

Social listening in the age of Infodemics: An AI-supported rapid risk assessment framework for public health threats

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Abstract

Background

Public health emergencies are increasingly accompanied by infodemics, where the overload of information in digital and physical spaces generates confusion, driving harmful behaviors. Evidence indicates a shift in trust away from healthcare and media institutions toward online platforms, social networks, peers, and influencers, particularly among younger populations. New analytical approaches are needed to support timely public health decision-making. This study pilots an AI-supported framework for rapid social listening, narrative identification, and risk assessment within digital information environments. The framework was tested on social media content related to hormonal contraception, a controversial topic in Serbia.

Methods

Publicly available posts from YouTube, TikTok, and Instagram were rapidly converted into a unified textual dataset, with video content transcribed using OpenAI Whisper and image-based content processed using EasyOCR. Data was analyzed through large language model-assisted content analysis using Gemini 2.5 Pro to identify dominant narratives within short analytical timeframes. Narratives were evaluated using a two-dimensional risk assessment matrix that integrates exposure and potential health outcomes, resulting in an overall narrative risk classification ranging from low to very high.

Results

Seventeen distinct narratives were identified, with nine classified as potentially harmful and subjected to risk assessment. High-risk narratives primarily involved personal negative experiences following hormonal contraception use, including psychological and physical side effects, framing emergency contraception as dangerous, synthetic hormones as unnatural, and emphasizing adverse effects after discontinuation. Non-harmful narratives included clarification of misinformation, endorsement of contraception as safe and effective, and the importance of consulting healthcare professionals.

Conclusions

The proposed framework enabled rapid social listening and narrative risk analysis within short timeframes and with minimal human resources. This approach offers a practical and scalable tool for early detection of infodemic risks, enabling timely and evidence-informed public health communication and response.

1. Background

An infodemic refers to an overabundance of information that accompanies disease outbreaks, including both inaccurate (misinformation) and intentionally misleading (disinformation) content circulating across digital and real-world environments [1, 2]. During public health emergencies, this rapid and amplified flow of information can outpace evidence generation, creating confusion, fueling rumors, and undermining appropriate risk perception and protective behaviors [3]. As emphasized during the early stages of the COVID-19 pandemic, infodemics represent a parallel threat to outbreak control, eroding trust in health authorities and complicating public health response efforts [1, 3].

An infodemic does not refer solely to false or misleading information, but rather encompasses the full range of content circulating within a broader information ecosystem. Information ecosystems are complex and dynamic systems in which people, technologies, and informational outputs interact, enabling the production, circulation, and interpretation of content within a given social context. They are embedded within wider political, economic, and cultural environments and shaped by patterns of media production, infrastructure, governance, and public engagement [4]. Within such ecosystems, misinformation and disinformation represent only part of a larger communicative landscape that also includes accurate information, personal narratives, institutional messaging, and commercial content. Understanding infodemics therefore requires attention not only to problematic content itself, but also to the structural and relational characteristics of the information ecosystem through which it spreads [5].

The Special Report on Trust and Health, of the 2025 Edelman Trust Barometer, highlights a shift in health-information trust from institutional to informal sources amid increasing digitalization [6]. Trust in media reporting on health has declined to 44%, while confidence in individuals' ability to find trustworthy information (76%) and evaluate medical advice (71%) has increased. Among younger people, 34% reported disregarding medical advice in favor of informal guidance and 28% relied on social media. In addition, 35% of the general population and 45% of young people believe that personal research can be as informative as professional medical expertise. Younger individuals are highly active in consuming and sharing health-related content on social media, with 64% regularly consuming such content and 59% sharing health-related information. Influence from individuals without formal medical credentials is substantial, affecting 45% of younger respondents [6].

In Serbia, patterns of trust reflect a broader historical and structural context. Previous research describes Serbia as a low-trust society characterized by persistently fragile institutional confidence [7]. Studies of institutional trust in post-socialist countries point to the long-term effects of political and economic transition, which have left public confidence in state institutions uneven and often unstable [8]. Regional evidence from the Western Balkans confirms that institutional and societal trust remain important determinants of public health behavior, including COVID-19 vaccination uptake, with particularly strong associations observed in Serbia [9]. The same study emphasizes the influence of misinformation, conspiracy beliefs, and information overload during the pandemic, indicating that fragile institutional trust operates within complex and often polarized information environments. The available evidence points to a context of constrained institutional confidence and heightened susceptibility to infodemic dynamics.

Social listening represents a systematic approach to observing, collecting, and analyzing public sentiments, beliefs, attitudes, and narratives within a given community. It aims to identify collective perceptions, knowledge gaps, emotional responses, and behavioral intentions related to health risks, scientific evidence, and public policies [10]. Data used in social listening may originate from diverse sources, including digital platforms, traditional media, health systems, epidemiological data, and socio-behavioral research [11]. When integrated with complementary indicators such as search trends and epidemiological patterns, social listening enables the structured identification and categorization of circulating narratives. This process forms the basis for generating infodemic insights, which synthesize key concerns, uncertainties, and areas of disagreement in order to inform proportional and context-sensitive public health responses [10]. A central component of the infodemic insights approach involves assessing the potential risk associated with each identified narrative according to predefined criteria [12].

Previous studies have demonstrated the feasibility of applying artificial intelligence (AI) to social listening and infodemic monitoring. The WHO Early AI-supported Response with Social Listening platform illustrates AI-assisted real-time monitoring of online COVID-19 conversations using machine learning-based categorization [13], while methodological work on infodemic signal detection has proposed structured approaches for identifying and prioritizing emerging concerns and information voids [14]. A systematic scoping review documents widespread use of computational techniques, including sentiment analysis, topic modeling, and supervised classification, in vaccination-related social media monitoring, although these applications are often limited to discrete analytical tasks rather than integrated operational workflows [15]. More recently, large language models have demonstrated potential to accelerate inductive thematic analysis of large social media datasets when combined with human validation [16]. Similarly, AI-supported vaccine infodemic risk assessment systems have been developed that integrate machine learning, sentiment analysis, and misinformation detection into dashboard-based surveillance platforms to support immunization programs [17]. Although global guidance documents provide extensive conceptual and operational direction for social listening and integrated analysis, they offer limited practical instruction on how to systematically integrate artificial intelligence models into routine workflows [11, 12, 18, 19]. In particular, they do not specify how AI can be used to generate rapid and scalable infodemic insights within short timeframes and under limited human resource conditions.

