Establishing infodemic management in Germany: a framework for social listening and integrated analysis to report insights at the national public health institute

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Abstract

Background: To respond to the need for establishing infodemic management functions at the national public health institute in Germany (Robert Koch Institute; RKI), we explored and assessed available data sources, developed a social listening and integrated analysis framework, and defined when infodemic management functions would activate during emergencies.

Objective: We aimed to establish a framework for social listening and integrated analysis for public health in the German context, using international examples and technical guidance documents for infodemic management.

Methods: At the RKI, we 1) identified (potentially) available data sources for social listening and integrated analysis; 2) assessed these data sources for their suitability and usefulness for integrated analysis in addition to an assessment of their risk using RKIs standardised data protection requirement; 3) developed a framework and workflow to combine social listening and integrated analysis to report back actionable infodemic insights for public health communications by the RKI and stakeholders; 4) defined criteria for activating integrated analysis structures in the context of a specific health event or health emergency.

Results: We identified and assessed 18 different types of data sources for social listening and integrated analysis in three categories: social media online listening data, RKI-specific data, and infodemic insights. Most data sources can be analysed on a weekly basis to detect current trends and narratives and to inform a timely response through reporting insights that include a threat assessment and scalar judgements of the different narratives and themes.

Conclusions: This work identified, assessed, and prioritized a wide range of data sources for social listening and integrated analysis to report actionable insights, ensuring a valuable first step to establish and operationalise infodemic management at the RKI. Ultimately, once operational, these activities will inform better and targeted public health communication at the RKI, and beyond. Clinical Trial: Not applicable.

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Establishing infodemic management in Germany: a framework for social listening and integrated analysis to report insights at the national public health institute

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Key words: infodemic; social listening; communication; infodemiology; public health; health promotion; misinformation; integrated analysis; infodemic insights

Abstract

Introduction: To respond to the need for establishing infodemic management functions at the national public health institute in Germany (Robert Koch Institute; RKI), we explored and assessed available data sources, developed a social listening and integrated analysis framework, and defined when infodemic management functions would activate during emergencies.
Objective: We aimed to establish a framework for social listening and integrated analysis for public health in the German context, using international examples and technical guidance documents for infodemic management.
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Discussion: This work identified, assessed, and prioritized a wide range of data sources for social listening and integrated analysis to report actionable insights, ensuring a valuable first step to establish and operationalise infodemic management at the RKI. Ultimately, once operational, these activities will inform better and targeted public health communication at the RKI, and beyond.
Trial Registration: Not applicable.

Introduction

The infodemic

Over the last decades, our information ecosystem has been undergoing changes and shifts, where the general public moved away from traditional media and institutions as a primary source of health information, to a more decentralised model with many different sources of information [1]. Different groups and generations have their own networks and information sources and ways of interacting and sharing information in our digitally-connected, increasingly polarised world [2]. The COVID-19 pandemic has made these trends increasingly clear, and has been accompanied by an *infodemic*—too much information including false or misleading information in digital and physical environments during a health emergency [3]. The lack of agreement between different information sources, as well as different levels of trust in different sources by different people, can cause uncertainty in the general population, and can impact the effectiveness of risk communication. There is more room for mis- and disinformation to spread, for trust in public policy and political actions to be undermined [3], and for public health measures to be jeopardized [4]. Initial studies evaluating the COVID-19 pandemic response have acknowledged the need of greater investment in risk communication and community engagement strategies to foster trust in public health guidance and ultimately, improve adherence to public health guidance and health decision-making more generally [5–8]. Consistent with these findings, trust in institutions has been strongly linked to their responsiveness and their reliability in delivering policies and services [9]. Therefore, one of Organisation for Economic Co-operation and Development's (OECD) key recommendations is to connect and engage better with citizens in policy design, delivery and reform, and ensure the inclusion of people at a higher risk from negative health impacts from infodemics. Infodemic management aims to do this through social listening and community engagement, as well as targeted public health messaging.

Infodemic management

One way to support people in making informed health decisions is to provide responsive, evidence-based, and target-group-specific risk and health communications [10]. These communications need to correspond to people's concerns and questions. Moreover, people need to be equipped with the right tools to find reliable information, identify misinformation [11], and assess the quality of (scientific) evidence. Well-planned and executed infodemic management can help develop the right messages for the right target groups at the right time as well as boost people's health and scientific literacy [12]. While the terms *infodemiology*, *infodemic*, and *infoveillance* have existed for a longer time [13,14], the field of infodemic management and its line of research have now been formally acknowledged by public health organizations as a novel, emerging scientific field and critical area of practice during a pandemic [15,16]. Responding to *narratives about* the virus requires an approach similar to responding to the spread of the virus itself: Both include (early) detection, diagnosis and identifying appropriate responses and interventions [17]. As both should happen early and in parallel, the European Centre for Disease Control and Prevention (ECDC) updated its guidance document in the year 2022, by adding infodemiology and infodemic management to the core competencies in applied infectious disease epidemiology [18]. Moreover, in 2023, the World Health Organization (WHO) is convening panels to develop WHO guidance and ethical considerations of social listening and integrated analysis, as well as WHO guidance on social listening and integrated analysis for public health, with an application to acute respiratory disease.

Social listening and integrated analysis

Risk communication and community engagement are crucial elements in the pandemic response [7]. Effective communication starts by listening, and therefore, social listening is an essential tool in the infodemic management toolkit. Social listening is defined as monitoring the understanding,

questions, concerns, information voids, narratives and mis/disinformation that circulate in both online and offline environments (also see **Box 1**) [19,20]. While it is common practice for businesses to engage in digital marketing and monitor social media channels for mentions of their brand, competitors or products [21], social media monitoring is just starting to find its way into the public sector. The increase in online communications has, in combination with computational power and artificial intelligence (AI), enabled real-time social listening, as for instance implemented with the pilot Early AI-supported Response with Social Listening (EARS) platform that tracks online COVID-19 conversations [22,23]. In addition to monitoring online conversations, offline social listening (including traditional media and other sources such as user search trends, epidemiological data and socio-behavioural data) can be used to understand ongoing narratives at the population level [24].

