Transparency on YouTube for radon risk communication

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ABSTRACT

Introduction: Scientific evidence has proven the link between exposure to radon in indoor environments and lung cancer. For this reason, radon gas is considered a threat to public health. Additionally, YouTube has also been confirmed as a source of medical information. **Methodology:** This research examines YouTube as a vehicle for the global dissemination of information about radon. All the channels available on the platform since its creation that contain videos on this gas are identified, along with the geographical areas in which

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they operate, the language they use to broadcast, the number of subscribers they have, and the number of views they amass. Using a sample of channels specifically focused on radon, the presence of this topic on YouTube is examined using a mixed methodological model (quantitative and qualitative) that explores themes, narratives and dissemination strategies. **Results:** The results reveal the absence of echo chambers and the lack of awareness on this social network regarding the public health issues surrounding radon gas. **Discussion and Conclusions:** The study highlights the limited presence of radon-related videos on YouTube, with a predominance of content in English, restricting accessibility in non-English-speaking regions. Radon channels underutilize YouTube features and lack community engagement, revealing a significant gap in recognizing radon as a public health issue on the platform. Successful channels demonstrate good practices, but overall awareness remains insufficient.

Keywords: Radon; YouTube; Risk; Public health; Risk communication; Echo chambers; Social media.

RESUMEN

Introducción: La evidencia científica ha demostrado la relación entre la exposición al radón en entornos interiores y el cáncer de pulmón. Por esta razón, el gas radón se considera una amenaza para la salud pública. Además, se ha confirmado que YouTube es una fuente de información médica. **Metodología:** Esta investigación examina YouTube como un medio para la difusión global de información sobre el radón. Se identifican todos los canales disponibles en la plataforma desde su creación que contienen videos sobre este gas, junto con las áreas geográficas en las que operan, el idioma que utilizan para transmitir, el número de suscriptores y la cantidad de visualizaciones que acumulan. Utilizando una muestra de canales específicamente centrados en el radón, se examina la presencia de este tema en YouTube mediante un modelo metodológico mixto (cuantitativo y cualitativo) que explora temas, narrativas y estrategias de difusión. **Resultados:** Los resultados revelan la ausencia de cámaras de eco y la falta de conciencia en esta red social con respecto a los problemas de salud pública relacionados con el gas radón. **Discusión y Conclusiones:** El estudio destaca la presencia limitada de vídeos relacionados con el radón en YouTube, con una predominancia de contenido en inglés, que restringe la accesibilidad en regiones no anglófonas. Los canales sobre el radón infrautilizan las funciones de YouTube y carecen de participación de la comunidad, revelando una brecha significativa en el reconocimiento del radón como un problema de salud pública en la plataforma. Aunque algunos canales exitosos demuestran buenas prácticas, la conciencia general sigue siendo insuficiente.

Palabras clave: Radón; YouTube; Riesgo; Salud pública; Comunicación de riesgos; Cámaras de eco; Redes sociales.

1. Introduction

Radon is an odorless, tasteless, and colorless gas. It is a natural radioactive gas that originates from the uranium decay chain. Despite being ubiquitous in nature, it is the leading cause of death from lung cancer amongst non-smokers (García-Talavera et al., 2013; García-Talavera and López, 2019). Although the most important determinant of indoor radon concentrations is the geological substrate on which the dwelling is located, the exposure is universal (Ruano-Ravina et al., 2014). It carries an environmental risk and, most importantly, it poses a high-impact public health threat. The way to combat radon gas should be quite straightforward, only requiring that people adopt adequate ventilation practices at work, at home and in leisure spaces. However, society's knowledge of the risks of radon is scarce (Khan et al., 2019) and its presence in traditional and native digital media is limited and ineffective (Bouder et al., 2021). Furthermore, not only is society's understanding of the risks associated with radon scarce, but also these risks are incomprehensible to the public (Makedonska et al., 2018).

From a historical perspective, the study of radon risk exposure first appeared in the coordinated actions of the International Commission on Radiological Protection (ICRP) in the late 1950s (Lopes et al., 2021). Radon

"95% of Spanish-speaking videos contained information on COVID-19 and that only 0.85% were misleading."

began to garner public attention more than 20 years later in 1985 in the United States, mainly through newspapers such as The New York Times[1]. In 1988, the World Health Organization (WHO) classified radon as carcinogenic when the exposure involves elevated levels in indoor environments, and suggested methods to prevent and reduce its concentration (García-Talavera et al., 2013; WHO, 2021).

Seventy-five years after the first steps were taken, we are currently experiencing the fourth wave of digital communication. This is an era marked by changes in communication. processes and characterized by the manipulation of information and the creation of false perceptions through social media. (García-Orosa, 2021). Particularly, social networks are now a tool of great reach and influence in the dissemination of health information, especially in audiovisual digital spaces, even though more research is still needed (Rhyan et al., 2021). Therefore, they occupy a key space in the world of public health because of the following three factors: (1) the detection of diseases and risks, (2) the prevention and intervention in diseases and (3) conduct and behavioral changes (Zhang and Fu, 2021).

