Health Leadership and Quality of Life. 2025; 4:756
doi: 10.56294/hl2025756

SYSTEMATIC REVIEW

Ethical dilemmas of health misinformation and the importance of scientific dissemination

Dilemas éticos de la desinformación en salud y la importancia de la divulgación científica

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Cite as: Alba-Leonel A, Mejía Argueta MÁG, Papaqui-Alba S, Sánchez-Ahedo R, Papaqui-Hernández J. Ethical dilemmas of health misinformation and the importance of scientific dissemination. Health Leadership and Quality of Life. 2025; 4:756. https://doi.org/10.56294/hl2025756

Submitted: 01-09-2024 **Revised:** 14-01-2025 **Accepted:** 03-09-2025 **Published:** 04-09-2025

Editor: PhD. Neela Satheesh

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ABSTRACT

Introduction: health misinformation represents an increasing ethical challenge in the digital age, as it affects individual and collective decision-making, undermining public health and trust in science. In this context, scientific dissemination becomes a strategic tool to counter the spread of false or misleading information.
Objective: to analyze the ethical dilemmas derived from health misinformation and highlight the importance of scientific communication as a mitigation strategy.
Method: a systematic literature review was conducted using the PRISMA 2020 methodology. The search included databases such as PubMed, SciELO, Medline, Embase, Cochrane, and Google Scholar, complemented by generative artificial intelligence tools (e.g., ChatGPT-4, Gemini). Studies published between 2020 and 2025 in English and Spanish were considered.
Results: a total of 896 documents were identified, of which 50 met the inclusion criteria. The analysis revealed the ethical impact of misinformation in health, such as the erosion of public trust, harmful decision-making, stigmatization, and political manipulation. Scientific dissemination was identified as a key strategy to foster education, critical thinking, media literacy, and community engagement.
Conclusions: health misinformation constitutes a pressing ethical dilemma requiring multisectoral responses. Scientific communication emerges as an essential strategy to promote access to reliable information, strengthen public health, and foster a critical and responsible citizenry.

Keywords: Ethical Dilemmas; Health Misinformation; Scientific Dissemination.

RESUMEN

Introducción: la desinformación en salud representa un reto ético creciente en la era digital, ya que afecta la toma de decisiones individuales y colectivas, comprometiendo la salud pública y la confianza en la ciencia. En este contexto, la divulgación científica se posiciona como una herramienta estratégica para contrarrestar la circulación de información errónea.
Objetivo: analizar los dilemas éticos derivados de la desinformación en salud y destacar la importancia de

la divulgación científica como mecanismo de mitigación.
Método: se realizó una revisión sistemática de tipo documental, utilizando la metodología PRISMA 2020. La búsqueda se desarrolló en bases de datos como PubMed, SciELO, Medline, Embase, Cochrane y Google Académico, complementada por herramientas de inteligencia artificial generativa (ChatGPT-4, Gemini, entre otras). Se incluyeron estudios publicados entre 2020 y 2025 en inglés y español.
Resultados: se identificaron 896 documentos, de los cuales 50 cumplieron con los criterios de inclusión. El análisis permitió evidenciar los impactos éticos de la desinformación en salud, tales como la pérdida de confianza pública, decisiones erróneas, estigmatización y efectos políticos. Asimismo, se reconoció el papel de la divulgación científica en la educación, el pensamiento crítico, la alfabetización mediática y la participación comunitaria.
Conclusiones: la desinformación en salud constituye un dilema ético urgente que exige respuestas multisectoriales. La divulgación científica emerge como una estrategia fundamental para promover el acceso a información veraz, fortalecer la salud pública y fomentar una ciudadanía crítica y responsable.

Palabras clave: Dilemas Éticos; Desinformación En Salud; Divulgación Científica.

INTRODUCTION

In the digital age, the immediacy and global reach of information have transformed the way knowledge is disseminated and consumed. However, this unprecedented advance has brought with it a problem of great magnitude and complexity, especially in the field of health: misinformation. The proliferation of fake news, conspiracy theories, and scientific misrepresentations, often amplified by social media, not only confuses the public but also has tangible and harmful consequences for decision-making, both individually and collectively. This phenomenon represents a considerable ethical challenge, as it compromises patient autonomy, trust in health institutions, and the effectiveness of health policies.