Textbox: Infodemic management terminology used in this work

- *Infodemic:* an overabundance of information—some accurate and some not— that occurs during an epidemic [3,15].
- *Infodemic management:* the systematic use of risk- and evidence-based analysis and approaches to manage the infodemic and reduce its impact on health behaviours during health emergencies. Infodemic management aims to enable good health practices through four types of activities: 1) Listening to community concerns and questions; 2) Promoting understanding of risk and health expert advice; 3) Building resilience to misinformation; and 4) Engaging and empowering communities to take positive action [25].
- *Infodemiology:* the epidemiology of information; describing and analysing information and communication patterns and its relationship to population health status [13].
- *Infodemic insights:* Findings or conclusions from a data source (report) that has its own analysis plan that is tailored to the data type, source, and context of where the data is collected and the population it covers [24]. It is used to make recommendations for action, for more effective engagement.
- *Infoveillance:* Using infodemiology data for surveillance [13,14].
- *Social listening:* or, infodemic surveillance [17], sometimes used as a synonym for ‘infoveillance’. Monitoring different online data (e.g. social media) and offline data (traditional media and other sources such as user search trends, epidemiological data and socio-behavioural data) sources to understand population understanding, perceptions, concerns and questions, information voids, narratives and mis- and disinformation and other relevant information about people’s reactions to a health topic [24].
- *Integrated analysis:* A planned methodological examination of different types of data sources which combine social listening intelligence with other types of information (e.g. health seeking behaviour, health service utilization, epidemiology, fact-checking and information seeking trends, mobility reports) to produce insights [24].
- *(Infodemic) insights report:* A reporting output of integrated analysis that contextualizes findings from social listening and other data sources for use by health authorities to act based on a planned methodological frame for prioritization of actions and interventions. Important elements to include are diagnosis of barriers and facilitators to desired behaviour and how possible recommended actions support desired public health behaviours, which may be internal to health system and externally-facing strategies [24].

- *Misinformation:* False information, regardless of the intent to mislead [11].
- *Disinformation:* Misinformation that is deliberately disseminated to mislead [11].

Integrated analysis extends online social listening through the consideration of data sources beyond social media data (also see **Box**). These can include news articles, Google searches, primary research, community dipstick surveys, citizen questions posed via hotlines, monitoring or surveillance reports, epidemiological and behavioural data, surveys and polls, and many more. Any data source that can give insight into behaviours, questions, concerns, information voids, circulating narratives and mis/disinformation (see **Box**) within a given population for a given public health event is eligible. In integrated analysis, the different data sources are combined to identify themes and narratives across data sources. One advantage to integrated analysis is that it is less biased towards social media users only and includes more diverse population groups. Another advantage is that a specific themes' importance may be judged more easily through triangulation (e.g., if the same theme comes up across many different sources). The scope of an integrated analysis can be varied based on current challenges and goals and based on available resources—e.g., one could monitor and assess narratives around COVID-19 and monkeypox as a whole (WHO infodemic insights reports for COVID-19 [23,24] and monkeypox [26]) or focus on vaccines and vaccine confidence (CDC State of Vaccine Confidence Insights Reports for COVID-19 [27] and monkeypox [28]).
Identifying and understanding the information voids, narratives and sentiments behind conversations regarding public health issues though social listening and integrated analysis, can help design adapted and targeted risk communication messages. These risk communication messages can have several aims: to prevent the circulation of misinformation by prebunking anticipated misinformation narratives, or respond to them if necessary; to counteract stigma against affected groups [29,30]; to fill information voids; to promote resilience; or to contribute to behavioural change. Social listening and integrated analysis also holds the power to identify research gaps and programmatic bottlenecks that the public perceives as a challenge (including access barriers), guidance that confuses people, or could potentially erode trust. These infodemic insights can point out confusion where the health authority is experiencing communications failures with the public, and what policy or programmatic levers can be used to address it, beyond risk communication activities.

The German context

In Germany, the Federal Centre for Health Education (*Bundeszentrale für gesundheitliche Aufklärung; BZgA*) [28] is tasked with health education and health promotion focused on the general public. During the COVID-19 pandemic, more and more citizens also turned to the national Public Health Institute (i.e., the Robert Koch Institute, RKI) - as well as to communications by the Federal Ministry of Health - for behavioural advice and information on the pandemic. One indicator of this is the number of daily visitors on the RKI website, which increased from ~30,000 in early February 2020 to an average of ~250,000-350,000 visits per day since the end of May 2020. The number of visits peaked on the 16th of March 2020 with 1,685,000 visits on that day. RKI's follower count on Twitter (@rki_de) increased from 12,000 (1st of January 2020) to 600,000 as of the time of writing (October 2022).
At the end of 2021, the German chancellor convened a scientific expert council of 19 members from different disciplines to develop evidence-based proposals to help curb the spread of the virus and tackle the pandemic [31]. In their fifth statement (20 January 2022), the council unanimously called for implementation of coordinated risk and health communication practices [4], that are also consistent with key infodemic management principles: (i) **generating** the best available knowledge to date (e.g. through monitoring media and the extent to which the public takes up health-relevant behaviours), (ii) **translating** relevant data, statistics and indicators into behaviourally relevant advice

for different target groups (Who is reached via which medium and format? How does information complexity need to be adapted?); as well as countering mis- and disinformation, (iii) **disseminating** communications via multiple channels, making use of online- and offline media, influencers (by providing them with adequate materials), e-Health offers (electronic health offers such as online consultations); collaborating with science communicators, (iv) **evaluating** the aforementioned measures and using the results for continuous quality improvement. As the council says, "in a decentralized and pluralistic society such as Germany, there will always be diverse actors that communicate and inform the general public" [4]. In Germany, these actors include political actors (e.g., the Federal Ministry of Health), public health institutes (the RKI at national level, as well as public health institutes in different federal states and federal districts), federal institutes tasked with public communication (BZgA), a diverse range of online- and offline media as well as individuals (e.g., influencers, individual scientists, journalists, politicians and science communicators). In such an environment, it is particularly important to set up infrastructures for coordinated, professional and evidence-based health communication. The expert council called for setting up such infrastructures quickly and in a sustainable manner to be better prepared for future crises.