Specifically, the use of YouTube for health communication, beyond the passive consumption of videos, also makes it possible to build communities and establish dialogues with various audiences (Erviti and Stengler, 2016). Though the transmission of scientific and health related content on YouTube is becoming increasingly professionalized, media corporations are not able to match the views and subscriptions of channels managed by individual users, despite professionally generated content being larger in number (Welbourne and Grant, 2016). This social network can be a very important tool for engaging and informing a wide range of audiences (Allgaier, 2020).

In this study radon is classified as a hazard, meaning that it carries the risk of harming aspects that human beings value (Rasmussen & Ihlen, 2017). Secondly, radon is considered a public health risk. As such, information on health risks is regarded as an essential component of public health activities, and research on risk communication in the field of health is seen as a fundamental element of prevention (Strekalova and Krieger, 2017).

Research in risk communication aims primarily to safeguard the public from various threats, such as those related to health (Plough and Krimsky, 2013). Risk communication encompasses any form of information exchange regarding health or environmental risks, involving affected parties such as government agencies, individual citizens, scientists, among others (Covello et al., 1986). This concept seeks to understand and analyze the decisions and behavior of modern society in the face of risk situations (Renn, 1991). In this context, the importance of a comprehensive approach is evident, allowing for the effective addressing of the complexity of communicative interactions surrounding risks, promoting greater understanding and public awareness. The evolution of research in this field reflects the constant need to adapt to emerging challenges and improve communicative strategies to strengthen society's resilience against potential threats.

Lastly, the relevance of the social networks as a source of information for individuals seeking to analyze certain risks, such as those regarding their own health care, is used as a baseline for this research (Vance et al., 2009). This makes it a platform with great interest and potential to study her relation to the radon issue.

The rise of YouTube as a source of medical information has been widely studied by the scientific community (Betancourt et al., 2021). Previous studies delve into YouTube's role in providing information regarding various topics in this field. These include the flu vaccine (Hernández and Tarancón, 2020), burn treatments (de Oliveira et al., 2020), obesity and diet (Castelló-Martínez and Tur-Viñes, 2021), anemia (Quispe et al., 2020), diabetes

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[1] Further information: https://www.nytimes.com/1985/11/17/weekinreview/radon-may-endanger-8-million-homes.html

(Fortes, 2022), obsessive-compulsive disorder (Abhishek et al., 2021) and even clinical trials on pediatric cancer (Godskesen et al., 2023), among many others.

In relation to vaccines, although disinformation about vaccination on YouTube had been previously studied (Donzelli et al., 2018), the COVID-19 pandemic triggered the emergence of audiovisual health information like never before (Loiti-Rodríguez et al., 2021; Gil et al., 2020). Researchers who studied the vaccine-related content, sources, and conspiracy theories on YouTube videos shared via the first Twitter conversations about COVID-19 (Ginossar et al., 2022) discovered that the spread of misinformative vaccine-related contents in Spanish led to the formation of an echo chamber. This practice expanded and reinforced certain ideas by means of transmission or repetition of biased information within a closed system. It was possible to access biased content and information using keywords such as 'anti-vaccine' or similar, but not the other way around. It means, it was not possible to access reliable information or content provided by official sources through these searches, thus creating an echo chamber (Sued, 2020). In other words, an echo chamber is a closed social structure in which members discredit external sources of information, while internal information and discourse are reinforced or amplified, without breaking through the barriers of that closed structure (Nguyen, 2020). The potential presence of echo chambers, even on social networks like in this case YouTube, can reflect a significant level of ignorance, even a structural one (Santos, 2021). As a result, the phenomenon of echo chambers is a critical aspect of this study.

After analyzing the use of YouTube as a source of information during health emergencies, it can be concluded that 95% of Spanish-speaking videos contained information on COVID-19 and that only 0.85% were misleading (Nieves-Cuervo et al., 2021). Benaissa (2018) stated that "Twitter was the social network that informants used the most (53.61 percent) followed by Instagram and Facebook. Twitter was the social network most widely used as a source of information considering all resources, aside from photographs (Instagram) and videos (YouTube)" (2018, p. 39). Some researchers (Chalil et al., 2015; Okagbue et al., 2020) have classified YouTube videos produced by users and broadcast on non-specialized channels as unreliable and of low quality. However, users' testimonials tend to accumulate a greater number of views than videos issued by official sources (Basch et al., 2019; Sahin et al., 2019).

That videos have become such an important medium in the dissemination of health communication comes from the fact that they facilitate verbal, vocal and visual communication for the user (Waters and Jones, 2011). They also bolster credibility as they allow for fact-checking (Wardle and Derakhshan, 2017). Outside of the medical field, there are also examples of studies that confirm the potential of YouTube as a relevant learning tool (Posligua and Zambrano, 2020), for example, in the study of foreign languages (Asensio, 2018) and also in politics (Gil, 2019).