Digital platforms have become key spaces where beliefs about contraception are formed, challenged, and shared. These environments frequently host emotionally charged or misleading narratives [20]. Contraceptive decision-making has long been influenced by informal social networks, where women exchange personal experiences about different methods, a process that digital platforms now extend into online spaces, where discussions frequently center on decision-making and perceived side effects [21, 22]. Previous analyses have shown that hormonal contraception is a topic of frequent misinformation online, with inaccurate or exaggerated claims undermining public trust in medical guidance [23, 24]. Globally, an estimated 121 million unintended pregnancies occur annually, of which approximately 61% end in abortion, with rates of unintended pregnancy remaining substantially higher in

middle-income countries compared to high-income settings [25]. Serbia, classified as an upper-middle-income country, reflects this pattern: despite the legal availability of abortion and modern contraceptive methods, national data indicate a continued reliance on induced abortion and comparatively low uptake of hormonal contraception, particularly among women with lower education and socioeconomic status [26, 27]. Given its social relevance, high degree of controversy, and the volume of online discourse, hormonal contraception presents an ideal case for testing a rapid framework for detecting and assessing health-related narratives within the information ecosystem.

2. Methods

This study aimed to develop and pilot a AI-supported framework integrating social listening with content and thematic analysis of narratives, followed by risk assessment, in the context of hormonal contraception in Serbia.

2.1. Framework design and process overview

Publicly available social media posts in textual, visual, and video formats were collected from most used platforms in Serbia, which were searched according to predefined criteria. During the data collection process, the authors strictly adhered to recommended ethical guidelines for working with data from digital sources [11], respecting the principles of user privacy and dignity. The identities of content creators, as well as any data that could lead to their identification, were fully protected and not included in the analysis.

Figure 1 shows the social listening and integrated analysis process diagram (the Framework). The Framework consisted of four sequential phases: developing a search strategy, identification of content, content processing, and analysis.

In line with ethical principles of transparency and responsible handling of large-scale data [11], all steps of the process, including data collection, transcription, analysis, and interpretation, are documented and presented in the following sections of the paper.

2.2. Search strategy development

First, we clearly identified the primary subject of investigation and determined relevant data sources. Hormonal contraception was selected as the primary topic, while most used social media platforms in Serbia served as the main sources of information. The choice of social media platforms was based on current data regarding internet use and the prevalence of social media within the population of the Republic of Serbia [28]. The platforms included in the analysis were YouTube, TikTok, and Instagram, selected due to their popularity, widespread usage, and the availability of persistent, publicly accessible content.

The definition of the search strategy included the use of thematically focused keywords and hashtags, the selection of appropriate sorting options adapted to each platform's specific features, and the application of clearly defined inclusion criteria. This approach enabled systematic, repeatable, and focused collection of digital data, while allowing flexibility in the scope of the search depending on available resources. Table 1 shows the thematically focused keywords and hashtags, sorting options, and inclusion criteria. The search terms were originally in Serbian language.

Table 1
Keywords, hashtags, sorting options, and inclusion criteria by platform

Social network	Search terms	Search results sorting	Inclusion criteria
Youtube	contraception, contraceptives, hormonal contraception, contraceptive pills, contraceptive tablets,	The search results were sorted by view count and relevance, and posts were reviewed in descending order of view count.	• The content was in Serbian or in a mutually intelligible regional language (e.g. Montenegrin, Bosnian, Croatian). • The content primarily addressed hormonal contraception or discussed hormonal contraception to an equal extent alongside other topics.
TikTok	morning-after pill, emergency contraceptive pill, plan b pill, intrauterine device, IUD, reproductive health	The search results were sorted using the “Top” category, and posts were reviewed in descending order of view count.	
Instagram	#contraception, #contraceptives, #hormonalcontraception, #contraceptivepills, #contraceptivetablets, #morningafterpill, #emergencycontraceptivepill, #planbpill, #intrauterinedevice, #IUD, #reproductivehealth	The search results were kept in the default sorting order, and posts were reviewed in descending order of like count.	

2.3. Identification of content and metrics extraction

To ensure balanced representation and manageability within the pilot framework, the sample was limited to 20 posts per platform, covering content from TikTok, YouTube, and Instagram. The collected content was sorted according to platform-specific popularity metrics and organized into databases, then selected based on the language of the post and thematic relevance, enabling the identification of digital narratives relevant for further analysis.

2.4. Content processing

Spoken content from video materials was transcribed using the Whisper automatic speech recognition model (version large-v3) [29], whereas textual content embedded in images was extracted using optical character recognition (OCR) via EasyOCR (version 1.7.2) [30]. Both methods enable the conversion of multimedia content into a unified textual format.

To ensure the accuracy and completeness of the transcripts, a structured quality control process was implemented to identify and correct errors introduced during automated speech transcription and OCR. In the first step, transcripts generated by the Whisper and EasyOCR pipelines were reviewed using a large language model (LLM), ChatGPT (version 4.5) [31], which was instructed to detect and correct transcription-level errors and typographical inconsistencies without altering sentence structure, grammar, or word order. In the second step, a researcher conducted a final manual verification by reading all transcripts and re-listening to or re-viewing the original multimedia posts to identify and correct any remaining errors not captured during the automated review. This two-stage quality control process provided an additional layer of validation and ensured the reliability of the final textual dataset. The output was a structured textual dataset that supports reliable content and thematic analysis.

The analysis was supported by Google Gemini (version 2.5 Pro) [32], an LLM which enabled rapid identification and classification of recurring themes and expressions within the dataset. This process consisted of the identification of inductive codes, which the LLM generated directly from the textual database based on recurring themes and modes of expression, as well as the recognition of deductive codes, which were predefined by the researcher and referred to commonly known concepts within the topic. The analysis was conducted using a predefined set of prompts based on chain-of-thought prompting [33], whereby the LLM was instructed to generate its reasoning step by step, for greater consistency, transparency, and reproducibility of the coding process. The prompts and chain-of-thought prompting used for various phases of the LLM-assisted content analysis are provided in **Additional file 1**.

During the coding process, the LLM was further instructed that, for each identified narrative, it must explicitly link the narrative to the underlying data by quoting at least one representative sentence from the corresponding transcript, with the quoted excerpt itself serving as justification for the narrative assignment. The researcher subsequently reviewed each narrative–quote pairing to confirm its appropriateness and accuracy. This step functioned as an additional quality control mechanism, to ensure transparency of the coding decisions and strengthening the traceability between narratives and the original data.

To further enhance analytical reliability, the content and thematic analysis was repeated multiple times using the same large language model and an identical, predefined chain-of-thought prompt structure. The results of all analytical iterations were then manually integrated by the researcher into a single consolidated dataset containing all identified codes, their frequencies, and associated transcripts. This researcher-led integration functioned as an additional quality control step and produced the final database used for subsequent analytical stages, including the risk assessment of individual narratives.

2.5 Narrative risk assessment

Narrative risk assessment represented the final stage of the analytical process, aimed at systematically evaluating identified narratives according to predefined criteria. Each narrative was assessed across two dimensions: the exposure of social media users to the narrative and the severity of potential health outcomes the narrative may have (see Fig. 2).