Aim and research questions

At the RKI, lots of expertise and information is available for social listening and integrated analysis, but is not fully leveraged to inform risk and health communication. Developing and testing structures to manage the infodemic is in line with RKI's strategy and research agenda for the year 2025 [32,33] according to which the institute seeks to develop evidence-based methods for communicating with specific target audiences. To respond to the need for infodemic management in Germany, and specifically, at the RKI, in this work, we review and explore opportunities for social listening and integrated analysis to enhance preparedness for future health crises [34,35]. This work focuses on two research questions: At the national public health institute for Germany, the RKI, (i) how can we establish response structures for social listening and integrated analysis?; and (ii) what are the criteria under which these social listening and integrated analysis be conducted to produce infodemic insights, and the accompanying response structures should be activated?

Methods

Approach, aim & objectives

Based on desk review, we gathered the available technical guidance [36] and training documentation [29,37–39] on infodemic management, as well as international examples of social listening and insights reporting [24,27,28]. We verified these sources and received technical assistance by our partners, WHO, and the US Centers for Disease Control and Prevention (CDC). We aligned our aim and objectives with the WHO's public health research agenda for infodemic management [40] stream 1 "Measure and monitor the impact of infodemics during health emergencies". We aimed to establish a framework for social listening and integrated analysis for public health in the German context. Our key objectives were: 1) to identify (potentially) available data sources for social listening and integrated analysis at the RKI; 2) to assess these data sources for their suitability and usefulness for integrated analysis at the RKI; 3) to develop a framework and workflow to combine social listening and integrated analysis, to report back actionable infodemic insights for public health communications by the RKI and stakeholders; 4) to define criteria for activating infodemic insights reporting in the context of a specific health event or health emergency. *Note: The actual insights reporting is outside of the scope of this work.*

Data sources

To identify all potential data sources and tools used for social listening in the context of public health, with relevance for Germany, we reviewed the identified documentation (technical

documentation [41,42], guidance documents, infodemic training materials [29,37–39]) and the methodology of insights reports [24,27,28]. The review team consisted of a health scientist and field epidemiologist (TSB) and a behavioural scientist (CL) both with training in infodemic management [38,43], and a psychology student assistant (PS) who completed the OpenWHO Infodemic Management 101 training [39].

First, we identified the largest social media platforms in Germany for online listening based on studies on media consumption [1,44] on which the RKI is also active and curates accounts, and identified the respective tools and analytics available for online social listening for these platforms. Most of these tools need a social media account to be used (e.g., @rki_de on Twitter). Second, we gathered internal, RKI-specific data sources in consultation with colleagues working in the department of infectious disease epidemiology (including the emergency operating centre), department for health monitoring, the risk communication unit, the press office, and the social media task force. Last, through desk research, we gathered infodemic insight reports by governmental institutions, academia and non-governmental organisations.

Integrated analysis to report insights

Subsequently, we assessed the suitability of these sources for social listening and integrated analysis for the RKI (see Table 1). Specifically, we assessed how each data source could potentially be analysed to identify themes and narratives for infodemic insights, how frequently data becomes updated and available and the extent to which there may be data protection risks. To make best use of the available resources at the RKI, we discarded several data sources from the initial list of potential data sources. The initial list of potential data sources and reasons for inclusion and exclusion are presented in the **Supplementary Data**. Our goal was to gather an as-diverse-as-possible pool of data sources given limited resources. For instance, while many tools are available to collect and analyse Twitter data, we decided to rely on the freely available tools TweetDeck and epitweetr to cover Twitter data.

We decided to include all RKI-specific data sources as they reflect questions directed at the RKI that are very different from Twitter data and all infodemic insights data sources that include survey data which is published less frequently as a report and is processed — and thus does not require many additional resources from an RKI-based infodemic insights team (e.g., to analyse raw data). These decisions were made within the RKI author group (SB, CL, PS) after trying out various data sources and tools for practical use and assessing costs/benefits of each data source. Thus, the list of data sources presented in the current work should be considered as a starting point that covers an as-diverse-set-as-possible while keeping in mind a reasonable allocation of resources (e.g., an initially small team of infodemic managers).

We tabulated the frequency with which each data source generates new data and thus, the frequency in which it should be analysed, and the type of data that can be extracted from each data source (i.e., different outcome variables or indicators per data source, such as the number of Twitter comments per topic). Furthermore, we evaluated each data source based on ethical and data protection considerations (e.g., a person writing a private message to the RKI should remain private and not end up in an infodemic insights report). The analysis of the heterogeneric set of identified data sources followed a mixed-methods approach to combine qualitative (analytics) and quantitative data (themes). Qualitative data was analysed through reflexive thematic analysis to identify themes (people's experiences, views and perceptions, and representations) regarding the public health event of interest [45,46], per data source.

Data protection & ethics

The many different data sources warrant careful consideration with regard to privacy and data protection before they can be used for active social listening and integrated analysis. To formally assess the data handling, two researchers performed an independent risk assessment of each identified data source using RKI’s standardised data protection questionnaire (Version 03/2019);

potential disagreement was discussed. The risk was categorised by the dimensions low, normal, high, or very high level of data protection required (**Supplemental Table 1** is an excerpt of the data protection questionnaire and summarizes what each of the dimensions entails).