2. Objetives

This descriptive investigation is based on the hypothesis that YouTube has become a vehicle for the dissemination of information about radon, in the same way that it is for other diseases, medical issues and health-related specializations. The primary objective of this study is to locate all YouTube channels that contain information about radon and to establish which ones focus specifically on this gas. This objective allows us to develop various secondary objectives. These are the followings:

O[S1]. Specify the basic data of these channels: the language used to broadcast their content, the country of origin, and the number of subscribers they have.

O[S2]. Develop a record of the number of videos hosted by each channel, the view-count, and the specific topic that they focus on.

O[S3]. Analyze basic elements of the channels: frequency of publication and use of communities.

O[S4]. Analyze the channels' strategies: use of cross-promotion, dissemination, and organization of content.

O[S5]. Analyze the channels' narratives.

O[S6]. Analyze the involvement of the audiences on the channels.

O[S7]. Detect the presence or absence of echo chambers in radon-related content on YouTube.

3. Methodology

This research emerges in a context with a significant scarcity of research on risk communication linked to public health on YouTube. Furthermore, currently, there are no previous studies on the use of YouTube as a tool for disseminating the risks associated with radon exposure. Therefore, this research is justified by the need to verify the use of this social network, one that has some 2,300 million users (Kolsquare, 2022), for the circulation of information about a gas that presents a public health problem. For this reason and the importance of society being informed about the risks of radon, the dangers of the low presence of this topic on YouTube and the lack of interest from users towards official sources must be taken seriously.

This study analyzes all those YouTube channels since its creation (2005) that contain information about radon gas and provides an overview of the presence and extent of this topic in this social network. To accomplish the main objective of this research, an exploratory search was performed on YouTube using keywords, namely the word 'radon'. During the initial phase, in September 2022, all channels that hosted content on radon were located and a cut-off score was established in order to filter out those channels that did not have at least two videos on radon. The search was carried out by three researchers from three different computers in different parts of Spain. To determine whether a video is about radon or not, all videos that had the word "radon" in the title, description, or both were viewed. If a video discusses radon gas for more than 50% of its duration, it is considered a radon-related video. This parameter made it possible to remove certain channels from the sample, such as those related to media outlets that may contain pieces of news about radon but don't have a specific focus on this gas. Quantitative techniques were used in this phase to keep record of the channels' country of origin, the number of subscribers, the broadcast language, the total number of videos and the number of videos on radon, as well as the date the channel was created and the number of views it accumulates.

A new cut-off score was established in October 2022 (in the second stage) for the resulting channels. A YouTube channel is considered to be specific when 50% or more of its videos are limited to one topic. In order to determine the level of specificity of the channel, the percentage of videos about radon within those channels that contained at least two videos on the gas was checked. Again, quantitative techniques were used to calculate the ratio of videos on radon among the total number of videos. Nonetheless, qualitative techniques for content analysis (Allen-Meares, 1984; Trilling and Jonkman, 2018) were also used to categorize the videos thematically. The download of data (subscribers, number of videos...) is done manually, channel by channel, based on the information provided and available to the user on YouTube. A reliability test was carried out applied to 10 channels.

Once the selection of specific channels on radon was decided, an investigation was undertaken according to the analysis sheet for YouTube channels proposed by Sixto-García and his collaborators. Sixto-García et al., (2021) designed an analysis model for YouTube channels (table 1) originally intended for the analysis of digital media channels, whose use is equally relevant for the analysis of all types of channels. This is thanks to the fact that the model includes the five most distinctive features that characterize this type of audiovisual format: frequency, community, cross-promotion, dissemination and organization of content, and narratives and co-creation.

This analysis model allows analyzing how YouTube channels use the mechanisms offered by this platform to disseminate content and information. This model also facilitates a comparison between the different channels analyzed. The layout consists of five modules and is articulated according to the methodological triangulation, in such a way that it combines purely quantitative aspects with other qualitative ones:

a) Quantitative aspects:

- Frequency of publication: Number of publications (videos) per day, week and month.

- Communities: existence of user communities within the channel and frequency of publication.

- Existence of cross-promotion: the dissemination and advertising of an organization's (owner of the YouTube channel) content through different digital platforms is considered: This can include promotion from the organization's website to its YouTube channel, from the organization's YouTube channel to its website, and from the organization's YouTube channel to other organizations' social networks and apps.

b) Qualitative aspects:

- Dissemination, resources and content organization. The preparation of ad hoc contents for the channel is evaluated positively. Ad hoc content refers to content that is intentionally created for YouTube. We would not include content that has been re-uploaded from broadcasts on television or another platform. This includes, for example, the existence of specific videos and shorts, together with cross-media dissemination strategies that allow for the same contents to be distributed on various platforms, including YouTube. Additionally, broadcast resources are classified; that is, whether the YouTube channels broadcast live, whether they act as a repository and whether they include podcasts. Lastly, whether the contents are organized into lists based on the subject is also evaluated.

