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Use of Big Data, Artificial Intelligence and Other Emerging Technologies in Public Health Communication Campaigns: A Systematic Review

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ABSTRACT

Introduction: Public health campaigns have begun to employ various emerging technologies such as artificial intelligence (AI) and Big Data for their design, implementation, and evaluation. These technologies offer new opportunities to enhance the effectiveness of health communication strategies by enabling more precise audience segmentation, personalized messaging, and real-time impact assessment. However, despite their potential, their application in public health campaigns remains a relatively new field of study. This systematic review aims to identify and analyze the scientific literature that examines the role of these tools in optimizing communication strategies aimed at promoting healthy behaviors and attitudes among the population. Methods: Following the PRISMA methodology, 129 potentially relevant articles were initially identified from the search in the WOS, Scopus and PubMed databases. However, only 18 met the established inclusion criteria. Results: We identified a scarcity of scientific articles focused on presenting findings on the application of emerging technologies in public health campaigns. Most of the research focused on the use of these tools for audience segmentation and impact assessment, while their use in campaign design was a minority. Conclusions: This study supports the usefulness of the application of these technologies at any stage of the campaign implementation process, and presents some limitations that can help optimize this approach and improve the reach and effectiveness of public health communication strategies.

Keywords: Public Health, Emerging Technologies, Artificial Intelligence, Communication Campaigns, Systematic Review.

INTRODUCTION

The main objective of public health communication campaigns is to disseminate messages on disease prevention strategies and the promotion of healthy behaviors, with both individual benefits and benefits for society as a whole (Park, Reber, & Chon, 2016; Wright, Sparks, & O'hair, 2012). Therefore, these campaigns are used to raise public awareness of diverse and heterogeneous health issues, including the promotion of vaccination, mental health, prevention of tobacco, alcohol and other drug use, road safety, and promotion of physical activity or healthy eating, among many others (Andrews, Foulkes, & Blakemore, 2020; Bayer & Fairchild, 2016; Power & Wardle, 2015; Riley, Ulrich, Hamann, & Ostroff, 2017; Lucas, Alonso, Faus, & Javadinejad, 2024).

In addition, health communication must provide accurate information and be able to provide facts and messages that quickly disprove the large amount of misinformation that users face today (Krishna & Thompson, 2021). The spread of misinformation can lead to inappropriate and dangerous beliefs and behaviors in the

population, and can impact the effectiveness of public health interventions (Matagi, 2024). Social media allow anyone to have a large platform to disseminate false information about health issues and, unfortunately, erroneous messages tend to be more viral than truthful ones (León, Martínez-Costa, Salaverría, & López-Goñi, 2022). In this sense, public health campaigns must make efforts to ensure that their message is eye-catching and supported by health professionals who are perceived as reliable sources for the audience.

Health communication is a fundamental area within communication studies, as it focuses not only on conveying information, but also on generating healthy behavioral changes and preventing the spread of false attitudes and beliefs that pose a risk to public health (Korda & Itani, 2013). Therefore, unlike other forms of communication, health campaigns face the challenge of conveying messages that often need to be concise and rapid because of the urgent need for public action. Actions developed in contexts of climatic catastrophes or epidemics, such as the recent COVID-19, are examples of this (Finset et al., 2020). For this reason, public health communication requires the development of specific strategies to guarantee the social impact of its messages, allowing them to reach different population groups, regardless of their socio-demographic characteristics (K. Thapliyal, M. Thapliyal, & D. Thapliyal, 2024).

Objectives of the Study

In this context, the present systematic review explores the intersection of emerging technologies, specifically AI and Big Data, with the design and evaluation of public health campaigns, in order to provide information on their potential as tools to optimize possible challenges in their future development.

LITERATURE REVIEW

These campaigns have traditionally employed a variety of media and communication channels to achieve a broad reach of their message, including television, radio, print or outdoor communication (A. Anwar, Malik, Raees, & A. Anwar, 2020; Gollust et al., 2019). In recent years, digital channels and social networks have also been used, given their potential to achieve rapid and high diffusion, especially among the youngest. Thus, digital marketing allows people from all over the world access to the campaign, greater interaction with the user, and greater ease to effectively measure the user experience. Thus, while traditional media limit viewer participation, digital channels allow for audience interaction and instant feedback which act as an active element in the campaign itself (Moorhead et al., 2013).

In parallel, the design of public health communication campaigns has recently undergone a significant transformation thanks to the introduction of emerging technologies, such as big data, artificial intelligence (AI), machine learning or augmented reality (Biswas, 2023; Luo, Wu, Gopukumar, & Zhao, 2016). These new tools can have several utilities in campaign development. On the one hand, they allow a deeper understanding of the behavioral patterns and needs of the population, contributing to determining the problems of different risk groups and, consequently, to an adequate segmentation of the population for the development of future public health campaigns (Giest, 2017). In this sense, there are powerful measurement tools that encompass and evaluate massive data from millions of users in an accurate way, which is an improvement in the knowledge of audience perceptions regarding advertising delivered through traditional media (Järvinen & Karjaluoto, 2015).

On the other hand, they contribute to the design and creation of more impactful and personalized communication strategies, thus increasing viewer empathy and potentially also their effectiveness in changing attitudes and behaviors (Baclic et al., 2020). As such, these technologies allow for greater personalization of campaign content. A process that is achieved through algorithms and analysis of user sentiment in real time, which favors the adaptation of the language and images of the spot according to the characteristics of each population group. And finally, they provide tools for an adequate evaluation of campaigns, allowing the analysis of large amounts of data and the extraction of important conclusions for the design and development of future products, actions and communication strategies (Viceconti, Hunter, & Hose, 2015). Additionally, AI can be useful in countering misinformation as it can perform analyses that identify sources and patterns of misinformation dissemination and take specific actions to mitigate them (Nguyen, Yan, & Thai, 2013). On Twitter (X) there are community notes that work through user collaboration by providing context to potentially misleading posts (Pilarski, Solovev, & Pröllochs, 2024). However, the use of emerging technologies in this area still has room for improvement, because in the time period in which the information is analyzed and the aforementioned community note is added, the post with misinformation may have reached high levels of dissemination. A possible measure that would increase the effectiveness of these tools in this function of limiting the spread of hoaxes could be the direct notification to all users who have interacted with the post of the clarification offered by the

community note. This would ensure that the entire audience, regardless of when they viewed the post, would receive the truthful information on their device.