Setting criteria for activating infodemic insights reporting

To define criteria for activating infodemic insights reporting structures in the context of a specific health event or health emergency, we (CH, TSB) consulted RKI's preparedness and response group. The emergency operating centre is within their portfolio, which is situated within the RKI department for infectious disease epidemiology. We identified and reviewed RKI's crisis management structures and preparedness & response plans for Germany, as well as the human resources (incl. potential surge capacity), to see when and where infodemic response activities could be activated.

Results

Identification and assessment of data sources

Table 1 presents the 18 data sources (including tools and reports) that we identified as suitable starting points for online and offline social listening and integrated analysis at the RKI (based on the full list provided in the **Supplementary Data**). They fall into three main categories: social media on online listening, RKI-specific, and infodemic insights. We included primary data sources, such as social media data, requests addressed to the institute (through the emergency operations centre [47] and press office), task force meetings, press requests, and secondary data sources, (i.e. secondary research data, reports [24,48–50]). Of note, three infodemic insights were COVID-19 specific (i.e. COSMO Snapshot Monitoring [48], BfR-Corona-Monitor [49], and Ministry of Health (MoH) COVID-19 digital emergency operating centre weekly briefing [51]), the WHO Infodemic Insights reports both on COVID-19 and monkeypox [24,26]; the general, non-COVID19 specific reports was by CEMAS [50].

Table 1. Data sources evaluated based on suitable variables to identify topics and narratives, data availability and analysis frequencies, and data protection risk assessment.

Data Source (Tool or organizational unit)	Data extraction	Data availability	Data protection risk assessment
Social media and online listening			
Twitter (TweetDeck)	(Number of) likes, retweets and number of comments of a post ("tweet") after 1 week and compare them with the average number of interactions (sum of likes, retweets and amount of comments) per post during the week. *Scan trending hashtags regarding COVID-19 related topics to detect upcoming topics that need communication. Therefor also scan tweets addressed to the RKI (Search for @rki_de).*	On demand/Weekly	Normal
Twitter (epitweetr [52])	Signal detection (alerts) of an unusual increase in the number of tweets for a specific time place and topic.	On demand/Weekly	Normal
Instagram (Instagram Insights)	Interactions with @rki_fuer_euch posts (likes, number of comments, amount of times post was saved) by topic and the number of people that saw the post (reach). If stories are posted, use the interactions with them by topic relative to the average number of interactions with stories	On demand/Weekly	Normal

	(sum of likes and shares) during the week.		
Google searches, web content (Google Alerts)	Published articles, blogs, etc. in a given timeframe based on taxonomy and Boolean search strings.	On demand/Weekly	Normal
Google searches (Google Trends)	Compare topic (keywords) to baseline topic (i.e. "COVID-19") and compute relative weekly average.	On demand/Weekly	Low
Social listening using multiple sources (e.g. Meltwater)	Depending on the tool and reporting options	On demand/Weekly	Normal
Robert Koch Institute specific			
Social media activity (RKIs social media accounts: Twitter @rki_de; Instagram @rki_fuer_euch; LinkedIn)	Count the number of direct messages and comments regarding a topic relative to the overall number of them in the given timeframe *and questions may be identify to know where information voids exist and new topics may emerge.*	Weekly	Comments: Normal Direct messages: High
Webpage metrics (RKI website traffic data, search patterns)	Use the number of visits on subpages relative to overall visits on the RKI-webpages.	Weekly	Low
Task Forces (RKI departments, emergency operations centre)	Ask RKI scientist with technical experience: 'What do you think is important and needs to be communicated, now and in the next month?' and let them rank these issues, then create an overall ranking across RKI experts.	Weekly	Normal
E-Mails and phone calls from citizens and journalists (RKI press office, emergency operations centre)	E-mails/calls regarding a topic relative to the overall number of e-mails/calls in the given timeframe *and questions may be identified to know where information voids exist and new topics may emerge.*	Weekly	High
RKI press conferences questions	Count the questions regarding a topic during the conference relative to overall number of questions *and use them to identify information voids.*	Ad hoc, depending on the interval of press conferences	Low
Freedom of Information Act requests (*FragDenStaat* Portal [53])	Count requests by topics addressed to the RKI.	Ad hoc, when requests are submitted	Low
‘Small requests’ from members of the German Federal Parliament [54]	Topics gain insights into the issues that politicians and/or their constituency are concerned with.	Ad hoc, when requests are submitted	Normal
Infodemic insights			
COSMO Snapshot Monitoring [48]	Scan report for sections relevant to the taxonomy. The output depends on how questions are framed (e.g. "How informed do you feel about vaccinations?" "X % do not feel very informed"). Read the summary: some results about knowledge show information voids. This also depends on how the question was framed in the survey. For relevant questions, use the proportion of respondents not knowing/worrying.	Ad hoc, when report is published (currently biweekly)	Low

	COSMO could also be used for identifying information voids and new topics that need communication.		
BfR-Corona-Monitor [49]	Perceived informedness: How informed do you feel regarding topic X? (less informed — more important topic). Use the proportion of respondents not feeling informed by topic. *This may be used to identify information voids and new topics that emerge and need communication.*	Ad hoc, when report is published (biweekly/monthly)	Low
MoH COVID-19 digital emergency operating centre, weekly briefing [51] (Cosmonauts and Kings)	Browse reports for sections relevant to the taxonomy. The report summarises findings of existing studies, social media data (posts, comments, analytics) and reports misinformation (Telegram, fact checking organisations); including narratives regarding the MoH.	Weekly	Low
WHO Infodemic Insights report [24,26] (Marble Global)	*Browse report* sections relevant to the taxonomy *(questions in English-speaking communities may also be relevant to German-speaking communities; misinformation across countries may be similar)*	Weekly	Low
Center for Monitoring, Analysis and Strategy; (CEMAS) [50]	Browse reports for sections relevant to the taxonomy. The output depends on how questions are framed. *Scan reports and blog posts for relevant topics.*	Ad hoc, when report is published	Low

Abbreviations in table: BfR = German Federal Institute for Risk Assessment (*Bundesinstitut für Risikobewertung*); CEMAS = Center for Monitoring, Analysis and Strategy; COSMO = Corona Snapshot Monitoring; MoH = ministry of health; RKI = Robert Koch Institute.