- Narratives and co-creation. The existence of transmedia narratives that require the user to visit other websites to complete the storytelling is evaluated, together with the use of co-creative spaces where the public can participate in the creation, development and marketing of contents.

Table 1. *Analysis model for YouTube channels.*

Assessment item		Variables	Grading
Frequency of publication		**Daily**	**1**
		Weekly	0,5
		Monthly	0,1
		> Monthly	0
Communities	Enabled community	**Yes**	**1**
		No	0
	Frequency of publication as a community	**Daily**	**1**
		Weekly	0,5
		Monthly	0,1
		> Monthly	0

Cross-promotion	Cross-promotion from website to Youtube	**Yes**	**1**
		No	0
	Cross-promotion from YouTube to website	**Yes**	**1**
		No	0
	Cross-promotion between YouTube and other networks or apps	**Yes**	**1**
		No	0
	Cross-promotion via external channels	**Yes (>10)**	**1**
		Yes (>1)	0,5
		Yes (1)	0,25
		No	0
Dissemination, resources and content organization	Dissemination of content	**Ad hoc + cross-media**	**1**
		Ad hoc	0,5
		Cross-media	0,5
	Dissemination resources	**Direct + repository**	**1**
		Direct	0,75
		Repository	0,25
		Podcasts	0,25
	Organizational lists for content	**Yes**	**1**
		No	0
Narratives and co-creation	Transmedia narratives	**Yes (>5)**	**1**
		Yes (>1)	0,5
		Yes (1)	0,25
		No	0
	Space for co-creation	**Yes (>5)**	**1**
		Yes (>1)	0,5
		Yes (1)	0,25
		No	0

Source: Sixto-García et al. (2021).

This analysis sheet allows for channels to receive a score of up to 12 points (12.25 if those podcasts that are not specific to the channels, and therefore considered complimentary, rather than mandatory, are considered) based on their level of development and the deployment of resources that YouTube allows. A grading system regarding the employment of the communicative possibilities to involve users offered by said channels was also configured. This system allows channels to be rated based on the score obtained in the previous analysis sheet. A higher score indicates that the channel's content dissemination strategies are more effective, while a lower score indicates the opposite. Four scales are added based on the score (Deficient, Efficient, Very efficient, Highly efficient) (see table 2).

Table 2. *Channels' rating in relation to their score.*

Score	Channels' rating
< 6 points	Deficient
6 to 7 points	Efficient
7 to 9 points	Very efficient
> 9 points	Highly efficient

Source: Own elaboration.

4. Results

4.1. Channels with 2 or more videos on radon

With a 36% increase in 2021, there were 51 million channels on YouTube at the time of this research in 2022, and according to Kolsquare (2022), this number is expected to continue growing. Only 43 out of all the available YouTube channels offer content related to radon in at least 2 of their videos (see Table 3). This is a clear display of the overall lack of importance given to this issue. In fact, videos of this kind account for only 0.000084% of all videos on YouTube. 26 of the channels are American and the vast majority (35) broadcast in English, although there are also channels in Spanish (3), Italian (2) and Danish (1), as well as a Canadian channel which broadcasts both in English and French (1). The average number of subscribers is 3,581, while the average number of videos hosted by the channels is 260.65. However, only an average of 21.34 are radon-related videos.

Table 3. *YouTube channels containing at least 2 videos on radon.*

Name of the channel	Country	Subscr.	Language	Total videos	Videos about radon	% of videos about radon	Upload date	Visual.
Vealiatv	Spain	73 600	Spanish	899	6	0,7%	09/01/2011	9,190,986
Home Performance	USA	44 600	English	671	8	1,2%	05/09/2008	7,438,919
DHSWI	USA	5860	English	1145	4	0,3%	16/09/2013	7,888,528
Instituto Torroja TV	Spain	4950	Spanish	867	17	2,0%	28/04/2014	831,877
Canadian Cancer Society	Canada	4390	English	222	4	1,8%	23/07/2009	12,217,756
Caloryfrio.com	Spain	3450	Spanish	195	6	3,1%	11/10/2013	857,212
Huntsman Cancer Institute	USA	3170	English	349	5	1,4%	07/12/2011	2,420,426
Florida Department of Health	USA	2420	English	141	7	5,0%	27/07/2009	3,961,087
AprilAire	USA	2360	English	147	5	3,4%	30/08/2013	2,020,746
Chemistry Story for Pleasure	Bangladesh	2330	English	152	3	2,0%	20/12/2019	80,382
American Radon Mitigation	USA	1080	English	118	89	75,4%	19/09/2016	338,111
Airthings	Norway	989	English	126	10	7,9%	26/08/2014	2,467,855
Caoimhín P Connell	USA	974	English	22	4	18,2%	07/07/2010	241,617
Inspector Services	USA	873	English	4979	115	2,3%	04/05/2011	390,925
Bundesamt für Strahlenschutz	Germany	793	German	40	2	5,0%	26/11/2013	186,516