Globally, the World Health Organization (WHO) has coined the term infodemic to describe the overabundance of information—much of it false—that makes it difficult for people to find reliable sources and expert guidance when they need it. This phenomenon became particularly evident during the COVID-19 pandemic, where a study revealed that up to 56 % of social media users in countries such as Mexico encountered false or misleading news. A clear example of the impact of this misinformation on public health can be seen in the epidemiology of vaccination: exposure to misinformation about the safety or efficacy of vaccines has been consistently associated with decreased immunization rates, thus increasing the risk of outbreaks of preventable diseases. Analysis of this issue is essential to understanding its repercussions on society.

The complexity of ethical dilemmas in health is not limited to misinformation alone. They also arise in research practice and clinical medicine, as Kaufer-Horwitz[1] has pointed out. These dilemmas involve constant evaluation of methodological rigor, weighing the risks and benefits for study participants, respecting data confidentiality, and making appropriate use of the scientific information generated. The absence of a single methodology for resolving these dilemmas underscores the need for critical reflection on the part of researchers and ethics committees, who must navigate an increasingly intricate landscape.

In this context, scientific dissemination emerges as a fundamental strategy to mitigate the effects of misinformation. It acts as a bridge between rigorous knowledge and public understanding, ensuring that evidence-based information reaches the population in a clear, accessible, and timely manner.

Therefore, it is necessary to analyze the ethical dilemmas arising from misinformation in health and highlight the importance of scientific dissemination as a mitigation mechanism and as a bridge between rigorous knowledge and responsible public access.

METHOD

A systematic review with a documentary approach was conducted to identify the ethical dilemmas of health misinformation and the importance of scientific dissemination, as well as their implications in the area of health, health services, and education. Based on these objectives, a systematic review of observational studies addressing ethical dilemmas of misinformation in the area of health was carried out. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology was used for the systematic review and meta-analysis in this research.

Search strategy

A mixed strategy was used to collect information. On the one hand, Generative Artificial Intelligence (GAI) models were used, such as ChatGPT-4, Perplexity Free, TextCortex (no specific version), Gemini 1.5, and Elicit. com. On the other hand, academic search engines and specialized scientific databases were used. Through the

GAI models, the following guiding prompt was formulated:

"Find academic documents such as journal articles, reports, and case studies on ethical dilemmas of misinformation in health and their implications. *Use academic databases such as Cochrane Library, Embase, Medline, PubMed, and reports from accredited health organizations on the following: current uses, benefits, ethical and legal challenges, case studies, future trends; how health misinformation and its implications and the importance of scientific dissemination. Consider the potential ethical dilemmas and their implications for health."*

In addition, an exhaustive search was conducted in academic databases such as PubMed, Embase, Medline, SciELO, Cochrane Library, and Google Scholar (using advanced search). To identify studies, Health Sciences Descriptors (DeCS) and Medical Subject Headings (MeSH) were used, employing the key terms: *ethics,* dilemmas, and health, and using the Boolean operators AND, OR, and NOT.

Inclusion and exclusion criteria

The search was limited to studies published between 2020 and 2025, in Spanish and English. The following inclusion criteria were established:

- Full-text articles,
- Open access,
- Published in the specified period,
- Including keywords directly related to the subject of the study in the title.
- Spanish and English languages

The following exclusion criteria were applied:

- Articles that only presented the abstract,
- Those that could not be accessed in full due to technical failures on the websites,
- Articles that were not freely accessible
- Studies whose titles did not contain the previously defined search terms.

Application of the PRISMA methodology

This review was conducted following the methodological guidelines of the PRISMA 2020 model, with the aim of identifying and analyzing relevant publications on the ethical dilemmas arising from health misinformation, as well as the role of scientific dissemination as a mitigation strategy. The search strategy was designed to retrieve scientific articles, academic essays, and technical documents from recognized databases, as well as through generative artificial intelligence tools applied to bibliographic analysis.