For data extraction, a public health taxonomy helps to identify thematic categories in conversations relevant to public health response. Validated public health taxonomies for social listening, i.e. the COVID-19 and monkeypox taxonomies developed by the WHO [23,55], formed the basis of the generic taxonomy related to public health issue X provided in **Figure 1**. The taxonomy includes (sub)topics to capture breadth of these conversations, and help identify structure and changes in narratives within thematic categories relevant to public health response. To create an infodemic insights report at the RKI, we translated the taxonomy to German (see **Supplemental Figure 1**). For some data sources, the taxonomy could directly be translated into German, and used as Boolean search terms. Question marks can be added to Boolean search terms to identify information voids (questions) [15]. The taxonomy provided for public health issue X is applicable to other infectious diseases or health emergencies, and will need to be adapted if the nature of the public health emergency in question is very different from COVID-19 and monkeypox (e.g., war, an extreme weather event). In all events, the taxonomy will follow an iterative process and needs to be updated regularly to reflect changes in the situation and themes that occur.

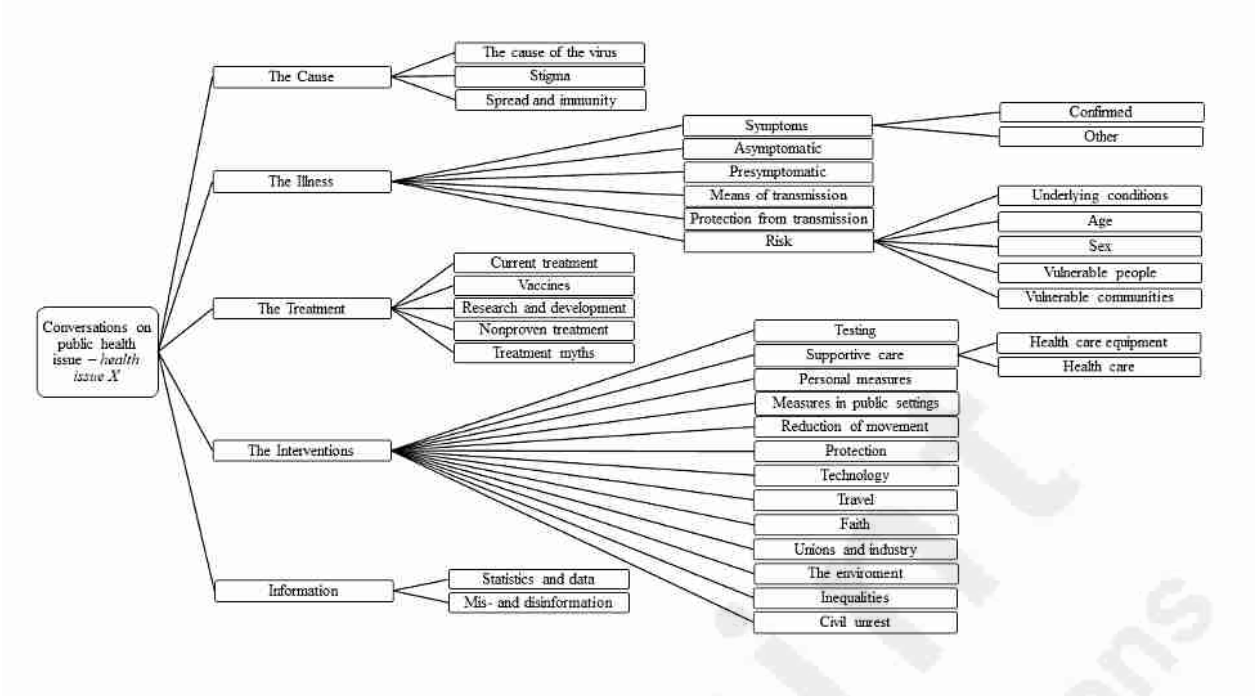

Figure 1. Taxonomy to systematically monitor key words in conversations related to public health issue X within thematic categories relevant to public health response.

German version provided in the supplemental material (Supplemental Figure 1). Based on the COVID-19 and monkeypox taxonomies [23,55].

Many data sources are available on a weekly basis (**Table 1**). Most social media and online data (analytics) can be collected more frequently and on demand, but subsequent analysis can still take place on a weekly basis. Other data sources can only be monitored less frequently as particular surveys and reports are published bi-weekly, monthly or on an ad hoc basis.

The data protection risk assessment indicated normal to low level risk for social media and online listening data sources. RKI specific data sources were assigned various levels of risk, from low to high. Social media activity on RKIs accounts were assigned normal (for comments) to high (for direct messages) risk; in all circumstances, user comments or sending a message will remain anonymous. Webpage metrics (RKI website traffic data, search patterns) were considered low risk. The data from task forces were assigned a normal risk level if RKI employees are informed that the information will be used to develop integrated insights (in anonymised form). E-mails and phone calls from citizens were assigned a high risk, as these are considered to be private/non-public; however, the data will be handled in aggregated form (counts per topic only). RKI press conferences questions and Freedom of Information Act requests [53] were considered low risk, because they are in the public domain already. So called ‘small requests’ for information from parliamentary groups or members of the German Federal Parliament [54] were assigned normal risk. Infodemic insights based on research, surveys or reports from other parties all had low risk (anonymous, aggregated data).