The exposure dimension (Ex) reflects the likelihood that social media users are exposed to a given narrative and potentially act in accordance with it. Exposure was operationalized using a scoring system applied to four quantitative components: narrative frequency (Fr), reach (Re), user interactions (In), and source authority (Au). Each component was independently scored based on predefined criteria reflecting its relative contribution to user exposure. Narrative frequency represents how often a specific narrative appears across the analyzed dataset. Narrative frequency was scored from 0 to 2 points depending on how frequently the narrative appeared in the dataset (low frequency = 0, medium = 1, high = 2). Reach captures the estimated number of users potentially exposed to content conveying the narrative across platforms. Reach was scored from 0 to 3 points based on the logarithmically normalized average reach of posts containing the narrative (negligible < 3.00 = 0; small 3.00–3.99 = 1; medium 4.00–4.99 = 2; large > 4.99 = 3). User interactions reflect the level of audience engagement, including likes, comments, shares, and saves, while source authority indicates whether the narrative was predominantly disseminated by healthcare professionals or by lay individuals. User interactions were also scored from 0 to 3 points using normalized engagement metrics (negligible < 2.50 = 0; small 2.50–3.49 = 1; medium 3.50–4.49 = 2; high > 4.49 = 3). Source authority contributed either 1 point when the narrative was predominantly communicated by lay individuals or 2 points when healthcare professionals were responsible for the majority of the content.

The four component scores were summed to obtain a cumulative exposure score ranging from 1 to 10. This cumulative score was subsequently converted into an exposure level (Ex) ranging from 1 to 5, where 1 represents very low exposure and 5 represents very high exposure. Specifically, cumulative scores of 1–2 corresponded to Ex = 1 (very low), 3–4 to Ex = 2 (low), 5–6 to Ex = 3 (moderate), 7–8 to Ex = 4 (high), and 9–10 to Ex = 5 (very high).

The health outcome dimension (Oc) was assessed by the Authors, considering potential outcomes related to health behavior, risk taking, and user perception, and was tailored to the specific topic under investigation. Each narrative was assigned a level of potential impact, ranging from a positive outcome (0 points) to severe health outcomes (5 points). A narrative classified as having a positive outcome was not subjected to further risk assessment, as it does not represent a public health concern.

The overall risk score was calculated by multiplying the narrative's exposure and health outcome scores, resulting in a final value that fell into one of four risk categories: low, moderate, high, or very high (see Fig. 4). This classification system was adapted from the World Health Organization's methodology for infodemic insights reporting [12].

Low risk narratives have limited relevance to the population, appear infrequently, generate little user engagement, and are not associated with potential negative effects on health behavior. Moderate risk narratives show some presence across platforms, may resonate with local concerns or uncertainties, and can provoke modest emotional responses or behavioral hesitation. High risk narratives are widely disseminated, strongly engage users, and show systematic evidence of influencing perceptions or health-related decisions across multiple communities. Very high-risk narratives are extensively disseminated, emotionally charged, and closely linked to harmful behaviors or loss of trust in health institutions, often requiring immediate public health intervention. This approach enables the mapping of narratives with potential public health relevance and serves as a foundation for further recommendations, interventions, and public communication strategies.

3. Results

A total of 60 social media posts were included in the analysis. Through LLM-assisted content analysis, 17 distinct narratives (codes) were inductively identified across these posts. Table 2 presents the identified narratives grouped into common themes, accompanied by selected representative transcript excerpts used to support and verify the narratives encompassed within each theme.

A major thematic domain focuses on the lived bodily and psychological experiences of hormonal contraception, encompassing a wide spectrum of user accounts. These narratives range from positive reports regarding improved dermatological health and menstrual regularity to significant adverse experiences, including weight gain, emotional distress, and physical "chaos" following the discontinuation of the medication. A second theme characterizes the framing of emergency contraception, which is frequently described through a risk-oriented lens. In these accounts, the morning-after pill is often metaphorically termed a "hormone bomb" and associated with potential misuse, though this is occasionally countered by narratives emphasizing its legitimacy and effectiveness for pregnancy prevention when used appropriately. The role of medical authority and professional guidance represents a third significant theme, where content emphasizes the necessity of gynecological consultation and the use of hormonal methods as therapeutic interventions for endocrinological disorders like polycystic ovary syndrome (PCOS). The analysis revealed a theme of system-level distrust, reflecting a lack of institutional confidence. Narratives within this category suggest that pharmaceutical companies may intentionally underreport risks to protect commercial interests and critique the accessibility of emergency contraception without adequate professional guidance. This skepticism often coincides with a fifth theme regarding perceived biological imbalance, in which synthetic hormones are viewed as "unnatural" disruptors. These narratives promote holistic health, lifestyle modifications, and natural alternatives as superior methods for managing hormonal health. Finally, contraception is framed within a broader context of social responsibility and education. These narratives critique biomedical solutions as temporary "patches" that mask underlying health issues rather than resolving them and highlight the persistent nature of contraception as a taboo topic in Serbia.

Table 2
Common themes and representative transcript excerpts

Theme	Transcript excerpts
Lived bodily and psychological experiences of hormonal contraception, encompassing both perceived benefits and adverse effects.	"While I was taking them, I felt wonderful. Everything was great. My cycles were regular, you knew to the hour when your period would come, my skin was excellent, everything was in perfect order." "I was extremely emotional. I felt like crying over everything. I was very dissatisfied, just everything felt terrible. I literally felt unpleasant to myself." "Those pills affected me very severely. I gained a lot of weight while taking them, around 10 kilos, even though I did not significantly change the way I was eating." "When I finally stopped taking the pill, my body was in chaos. Irregular cycles, absence of ovulation, extremely painful periods, nutritional deficiencies."
Framing of emergency contraception as risky, frequently misused, or appropriate only under specific conditions.	"Morning-after pills are what gynecologists also refer to as a hormone bomb. It is a hormonal bomb that you introduce into your body." "The pill can also be used multiple times within a single menstrual cycle, but this is not recommended as a form of long-term contraception." "The morning-after pill, that is, emergency contraception, effectively reduces the risk of pregnancy after unprotected sexual intercourse when used correctly."
Medical authority and professional guidance in shaping contraceptive decision making.	"No, do not worry. You will not gain weight from hormonal contraception. On the contrary, certain pills lead to stabilization of body weight or even to weight reduction." "I want to emphasize right at the beginning that contraceptive pills should be taken in agreement and consultation with your gynecologist." "Unlike other pills that contain hormones, the morning-after pill has no contraindications. For this reason, it can be purchased without a prescription and can be taken by anyone." "We prescribe contraception as a form of treatment, of course also in cases of irregular menstruation or other endocrinological, that is, hormonal disorders."
System-level distrust and perceived underreporting of risks by pharmaceutical and healthcare institutions.	"Because if the pharmaceutical companies came out and said, 'your hormones will be disrupted for two years,' maybe some girls would think, 'hmm, maybe I should not buy them,' but then sales would not go through." "The first thing I do not like is that you can simply buy that pill. You walk in and say, 'Hello, I would like a morning-

