of availability of radon information, accessibility, stakeholder interaction, dialogue, responsiveness, content and design, and transparency/openness is of particular importance at local level, which has been proven most effective in raising awareness and implementation of remedial actions, as well as changing health behaviors. Radon is an important

Table 3
Consolidated analysis into a list of recommendations for stakeholder engagement.

Engagement factors	Good practice for stakeholder engagement in radon issues identified
Availability of radon information on internet	• Webpages of national and local authorities include radon related topics. • A special, dedicated radon internet page is developed at national level. • The internet page of the local community has a special radon sub-page. • Radon information is clearly identified and all information is collected on one sub-page. • The internet page includes outreach documents, such as brochures. • National and local radon webpages are cross-linked.
Accessibility	• The design of the webpage is adapted to different mobile applications and devices (e.g. computer, smartphone). • Personalized and customizable features are included on the webpage (e.g. GPS coordinates linked to radon prone areas, interactive radon map, radon concentrations included on the map). • All links mentioned in the webpage are functional and tested regularly.
Stakeholder interaction	• Feedback forms and satisfaction questionnaire are included in webpages. • Tools designed for collecting stakeholder questions and answers are on-line and open to all stakeholders, not only to residents. • A stakeholder can follow radon-related discussions by broadcastings and can participate in Webinars related to radon. • Information for direct personal communication about radon is available and inviting. • New social media are integrated and encourage enhanced stakeholder engagement in radon issues (e.g. Facebook, Twitter, YouTube).
Dialogue	• Chat areas and message boards are open to everybody and the content is visible to everybody. • A stakeholder can register for email updates, newsletters etc.
Responsiveness	• E-mail addresses published on-line are functional, and there is a person that responds to the stakeholders' questions. • Response to an email is given in a reasonable time, it contains factual information and addresses risk perception and empathy, if appropriate. • Response is taken as an opportunity to engage.
Content for different stakeholders groups	• The organizational structure of the webpage is clear and easy-to-use. • The webpage is user orientated and user-friendly. • The webpage story is clearly structured around radon issues. • The content is personalized and includes greetings for radon stakeholder. • Different stakeholder groups have special sub-pages and designed content. • Webpage is easy to learn. • Basic radon information is easy to find: where to get self-radon test, how much the kit cost, where will be results published.
Transparency and openness	• The radon action plan is published online. • Radon subventions and applications are published online. • Tenders for radon mitigation activities are published online. • Financial documents related to radon action plan are published online. • The new Basic Safety Standards Directive is published on the webpage. • National legislative documents directly or indirectly linked to the radon issues are easy to find. • Radon mapping activities and plans are easy to find and follow. • Mitigation activities are regularly and transparently reported.

public health problem, thus investment in more engaging internet pages of local and national authorities related to radon is worth the effort since it can lead to improved risk mitigation and, consequently, a significant decrease in the numbers of lung cancers in the population.

Further research should address the effect of radon related internet pages on the internet users, particularly their subsequent changes in protective behaviors with respect to radon risks.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvrad.2019.106123.

Annex 1. List websites evaluated

https://afcn.fgov.be/fr/dossiers-dinformation/radon-et-radioactive-dans-votre-habitation/radonhttps://afcn.fgov.be/fr/dossiers-dinformation/radon-et-radioactive-dans-votre-habitation/radon

https://www.sami.be/

https://www.province.namur.be/action-radon-3-10-16https://www.province.namur.be/action-radon-3-10-16

http://www.province.luxembourg.be/fr/radon-en-province-de-luxembourg.html?IDC=4378&IDD=54677#.W4T_UOQUlN4http://www.province.luxembourg.be/fr/radon-en-province-de-luxembourg.html?IDC=4378&IDD=54677-.W4T_UOQUlN4

https://www.provincedeliege.be/fr/node/9850https://www.provincedeliege.be/fr/node/9850

http://www.amay.be/actualites/action-radon-commandez-votre-detecteur-avec-la-province-de-liegehttp://www.amay.be/actualites/action-radon-commandez-votre-detecteur-avec-la-province-de-liege

http://www.amel.be/dienste/verwaltung/bevoelkerungsamt/#c990http://www.amel.be/dienste/verwaltung/bevoelkerungsamt/-c990

http://www.ans-commune.be/search?SearchableText=radonhttp://www.ans-commune.be/search?SearchableText=radon

http://www.aubel.be/fr/@@search?SearchableText=radonhttp://www.aubel.be/fr/@@search?SearchableText=radon

http://www.awans.be/images/action-radon-2018.jpg/view?searchterm=radonhttp://www.awans.be/images/action-radon-2018.jpg/view?searchterm=radon