Integrated analysis & workflow to report insights

The taxonomy (**Figure 1**) serves as a starting point for themes that may emerge in the data and ensures some basic comparability across data sources. Additional topics can be added if they are not contained in the pre-defined taxonomy. Topics that emerge across many different data sources, may be (relatively) more important than topics that emerge only rarely — however, final judgments of the relative importance of particular topics and the urgency with which they require a response are made on the basis of a threat matrix (also see **Figure 3**).

Figure 2 shows a proposed workflow to create an infodemic insights report based on the data

sources shown in **Table 1**. The infodemic insights team lead decides which data sources should be included for analysis, based on the availability of the team members and the timeframe. Each team member can be responsible for one or more data sources and independently extracts the data and identifies themes and (sub)topics based on the taxonomy (Figure 1) and adding additional themes that emerge, collected in a spreadsheet. In a group meeting, the core team discusses the initial data extraction and identifies potential examples of insights that could be included in the report as an illustrative example of the identified narrative (e.g., public comments or posts on Twitter).

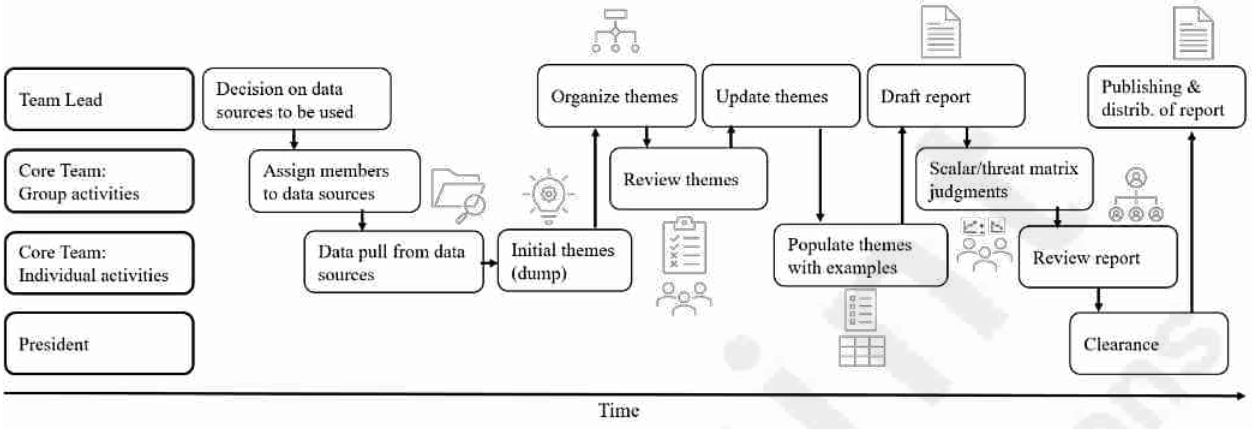

Figure 2. Swim lane graph showing roles and responsibilities across the infodemic management team, and a proposed workflow to combine different data sources into an insights report. Adapted from Kolis and Voegeli.[56]

The team lead drafts an insights report based on the main themes and topics. The core team then judges each theme in a threat matrix and uses a scalar judgement (**Figure 3**), which is based on US CDC's Vaccine Confidence Insights Reports [27,28] and adapted for broader public health topics. First, the level and type of threat is assessed based on the impact on health promoting behaviour, reach and the level of pervasiveness and dissemination. High risk themes can be those that lower health-promoting behaviours, have wide reach and are pervasive whereas low risk themes are concerning but have limited reach and dissemination. Moderate risk can trigger hesitancy to follow health-promoting behaviours, tend to have a moderate reach and moderate dissemination. Low risk is assigned to themes that can trigger hesitancy, but have limited reach and limited dissemination. No risk themes can include themes that are not concerning or even increase health-promoting behaviours. Subsequently, the scalar judgement assesses directionality of the theme over time (e.g., since the last report): increasing, stable, decreasing. Then, the entire team reviews the report, which then undergoes scientific clearance by RKI's president and distributed to our stakeholders.