Theme	Transcript excerpts
	after pill,' and they give it to you and sell it to you, without any instructions or guidance."
Perceived biological imbalance and natural health alternatives to hormonal contraception.	"Contraceptive pills and other forms of hormone therapy that contain estrogen can significantly reduce levels of B vitamins in the body, particularly vitamin B6, vitamin B12, and folic acid." "I am really not a supporter of any synthetic hormones. I believe that we should view true health primarily from a holistic perspective." "We started eating properly, we started nourishing ourselves the right way, we started taking vitamins, minerals, and plant-based products, and we started engaging in physical activity."
Contraception framed through responsibility, education, and perceived inadequacy of biomedical solutions.	"When we understand that this is only a patch on a wound that needs to be stitched, and not a real solution." "If you were taking the pill because of skin problems, it is very likely that acne will return, because the pills only mask the problem and do not resolve it." "One third of young people do not use any form of contraception. Intrauterine devices, condoms, pills, these are all options we need to know more about. Sexual education must not be a taboo." "It is a fact that in Serbia contraception is a taboo topic and that contraception practically does not exist."

Health outcome scores (Oc) were assigned to all 17 identified narratives. Of these, eight were classified as expressing a positive outcome and were therefore excluded from further risk assessment, as they do not represent a public health concern. They commonly highlighted the therapeutic use, safety, and benefits of hormonal contraception as endorsed by medical professionals. The remaining nine narratives were evaluated by a public health specialist and assigned Oc scores ranging from 1 to 5. These narratives were subsequently evaluated across four exposure dimensions (Ex): narrative frequency (Fr), reach (Re), user interactions (In), and source authority (Au). All 17 identified narratives, including those with positive outcomes, are presented in Table 3.

Table 3

Identified narratives, their health outcome score (Oc) and exposure dimension scores (Fr – frequency, Re – reach, In – interactions, Au – authority)

Narrative	Oc	Fr	Re	In	Au
Personal negative experiences during or after the use of hormonal contraception involving psychological side effects	4	1	2	2	1
Personal negative experiences during or after the use of hormonal contraception involving physical side effects	4	2	2	1	1
The morning-after pill is a dangerous "hormonal bomb" that is misused and may lead to serious consequences	4	1	2	1	2
Experts (doctors and pharmacists) demystify fears, correct misinformation, and emphasize the positive effects of contraceptive pills	Positive sentiment				
The morning-after pill is a legitimate and effective emergency contraception method that should be used as soon as possible	Positive sentiment				
Contraceptive pills are seen as a temporary solution that does not treat the underlying issue but merely masks it	3	1	2	2	1
The IUD (intrauterine device) is presented as an effective long-term contraceptive method, supported by personal experiences and expert explanations	Positive sentiment				
The importance of consulting a doctor or pharmacist before using any form of hormonal contraception is emphasized	Positive sentiment				
The use, or absence of contraception is framed as a broader social issue involving irresponsibility, lack of education, and insufficient communication	1	1	2	1	2
The healthcare system and pharmaceutical industry are criticized for a lack of transparency and profit-driven motives	2	0	3	2	2
A narrative on the unnaturalness of synthetic hormones, promoting alternative "natural" solutions to hormonal issues instead of contraceptive pills	5	1	1	1	1
A narrative on the therapeutic use of hormonal contraception to treat medical conditions (PCOS, endometriosis, acne, painful periods)	Positive sentiment				
Positive experiences and benefits during the use of hormonal contraception	Positive sentiment				
Issues following the discontinuation of hormonal contraception (e.g., acne, amenorrhea, post-pill syndrome)	4	1	2	1	1
Emergency contraception is for urgent cases only and is not a substitute for regular contraception	Positive sentiment				
A narrative portraying hormonal contraception as a safe and beneficial medical option recommended by healthcare professionals	Positive sentiment				

Narrative	Oc	Fr	Re	In	Au
A narrative linking hormonal contraception to deficiencies in vitamins and minerals	2	0	1	1	1

The nine narratives identified as potentially harmful were prioritized according to their health outcome (Oc) scores, which quantify their potential for negative impact on public health. The highest assigned health outcome score of 5 was attributed to the narrative portraying synthetic hormones as "unnatural" and advocating for "natural" solutions, which exhibited moderate presence across the exposure dimensions with a frequency (Fr) of 1, a reach (Re) of 1, and an interaction (In) score of 1, primarily disseminated by lay individuals (Au=1). Within the group of narratives assigned an Oc score of 4, the account of personal negative physical experiences demonstrated the highest frequency (Fr=2) and moderate reach (Re=2), though it generated relatively lower audience engagement (In=1) and was characterized by low source authority (Au=1). In contrast, the narrative concerning negative psychological side effects (Oc=4) showed a lower frequency (Fr=1) but higher audience interaction (In=2), while maintaining a reach (Re) of 2 and an authority score (Au) of 1. Notably, the characterization of the morning-after pill as a dangerous "hormonal bomb" (Oc=4) was marked by high source authority (Au=2), suggesting influence from professional or perceived expert sources, despite recording a frequency (Fr) of 1, reach (Re) of 2, and interaction (In) score of 1. The final narrative in this high-impact category, regarding issues following the discontinuation of contraception, recorded scores of 1 for frequency, interaction, and authority, with a reach of 2.

Among the narratives with moderate to lower health outcome scores, the narrative framing contraceptive pills as a temporary "masking" solution was assigned an Oc score of 3 and showed notable audience engagement (In=2) and reach (Re=2), despite a frequency (Fr) of 1 and low source authority (Au=1). Among narratives with an Oc score of 2, the critique of the healthcare system and pharmaceutical industry exhibited the highest reach recorded in the dataset (Re=3) and high interaction (In=2), supported by high source authority (Au=2), even though its recorded frequency (Fr) was 0. The narrative linking hormonal contraception to vitamin and mineral deficiencies (Oc=2) recorded minimal exposure metrics, with a frequency of 0 and scores of 1 for reach, interaction, and authority. Finally, the narrative framing contraception as a broader social issue received the lowest health outcome score of 1 but demonstrated significant potential for dissemination with high source authority (Au=2), a reach (Re) of 2, and frequency (Fr) and interaction (In) scores of 1.

Risk assessment results for the nine narratives that were not classified as expressing a positive sentiment are presented in Table 4. The overall risk score for each narrative was then calculated by multiplying the exposure (Ex) score by the corresponding health outcome score (Oc).

