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ORIGINAL ARTICLE

Infodemiology of Anthrax in Indonesia: Insights from Google Trends (2014–2024)

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ABSTRACT

Background: Anthrax remains a persistent zoonotic disease in Indonesia, with recurrent outbreaks reported in endemic provinces such as Yogyakarta, Gorontalo, Central Java, and East Nusa Tenggara. Outbreak control is further challenged by the circulation of misinformation, which shapes community perceptions and undermines prevention efforts. Digital epidemiology offers opportunities to complement conventional surveillance by capturing public information-seeking behavior, yet its application in anthrax research in Indonesia remains limited.

Methods: This study analyzed temporal and spatial dynamics of public interest in anthrax using Google Trends data from January 2014 to December 2024. Two search terms, *antraks* (Indonesian) and *anthrax* (English), were examined to assess monthly patterns, regional distribution, and related search queries. Descriptive analyses were performed to identify peaks of interest, geographic differences, and themes of related and rising queries.

Results: Overall search activity was low and stable throughout the 11 years, with distinct peaks corresponding to outbreaks, most notably in July 2023 during the Yogyakarta outbreak. Regional analysis revealed Yogyakarta and Gorontalo as the dominant provinces of search activity. Linguistic patterns showed that *antraks* was more widely used in western Indonesia, while *anthrax* was relatively more frequent in eastern provinces. Related queries reflected demand for basic knowledge of symptoms, transmission, and prevention, while rising queries aligned with outbreak-related events.

Conclusion: Online search patterns mirror epidemiological risk, cultural context, and digital access. Infodemiology provides timely insights that may enhance outbreak preparedness and risk communication. Integrating digital surveillance with conventional monitoring can support more effective and locally relevant health education strategies for anthrax control in Indonesia.

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Introduction

Anthrax is a zoonotic disease caused by *Bacillus anthracis*, a gram-positive, spore-forming bacterium capable of persisting in the environment for decades, particularly in contaminated soil [1, 2]. *B. anthracis* might infect animals, especially livestock, and humans, with various routes of transmission including skin, inhalation, and ingestion of its spores [2–3]. Signs and symptoms differ depending on the route of infection, ranging from cutaneous, pulmonary, and gastrointestinal manifestations, with various degrees of severity [3].

Globally, anthrax continues to pose a public health challenge, with the highest burden reported in agricultural-based communities and rural areas with limited livestock health management, notably across Asia and Africa [3, 4], as well as in livestock-based communities where animal health management remains limited, particularly across Asia and Africa [1]. In Indonesia, human and animal cases have been consistently reported in several endemic provinces, with the greatest incidence over the past decade occurring in the Special Region of Yogyakarta (notably Gunungkidul District), as well as in Central Java, Gorontalo, East Nusa Tenggara, and South Sulawesi [4–7]. Case occurrence tends to recur, especially during the dry season, reflecting the long-term persistence of B. anthracis spores in soil and water sources within the same areas [8, 9]. These epidemiological data suggest that anthrax control is challenging, as outbreaks may reemerge even after prolonged periods without clinical cases.

Conversely, efforts in anthrax control are further challenged by the infodemic phenomenon, where an overabundance of information emerges during outbreaks and shapes community responses [10, 11]. As there is a range of information, from verified facts to misleading hoaxes, misconceptions persist among the community. For example, there is a belief that meat from dying animals is safe if thoroughly cooked, or the adoption of stigmas in particular communities [6, 8]. The rapid misinformation through social media reinforces high-risk behavior [12]. Therefore, there is an urgent need for robust, evidence-based communication strategies that are transparent, accessible, and easy to understand to improve the health literacy and strengthen the public trust in anthrax prevention [11, 12].

Digital epidemiology offers a promising approach to complement conventional surveillance. Google Trends has captured spikes in public interest during outbreaks, such as the Pacitan case in 2023, and revealed clusters of attention in endemic provinces, including Yogyakarta, Gorontalo, East Nusa Tenggara, and Central Java [4, 5, 12, 13]. However, such applications remain limited in anthrax research in Indonesia. This study, therefore, analyzes the temporal and spatial dynamics of public interest in anthrax using Google Trends and explores its potential to monitor perception, enhance preparedness, and strengthen risk communication [10].