Sources of information and search strategy

The following sources were consulted:

- PubMed (n = 5),
- Google Scholar (n = 320),
- SciELO (n = 137),
- Generative AI tools (n = 434), resulting in a total of 896 documents identified in the initial search.

In total, 896 records were identified. Filters were applied by language (Spanish and English), publication date (last 5 years), thematic relevance (ethics, health, misinformation, scientific dissemination), and full-text availability.

Table 1 of the PRISMA flow diagram illustrates this process:

Table 1. PRISMA process flow

Stage of the process	Number of records
Records identified in the initial search	896
- PubMed	5
- Google Scholar	320
- SciELO	137
- Generative AI	434
Duplicate records removed	49
Unique records after removing duplicates	847
Records excluded due to thematic irrelevance	23
Records selected for full-text review	73
Records included in the final analysis	50

Ethical Considerations

Given that this work is based on a systematic review of the literature, it did not require the direct participation of human beings or the collection of personal or sensitive data. However, fundamental ethical principles in scientific research were observed, such as respect for intellectual authorship, academic integrity, and methodological transparency. All sources consulted were properly cited, and the rights of open access and responsible use of knowledge were respected. Likewise, any intentional bias in the selection and analysis of documents was avoided.

RESULTS

The ethical dilemmas of health misinformation Impact on decision-making

Health misinformation refers to the dissemination of false or misleading information that can negatively affect public health.[2] One of the most significant ethical dilemmas of misinformation is its impact on individual and collective decision-making. When people access erroneous or manipulated information, they may make decisions that are harmful to their health and well-being and that of others. A clear example of this occurred during the COVID-19 pandemic, when the spread of false news about unproven treatments, as indicated by Roozenbeek[3] and the alleged dangers of vaccines led many people to reject effective prevention.[4] This misinformation not only affected those who believed it, but also contributed to prolonging the health crisis and increasing the number of preventable deaths.

From an ethical standpoint, misinformation raises serious questions about the responsibility of health communicators and all platforms that disseminate information. Is it ethical to allow misinformation to circulate freely, knowing that it can cause harm? Should technology platforms be responsible for verifying information before it is disseminated? Misinformation on social media can have adverse effects on public health. That is why there is now a need for social media platforms such as Facebook and Twitter to play a crucial role in shaping the public conversation about health, and their lack of regulation on misinformation can lead to a crisis of confidence in science.[5]

Furthermore, misinformation can contribute to the stigmatization of certain populations, as the spread of misinformation about diseases such as HIV/AIDS or COVID-19[6] can fuel prejudice and discrimination, which in turn affects the mental and physical health of the communities affected.

In the political arena, disinformation has also proven to be a powerful tool for influencing elections and government decisions. The manipulation of public opinion through the dissemination of fake news has been used in election campaigns in various countries, creating an environment of polarization and distrust of democratic institutions. This raises an important ethical dilemma: while freedom of expression is a fundamental right, to what extent should the dissemination of fake news that can negatively influence society be allowed?

The Importance of Scientific Dissemination

Scientific dissemination is an essential means of combating misinformation, as effective communication of science can empower communities and build trust in health professionals. Dissemination involves not only the transmission of accurate information, but also the ability to contextualize scientific data and explain its relevance to health and daily life.

Therefore, health education is essential for disease prevention and the promotion of healthy lifestyles, but it is not possible due to a lack of understanding of scientific concepts, which can also facilitate the acceptance of misinformation. Therefore, scientists, health personnel, and health communicators must work together to create accessible and understandable materials that respond to the questions and concerns of society or the general public. Hence the importance of considering a participatory approach to scientific dissemination, where communities are involved in the content creation process. This not only increases the relevance of the information, but also helps to build trust, as people see that their voices are heard and their concerns are addressed, making them more likely to accept scientific information.[7]

Responsibility of information creators and disseminators

Another crucial ethical dilemma is the responsibility of those who generate and share false information.[8] In some cases, misinformation is promoted with financial incentives, as is the case with websites that publish sensationalist news to attract traffic and generate advertising revenue. In other cases, there are political or ideological interests behind the spread of false information, such as smear campaigns against science or denialist movements on issues such as anti-vaccination, climate change, and evolution.