Table 4
Identified narratives and their risk levels (Oc – health outcome, Ex – exposure)

Narrative	Oc	Ex	Risk (Oc x Ex)
Personal negative experiences during or after the use of hormonal contraception involving psychological side effects	4	3	High (12)
Personal negative experiences during or after the use of hormonal contraception involving physical side effects	4	3	High (12)
The morning-after pill is a dangerous "hormonal bomb" that is misused and may lead to serious consequences	4	3	High (12)
Contraceptive pills are seen as a temporary solution that does not treat the underlying issue but merely masks it	3	3	Moderate (9)
The use, or absence of contraception is framed as a broader social issue involving irresponsibility, lack of education, and insufficient communication	1	3	Low (3)
The healthcare system and pharmaceutical industry are criticized for a lack of transparency and profit-driven motives	2	4	Moderate (8)
A narrative on the unnaturalness of synthetic hormones, promoting alternative "natural" solutions to hormonal issues instead of contraceptive pills	5	2	High (10)
Issues following the discontinuation of hormonal contraception (e.g., acne, amenorrhea, post-pill syndrome)	4	3	High (12)
A narrative linking hormonal contraception to deficiencies in vitamins and minerals	2	2	Moderate (4)

The analysis identified narratives related to hormonal contraception, classified into high, moderate, and low risk categories, as well as positive sentiment narratives. High-risk narratives, characterized by risk scores ranging from 10 to 12, represent the most critical areas for public health attention identified within the digital information ecosystem. Four specific narratives attained the highest recorded risk score of 12: personal negative psychological experiences, personal negative physical experiences, the portrayal of the morning-after pill as a dangerous "hormonal bomb," and health issues following the discontinuation of hormonal contraception. Each of these narratives was characterized by a high potential for adverse health outcomes (Oc=4) coupled with a moderate level of audience exposure (Ex =3). Additionally, the narrative concerning the "unnaturalness" of synthetic hormones and the promotion of alternative natural solutions was classified as high risk with a score of 10, driven by the highest recorded potential for harm (Oc=5) despite a lower exposure level (Ex=2).

Moderate risk narratives were identified for the portrayal of contraceptive pills as a temporary solution (Risk = 9), systemic criticism of the healthcare and pharmaceutical industries (Risk = 8), and the narrative linking contraception to vitamin and mineral deficiencies (Risk = 4). Notably, the critique of the healthcare and pharmaceutical systems achieved its moderate risk status primarily through the highest recorded

exposure score in the study ($Ex=4$), which offset its lower health outcome score ($Oc=2$). The narrative framing contraceptive pills as a "masking" solution received a score of 3 for both dimensions. Finally, the narrative framing the use or absence of contraception as a broader social issue was the only theme classified as low risk, with a score of 3, resulting from the lowest assigned health outcome score ($Oc=1$) notwithstanding its moderate exposure level ($Ex=3$).

Positive narratives highlighted the safety, therapeutic uses, and benefits of hormonal contraception, endorsed by medical professionals.

4. Discussion

In this study, we developed and tested a rapid, reproducible framework that combines social listening with integrated content analysis and narrative risk assessment. Applied to social media discussions on hormonal contraception in Serbia, the framework enabled the identification of multiple narratives circulating across platforms and their classification according to potential public health risk. The findings highlight the coexistence of narratives emphasizing negative experiences and perceived risks of hormonal contraception alongside those promoting its safety and the importance of professional consultation. Together, these results illustrate the complexity of the online information ecosystem and demonstrate the potential of the proposed framework to rapidly identify narratives with public health relevance, especially during health emergencies.

The analysis revealed several recurring thematic patterns in online discussions on hormonal contraception. A prominent theme involved lived bodily and psychological experiences with hormonal contraception, encompassing both perceived benefits and adverse effects. Other narratives framed emergency contraception as risky, frequently misused, or appropriate only under specific conditions. Discussions also frequently emphasized the role of healthcare professionals in guiding contraceptive decisions, while some narratives expressed broader distrust toward pharmaceutical companies and healthcare institutions. In addition, several narratives promoted "natural" approaches and framed hormonal contraception as potentially disruptive to biological balance, whereas others presented contraception within a broader context of personal responsibility, education, and perceived shortcomings of biomedical solutions.

Our findings align with previous studies examining contraceptive discussions and decision-making. Research has shown that women frequently evaluate hormonal contraception through the lens of personal experiences and perceived side effects, often drawing on narratives of bodily and psychological experiences with contraceptive methods [20]. Concerns about risks, particularly regarding emergency contraception and potential adverse effects, have also been identified as an important factor shaping attitudes toward contraceptive use [24]. Other studies highlight the role of healthcare professionals in shaping contraceptive decision making, while also documenting tensions between medical authority and experiential knowledge, including skepticism toward pharmaceutical companies and healthcare institutions and perceptions that clinical encounters may not always provide sufficient space for

discussing women's experiences with contraception [22, 23]. In addition, research suggests that contraceptive decision making is frequently framed within broader discussions of responsibility, knowledge, and informed decision-making [26]. The alignment between literature data and the results of our analysis validate our approach.

Some of the thematic patterns identified in our analysis, including perceptions of health risks, trust in medical authority, and the framing of health decisions through responsibility and personal experience, resemble broader communication dynamics observed in public health emergencies and disaster contexts. Research on risk communication has shown that individuals often interpret health-related information through narratives of perceived risk, trust in institutions, and experiential knowledge when making decisions in situations of uncertainty [34, 35]. These parallels suggest that similar narrative mechanisms may shape public understanding of health interventions across different health communication environments.

Our analysis using the proposed Risk Assessment Framework identified seventeen narratives, eight of which were classified as having a positive outcome (and therefore not subjected to further risk assessment), while nine were scored and allocated to low, moderate, and high risk categories (no very high-risk narratives were observed in this sample). Several of the narratives classified as high risk (usually with a high potential health outcome score and moderate exposure score) in our analysis centered on perceived health risks associated with hormonal contraception, particularly personal experiences involving psychological and physical side effects, concerns about post-contraception health problems, and the portrayal of emergency contraception as a dangerous "hormonal bomb." Similar themes have been documented in previous research, where concerns about side effects represent one of the most frequently cited reasons for rejecting or discontinuing hormonal contraception [20]. A qualitative study of discussions around emergency contraception (EC) in Spain reports an explicit quotation where participants describe EC as "a hormonal bomb for your body", providing concrete evidence that at least some users characterize hormonal contraceptive methods in this extreme way [36]. Interestingly, in our sample the negative theme is used more general referring to hormonal contraception. On the other hand, another quote in the same Spanish study notes that participants associated EC with abortion notions, reflecting moralized framings that accompany some narratives about hormonal contraception, which is not seen in our sample – indicating potential cultural differences between Spain and Serbia. In digital environments, however, such concerns may be amplified through personal testimonies and anecdotal accounts that attribute a wide range of symptoms to hormonal contraception. This pattern aligns with broader evidence indicating that social media platforms frequently host misleading or exaggerated claims related to women's reproductive health, contributing to distorted risk perceptions about contraceptive methods [24].