Radon Man	USA	665	English	101	70	69,3%	12/08/2018	129,814
RadonAway	USA	161	English	39	20	51,3%	04/11/2016	52,799
STOP RADON	USA	159	English	44	13	29,5%	19/02/2016	14,601
ALA Clean Air Initiatives	USA	139	English	172	116	67,4%	26/07/2013	118,131
Radonova Laboratories	Sweden	112	English	36	32	88,9%	29/09/2017	74,197
Protezione Radon	Italy	102	Italian	7	7	100,0%	16/02/2016	214,831
Ecosense	USA	96	English	40	30	75,0%	21/06/2019	13,046
SunRADON LLC	USA	94	English	16	14	87,5%	20/04/2020	15,724
SWAT Enviromental	USA	94	English	57	54	94,7%	02/12/2013	773,718
Clarity Inspections and Radon	USA	90	English	11	11	100,0%	13/08/2017	3,602
Radon Away	USA	81	English	33	17	51,5%	12/08/2009	35,479
Radon Enviromental	USA	62	English	40	40	100,0%	09/11/2011	42,733
Take Action On Radon	Canada	40	English/ French	13	13	100,0%	25/10/2013	150,904
UK RADON ASSOCIATION	U.K.	37	English	19	19	100,0%	22/04/2014	7,485
Arch. Fausto Redondo - STUDIO ARCHITETTURA & AMBIENTE	Italy	29	Italian	38	6	15,8%	18/01/2015	3,811
Metro Property Inspection	USA	28	English	114	13	11,4%	18/12/2013	45,298
Radon Removal and Home Solutions	USA	27	English	17	17	100,0%	13/11/2018	6,653
Radon Eliminator	Mitigation	Testing	USA	29	English	96	29	30,2%	23/09/2015	151,211
Akron Radon Reduction Systems	USA	27	English	80	50	62,5%	28/11/2017	22,673
3 Rivers Home Inspections	USA	22	English	66	20	30,3%	01/08/2020	4,902
Radon MED TECH	India	18	English	13	2	15,4%	01/02/2021	207
Home Wirk	USA	17	English	25	5	20,0%	16/03/2022	8,872
Radon Defense Midwest	USA	10	English	23	7	30,4%	13/05/2020	1,436
Simon Air Quality	Canada	10	English	11	8	72,7%	15/08/2015	1,944
Radon-Stop	Denmark	9	Danish	11	11	100,0%	28/12/2018	40,872
Radon Cancer Centre	India	9	English	7	3	42,9%	24/06/2022	526
National Rdon Program Services	USA	7	English	2	2	100,0%	11/10/2016	1,556
Radon Spain	Spain	4	Spanish	4	4	100,0%	16/12/2018	421
Average		**3581**		**260,65**	**21,34**	**46,0%**		**1,220,241**

Source: Own elaboration (data extracted from YouTube on 10/27/2022).

4.2. Specific channels on radon

A channel is considered to be topic-specific when at least 50% of its videos deal with a specific, single topic. There are only 20 radon-specific YouTube channels and 47.61% of those channels that host at least 2 videos about radon have a focus on this gas (see table 4), accounting for 0.000039% of the total channels that exist site-wide on YouTube. The resulting average number of radon-related videos in those specific channels is 33.20, out of a total number of 43.40 average videos per channel. This means that 76.49% of the videos on such channels are about radon (664 videos), although only 9 channels dedicate all of their videos to just radon (45%).

America is the continent most concerned with circulating information related to radon (75%) and is also the continent of origin of most of the channels (65%), followed by Europe (25%). English is still the predominant language of the content (85% of the videos), although there are also some videos in Spanish (5%), Danish (5%), French (5%) and Italian (5%). The average number of views on these channels (103,036) is much lower than the average for non-specific channels (1,244,854).

Table 4. *Radon-specific YouTube channels (at least 50% of their videos).*

Channel	Country	Subscr.	Language	Total videos	Videos about radon	% of videos about radon	Theme	Upload date	Visual.
American Radon Mitigation	USA	1080	Eng	118	89	75,4%	Construc.	19/09/2016	338 111
Radon Man	USA	665	Eng	101	70	69,3%	Construc.	12/08/2018	129 814
Radon Away	USA	161	Eng	39	20	51,3%	Construc.	04/11/2016	52 799
ALA Clean Air Initiatives	USA	139	Eng	172	116	67,4%	Construc.	26/07/2013	118 131
Radonova Laboratories	Sweden	112	Eng	36	32	88,9%	Construc.	29/09/2017	74 197
Protezione Radon	Italy	102	Italian	7	7	100,0%	Construc.	16/02/2016	214 831
Ecosense	USA	96	Eng	40	30	75,0%	Construc.	21/06/2019	13 046
SunRAD ON LLC	USA	91	Eng	57	54	94,7%	Construc.	20/04/2020	15 724
SWAT Enviromental	USA	91	Eng	57	54	94,7%	Construc.	02/12/2013	773 718
Clarity Inspections and Radon	USA	90	Eng	11	11	100,0%	Construc.	13/08/2017	3602
Radon Away	USA	81	Eng	33	17	51,5%	Construc.	12/08/2009	35 479
Radon Enviromental	USA	62	Eng	40	40	100,0%	Construc.	09/11/2011	42 733
Take Action On Radon	Canada	40	Eng/ French	13	13	100,0%	Construc.	25/10/2013	150 904
UK RADON ASSOCIATION	U.K.	37	Eng	19	19	100,0%	Health	22/04/2014	7485
Radon Removal and Home Solutions	USA	27	Eng	17	17	100,0%	Construc.	28/11/2017	22 673