The situation is exacerbated by the role of social media, which operates using algorithms designed to prioritize content that generates the most interaction, regardless of its veracity. This allows misinformation to spread rapidly and reach millions of people in a matter of minutes.[9] This raises the ethical question of whether digital platforms should be more strictly regulated in terms of the content that is shared, without undermining freedom of expression.

Consequences for the perception of science

Misinformation also affects public confidence in science and academic institutions. The dissemination of conspiracy theories and the manipulation of scientific data has generated skepticism on fundamental issues such as vaccines, drug treatments, and climate change, among others. When the population loses trust in science, it becomes difficult to implement evidence-based policies and opens the door to decisions guided by unfounded beliefs or particular interests.

For example, the use of so-called miracle products (those that promise miraculous cures or benefits without scientific evidence and are not authorized or regulated by the competent authority) however, these products can pose risks to health and the economy, as they are often expensive and do not meet safety standards. These products are generally promoted by groups with economic interests, which has delayed the adoption of urgent measures to mitigate their adverse reactions. In this context, it is essential to ask who is responsible for correcting misinformation and what mechanisms can be used to ensure that the public has access to reliable scientific information.

The importance of science communication

Given the proliferation of misinformation, science communication becomes a key tool for promoting critical thinking and ensuring that society makes informed decisions. Communication not only seeks to convey scientific knowledge, but also plays an essential role in educating citizens to discern between reliable information and fake news.

Specifically, communication helps reduce harm to public health, strengthen trust in institutions, improve information management, and lessen negative psychological impacts. Communication strategies, such as collaboration between scientists and journalists, the use of verified sources, and the promotion of media literacy, are essential for addressing these challenges in different social contexts.[9]

Accessibility and adaptation of scientific knowledge

One of the main challenges of science communication is making knowledge accessible without losing its scientific rigor. Science, by its very nature, uses technical language that can be difficult for the general public to understand. Therefore, science communicators have the daunting task of translating information into understandable terms without resorting to simplifications that distort reality.

It should be noted that communication must be adapted to different formats and platforms so that it is accessible to people and they can consume the information. Currently, many citizens get their information through different social networks, so it is essential that scientific communication uses these channels to counteract misinformation. Educational videos, Twitter threads, infographics on Instagram, webinars, TikTok, and podcasts are some of the strategies that can be used to effectively reach different public audiences and different groups of people.

Promoting critical thinking

Another key aspect of science communication is its contribution to the development of critical thinking. When people have the tools to evaluate the veracity of information, they are less likely to fall prey to misinformation. Science education should be included from childhood or even from preschool, encouraging curiosity, informed skepticism, and the ability to question all sources of information.

Critical thinking not only helps detect fake news, but also strengthens informed decision-making in all areas of life. A well-informed society is less vulnerable to manipulation and better prepared to face global challenges such as epidemics, pandemics, and the use and management of technological advances.

The role of scientists and communicators.

Scientific dissemination should not be the sole responsibility of journalists or professional communicators; scientists themselves must be involved in communicating their findings in a clear and accessible manner based on evidence and in language that is understandable to the public. Collaboration between scientists and journalists seeks to promote clear risk communication, prevent the spread of misinformation, and strengthen public trust.[10] In many cases, the lack of effective communication between the scientific community and society has allowed misinformation to gain ground.

The media plays a key role in this process. It is crucial that science journalists receive adequate training to interpret and explain studies accurately, avoiding sensationalist headlines or misinterpretations of data. In addition, it is important that the media give space to reliable sources and avoid giving voice to unfounded theories in an attempt to present a “false equivalence” between scientific evidence and misinformation.

Science communication is a fundamental tool for combating health misinformation for several reasons:
Education and Awareness

Science communication allows the general population to be educated on basic health and science concepts.

By providing clear and accessible information that facilitates the understanding of complex topics, it helps people make informed decisions. For example, explaining how vaccines work or the mechanisms of diseases can reduce the acceptance of erroneous claims.

Promoting Critical Thinking

Science communication can teach people to develop critical thinking skills, enabling them to evaluate the quality and reliability of the information they need. It also teaches them to distinguish between reliable and unreliable sources of information and to understand the importance of scientific evidence.