Another high-risk narrative identified in our analysis framed hormonal contraception as "unnatural" and potentially disruptive to the body's biological balance, while promoting alternative or "natural" approaches to managing hormonal health. Similar attitudes have been documented in previous research examining contraceptive decision making. A systematic review found that preferences for hormone-free

or “more natural” contraceptive methods were frequently cited as an important factor shaping contraceptive choices [20]. In addition, studies of reproductive health behaviors in Serbia suggest that individuals often rely on less effective or “natural” or “traditional” contraceptive practices rather than hormonal methods [26]. Such narratives also reflect broader communication patterns observed in online media environments, where alternative health practices are frequently promoted through appeals to naturalness, tradition, and convenience, often without clear scientific evidence supporting the claims [37].

Among the narratives identified in our analysis, several emphasized the importance of consulting healthcare professionals before using hormonal contraception. These narratives were classified as positive sentiment narratives and therefore were not subjected to risk assessment. Notably, no narratives explicitly undermining the authority or credibility of healthcare professionals were identified in the analyzed sample. This finding differs from patterns reported in previous studies examining online discussions on hormonal contraception. Research has documented increasing skepticism toward medical institutions and pharmaceutical companies in digital environments, where online communities may challenge medical expertise or promote alternative interpretations of health risks [23, 24]. In contrast, the narratives identified in our dataset frequently framed healthcare professionals as a trusted source of guidance in contraceptive decision making, and no narratives explicitly undermining medical authority were observed. Similar dynamics have also been reported in qualitative research, where women were found to trust healthcare providers as sources of contraceptive information while simultaneously relying on advice and experiences shared within their social networks [38]. The common suggestion to consult health professionals in social media posts might primarily be used as a disclaimer by lay persons sharing their experience and advice online, and there are no studies offering evidence regarding the frequency in which this suggestion is actually followed.

Proposing an innovative, AI-assisted method for online social listening and risk assessment requires strong quality control, which was implemented at multiple stages of the data processing and analysis pipeline in our study to ensure the accuracy, consistency, and traceability of the final dataset. Transcripts generated through automated speech recognition and optical character recognition were reviewed using a large language model to identify transcription errors and typographical inconsistencies without altering the original sentence structure or wording. This automated review was followed by a full manual verification, during which the researcher re-examined all transcripts and compared them with the original multimedia content to identify and correct any remaining inaccuracies. Previous research has demonstrated the value of human checks against AI outputs to ensure fidelity to the original audio and to verify consistency across translations or adaptations [39, 40]. Although in our study, a human check was done on the whole sample, a common suggestion for larger datasets would be to allocate independent human checks on a subset (e.g., 10–20%) of transcripts to estimate error rates and bias [39].

Chain-of-thought (CoT) prompting has been used in literature to elicit more interpretable AI reasoning pathways, but CoT prompts should be followed by strict human review and grounding in the data.

Evidence from AI-assisted thematic analysis literature indicates that prompting strategies (including stepwise or definition-based prompts) can influence AI classification behavior and reliability; thus, human oversight remains essential [41–43]. In our study, the LLM-assisted thematic analysis was conducted using a predefined chain-of-thought prompting structure, which instructed the model to generate its reasoning step by step before assigning codes. This approach improved analytical transparency and helped reduce inconsistent or superficial classifications. For each transcript assigned to a given narrative, the LLM was required to provide the exact quotation from the transcript that justified the narrative classification. The researcher subsequently reviewed every narrative–quotation pair to verify its accuracy and contextual appropriateness. This practice supports auditability and allows readers to verify interpretations directly against the source data, aligning with recommended practices for transparent qualitative analysis that integrates AI assistance [39, 40, 42].

To further enhance analytical reliability, the coding process was repeated multiple times using the same large language model and an identical prompt structure. The results of all analytical iterations were then manually integrated by the researcher into a single consolidated dataset containing all identified codes and their associated transcripts. While this multi-stage validation approach strengthened the reliability of the textual corpus and improved the transparency and traceability of the narrative identification process, it required additional resources. Researchers should weigh resource constraints and report the extent of retesting they performed to enable interpretation of dataset quality [44].

Several limitations should be considered when interpreting the findings of this study. The analysis was based on a relatively small sample of social media posts ($N = 60$), which was intentionally limited as part of the design used to test the feasibility of the proposed Risk Assessment Framework. As a result, the restricted sample size may not fully capture the diversity of narratives circulating across digital platforms. Nevertheless, the identified narratives fit well into the existing body of literature regarding the topic at hand which validates our approach. Future applications of the framework could and should include larger datasets and advanced sampling strategies to improve representativeness and quantitative comparisons between narratives and platforms. In real-life scenarios, expanding the dataset until thematic saturation is reached, where additional content is analyzed until no new narratives or themes emerge in the dataset should be considered [45]. Although the use of large language models enabled rapid processing and thematic coding of multimedia social media content, LLM-assisted analysis may introduce potential sources of bias related to prompt design, model variability, and interpretation of textual context. Previous studies have shown that LLM-generated themes may not fully correspond to those identified through manual qualitative analysis and that variability between repeated model runs may occur [16]. In this study, these risks were mitigated through standardized prompting, repeated analytical iterations, and human verification of narrative assignments. Nevertheless, future research should continue exploring hybrid analytical approaches that combine automated coding with independent human validation in order to further strengthen analytical reliability. The identification and classification of narratives in this pilot study relied on inductive thematic analysis rather than on a predefined taxonomy of health narratives. While this approach allowed for the flexible detection of emerging themes in the dataset, the absence of a standardized narrative taxonomy may limit

comparability with findings from other studies or monitoring systems. Future research could benefit from the development or adaptation of structured narrative taxonomies that enable more consistent categorization and cross-context comparison of digital health narratives, such as those proposed within social listening and infodemic monitoring frameworks [14, 46]. The assessment of potential health outcomes associated with identified narratives relied on evaluations conducted by a limited number of public health professionals. While expert judgment provides valuable contextual interpretation, the inclusion of a broader multidisciplinary panel could strengthen the reliability of health outcome scoring. Future implementations could benefit from structured expert consensus approaches, such as Delphi-based methods, which are commonly used in healthcare research to obtain consensus among experts in areas where empirical evidence is limited or uncertain [47]. The proposed framework currently relies on locally executed AI models for speech transcription and optical character recognition, which require access to GPU-enabled computational resources. This technical requirement may limit the immediate scalability of the approach in settings with restricted infrastructure. There is evidence that GPU-backed computing underpins feasible, scalable AI-assisted transcription and coding workflows, and that researchers frequently invoke hardware acceleration as a justification for practical deployment of GenAI tools in qualitative research workflows [48–50]. Future work should therefore explore alternative deployment strategies, including cloud-based solutions or lighter computational pipelines that could increase accessibility in resource-constrained environments.