Materials And Methods

Data Collection

We retrieved data on public search interest related to anthrax in Indonesia from **Google Trends** (https://trends.google.com/), an open-access web-based tool that analyzes the popularity of search queries in Google Search. The data covered the period from January 2014 to December 2024. We used two search terms: *antraks* (Indonesian term) and *anthrax* (English term), restricted to the geographic region of Indonesia. Monthly relative search interest scores (range: 0–100) were extracted for each term. We also collected regional distribution scores, top related queries, and rising queries provided by the platform.

Data Analysis

We performed descriptive analyses of the temporal trends, identifying months with unusually high interest scores (peaks). Regional distribution was summarized using relative scores per province. Related and rising queries were examined to identify recurring themes, potential misconceptions, and interest patterns linked to outbreaks. All analyses were performed using Microsoft Excel® for Microsoft 365 (Version 2506 Build 16.0.18925.20076, Microsoft Corporation, Redmond, WA, USA).

Data Presentation

Results were summarized using line charts to illustrate monthly trends of search interest over the 11 years. Regional distribution was presented in tabular format, showing the top provinces with relative scores and proportions of the two terms. Related and rising queries were displayed in a separate table. All visualizations were created and refined using Microsoft Excel® to ensure clarity and consistency.

Results

Temporal Trends in Search Interest

Public interest in anthrax remained low and stable between 2014 and 2024, with notable spikes (Figure 1). The highest monthly interest was observed in July 2023 for *antraks* (score = 100). Other peaks occurred in January 2017 (score = 20) and January 2020 (score = 17). The English term anthrax consistently had lower and more stable interest compared to *antraks*. Detailed monthly data are provided in Supplementary Table 1.

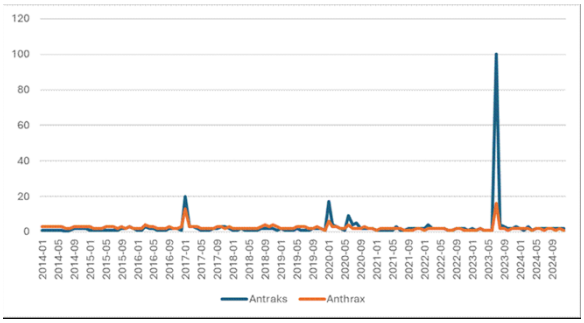
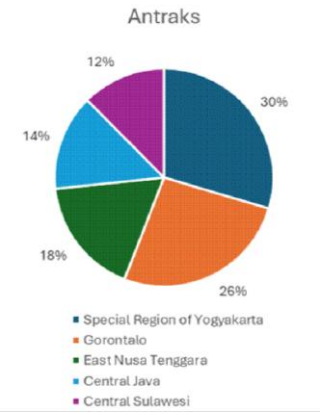


Figure 1. Monthly public search interest for *antraks* and *anthrax* in Indonesia, 2014–2024. The figure shows relative search interest (0–100) per month. Peaks correspond to reported outbreaks.

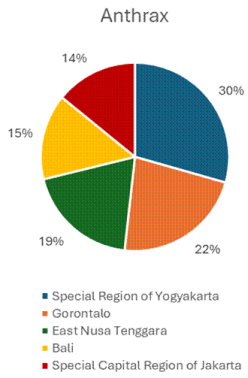
Regional Distribution of Search Interest

The highest interest for *antraks* was recorded in the Special Region of Yogyakarta (score = 100), followed by Gorontalo (89), East Nusa Tenggara (59), and Central Java (48). A similar pattern was observed for *anthrax*, with Yogyakarta (100) and Gorontalo (76) as the top regions (Supplementary Table 2).

Figure 2a and 2b illustrate the distribution of search interest for *anthrax*, respectively, across the top five provinces in Indonesia from 2014 to 2024. For *antraks*, the Special Region of Yogyakarta accounted for the largest proportion of searches (30%), followed by Gorontalo (26%). The search interest for *anthrax* was similarly concentrated in Yogyakarta (30%) and Gorontalo (22%). These findings highlight Yogyakarta and Gorontalo as consistently dominant regions for both terms, while Bali and Jakarta appeared only in the top five for anthrax.



(a)



(b)

Figure 2. Regional distribution of relative search interest in the top five provinces in Indonesia during 2014–2024, presented as pie charts. Panel **(a)** shows the distribution for the term antraks, while panel **(b)** shows the distribution for the term anthrax, based on Google Trends data.