Despite the potential of AI, Big Data and other emerging technologies for the design and evaluation of public health campaigns, the current use of these tools remains limited in professional practice (Albahri et al., 2021). The use of these technologies is at an early stage, so it is important to develop scientific research to provide evidence on their utility, as well as on the adjustments that can be made to maximize their effectiveness in the public health sector.

Impact of Emerging Technologies on Communication Theories

Communication theories have traditionally been used for the design of persuasive messages in various fields, including health communication. These theories provide relevant information for the development of effective campaigns, since they explain the psycho-social mechanisms that influence the reception of messages (Dutta-Bergman, 2005). With the introduction of new emerging technologies in the process of campaign design and dissemination, it is necessary to identify how to integrate the utility of these tools into the theoretical models that guide the development of public health content and messages.

In this sense, and as practical examples of this integration, the potential application of AI and Big Data in the Elaboration Probability Model (Petty & Cacioppo, 1986) is identified. This theory argues that the level of information processing of each person depends on various factors such as motivation, opportunities or skills. Greater message elaboration occurs when the central processing pathway is activated, favoring critical thinking about the information received by the viewer. Conversely, the peripheral route is activated in cases where low reflection and processing of the message is required. With this premise, emerging technologies and their capacity to analyses large amounts of data would make it possible to identify the behavioral pattern of a social network user and, consequently, to segment the audience according to whether they are inclined to process this type of message via the central route or the peripheral route. In this way, public health content could be personalized by presenting detailed information to people identified as highly motivated by the topic. And, on the other hand, short and visually appealing messages that capture the attention and impact without the need for elaborate processing, aimed at people who tend to use the peripheral route in this type of content.

For its part, the Social Cognitive Theory sustains the value of the cognitive factor in the learning of attitudes and behaviors, relating it especially to the concept of self-efficacy. In the same way, it also points to modelling as a fundamental tool in behavior change (Bandura, 2011). Thus, emerging technologies can contribute to the identification of public figures who are references for certain population groups, in order to transmit health messages to their audience. In any case, it is important that the people selected as role models have a discourse that is in line with the message to be disseminated. Inconsistencies between the content of the public health campaign and the subsequent behavior of the person representing the source of information can have a negative impact on the effectiveness of the message conveyed. In parallel, AI algorithms can also act to recommend content that increases the perceived self-efficacy of users, motivating them to perform healthy behaviors and taking as references behavioral models that are perceived as achievable.

The Health Belief Model (Becker, Maiman, Kirscht, Haefner, & Drachman, 1977) also identifies the usefulness of emerging technologies in their application in public health campaigns. This theory holds that a person's willingness to adopt a health behavior will be determined by the perceived vulnerability to becoming ill and the perceived severity of the consequence of the illness. Therefore, Big Data allows an analysis and segmentation of population groups that tend to perceive a low vulnerability to certain health problems. Consequently, specific messages can be developed for the identified groups, highlighting the consequences of not carrying out the indicated preventive behaviors. Additionally, AI and ChatsBots have the capacity to generate messages that act as automated reminders at strategic moments when specific action is required from certain groups of users.

METHODOLOGY

To meet the objective of the proposed study, this research followed a systematic review approach. This method involves the exhaustive collection, analysis and conclusive synthesis of relevant research on a specific topic following a standardized protocol (Rother, 2007). Thus, the systematic review adhered to the recommendations established by the Cochrane Review Group (Lundh & Gtzsche, 2008) and complied with the PRISMA 2020 quality standards and protocols (Page et al., 2021), following four standard steps based on expert literature, as follows.

Step 1: Identification of the Research Question

In this phase, the research topic was defined, and the inclusion and exclusion criteria related to the content were established, which delimit the process of identifying the articles that could be selected for review. In this line, the present systematic review seeks to understand the application of emerging technologies in the development of communication campaigns in the public health sector.

Therefore, research on various aspects related to the topic analyzed was covered, such as the application of these technological systems in the different phases of the process of developing a campaign, from design to implementation and evaluation of its impact. On the other hand, studies unrelated to this concept were excluded from the review, and research on the use of emerging technologies in the clinical management of individual diseases or in hospital administration was not included. Studies dealing with the application of these technologies in commercial marketing campaigns, political campaigns, or any other type of communication campaign not directly related to the promotion of public health were also excluded.

Step 2: Search for Relevant Previous Studies (Sources of Information)

In the first instance, a scoping review was conducted, which is essential in research and usually precedes a full systematic review. This mapping of the literature allows an understanding of the breadth and variety of evidence on the topic addressed, thus facilitating the identification of the potential and scope of the research objectives. This process also contributes to the identification of the optimal key terms that will subsequently be used in the search strategies of the systematic review.

The PubMed, Scopus and Web of Science databases were used for the literature search, which were selected for their unanimous endorsement by the scientific community, which recognizes them as reliable indicators of quality. Moreover, they are databases with a broad thematic coverage. Specifically, PubMed provides access to health and clinical research including analyses on health communication, while Scopus and Web of Sciences present interdisciplinary studies, connecting areas of health and communication for a more holistic approach (AlRyalat et al., 2019). Complementarily, reference lists of scientific publications that could have been relevant but were not identified by the search methods used were examined.

The search was conducted during the last week of February 2024. No exclusion criteria based on year of publication were applied, implying that all scientific literature available up to the search date was included.

Step 3: Selection Criteria

In this phase of the review process, articles that were not directly related to the object of the investigation were excluded. To minimize selection bias, the authors of this article independently carried out the selection, evaluation, and data extraction. Subsequently, articles identified as potentially suitable were shared and final decisions on their inclusion in the review were made by consensus.