5. Conclusion

This pilot demonstrates that rapid, reproducible social listening and narrative risk assessment can be conducted with AI-enabled tools by a small team on short timeframes. The framework identified multiple narratives, including several high-risk ones, thereby enabling prioritization of topics for action. Applying this approach allows public health systems to more quickly detect information gaps and risk patterns, target communication interventions, and align messaging with community needs. By optimizing and automating the analysis pipeline, expanding the sample, and using expert consensus for health outcome assessment this tool can be turned into a sustainable early-warning and decision-support mechanism.

Abbreviations

AI
artificial intelligence
OCR
optical character recognition
LLM
large language model
Ex
exposure
Fr
frequency

Re
reach
In
interactions
Au
authority
Oc
health outcome

Declarations

Ethics approval

Ethical approval was not required for this study as it relied solely on the collection and analysis of publicly available social media content. The research was conducted in strict accordance with recommended ethical guidelines for utilizing digital data sources, with a primary commitment to upholding the privacy and dignity of all users. To ensure the protection of individual identities, all personal identifiers and any data that could potentially lead to the identification of content creators were removed prior to analysis and were not included in the study findings. Furthermore, all procedures related to data collection, transcription, and interpretation adhered to established ethical principles of transparency and the responsible handling of large-scale data.

Consent for publication

Not applicable. This study does not contain any individual person's data in any form, including individual details, images, or videos, that would require specific consent for publication. All data analyzed in this research were obtained from publicly accessible social media platforms. To maintain the privacy and anonymity of the content creators, any data that could potentially lead to their identification were removed during the processing stage and were not included in the final analysis or manuscript.

Competing interests

None.

Funding

None.

Author Contribution

LP was responsible for the execution of the research, including the detailed development and refinement of the methodology, extensive testing and re-testing of the AI-supported pipeline, and the application of the framework to the dataset. LP also performed the primary data analysis, transcript verification, and

drafted the original manuscript. Both authors read and approved the final version of the manuscript. SMR was responsible for the conception of the study, including the development of the research aim and the primary methodology. As the laboratory coordinator, SMR provided overall oversight, coordination, and administrative supervision throughout the project, while also contributing to the data analysis and performing critical revisions of the manuscript for important intellectual content.

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Data Availability

The datasets generated and analyzed during the current study are not publicly available as the data are still undergoing further analysis, but they are available from the corresponding author on reasonable request. All other methodological materials, including the specific prompts and chain-of-thought structures utilized for the large language model-assisted content analysis, are included within this article and its supplementary information as Additional file 1.