Demystifying Science

Science is often perceived as a complicated and distant field. Science communication can help demystify science by presenting it in a way that is understandable in everyday life. This can help reduce mistrust of science and health professionals, which is crucial in times of public health crises.[11]

Community Interaction and Participation

Effective science communication often involves the community in the communication process. By involving people in content creation and dialogue on health issues, it promotes the relevance of information and generates a sense of ownership over public health. It can also help address specific concerns that communities may have, which promotes and facilitates the acceptance of scientific information.

Use of Digital Platforms

Social media and other digital platforms are very important channels for science communication. By using these platforms, scientists and communicators can reach a wider audience and respond quickly to misinformation. Informative publications, infographics, and videos can be shared and disseminated, allowing verified information to reach many people effectively.

Rapid Responses to Crises

During crisis situations, such as a pandemic, science communication must provide rapid and accurate responses. By providing up-to-date, evidence-based information on public health mitigation measures, treatments, and prevention, the spread of rumors and misinformation that often arise at such times can be counteracted.

Building Trust

Clear, simple, and transparent communication of science builds trust between the community and health experts. When people feel they are receiving reliable, evidence-based information, they are more likely to follow health recommendations and trust scientific processes.

Interdisciplinary Collaboration

Science communication can also involve collaboration between scientists, communicators, educators, and health professionals. By working together, they can develop effective strategies to address misinformation and create communication campaigns that reach diverse audiences.

Mitigating harm to public health

The dissemination of science, especially in the field of medicine, helps provide real, reliable information to people with diseases and their families, reducing the spread of potentially harmful data that could affect human health.

Reduce psychological impacts and manipulation

Information backed by reputable institutions is verified and can be obtained through various media such as scientific journals, newsletters, or books, either in traditional or digital formats, which help reduce uncertainty, fear, anxiety, and emotional manipulation that can be caused by false or alarmist data.

DISCUSSION

Misinformation in the field of health, as discussed in the text, reveals a profound ethical dilemma in the digital age. The results identify misinformation as a factor that is detrimental to individual and collective decision-making. This data coincides with the growing body of evidence that has positioned this phenomenon as a global challenge. The fact that up to 56 % of social media users in Mexico encountered fake news during the COVID-19 pandemic, for example, underscores the magnitude of a problem that transcends mere opinion and directly impacts public health. In this sense, it is clear that the analysis of the infodemic is not only a matter

of communication, but also of fundamental ethics, as various authors in the field of bioethics and digital health have pointed out.

Our findings, obtained through a mixed methodology that included the use of Generative Artificial Intelligence (GAI) and academic databases, allowed us to identify the ethical implications of misinformation. Comparing our results with those of other authors, such as Kaufer-Horwitz[1], confirms that ethical dilemmas are not unique to misinformation but also extend to research practice, a crucial point that links both phenomena. Lack of methodological rigor, data confidentiality, and misuse of information are recurring themes in the literature and reinforce the idea that scientific integrity is an indispensable pillar for counteracting disinformation.

The text also mentions that misinformation on social media can lead to a crisis of confidence in science,[5] a claim reinforced by epidemiological studies linking vaccine misinformation to declining immunization rates. This connection is critical, as it demonstrates that the problem is not merely theoretical but has direct and measurable consequences for public health.

The central ethical debate centers on the responsibility of those who create and disseminate information. Should digital platforms, such as Facebook and Twitter, be more strictly regulated to mitigate the spread of misinformation, even if this could conflict with freedom of expression? From our perspective, it is crucial to find a balance. Freedom of expression is a fundamental right, but it should not be a shield for the dissemination of information that causes harm. Therefore, greater transparency in social media algorithms must be promoted so that they do not prioritize sensationalist content over truthful content, and data verification mechanisms must be strengthened without this representing an act of censorship.

Scientific dissemination, as discussed in the text, is presented as a key strategy to mitigate these effects. However, it is important to debate the approach. Simply transmitting "correct" information is not enough. Science communicators must not only be communicators, but also educators who foster critical thinking and media literacy in the population. Community participation in the creation of health,[7] content is a point of view that should be considered essential. This participatory approach not only increases the relevance of information, but also empowers communities and builds the trust that misinformation has eroded.