Akron Radon Reduction Systems	USA	27	Eng	80	50	62,5%	Construc.	28/11/2017	22 673
Simon Air Quality	Canada	10	Eng	11	8	72,7%	Construc.	15/08/2015	1944
Radon-Stop	Denmark	9	Danish	11	11	100,0%	Construc.	28/12/2018	40 872
National Radon Program Services	USA	7	Eng	2	2	100,0%	Health	11/10/2016	1556
Radon Spain	Spain	4	Spanish	4	4	100,0%	Health	16/12/2018	421
Average		**147**		**43,40**	**33,20**	**85,2%**			**103 036**

Source: Own elaboration (data extracted fromYouTube on 10/27/2022).

Channels that dedicate at least 50% of their content to radon can be classified into two categories: construction and health. Some 85% of the channels address issues related to the prevention of the presence of radon in buildings and homes through construction elements, while only 15% address its health risks. The general average number of subscribers to these channels is 147, although construction videos reach a higher average (170) than health videos (16), and the number of views is much higher for construction videos (120,662) than for health-related videos (3,154).

None of the radon-specific channels publish content on a daily basis (see table 5). Although the average publication frequency stands at 0.115, most channels (65%) don't even publish content once a month, while only 20% register at least one publication per week. The timeframe of reference was the entire year 2022.

Although YouTube communities are the most interactive space on the social network, and despite them being specifically designed for creators to maintain contact with their followers and receive feedback on posts, radon-related channels do not make use of this feature in 95% of the cases. One single channel (5%) has enabled the community tab and, even then, the dissemination of content is performed only on a monthly basis.

Some 35% of the organizations that own radon YouTube channels have implemented cross-promotion strategies from their website to YouTube. This percentage rises to 75% when it comes to strategies to redirect users from YouTube to the corporate website. Some 40% of the channels present cross-promotion options from YouTube to other networks or apps, while 30% cross-promote on other external channels (of which 83.33% use more than 10 external channels). Thus, for example, a large part of the content published by ALA Clean Air Initiatives are videos featuring students who took part in a contest organized by the Iowa High School. These are also uploaded to other spaces such as blogs that are not related to the channel. For instance, Ecosense is linked from LinkedIn posts and from the products they sell on Amazon, while the UK Radon Association or Akron Radon Reduction Systems are featured on third-party blogs, and Simon Air Quality is promoted in the description of the products they distribute.

Whilst 95% of the channels host ad hoc content, 35% reuse and distribute videos from other websites (30% combine both options). Although live broadcasts and podcasts are nonexistent, all channels function as repositories for videos designed to be passively consumed rather than to seek active involvement from the public. This may be the reason why the channels' managers use lists to organize their contents (80% of the cases).

The average use of transmedia narratives to encourage users to visit another network or website in order to resume the storytelling is 0.312. Some 35% of the channels make use of this type of narrative and in most cases (83.33%) there are more than 5 examples per channel. Only 10% of the channels save some space for

the co-creation of content, which means that 90% present a one-way discourse that fails to involve users in the development or creation of their featured content.