The Boolean operators used in the search were (“campaigns” OR “campaigns”) AND (“public health” OR “public health”) AND (artificial intelligence OR artificial intelligence OR big data OR emerging technologies OR emerging technologies"). In addition, other keywords related to potential campaign topics were used, both in Spanish and English, such as “disease prevention”, “road safety”, “healthy eating”, “drugs”, “social influence”, “digital health communication”, among others.

To maximize the scope of the search, it was decided not to exclude “gray literature” (as long as it was empirical and original) because the initial scoping review found that the topic has a limited number of scientific papers investigating it. For this reason, documents of different typologies could be considered, such as doctoral theses, communications to congresses, editorials or others, as long as they were in line with the research objectives.

Step 4. Synthesis and Reporting of Results

The selected articles were recorded in Table 1, which synthesizes and organizes the information presented, including the variables: authors, year, country, objectives, methods, main findings and limitations.

The quality of the articles was evaluated using the Critical Appraisal Skills Program (CASP) tool to ensure that possible technical deficiencies in the selected research did not significantly alter the results.

Finally, a discursive analysis of the analyzed research results was carried out using the VOS viewer tool, which allows the construction and visualization of bibliometric networks that identify the communities of words present in the set of selected articles and their relationships.

RESULTS

Results of the Source Search

Once the process of filtering and elimination of potentially duplicate articles collected during the first three stages of the search process was completed, a total of 129 articles were obtained that could be considered for the study. Subsequently, two screening processes were carried out, one after reading the titles and abstracts, and a second after a complete and exhaustive reading of the remaining articles. In this process, a total of 111 studies were discarded because they did not completely meet the established inclusion criteria. As a result, 18 original and significant articles were included in the review, as schematically illustrated in **Figure 1.**

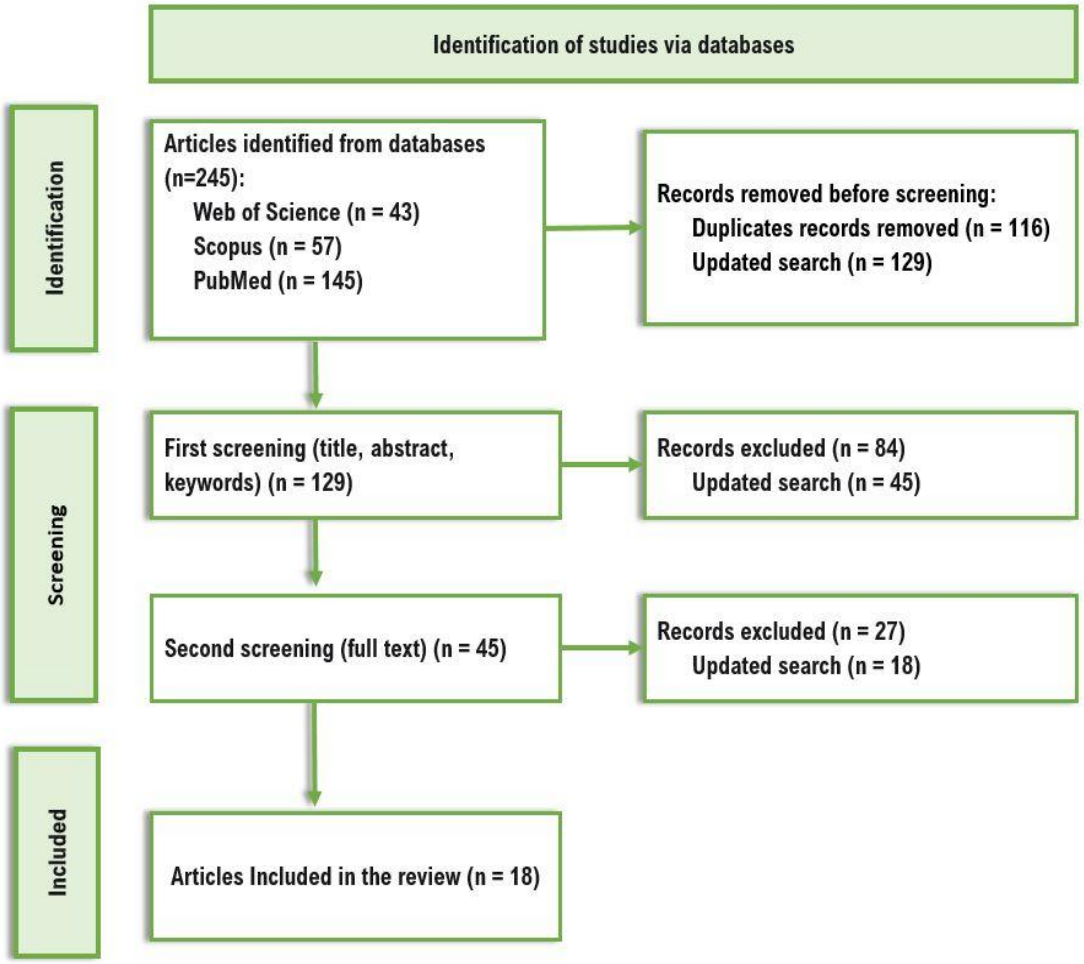

Figure 1. PRISMA Diagram

Characteristics of the Selected Research Articles

Analysis by Geographic Distribution

The selected articles were published between 2013 and 2024, and taking into account that no exclusion criteria associated with the date of publication have been applied in this research, it indicates the timeliness of the topic investigated.

In relation to the region of publication, **Figure 2** graphically represents the countries that have conducted the most studies on the investigated topic. Specifically, five countries distributed over three continents are represented. Thus, from highest to lowest number according to their frequency, the studies were the result of research conducted in the United States (n=12), United Kingdom (n=3), Brazil (n=1), Saudi Arabia (n=1) and Japan (n=1). All articles were published in English.