Regional Dominance of *Antraks* and *Anthrax* Search Terms

The geographic distribution of dominant search terms revealed distinct patterns between western and eastern Indonesia (Figure 3). Most of western Indonesia, including Sumatra, Java, and Kalimantan, exhibited higher interest in the local term *antraks*, while several areas in eastern Indonesia, particularly the Maluku and Papua regions, showed relatively higher interest in the English term *anthrax*. This contrast reflects regional differences in language preference and search behavior, with *antraks* being more prominent in the west and *anthrax* more common in parts of the east. A detailed comparison of provincial-level proportions is provided in Supplementary Table 3.

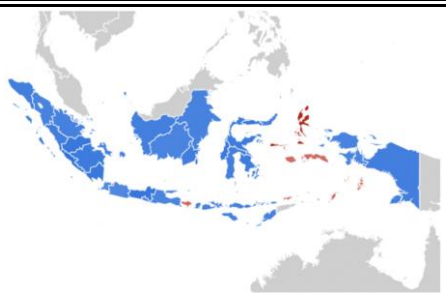


Figure 3. Geographic distribution of dominant search terms for anthrax in Indonesia (2014–2024). Map showing the geographic distribution of dominant search terms for anthrax in Indonesia based on Google Trends data (2014–2024). Provinces with higher relative search interest for *antraks* are shown in blue, while those with higher interest for *anthrax* are shown in red. The map base layer was obtained from Google Trends (https://trends.google.com/).

Related and Rising Search Queries

For *antraks*, the most common related queries included "penyakit antraks," "antraks adalah," and "gejala antraks," indicating interest in disease definition and symptoms (Table 1). Rising queries reflected public reaction to specific outbreaks, notably in Gunungkidul/Yogyakarta, with breakout queries such as "antraks gunung kidul" and "antraks di gunung kidul." For anthrax, similar patterns were observed, but mixed with unrelated queries (e.g., music band Anthrax). A detailed list of related and rising queries is provided in *Supplementary Table 4.*

Table 1. Top related and rising queries for "antraks" and "anthrax," Indonesia, 2014–2024.

Term	Top Related Queries (Score)	Top Rising Queries
Antraks	Penyakit antraks (100), antraks adalah (81), gejala antraks (15), antraks pada sapi (13)	Gunung kidul (Breakout), gejala antraks pada manusia (Breakout), ciri antraks pada manusia (Breakout)
Anthrax	anthrax penyakit (100), anthrax adalah (92), anthrax virus (43), anthrax pada sapi (26)	anthrax gunung kidul (Breakout), anthrax jogja (Breakout), anthrax di gunung kidul (Breakout)

Top related and rising search queries associated with "*antraks*" and "*anthrax*" in Indonesia (2014–2024) based on Google Trends data. Rising queries marked as "Breakout" indicate a relative increase of more than 5000% compared to the previous period, reflecting sudden spikes in public interest.

Discussion

Patterns of Online Search Interest

The monthly distribution of search interest illustrates a largely stable pattern with only occasional fluctuations over the past decade (Figure 1). Searches for *antraks* and *anthrax* remained low and relatively constant from 2014 to 2024, largely reflecting the rarity of major outbreaks, limited public exposure, and a gradual decline in media and research attention. During this period, no globally significant anthrax events or high-profile bioterrorism incidents occurred that might have sustained wider public or international interest. Reported cases were predominantly localized, particularly within rural or agricultural communities, and rarely escalated to a scale that could generate substantial concern or widespread search activity [15, 16]. As a neglected zoonotic disease with stable global distribution and generally Low risk to the wider population, anthrax remains largely absent from public discourse. Consequently, search volumes remained consistently low, mirroring the absence of ongoing urgency or widespread awareness [17].

At the same time, the relative stability of search activity can be interpreted as the outcome of persistent background factors. Endemic circulation in several Indonesian provinces sustains a baseline demand for information, particularly among livestock farmers, veterinarians, and other at-risk groups [4]. Educational initiatives, veterinary regulations, and continuous surveillance further reinforce this level of interest outside outbreak periods [18]. Collectively, these conditions indicate that anthrax-related information seeking in Indonesia is closely tied to its endemic nature and ongoing relevance for specific populations, reflecting a pattern common to neglected but persistent zoonotic diseases.