Table 5. *YouTube channels' analysis according to the methodological sheet.*

Channel	Freq.	Communities		Cross-promotion				Dissemination						Narrative		Score
		Yes	Freq.	Web to YT	YT to web	YT to social media /apps	Exter.	Ad hoc	Cross	Live	Rep.	Pod	Lists	Trans	Co	
American Radon Mitigation	0.5	1	0.1	1	1	1	0.5	0.5	0	0	0.25	0	1	0.25	0	**7.1**
Radon Man	0.5	0	0	0	0	0	0	0.5	0	0	0.25	0	1	0	0	**2.25**
Radon Away	0.1	0	0	0	1	0	0	0.5	0	0	0.25	0	0	0	0	**1.85**
ALA Clean Air Initiatives	0.1	0	0	1	1	1	1	0.5	0	0	0.25	0	1	1	1	**7.85**
Radoneva Labs	0.1	0	0	0	1	1	0	0.5	0	0	0.25	0	1	0	0	**3.85**
Protezione Radon	0	0	0	1	1	0	0	0.5	0.5	0	0.25	0	0	0	0	**3.25**
Ecosense	0.5	0	0	1	1	1	1	0.5	0	0	0.25	0	1	1	0	**7.25**
SunRadon LLC	0.5	0	0	0	1	0	0	0.5	0	0	0.25	0	1	0	0	**3.25**
SWAT Enviromental	0	0	0	0	1	0	0	0.5	0.5	0	0.25	0	1	0	0	**3.25**
Clarity Inspections & Radon	0	0	0	0	1	1	0	0.5	0	0	0.25	0	1	1	0	**4.75**
Radon Away	0	0	0	0	1	0	0	0.5	0	0	0.25	0	0	0	0	**1.75**
Radon Enviremental	0	0	0	1	1	0	0	0.5	0.5	0	0.25	0	1	1	0	**5.25**
Take Action on Radon	0	0	0	0	1	0	0	0.5	0.5	0	0.25	0	1	1	0	**4.25**
UK Radon Ass	0	0	0	1	1	1	1	0.5	0.5	0	0.25	0	1	0	0	**6.25**
Radon Removal and Home Solutions	0	0	0	0	0	0	0	0.5	0	0	0.25	0	1	0	1	**2.75**
Akron Radon Reduction Systems	0	0	0	1	1	1	1	0.5	0	0	0.25	0	1	0	0	**5.75**
Simon Air Quality	0	0	0	0	1	1	1	0.5	0	0	0.25	0	1	1	0	**4.75**
Radon-Stop	0	0	0	0	0	0	0	0.5	0	0	0.25	0	1	0	0	**1.75**
National Radon Program Services	0	0	0	0	0	0	0	0	0.5	0	0.25	0	1	0	0	**1.75**
Radon Spain	0	0	0	0	0	0	0	0.5	0.5	0	0.25	0	0	0	0	**1.25**
Average	**0.11**	**0.05**	**0.005**	**0.35**	**0.75**	**0.27**	**0.27**	**0.47**	**0.17**	**0**	**0.25**	**0**	**0.8**	**0.31**	**0.1**	**3.59**

Source: Own elaboration from the model developed by Sixto-García et al. (2021).

After a careful review of all the parameters and having considered the average result for each of them (available on table 5), only 4 channels (20% of the total) managed to pass (6 or more points) in relation to their ability to exploit the communicative possibilities offered by YouTube channels to connect and involve audiences (see table 6). The vast majority of channels (80%) are not making full use of the options provided by YouTube. They use the social network as a basic repository for videos, failing to refresh their contents and encourage interactive communities.

Table 6. *YouTube channels ratings according to their scores.*

Score	Number of channels	Channels' rating
< 6 points	16 (80%)	Deficient
6 to 7 points	3 (15%)	Efficient
7 to 9 points	1 (5%)	Very efficient
> 9 points	0 (0%)	Highly efficient

Source: Own elaboration.

5. Discussion and Conclusions

From the results of this investigation, it cannot be concluded that radon is treated as a public health risk on YouTube. Although the initial hypothesis in relation to the existence of channels for the dissemination of information on radon is verified, as previous studies on diseases and medical specializations had already proven (Betancourt et al., 2021; Hernández and Tarancón, 2020; de Oliveira et al., 2020; Castelló-Martínez and Tur-Viñes, 2021; Quispe et., 2020; Fortes, 2022; Abhishek et al., 2021; Godskesen et al., 2023), its quantitative presence is still limited. Only 7.27% of all videos on the channels in the study are about radon. Therefore, the opportunities identified by Zhang and Fu (2021) for social networks to communicate health-related issues are not fully availed of.

In relation to the achievement of the primary objective, we found that among all YouTube channels, only 43 have at least two videos on radon. However, it is not possible to categorize these channels as specific to this gas, as only 20 of them are considered to be so. This is due to the fact that these are the only channels in which at least half of their videos offer radon-related information. Of these 20 specific channels, 9 are dedicated solely to radon gas.

Regarding the first secondary objective (O^{S1}), English is the predominant language for the dissemination of radon information. Despite the fact that English is the most widely spoken language in the world and that YouTube allows subtitles, the language can be a barrier to science education in different regions of the world. Especially for users who are not familiar with YouTube's tools, such as subtitle settings. Nonetheless, America is the geographical area most dedicated to spreading the word on the risks of radon. In fact, this is the country where three out of four radon YouTube channels in the world are located. Others are located in Europe, and the presence of radon-related YouTube channels in Africa, Asia, or Oceania is almost non-existent. This means that it is difficult for people in the aforementioned regions to access radon-related information due to it being emitted from American sources, in English. Considering the number of subscribers, the topic generates less interest in the specific channels (147 subscribers on average) than in the channels with a broader scope than just radon (3,648 subscribers on average).