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Figures

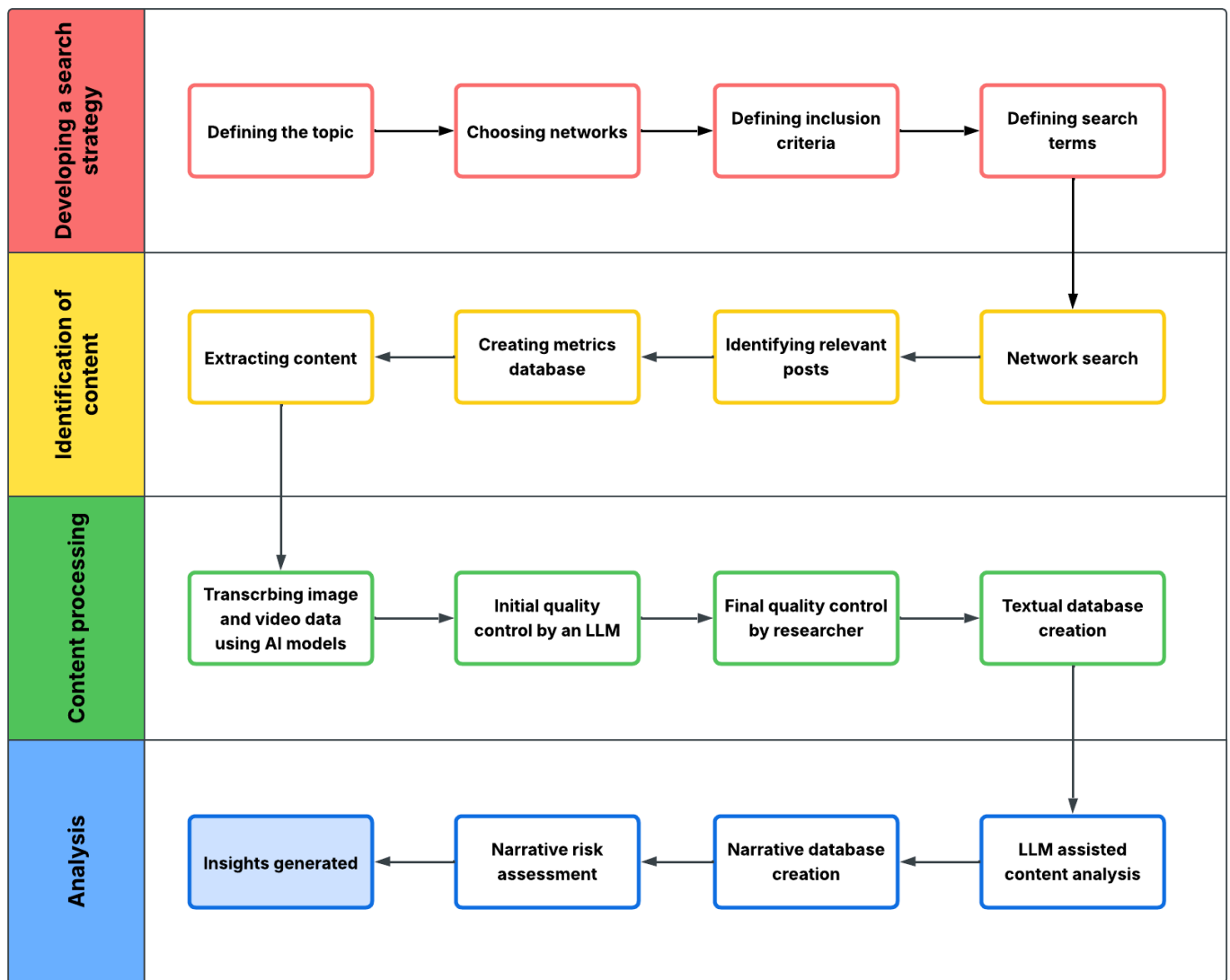


Figure 1

Figure 1. Social Listening and Integrated Analysis Process Diagram

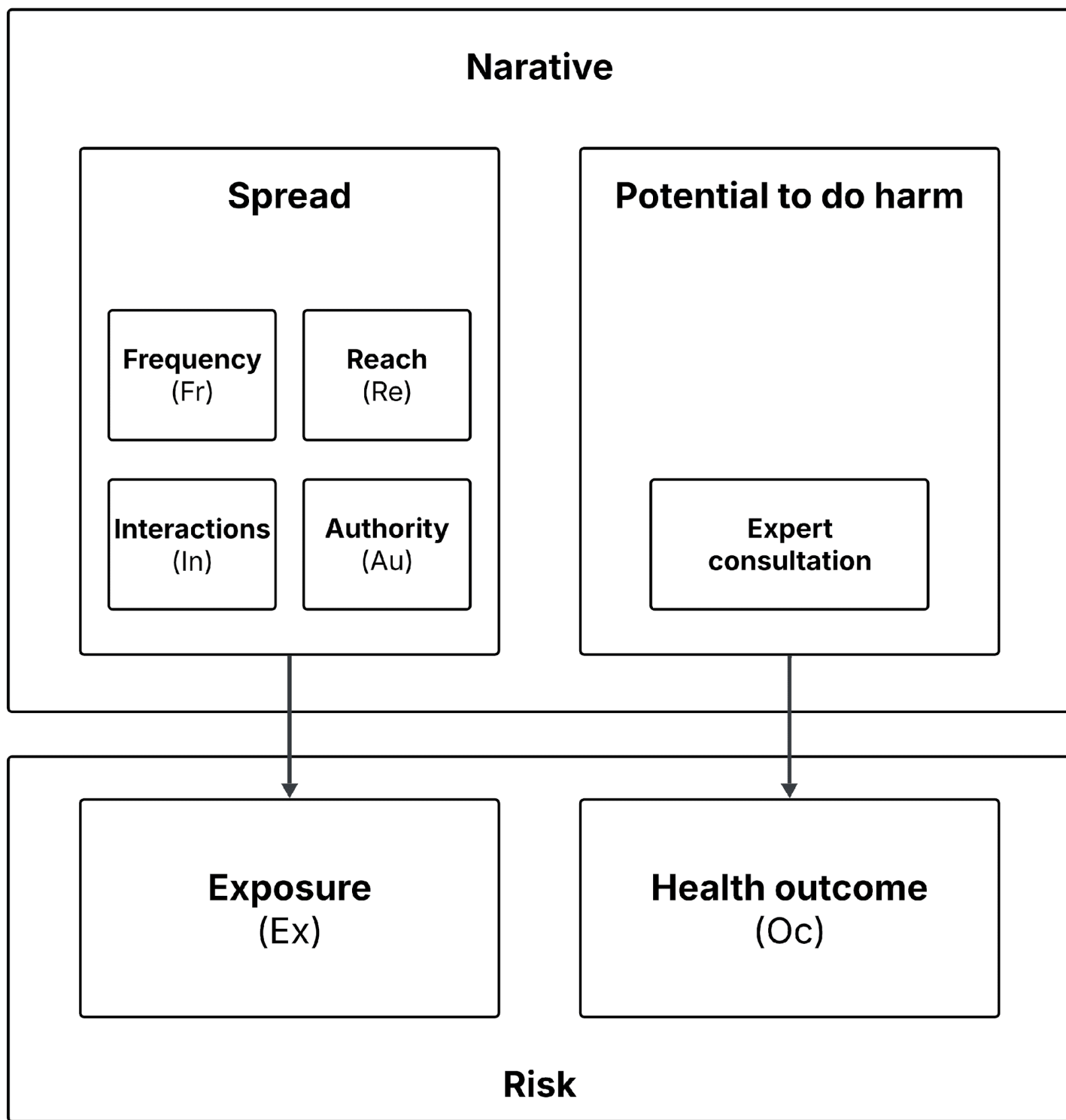


Figure 2

Figure 2. Narrative Risk Assessment Process Diagram

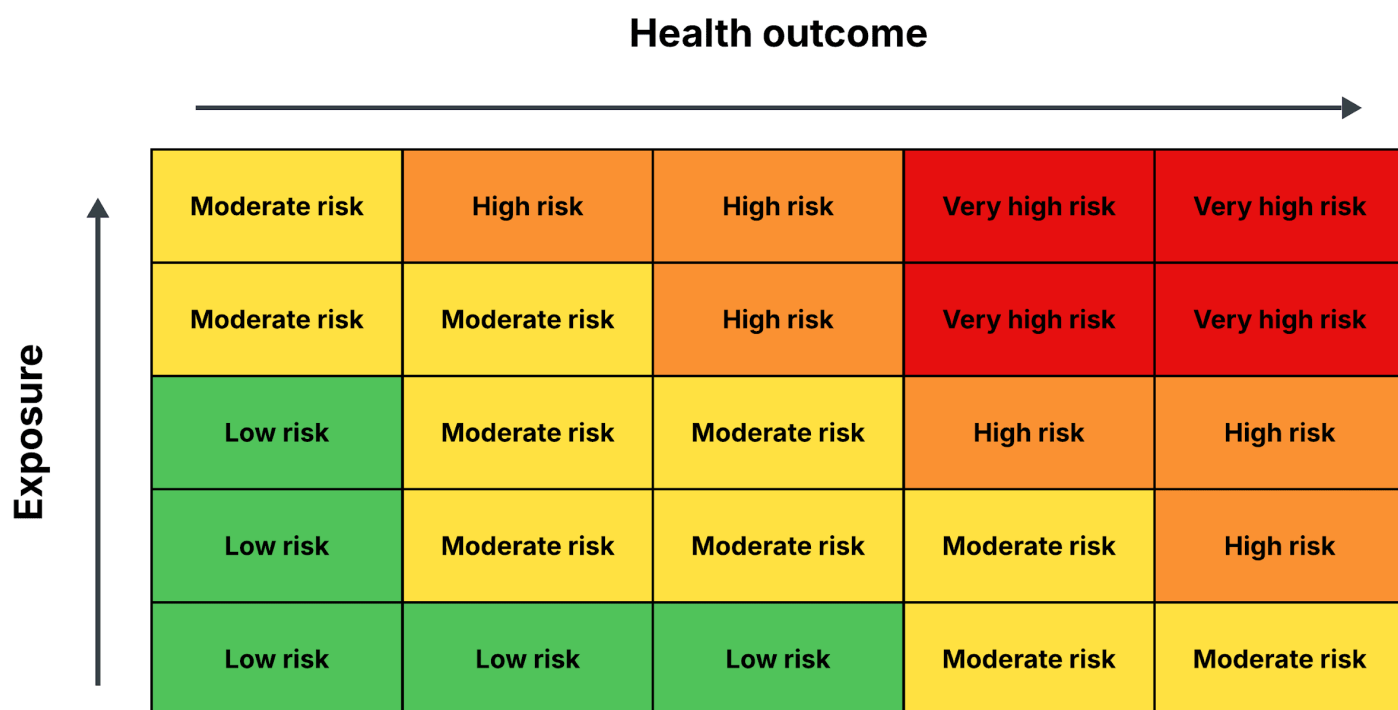


Figure 3

Figure 4. Narrative Risk Matrix

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