Although interest generally remained low, a notable deviation was observed in July 2023. The most pronounced surge occurred during this period, when searches for antraks reached a maximum score of 100, reflecting heightened public awareness. This increase coincided with an anthrax outbreak in Yogyakarta, which caused three fatalities and multiple infections following the consumption of contaminated livestock meat distributed through local tradition [7, 19]. The outbreak attracted widespread media attention and occurred near Eid al-Adha, a major religious festival involving increased livestock slaughter and meat consumption, which may have amplified both public concern and information-seeking. In response, the Directorate General of Livestock and Animal Health Services, Ministry of Agriculture, issued a circular letter to provide guiding anthrax prevention and control measures [20]. Taken together, these factors underscore how disease outbreaks, cultural practices, and government responses can collectively shape public information-seeking behavior and awareness of anthrax.

Interplay of Epidemiology, Media, and Digital Access in Search Behavior

Search interest in Indonesia shows a clear preference for the term *antraks* over *anthrax*, highlighting the role of language and cultural context in shaping public information-seeking behavior. *Antraks* is the officially recognized Indonesian adaptation of *anthrax* and is consistently used in government documents, public health campaigns, and media coverage. Its widespread use in educational materials and official reports has made it the term most familiar to the

population, reflecting Indonesia's broader practice of localizing scientific and medical terminology to improve clarity, accessibility, and cultural relevance. Through strategies such as naturalization of spelling, translation, transcription, and the use of figurative or culturally resonant language, medical terms are adapted to bridge the gap between technical language and everyday understanding [21, 22].

Regional variation in search interest for the terms *antraks* and *anthrax* in Indonesia reflects differences in language use, health communication strategies, and exposure to local or international information sources. The use of medical terminology in Indonesia reflects a complex interplay of social, cultural, and educational factors. Many Indonesians, particularly in the western regions, express pride in their local languages and accents, which reinforces the tendency to adopt and maintain local terms for medical conditions [23]. In contrast, some eastern regions regard English as a gateway to global communication and professional advancement, creating a stronger interest in English-derived terminology [24]. Beyond geographical differences, exposure to education, urbanization, and digital media also plays an important role in shaping language preferences. Consequently, the variation in terminology across regions underscores not only the diversity of Indonesia's linguistic landscape but also the social meanings attached to language choice in medical contexts.

This process has important implications for health communication and outcomes. Localized terminology not only enhances comprehension and health literacy but also fosters trust in health messages, particularly among rural or less-educated communities [25]. Standardization across campaigns and media ensures consistency between professionals and the public, while the use of accessible terms reduces apprehension and encourages people to seek formal healthcare services [22]. The prevalence of *antraks* over *anthrax* thus demonstrates how language adaptation functions as an effective public health strategy, improving communication, community engagement, and ultimately the effectiveness of disease prevention and treatment efforts.

Geographical Distribution of Public Search Interest in Indonesia

Beyond temporal fluctuations, search interest for *antraks* and *anthrax* also showed marked geographical variation. The provinces with the highest search activity largely overlap with long-recognized anthrax-endemic regions in Indonesia, suggesting that elevated online information-seeking reflects underlying disease prevalence. Anthrax is endemic in at least 14 provinces, including Yogyakarta, Central Java, East Java, Gorontalo, and East Nusa Tenggara, with recurrent outbreaks reported in both livestock and humans [4]. Yogyakarta and Central Java, for example, have repeatedly reported anthrax cases, supported by environmental confirmation of B. anthracis and sustained by risk factors such as inadequate vaccination, livestock movement, and traditional slaughter practices [26]. Similarly, Gorontalo and East Nusa Tenggara have documented outbreaks with B. anthracis isolated from both animals and soil [27]. These endemic characteristics align with the provinces showing the greatest search activity, reinforcing the link between local epidemiology and digital health-seeking behavior.

At the same time, regional differences in digital access and literacy may shape the extent to which outbreaks are reflected in online search data. Yogyakarta, for instance, not only represents an endemic anthrax region but also leads the country in digital literacy and internet access, with an index score of 3.64, substantially higher than many other provinces [28]. This makes its population more likely to search for health information online compared to residents of less connected regions. Consequently, elevated search activity observed in Yogyakarta likely reflects not only the presence of recurrent anthrax outbreaks but also the province's relatively advanced digital infrastructure and literacy. In contrast, provinces with lower digital access may show reduced online activity despite experiencing outbreaks. Interpreting search patterns in light of both epidemiological distribution and socio-digital inequalities provides a more comprehensive understanding of infodemiological signals in Indonesia.