CONCLUSION

Health misinformation is a multifaceted problem that requires an interdisciplinary response. Addressing this challenge goes beyond simply correcting false data; it requires a comprehensive strategy that fosters a culture of critical thinking, transparency, and accountability in all spheres of communication, from academia to digital platforms. At the same time, this article highlights that science communication is an essential tool for mitigating the effects of misinformation, strengthening public trust in evidence, and promoting responsible decision-making, serving as a crucial bridge between rigorous knowledge and a well-informed society.

Study Limitations

One of the main limitations of this study is that, as it is a systematic review, the findings depend largely on the availability and quality of the sources identified. Furthermore, although artificial intelligence tools were used to expand the search, studies with their own empirical data and interviews with experts were not included, which limits the depth of the analysis. It is also possible that some relevant articles may have been excluded due to access limitations or predefined search criteria. These limitations should be considered when interpreting the results and their applicability.

REFERENCES

1. Kaufer-Horwitz M. Dilemas éticos en la investigación en salud y nutrición. Rev Nutr Clin Metab. 2021;4(Supl 1):78-85. doi:10.35454/rncm.v4supl1.333

2. Castro MS. Bioética, investigación y salud pública, desde una perspectiva social. Rev Cubana Salud Pública. 2007;33(1):. doi:10.1590/s0864-34662007000100013

3. Roozenbeek J, Schneider CR, Dryhurst S, Kerr J, Freeman ALJ, Recchia G, et al. Susceptibility to misinformation about COVID-19 around the world. R Soc Open Sci. 2020;7(10):201199. doi:10.1098/rsos.201199

4. Organización Panamericana de la Salud. La desinformación alimenta las dudas sobre las vacunas contra la COVID-19, según la directora de la OPS. OPS/OMS; 2021. Disponible en: https://www.paho.org/es/noticias/21-4-2021-desinformacion-alimenta-dudas-sobre-vacunas-contra-covid-19-segun-directora-ops

5. Espinoza-Portilla E, Mazuelos-Cardoza C. Desinformación sobre temas de salud en las redes sociales. Rev Cubana Inf Cienc Salud. 2020;31(2):. Disponible en: http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S2307-21132020000200002

6. López-Borrull A, Ollé C. Curación de contenidos científicos en tiempos de fake science y COVID-19: una aproximación entre las ciencias de la información y la comunicación. En: AE-IC. Comunicación y diversidad. Valencia: AE-IC; 2020. p. 281–9. doi:10.3145/AE-IC-EPI.2020.E16

7. Peñafiel-Saiz C, Ronco-López M, Castañeda-Zumeta A. Ecología comunicativa en tiempos del coronavirus SARS-CoV-2. Del moméntum catastróphicum al virtus véritas. Rev Esp Comun Salud. 2020;1:328. doi:10.20318/recs.2020.5466

8. Ruíz-Cano J, Cantú-Quintanilla GR, Ávila-Montiel D, Gamboa-Marrufo JD, Juárez-Villegas LE, De Hoyos-Bermea A, et al. Revisión de modelos para el análisis de dilemas éticos. Bol Med Hosp Infant Mex. 2015;72(2):89–98. doi:10.1016/j.bmhimx.2015.03.006

9. Ibáñez-Hernández A, Carreton-Ballester MC. Desinformación en salud y su impacto en el desarrollo sostenible (Scopus 2017–2023). Rev Int Relac Públicas. 2024;14(27):47–70. doi:10.5783/revrrpp.v14i27.861

10. Quian A. (Des)infodemia: lecciones de la crisis de la COVID-19. Rev Cienc Comun Inf. 2023;28:1–23. doi:10.35742/rcci.2023.28.e274

11. Barrios CJC. Aspectos éticos en la publicación de manuscritos científicos: una revisión de literatura. Salud Cienc Tecnol. 2022;2:81. doi:10.56294/saludcyt202281

FUNDING

The authors did not receive funding for the development of this research.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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