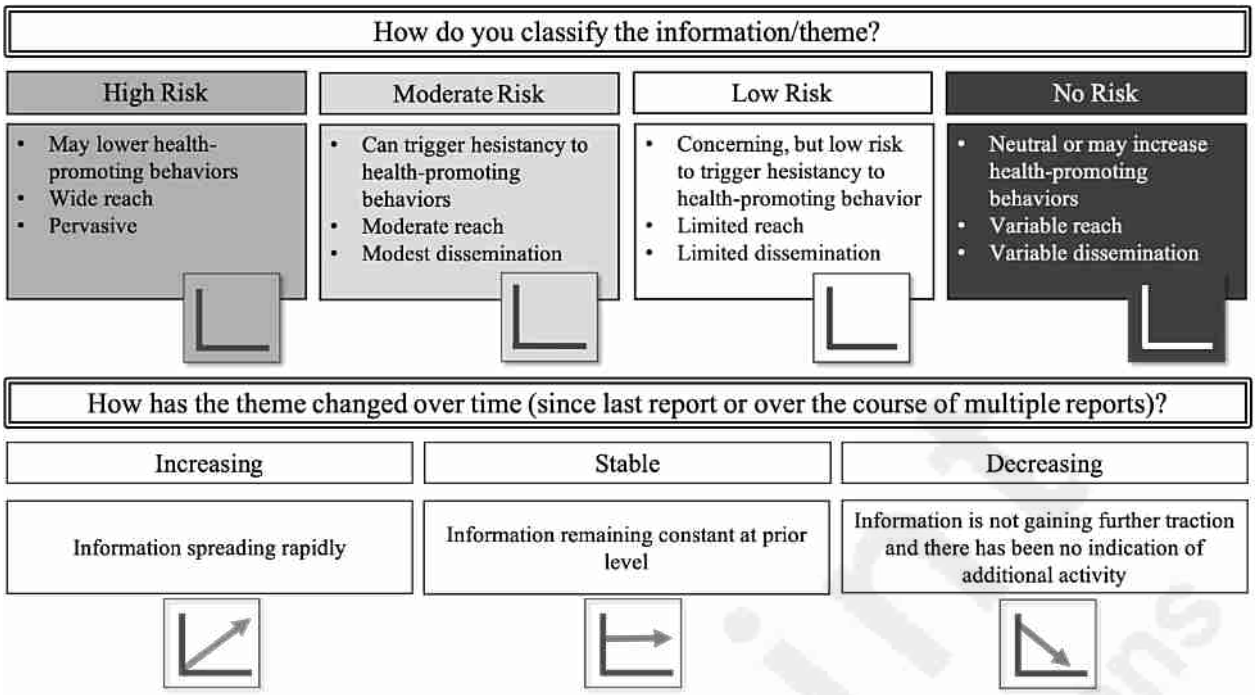

Figure 3. Threat matrix and scalar judgements, adapted from the US CDC Vaccine Confidence Report methodology [27,28]**.**

Reporting back actionable infodemic insights

Communicating insights and actionable recommendations based on social listening and integrated analysis is essential to support the public health response. The level of reporting detail will depend on the availability of resources (i.e., the number of team members available, number of hours that can be spent on the project). The output could range from a full-fledged insights report including actionable recommendations, to a potential set of indicators that can be integrated into existing reports (e.g., RKI's situation reports focused on epidemiological trends and developments). In public health emergencies, speed trumps perfection and so, depending on the situation, a quick overview in an (epidemiological) situation report may trump a stand-alone (infodemic) report. Nevertheless, careful consideration of the impact of the published report or indicator is needed before it is sent out to various audiences or published online. To put the integrated analysis results to best use, the insights report should be shared widely with partners and interested stakeholders who can use these insights for their risk communication and community engagement activities. These partners and stakeholders include but are not limited to other German public health institutes (state, local), governmental institutions and ministries (Ministry of Health, Federal Centre of Health Education), community and religious organizations, science communicators, journalists/media and fact-checking organizations.

Criteria for activating social listening and integrated analysis structures

Social listening and integrated analysis structures could be activated in the context of RKI's crisis management structures [47,57]. Due to the primary responsibility at the district and federal state level in dealing with significant epidemic situations, the RKI (federal level) usually only becomes active in the case of major or exceptional epidemiological situations [58]. The term significant epidemic situations refers to either the local or temporal clustering of threatening communicable diseases, or of threatening diseases in which pathogens or toxins can be considered as the cause, or the concretely justified possibility that such diseases or illnesses may occur in the near future [58]. The activation of crisis management structures depends on the internal evaluation of the internal

workload, number of possibly affected people, severity of disease, geographic distribution and public perception of the situation [47]. However, social listening and integrated analysis structures to report insights can also be activated for public health emergencies concerning Europe, as a support and prevention of the spread of a communicable disease to Germany as judged by RKI experts, as our analyses focus on the German-speaking context.

Discussion

In this work, we propose a framework to establish social listening and integrated analysis to report insights at the national public health institute in Germany. We identified and assessed 18 different type of data sources for social listening (at the time of writing, fall 2022), which fall into three main categories: social media and online listening data, RKI-specific data, and infodemic insights. Monitoring these online and offline data sources can help to understand population understanding, perceptions, concerns and questions, information voids, narratives and mis- and disinformation and other relevant information about people's reactions to a health topic in Germany [24]. The majority of these data sources can be analysed on a weekly basis, to detect current trends and narratives and to inform a timely response. Emerging data sources can always be added. One forthcoming data source that has the potential of providing key infodemic insights is the platform 'RKI Panel - Health in Germany' [57], which plans to repeatedly survey a group of people on various health scientific topics. The selection of data sources used for each public health event might defer, depending on the situation and resources available.

Subsequently, a methodological examination is planned to produce infodemic insights at the RKI. These insights can point out confusion, where the health authority is experiencing communications failures with the public, and what policy or programmatic levers can be used to address it (including but not limited to risk communication activities). While there are many reasons for misinformation spreading [59] (e.g., individual differences, information voids), identifying and tracking misinformation early can help to pre- and debunk misinformation (for guidance on when and how to pre- and debunk, see the Debunking Handbook [11]).

The scope and extent to which integrated analysis is put into place depends on the resources available to the project. We relied on prior experiences by the US CDC [27] to lay out the resources needed for different tasks and responsibilities such as analysing specific data sources but also identify common themes across data sources, and finally write up a structured insights report. The outputs are flexible: either key infodemic insights are added to existing situation reports or a stand-alone report can be published. The primary audiences for the insights reports are the RKI emergency operating centre and task forces. In addition, other public stakeholders and communicators involved in acute public health events [57], including but not limited to the Federal Ministry of Health, the Federal Centre of Health Education, and the Federal Institute for Risk Assessment, as well as state and local level public health authorities and governmental institutions, could benefit from these reports. The collaboration and exchange with these organisations should be sustained and strengthened through wide sharing of the infodemic insights and could also create access to additional data sources for social listening (e.g., analysis of hotlines for citizens from the Federal Centre of Health Education).

Last, we considered different criteria for activating integrated analysis structures, and described how these activities could fit into RKI's existing crisis response structures and Germany's legal framework [47,58]. The infodemic management activities proposed in this work are deemed suitable to be added to existing preparedness and response structures at the RKI.