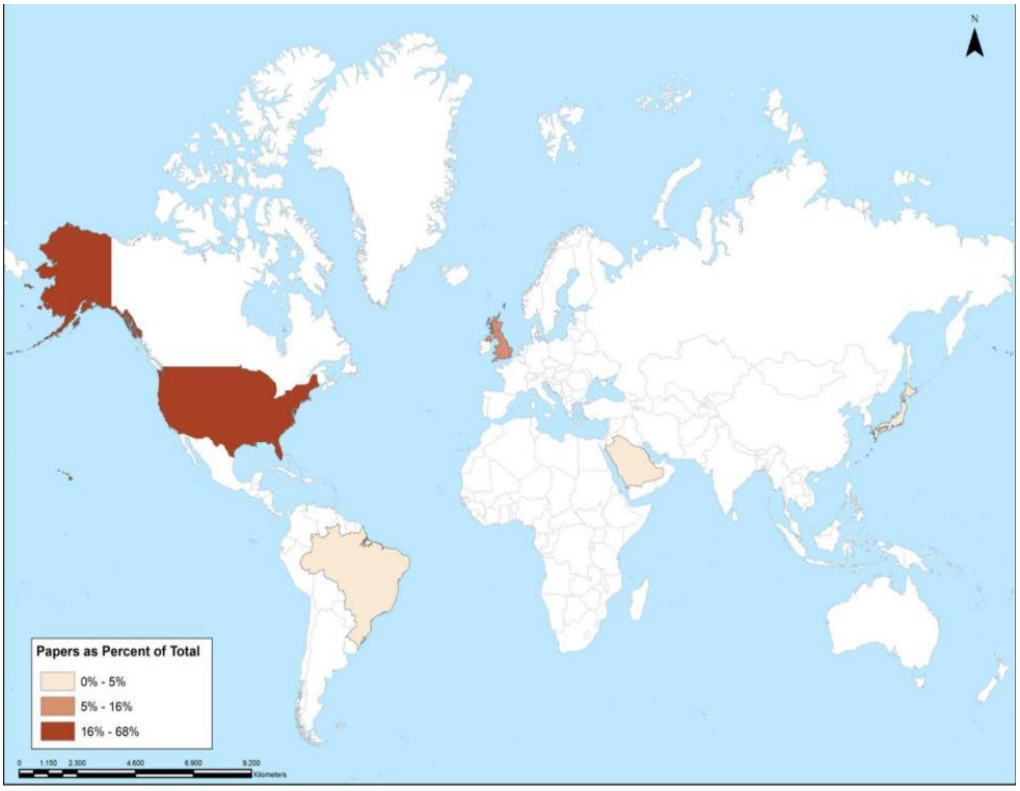

Figure 2. Geographical Distribution of the Original Studies Analyzed

Content-Based Analysis

In terms of content, all the articles present empirical results and/or theoretical conceptualizations on the use of emerging technologies in public health campaigns. However, there are some differences depending on the purpose for which this technology is used within the campaign. **Tables 1** and **2** show the general characteristics of the selected research articles, providing an overview of the results of the research. Specifically, **Table 1** presents the articles that employ these tools in the initial phases of the design and creation of the campaigns. There are 3 articles (16.7%) in which they are used for the development, planning and/or design of the campaign, and 6 articles (33.4%) in which these tools are used for audience segmentation and the establishment of the target audience. In general, in this type of studies, machine learning, language processing, ChatBots and Big Data are used to identify the target audience's profile for the reception of specific information, automate processes and adapt the messages to the target group or population sector.

Table 1. Summary of Characteristics of Studies Using Emerging Technologies for the Design and Creation of Public Health Campaigns

Authors, Year and Country	Objectives and Methods	Main Findings
Kreps & Neuhauser, 2013 USA	Analysis of the shortcomings in digital communications about Crohn's disease and propose how AI can contribute to its improvement.	An increase in the immediacy, relevance, emotion, processing and power of attraction of health communications is identified, increasing user engagement.
Olorunsogo et al., 2024 United States	Review of existing evidence to provide a theoretical framework for the use of AI and big data in health sector communication.	The results indicate that AI and big data improve the effectiveness of public health campaigns, due to their ability to adapt to the user and the capacity to process and integrate large amounts of information.
Sebastian, George, & Jackson Jr, 2023 United States	Evaluation of different communication strategies in promotional advertisements using AI to a sample of 150 participants.	The different strategies employed were shown to be effective in addressing user concerns about the proposed health issues.

Authors, Year and Country	Objectives and Methods	Main Findings
Kreps, 2020 United States	Documentary review of different communication strategies, including emerging technologies.	New technologies are highlighted as an effective way to transmit information to the user in public health campaigns.
Eskandari et al., 2022 United Kingdom	Review the applicability of AI for road accident prevention.	Clear connections are identified between the use of AI and road safety benefits, both in information monitoring and accident prediction.
Augusto et al., 2021 United States	Created an AI-based framework for automated micro-planning of immunization campaigns with implementation in 29 countries.	The application revealed that 68 million people are within 5 km of a health center, identifying the feasibility of employing personalized micro plans for health campaigns.
Sheeran et al., 2024 United States	Analyzing the degree of reliability of OpenAI in an adolescent vaping prevention campaign.	It reveals that AI can reliably simulate scores, having potential to become an effective tool for prevention campaigns.
Wusylko et al., 2024 United States	Exploring how machine learning and Big Data techniques can provide insights into student participation in campaigns.	The different analyses with machine learning and Big Data served to learn about students' attitudes, opinions, interactions, reactions and engagement with respect to these campaigns.
Alrige, Bitar, Meccawy,& Mullachery, 2022 Saudi Arabia	Applying geospatial intelligence and user modeling to profile Jeddah city districts to enable a COVID-19 pandemic awareness campaign.	The results indicate that the geo-intelligent map is suitable for daily use. This research provides a legitimate approach to personalizing health awareness messages during pandemics

Table 2 presents the articles that use emerging technologies for the procedure of dissemination and evaluation of health campaigns. Specifically, there are 6 articles (33.4%) that use emerging technologies for the evaluation of campaigns, mainly for the processes of extracting large amounts of data and information, in various media such as social networks and other digital media, in which AI allows us to know the opinions and trends of the audience with respect to the campaign in question. Additionally, there are 2 articles (16.7%) in which AI is used in the actual dissemination and implementation of the campaign, since, through geolocation and Big Data tools, it allows modulating and adapting the message launched according to fluctuations in the degree of severity of the problem to which it refers. Therefore, it allows real-time changes in the degree of harshness and the characteristics of the message depending on the broadcast area. Finally, there is an article (5.5%) that applies AI to the identification of potential improvements in public health campaigns through the analysis of large amounts of data from different media and campaigns.