http://www.aywaille.be/

http://www.baelen.be/search?SearchableText=radonhttp://www.baelen.be/search?SearchableText=radon

http://www.bassenge.be/actualites/radon-la-commune-de-bassenge-nest-pas-concernee-0/?searchterm=radonhttp://www.bassenge.be/actualites/radon-la-commune-de-bassenge-nest-pas-concernee-0/?searchterm=radon

http://www.berloz.be/@@search?SearchableText=radonhttp://www.berloz.be/@@search?SearchableText=radon

http://www.beyne-heusay.be/fr/search/radonhttp://www.beyne-heusay.be/fr/search/radon

http://www.blegny.be/?s=radonhttp://www.blegny.be/?s=radon

http://www.braives.be/ma-commune/services-communaux/services-en-ligne/documents-a-telecharger/urbanisme-patrimoine/annexe-4-pu-avec-archi.pdf/viewhttp://www.braives.be/ma-commune/services-communaux/services-en-ligne/documents-a-telecharger/urbanisme-patrimoine/annexe-4-pu-avec-archi.pdf/view

http://www.buellingen.be/index.php?id=suche&L=0q

http://www.burdinne.be/WEBSITE/BEFR/01/Homepage01.phphttp://www.burdinne.be/WEBSITE/BEFR/01/Homepage01.php

http://www.burgreuland.be/home/

http://www.butgenbach.be/fr/accueil/

https://www.chaudfontaine.be/depistage-du-radon/

http://www.clavier.be/search?SearchableText=radonhttp://www.clavier.be/search?SearchableText=radon

http://www.comblainaupont.be/search?SearchableText=radonhttp://www.comblainaupont.be/search?SearchableText=radon

http://www.crisnee.be/recherche?searchword=radon&searchphrase=allhttp://www.crisnee.be/recherche?searchword=radon&searchphrase=all

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http://www.engis.be/news/action-radon-commandez-votre-detecteur-avec-la-province-de-liege/?searchterm=radonhttp://www.engis.be/news/action-radon-commandez-votre-detecteur-avec-la-province-de-liege/?searchterm=radon

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Annex 2. Website evaluation metrics

Evaluation criteria	Indicators	Coding
Availability of the radon information on internet	Webpage of a national and local authorities includes radon related topics.	1 = no internet page; 2 = nothing related to radon; 3 = only brochure or other pdf related to radon available; 4 = dispersed radon information on different subpages; 5 = dedicated radon internet page
Accessibility	Design of the webpage is adapted to different mobile applications and devices (e.g. computer, smartphone)	1 = mobile unfriendly; 2 = mobile friendly
	Personalized/customizable features:	GPS coordinates linked to radon prone areas: no (1), yes (2); Interactive radon map no (1), yes (2); Radiation measurements at place no (1), yes (2);
	Number of Broken links (W3C validator)	Number
Stakeholder interaction	Feedback forms and satisfaction questionnaires	no (1), yes (2)
	Q&A	no (1), yes (2)
	Broadcastings, webinars	no (1), yes (2)
	Facebook, Twitter, YouTube, etc…	no (1), yes (2)
Dialogue	Chat areas/message boards	no (1), yes (2)
	Institutional email addresses	no (1), yes (2)
	Email updates, newsletters	no (1), yes (2)
Responsiveness	Response to the e-mail	Not received (1), received (2)
	Time for the response	Number of working days
	Information	Does not respond with the information (1); information included in the response (2)
	Empathy	Not expressed (1); expressed (2)
	Risk perception characteristics	Not addressed (1); addressed (2)
	Social media plug-ins: User participation: possibilities	Post (1); follow (2)
	Visitors, likes, followers and share for social media	Number
Content and design for different stakeholders groups	Website story: jingle/tune, red-line, clear organization structure, easy-to-use navigation system, user-centered design	clear webpage story (1), some dispersed elements of a story (2), unclear or no story (3)
	Personalisation	Not personalized at all (1), a bit personalized (2), personalized (3)
	Different sub-pages for different stakeholder groups	no (1), yes (2) open category
	Number of clicks: how easy is to learn where to get radon test; how much does the measurement kit cost; where to bring dosimeter; where will be results published	Number of clicks
Transparency and openness	Tenders for labs for the analysis on-line; (Draft) national action radon plan on-line; Financial documents related to radon action plan published; The new Basic Safety Standards Directive on-line; Other national legislative documents on-line; Radon mapping plan online; Announcement where the radon mitigation activities are taking place on-line	no (1), yes (2)

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