In relation to the second secondary objective (O^{S2}), taking the number of views that the channels amass as a reference, it is reconfirmed that the more thematically focused on radon a channel is, the lesser the views (1,220,241 on average compared to 103,036 in specific channels). The public does not seem to be aware of the fact that radon is a public health issue which poses significant risks (Khan et al., 2019). Based on the aforementioned quantitative data, at the very least, they seem not to consult YouTube when they need a source of information. Nonetheless, it is also true that the average of videos published on non-specific channels (260.6) is much higher than on specific ones (43.4), though the percentage of videos on radon is much higher on the specific channels (76.49%) than on the non-specific ones (8.19%). Once again, this highlights the lack of interest on the part of the audiences when it comes to this particular topic and

"Videos have become such an important medium in the dissemination of health communication comes from the fact that they facilitate verbal, vocal and visual communication for the user."

exposes the lack of echo chambers. Also, the prevalence of informative coverage on radon from the construction industry perspective rather than from a medical standpoint is evidenced. From a qualitative point of view, only 15% of the channels directly relate radon and health, and the number of views of this type of channel is lower than for those that deal with construction and home safety, which stresses the popularity of videos that allow for the verification of facts (Waters and Jones, 2011).

This research has unveiled that radon-focused channels are not living up to their potential in terms of the multiple features offered by YouTube. Instead, they primarily use the social network as a simple video repository. As for the third secondary objective (O^{S3}), the publication frequencies are low and there are virtually no communities.

Regarding the next secondary objective (O^{S4}), the vast majority of channels host ad hoc videos, but they miss out on other more dynamic and interactive communication options such as live streamings that could potentially boost audience interest. Despite the fact that informative and educational materials are usually prepared specifically to be broadcast on the channel, cross-promotion synergies are also common, both from YouTube to other corporate spaces (website, networks, apps…) and third parties (products for sale on Amazon). These dynamics also work the other way around, that is, from third-party and corporate spaces to the YouTube channels.

According the secondary objective O^{S5}, related to the use of narratives, although the average use of the channels' potential falls below acceptable standards (3.59 points out of 12), the good work carried out by channels such as the American Radon Migration deserves praise. Aside from publishing on a regular basis and keeping an active community, they also conduct surveys amongst subscribers and advertise information on the webinars they organize. Additionally, they implement different cross-promotion strategies, transmedia narratives and keep their content structured into lists. A similar situation can be applied to the ALA Clean Air Initiatives channel, which encourages co-creation by involving users in short term radon test kits. Also of note is the production of ad hoc content by the Ecosense channel, which includes YouTube stories, the so-called shorts. There are also examples of good practices in Europe, such as the channel of the UK Radon Association, that contains videos focused on health issues, especially on radon protection for new buildings.

Related to the previous secondary objective O^{S5}, but specifically addressing the involvement of the public, that is, the sixth secondary objective (O^{S6}), there is a perceived preference for the use of transmedia narratives that require visiting several platforms to resume the storytelling, as opposed to the co-creative spaces that allow direct participation and promote audience involvement.

Finally, regarding the last secondary objective (O^{S7}), on this occasion it is not possible to refer to the existence of echo chambers. Considering Sued (2020) criteria for echo chamber detection, we can conclude that there is no presence of such a phenomenon. This is because within the analyzed content, there is no single point of view on the radon issue. The videos on radon in the analyzed channels offer varied information and content that do not reinforce a single thought or belief on this topic.

All in all, there is still a long way to go for radon to be perceived as a public health issue on YouTube. The same is true regarding the steps that need to be taken for the potential that the social media platform offers in terms of risk communication. This study emphasizes that reputable sources of information, such as official organizations or professionals, may not pay attention to YouTube as a platform for the dissemination and communication of radon-related information. This is based on the finding that videos published by such sources achieved less popularity than those created by anonymous users, a discovery that various authors had previously noted (Basch et al., 2019; Sahin et al., 2019; Welbourne & Grant, 2016). This could also be because they may not be using all the tools available on the platform.

6. Limitations and future research

This study has certain limitations. The search for content on YouTube was done using "keywords". All content with the word "radon" in the title, description or both was selected. Therefore, there is a possibility that content dealing with radon was not included in the study because it did not use the word "radon" in its title or description. In addition, geolocation removal software was not used to avoid personalized results. Finally, the searches depend on YouTube's algorithm, so it is possible that some content was hidden during the search process.

In future investigations, the evolution of these channels must be tracked in relation to all the parameters analyzed. It is imperative that the field work be done again in order to verify whether new channels have emerged. Additionally, it is very important for the scientific community to continue to investigate whether institutional videos maintain a lower view count than those uploaded by users, and how this could affect disinformation, media literacy and, by extension, the stability of our democratic values. It would also be interesting to carry out studies that analyze other more qualitative aspects of YouTube video content. For example, to measure the quality of the information on radon they provide.

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CONTRIBUTIONS FROM AUTHORS, FUNDING, AND ACKNOWLEDGEMENTS

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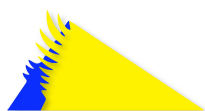noel.pascual.presa@usc.es

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