Table 2. Summary of Characteristics of Studies Using Emerging Technologies for Dissemination and Evaluation of Public Health Campaigns

Authors, Year and Country	Objectives and Methods	Main Findings
Lim & Schmälzle, 2023 USA	Comparison between AI-generated and human-generated folic acid messages, with computational text analysis performed to examine similarities between messages in terms of content and semantic structure.	AI-generated messages ranked higher in quality and clarity among young people. And these messages were on par with human-generated messages in terms of sentiment, readability, and semantic content.
Chu, Colditz, Malik, Yates, & Primack, 2019 United States	Analysis of Twitter users' perceptions of smoking through language processing software and identification of ideal user groups for an intervention.	Big data makes it possible to segment the population and identify users who would benefit most from public health interventions, enabling the development of targeted to more receptive audiences.
Ayers et al., 2016 United States	Evaluation of a campaign on smoking through the use of big data from different information sources.	Related news stories increased by 61%, tweets by 13% and Google searches by 25% compared to what would have been

Authors, Year and Country	Objectives and Methods	Main Findings
		expected if the campaign had not been run.
Cresswell et al., 2021 United Kingdom	Social network analysis with AI to understand public perceptions of COVID-19 contact tracking applications.	A 76% positive and 12% negative sentiment, which varied over time modulating depending on the campaigns and messages launched to the population.
Anan et al., 2021 Japan	Assessment of musculoskeletal symptoms in workers after the implementation of an interactive chatbot-assisted health system.	This study shows that the short exercises provided by the AI-assisted health program improved neck, shoulder and low back pain in 12 weeks.
Aggarwal et al., 2023 United States	Review of the evaluation of the efficacy and intervention characteristics of AI chatbots to promote health behavior change	Of the 15 included studies, 13 showed efficacy in smoking cessation, promotion of healthy styles, adherence to treatment or reduction of substance use. Others were mixed with respect to feasibility and ease of use.
Pinto et al., 2022 Brazil	Review of the impact of public health campaigns through various indicators with information technology.	Information technology tools are effective for evaluation with growth indicators of internet news, social media posts and Google searches.
Chew, Kim, Chen, Ruddle, & Morgan-Lopez, 2018 United States	Use of machine learning in an anti-smoking campaign through public Twitter data, creating graph networks and age predictors.	AI coupled with public data mining on social networks allows for the identification of key communities to maximize the reach of messages to target audiences.
Hussain et al., 2021 United Kingdom	Application of AI to analyze public sentiment in social networks in a campaign on vaccination COVID-19.	Optimism about the vaccine's efficacy was identified, as well as concerns about its safety and feasibility.

Specifically, AI is the most widely used emerging technology in public health communication campaigns, accounting for 45% of studies on campaign design and audience segmentation, as well as 30% of those using this technology for dissemination and evaluation (**Figure 3**). ChatBots are especially used for campaign evaluation and monitoring, allowing direct interaction with the audience (20%). Other emerging technologies have also been used, including geospatial intelligence, language processing, user modelling, and articles in which various emerging technologies have been used to identify their potential for this type of campaign.

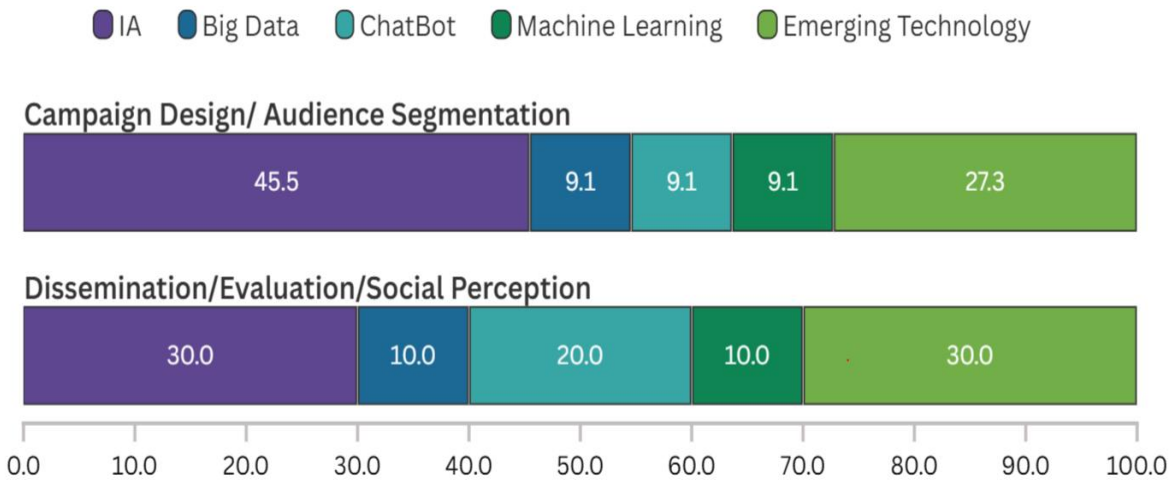

Figure 3. Distribution of the Type of Emerging Technology Used in the Selected Articles

In relation to the topics addressed, those that most use this type of tool for at least some of the aspects of the application of campaigns in the field of public health are the prevention of tobacco use and vapers (n=4; 22.2%), prevention of COVID-19 (n=3; 16.7%), promotion of vaccination (n=1; 5.5%), prevention of traffic accidents (n=1; 5.5%), and different medical conditions such as folic acid (n=1; 5.5%), Crohn's disease (n=1; 5.5%) and musculoskeletal symptoms (n=1; 5.5%).