The comparatively lower search activity for *antraks* in provinces such as Maluku and Bali, despite the recognized national endemicity of *anthrax*, can be explained by a convergence of epidemiological, social, and informational factors. Search behavior is strongly shaped by local outbreak frequency and perceived risk; provinces such as East Java, Central Java, and Yogyakarta, which experience more frequent or widely reported cases, demonstrate greater public concern and thus higher online engagement, whereas Maluku and Bali, with fewer reported outbreaks and limited media coverage, generate lower motivation for information seeking. Public awareness is also

unevenly distributed, as communities without recent cases or targeted educational campaigns often perceive anthrax as a distant or irrelevant threat. Socioeconomic and cultural conditions reinforce these disparities: in areas where livestock farming is integral to livelihoods and human–animal interaction is intense, anthrax risk is more salient, while in provinces where livestock plays a less central role, public attention remains minimal [4]. Differences in surveillance strength and media attention contribute to shaping search activity, with outbreak-prone provinces benefiting from greater monitoring and more frequent reporting that raise public awareness, while the relative lack of such coverage in Maluku and Bali corresponds with lower levels of engagement. Collectively, these factors demonstrate how regional epidemiology, sociocultural context, and information environments interact to produce heterogeneous infodemiological patterns across Indonesia, even under the shared condition of national endemicity.

Public Search Behavior in Response to Anthrax Awareness in Indonesia

Public interest in anthrax, as reflected in online search patterns, demonstrates a strong demand for foundational knowledge about the disease. The majority of queries during outbreaks focus on definitions, symptoms, and transmission, reflecting a public desire to assess personal risk and take protective action [29, 30]. This heightened attention likely arises from limited baseline awareness, since anthrax primarily affects livestock and is relatively rare in humans [31]. Media reports of outbreaks appear to prompt the public to seek understanding of the disease's causes, transmission routes, and clinical manifestations. The acute and zoonotic characteristics of anthrax further increase concern. Sudden and severe symptoms, including fever, bleeding, swelling, or sudden death in animals, combined with the potential for human infection, motivate early recognition and response. Elevated perceived risk and negative emotions, including fear and anxiety, serve as powerful drivers for information-seeking behavior during outbreaks. As the threat or severity of the disease rises, these emotions intensify, increasing the public's perception of insufficient knowledge and motivating consultation of multiple information sources [32, 33]. Empirical evidence indicates that peaks in public anxiety and fear closely correspond with surges in online searches and other information-seeking behaviors during significant outbreaks [34, 35]. These observations are consistent with previous research indicating that diseases with dramatic or life-threatening presentations elicit intensified public information-seeking behavior.

These patterns emphasize the importance of public health communication in shaping awareness and guiding responses. Peaks in public attention, as reflected in search behavior, often coincide with outbreak reports, suggesting that the population seeks to assess risk for themselves or their livestock [36]. From a health policy perspective, these insights highlight the importance of timely, accessible, and accurate communication strategies that both inform and guide preventive and therapeutic actions. Strengthening digital and community-based education on anthrax symptoms, transmission pathways, and early intervention may improve outbreak preparedness and reduce morbidity.

Conclusion

Anthrax-related search dynamics in Indonesia show that public engagement with health information is shaped by a mix of epidemiological risk, cultural identity, language practices, and digital access. Search activity overall tends to be low and fairly constant, which aligns with anthrax's status as an endemic but geographically limited disease, although sudden spikes appear during outbreaks when media coverage raises public concern. The widespread use of the localized term antraks points to the role of language in making health messages more accessible and trustworthy, while the occasional use of anthrax reflects different sociocultural orientations and exposure to global information. Differences across regions also mirror variations in internet access and surveillance, with endemic provinces showing higher engagement, and areas with weaker monitoring or limited reporting showing less activity. Together, these patterns suggest that online search behavior reflects not only disease trends but also the broader social and infrastructural conditions that shape how information is shared and received. For infodemiology, this highlights the importance of interpreting digital signals within their epidemiological and cultural context to reduce information gaps and support more effective, locally relevant communication on neglected zoonotic diseases like anthrax.

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Conflict of Interest

The authors declare no conflict of interest.

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