Specifically, analyzing the content of the selected scientific papers, five thematic groups or clusters are identified, represented in **Figure 4.** The red cluster presents terms related to interpersonal, digital and media communication in the context of public health, through emerging technologies such as AI or virtual reality. Logically, given the subject matter of the documentary review carried out, this is the central block from which the rest of the word communities are developed. The blue cluster contains terms that suggest a focus on how public policies and health services are developed and implemented, specifically on the role of technology in improving access to care and dissemination of medical and public health information. For its part, the green cluster encompasses all the emerging technologies employed in the different selected studies such as big data and natural language processing, which are crucial for handling large volumes of data and extracting valuable information for public health campaigns. In relation to the purple cluster, it focuses on demographic variables such as gender and age, and their influence on the perception and response to public health campaigns. Finally, the yellow cluster presents a set of terms related to clinical research and health evaluation, especially with regard to the attitudes and behaviors of patients and health personnel, which includes the different issues involved in the campaigns analyzed in the selected articles, such as COVID-19 and vaccination.

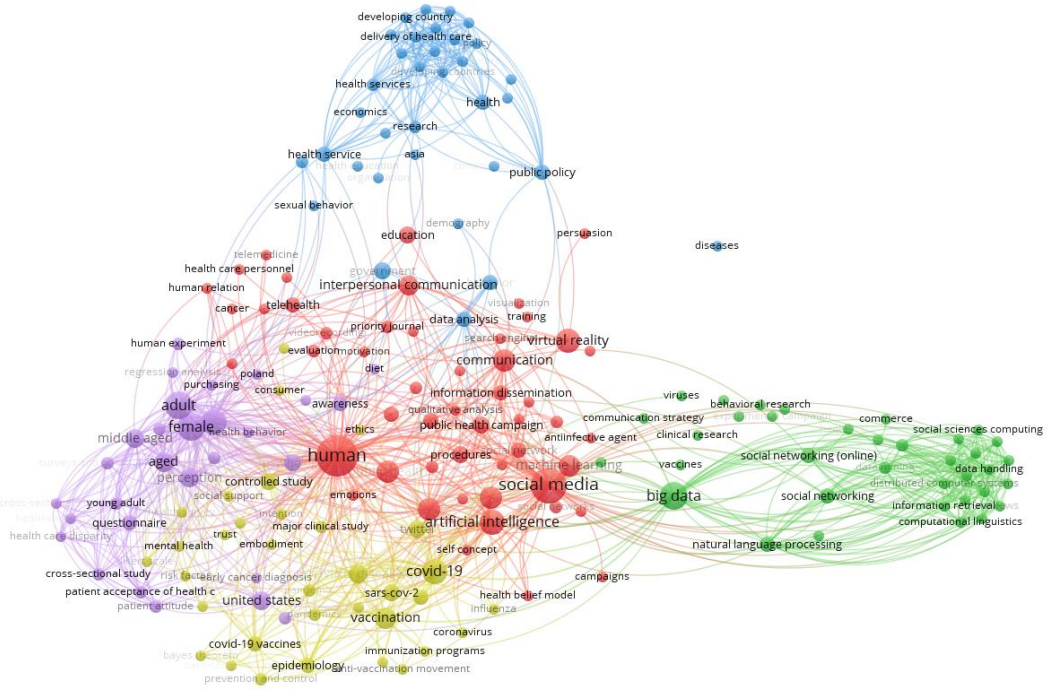

Figure 4. Representation of the Word and Discourse Communities of the Analyzed Articles, Centered on Thematic Patterns within the Existing Bibliographic Corpus

Note: The colors of the zones in the graph define the key themes, trends and research groups within a specific field or subject area, as specified in the last paragraph of the point. 3.2.2.

Methodology-Based Analysis

From the methodological point of view, all the studies were of a cross-sectional type, carrying out the research over a specific period of time. On the other hand, there were no longitudinal studies that evaluated the evolution of the impact of a campaign over time. On the other hand, all the studies present at least a quantitative analysis of the data. But, in addition to this, in some of them, certain qualitative analyses are performed, generally related to the identification of opinion trends and analysis of audience sentiment (n=5; 27.8%).

Regarding the type of study, 22.2% of the studies are based on documentary review (n=4), while one of them

is experimental (5.5%), in which a control group and an experimental group are established to evaluate the quality and sentiment generated by messages elaborated by AI and by humans. However, most studies are observational, since no external manipulation of the variables evaluated in the study has been performed (n=13; 72.2%). Within this group, several ways of studying the use of AI in campaigns can be differentiated, among which stand out the analyses on the data available in social networks or other digital sources derived from a specific communication campaign (n=4, 22.2%), the improvement of campaigns through the comparison of results and impact of different spots with a variable AI use (n=5, 28%), and the use of questionnaires or other self-reported data collection tools to assess the sentiment generated by campaigns (n=2, 11%).

Assessment of Study Quality Based on the CASP Protocol

The quality assessment methodology provided by the Critical Appraisal Skills Program (CASP) was applied, being a tool that facilitates evaluators to assess the level of rigor, reliability and relevance of each study through a set of ten specific questions (Long, French, & Brooks, 2020). The specific results of the evaluation are shown in **Figure 5.** It is relevant to note that all studies were incorporated into the review due to their low risk of bias, and no articles previously selected in the screening phase were excluded during this process.

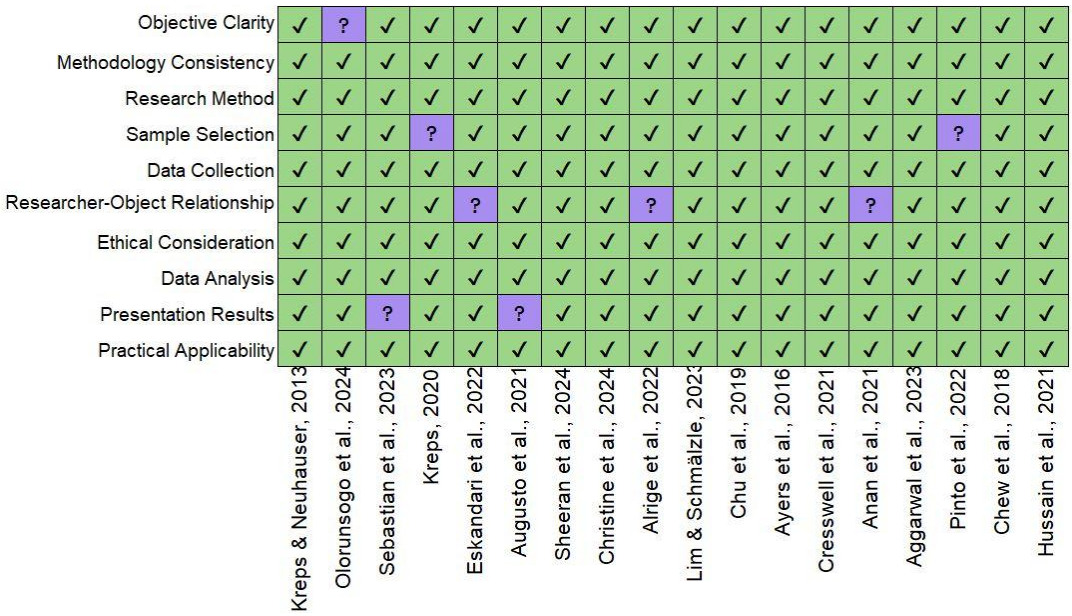

Figure 5. Criteria-Based Evaluation of the Quality of the Articles Selected by CASP

DISCUSSION

Although multiple studies have recently been developed that analyze the use of social networks for health promotion and, specifically, for the dissemination of communication campaigns and messages on various issues encompassed in this field, few scientific studies evaluate the application of emerging technologies in public health campaigns (Aggarwal, Tam, Wu, Li, & Qiao, 2023; Olorunsogo et al., 2024). In this regard, research on the implementation of AI, Big Data and other emerging technologies is considerably less frequent in the scientific community.

Message Personalization and Audience Segmentation

Within the few studies available, most focus on the role of these technologies in campaign evaluation and audience segmentation, highlighting their importance in measuring the effectiveness of campaigns in real time and enabling rapid adjustments based on the data collected (Lim & Schmälzle, 2023; Chu, Colditz, Malik, Yates, & Primack, 2019 ; Ayers et al., 2016), as well as their ability to identify and target specific population groups with personalized messages (Alrige, Bitar, Meccawy,& Mullachery, 2022; Augusto et al., 2021). Scientific literature indicates that public health messages that appeal to emotions of fear or surprise are generally more effective in capturing audience attention and generating behavioral change (Davis & Jansen, 2016). However, with the use of

machine learning and AI algorithms to identify vulnerable groups or groups with distinctive socio-demographic or psychosocial characteristics, a more complex analysis can be performed, which is not limited to basic segmentation and therefore allows for message personalization with high personal emotional impact and greater potential to influence viewer behavior change compared to generic messages (Chu, Colditz, Malik, Yates, & Primack, 2019). Emerging technologies contribute to providing detailed data on personal characteristics such as beliefs, attitudes and lifestyle of each population segment, as well as social characteristics such as gender, age, socio-economic status, among many other variables. Therefore, it allows the optimization of the message because it anticipates the emotional response of the audience, identifying the tone and communicative style that will generate positive and negative reactions in each population group (Cresswell et al., 2021). This process can be consistently interactive, with the possibility of adapting and modifying based on user feedback. This type of interaction can take place on social networks, but also on other types of platforms such as ChatBots. In this way, viewers are not passive subjects who receive information from the media, but are transformed into active subjects who must have processed the information received in order to be able to react to it. This active participation, in turn, increases the audience's engagement with the message and its effectiveness for behavioral change.

Campaign Design and Development

For its part, it should be noted that there is very little research addressing the use of these technologies in the process of creating and designing these campaigns, which is not congruent with the growth in the number of public health advertisements that do employ it for this purpose.

Some examples of the incipient appearance of these emerging technologies in the design of public health campaigns can be found in traffic and road safety ads (**Figure 6**). In recent years, this area of communication has made use of artificial intelligence and Big Data to visualize the numbers of deceased, leading to greater empathy in the audience. The way in which information is presented is no longer through graphs or data reports, as was traditionally the case. On the contrary, it is about advertisements that seek to personalize and identify with real individuals and scenes the risk behaviors, statistics and data that in previous years were presented in a more rational and merely informative way.

The campaign “Los 36” (The 36), developed by the General Directorate of Traffic and broadcast in Spain during the Easter holiday period of 2022, shows the viewer people with the sociodemographic characteristics that big data has predicted will die during those days, and challenges them to make this tool wrong, and actually produce a lower number of victims (DGT, 2022). In the same year, ‘The album of the Christmases you could not live’ (2022) is also broadcasted, in which a family visualizes several photographs of the festive season in which the father of the family has been included with artificial intelligence, as he does not appear in the real images because he died in a traffic accident years ago (DGT, 2022).

In France, there was also a shocking live campaign aimed at pedestrians in 2017, in which, when some person crossed a red light, a loud sound was played that made the pedestrian think that he/she was going to be run over imminently. Subsequently, on a billboard located right next to it, the image of that person was projected in real time just before the alleged hit-and-run, with the message “Ne prenez pas le risque de voir la mort en face” (Don't risk seeing it head-on) (DRIEAT Ile de France, 2017). Thus, this campaign generates a strong impact on the viewer, because he is watching his own face just moments before a road accident, and it would be impossible without the resources provided by emerging technologies.

Figure 6. Images of the Campaigns "Los 36" (The 36) and "Ne Prenez Pas Le Risque De Voir La Mort En Face" (Don't risk looking death in the face).

Therefore, in recent years, there has been a nascent use of emerging technologies in the design of public health campaigns to increase empathy, impact and viewer awareness. However, there is little research investigating this specific functionality of these tools.

Integration and Analysis of Diverse Data Sources

The selected studies identify the usefulness of AI and Big Data for the development, implementation and evaluation of public health campaigns, allowing adaptation to the target group, both in relation to the characteristics of the messages disseminated and in terms of identifying the population groups that are most vulnerable to a given problem and therefore require the design of campaigns and other specific measures (Wusylko et al., 2024; Hussain et al., 2021).

However, the ability of these tools to integrate and analyze data from multiple sources has not been explored extensively (Baah-Peprah & Shneor, 2022). Public health campaigns have traditionally relied on limited data, such as surveys and medical records (Salathé, 2016). However, several studies from the commercial marketing sector point out that, with the evolution of technology, it is now possible to incorporate a much wider variety of useful data to establish more effective spots in promoting products and services (Okorie et al., 2024). These strategies can potentially be used in public health campaigns as well, integrating information from multiple databases. Thus, one could consider information from social networks, where there is real-time data on the attitudes and behaviors of individuals towards health. But also integrate data from medical records and data from wearable devices, which provide information on the prevalence of diseases, and health outcomes of users, allowing a greater adjustment in the design of campaigns and the determination of the target population (Witt, Kellogg, Snyder, & Dunn, 2019). Similarly, information on the impact of demographic and socioeconomic variables on specific health problems can also be integrated to develop more personalized and targeted messages (Koebnick et al., 2012). The ability to combine these various data sources provides a holistic comprehensive view that allows for the design of more precise and effective interventions.

Evaluation of Public Health Campaigns that Employ Emerging Technology

In this sense, campaigns that employ technology in their design are being carried out, but their effectiveness is not being evaluated sufficiently. The fact of not measuring in a systematic way and with reliable and validated tools the effectiveness of public health advertisements is a clear detriment for the future development of campaigns. It is essential to have precise knowledge about what strategies, contents, techniques and methodologies are most appropriate for the spot to have the desired impact. Therefore, it is advisable that public health campaigns are evaluated at different times and with different indicators such as knowledge, attitude and behavior indicators, among others (Valente & Kwan, 2001; Eshuis, Braun, & Klijn, 2013).

Evidence suggests that a possible explanation for this phenomenon could be related to economic reasons.

Public and private institutions generally invest most of their resources in the execution of the aforementioned campaigns, leaving little or no budget for research and scientific evaluation of the results (Green, Crawford, K.A. Williamson, & DeWan, 2019). Moreover, even in cases where evaluations are conducted, the findings may not be adequately disseminated in the scientific community, limiting the shared knowledge on best practices for action, as well as the errors or deficiencies identified. In this sense, the importance of carrying out the tasks of evaluation and dissemination of the findings, both positive and negative results, is pointed out, as they are fundamental for the development of future campaigns (Faus, Fernández, Alonso, & Useche, 2023). Thus, in order to strengthen this line of research, the entities responsible for establishing criteria and standards in the development of these campaigns could establish as one of the mandatory requirements, the development of evaluation processes of the campaigns in relation to their social impact and the effectiveness of the technological and communicative strategies used.

AI and Big Data Barriers: Ethics and Privacy

Although the ideal is to be able to use data from multiple sources for the benefit of citizens, this also poses challenges and difficulties in terms of data management, requiring standardized protocols to ensure that the information is complete, secure and accessible (Hauer, 2022). In addition, concerns related to user anonymity, privacy, and data security have been raised because users must be guaranteed that their data will be treated ethically and in accordance with current regulations (Hickman, Baxter, & Gilbert, 2021). Along these lines, some of the studies selected in the present systematic review mention these issues, limiting the evaluation of the campaigns' results and impact (Chu, Colditz, Malik, Yates, & Primack, 2019; Wusylko et al., 2024).

To protect the privacy of individuals, data must be properly anonymized, with transparency (White & Bradley, 2022). In addition, it is essential to implement reliable and empirically valid security measures for the protection of data integrity and to avoid security breaches that may have serious consequences for users' privacy (Ienca et al., 2018; Salerno, Knoppers, Lee, Hlaing, & Goodman, 2017). Finally, complying with legal and ethical regulations, such as the General Data Protection Regulation (GDPR) in Europe and other local legislation, is essential to ensure proper and ethical data management (Zaeem & Barber, 2020).

CONCLUSIONS

This systematic review points to the potential of AI, Big Data and other emerging technologies in the design, dissemination and evaluation of public health communication campaigns. In the process of maximizing their usefulness, the integration of these functionalities with theoretical models of communication is important as they facilitate the identification of psychosocial variables that explain behavioral change. Therefore, it is these variables that need to be promoted through specific messages adapted to vulnerable user groups, through the use of emerging technologies.

In this sense, the practical recommendations that the evidence points to is the use of these tools for the precise segmentation of the audience, increasing interactivity with the user in the design of health campaigns, increasing the reach and favoring the dissemination of the message to specific groups, allowing real-time adjustments to the content of the campaigns based on the feedback received and obtaining both short and long-term evaluation of the campaigns that allows the identification of the best communication strategies that maximize the social impact of the message.

This process of implementing emerging technologies in public health campaigns is not without some limitations or barriers. It is currently at an early stage and ethical and privacy challenges need to be addressed through the establishment of a clear legal framework. The establishment of a legal and social context will enable more effective implementation, maximizing the utility and impact of emerging technologies for the promotion of healthy attitudes and behaviors in the population.

LIMITATIONS

All systematic reviews have some limitations that should be taken into account. Thus, publication bias may be occurring, in which studies with positive results are more likely to be published, while those with negative results may not be as visible, which may distort the overall understanding of the available evidence (Dwan, Gamble, P. R. Williamson, Kirkham, & Reporting Bias Group, 2013; P. R. Williamson & Gamble, 2005). Also, not including studies in languages other than English and Spanish may introduce a linguistic bias, whereby relevant evidence in other languages is possibly being excluded (Grzybowski & Kanclerz, 2019).

In relation to future research, this systematic review can serve, in a solidly oriented way, to the development of studies on ways and forms of implementation of social communication strategies and campaigns that, supported by emerging technologies, increase their creativity and impact and, in short, their degree of effectiveness and social service. Specifically, for future research, the use of experimental methodologies that analyses the differences in users' perception of human- and AI-generated messages is recommended (Pinto et al., 2022). This would make it possible to identify the characteristics that influence message comprehension and predisposition to change after viewing the message. As well as determining the degree to which automation achieves a similar or superior persuasion and training in the health issue addressed than conventional methods.

In addition, it is recommended that longitudinal studies be carried out using Big Data to obtain information on the effectiveness of these campaigns in the long term. The context and social environment is changing and this type of analysis would favor the detection of potential new needs in the way messages are transmitted. In the same way, future research should consider interdisciplinary approaches involving professionals from different areas such as communication, technology and public health.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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