As we applied the methods of the WHO's infodemic insights report to the German context, on the methodological level, this provides an opportunity to test how robust findings are across languages and geography (e.g., compared to findings in the context of the WHO infodemic insights report). It is important to note that German-speaking does not mean 'within Germany' as netizens are widely connected. There is both a German-speaking community outside Germany, Austria and Switzerland

(DACH region) that would be captured well by the analysis, and a non-German-speaking community within Germany that would not be captured well by the proposed analysis.

Limitations

The proposed activities should be interpreted carefully. The data sources identified include more online than offline sources, and all data sources cover different audiences and come with inherent biases. Twitter appeared to be a particularly fruitful source as the data available for analysis is very comprehensive. Despite being a popular platform, Twitter users are not representative of the general population [57]. Twitter has a major influence on the information ecosystem, e.g., through journalists who can bring trending topics to offline media or scientists and politicians who serve as multipliers. It is still necessary to include more offline sources, such as community dipstick surveys or townhall discussions. This would require additional personnel who are trained in conducting field studies (e.g., anthropology, ethnography). Similarly, we included citizen questions that are directed to the RKI but not to other public institutions (such as the Federal Ministry of Health or the Federal Centre for Health Education), science communicators, politicians or other actors. Importantly, even though the general public seeks information at the RKI, the RKI predominantly deals with (public) health professionals, which could affect the data collection for social listening activities. Public health professionals can, however, still provide valuable insight into ongoing narratives in the general population, and also serve as an audience for the insights report. Furthermore, there is a speed-accuracy trade-off. The goal of an integrated analysis is to identify important narratives quickly, and to be able to rapidly respond (e.g., to misinformation) as well. Iterative updates, internal (clearance) procedures and publishing timeframes can hinder swift publication of infodemic insights. Even ambitious (bi-)weekly reporting might be too slow for a timely operational response to the current narrative, information voids, or an outbreak of misinformation, especially on social media.

Next steps

To put the proposed framework for social listening and integrated analysis into practice [10], several activities are planned to operationalise social listening and integrated analysis to report insights at the RKI. First, the proposed set-up for data handling will be submitted for ethics clearance and data protection clearance. For data protection clearance, the identified data sources and variables to be obtained will be discussed closely with the data protection officer. Second, in collaboration with RKI's newly established Center for Artificial Intelligence in Public Health Research, we will seek to further explore RKI's online social listening capacities using artificial intelligence techniques, using the data sources identified for social media and online listening. Third, the integrated analysis proposed here could potentially be piloted in the form of a field infodemiology project, by field epidemiology fellow(s) in Germany, under supervision of and in collaboration with RKI'S risk communication group and the department of infectious disease epidemiology, unit for preparedness & response. During this field phase (pilot), the data sources, taxonomy, integrated analysis, and workflow will be tested and evaluated for the German context. This will help to identify potential difficulties in combining the different data sources and in subsequent reporting—particularly as many decisions in the process are subjective. The pilot will also provide insight in the amount of (human) resources needed to operationalise the proposed social listening and integrated analysis activities, as well as their appropriate turn around and reporting time frame. If the pilot is successful, the analysis can be extended to other health topics (e.g., the climate crisis). For these, novel taxonomies and Boolean search strings need to be developed. The need to analyse narratives surrounding a particular topic (and which) constantly needs to be (re-) evaluated.

Moreover, a continuous and interative (re-)evaluation of the data sources, insights reporting and workflow is required to build sustainable and effective infodemic management activities at the RKI. International exchange with other public health institutes building experience with social listening [60,61] and communities of practise can foster further advancement in this area. A final important

next step is to involve stakeholders and partners and create appreciation and a demand for insights reporting and integrate this into regular policymaking and programmatic decision making [10]. Actively reaching out to these partners is essential to create demand for the report. Conversely, these partners can deliver additional data sources and inputs for future reports in return. Ultimately, an English version of the findings could be reported to the ECDC and the WHO to add to the global level of reporting on the infodemic (like national surveillance data is being shared through this route, feeding into international surveillance reports).

Conclusion

RKI identified and assessed a wide range of data sources for social listening and integrated analysis to report actionable insights, ensuring a valuable first step to establish and operationalise infodemic management at the RKI. Setting up the right tools for social media and online social listening will help to automate parts of the process. Pilots of the proposed work will help to refine the proposed workflow, and show its value in informing the public health response. Ultimately, this work will inform better and targeted public health communication at the RKI, and beyond.

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Author contributions

Conception or design of the work: TSB, CL. Data collection: TSB, CL, PS. Data analysis and interpretation: TSB, CL, PS, CH, TDP, AI, EW, CV. Drafting the article: TSB, CL, PS. Critical revision of the article: TDP, AI, EW, CV, LW, TSB, CL, PS. Final approval of the version to be published: all authors.

Conflict of interest

TSB, CL, PS, CH, TDP, AI, CV, LW and EW report no conflict of interest. TDP and AI are staff of the World Health Organization, are alone responsible for the views expressed in this article, and do not represent the views of the organization. The findings and conclusions in this manuscript are those of the authors and do not necessarily represent the official position of the US Centers for Disease Control and Prevention. Control and Prevention.

Abbreviations

AI	artificial intelligence
EARS	Early AI-supported Response with Social Listening, a WHO platform for AI-supported real-time online social listening of COVID-19 conversations [22]
BfR	German Federal Institute for Risk Assessment (*Bundesinstitut für Risikobewertung*)
BzGA	German Federal Centre for Health Education (*Bundeszentrale für gesundheitliche Aufklärung*)
CDC	US Centers for Disease Control and Prevention
CEMAS	Center for Monitoring, Analysis and Strategy
COSMO	COVID-19 Snapshot Monitoring
ECDC	European Centre for Disease Control and Prevention

MoH	Ministry of Health
OECD	Organisation for Economic Co-operation and Development
RKI	Robert Koch Institute (Germany's national public health institute)
WHO	World Health Organization

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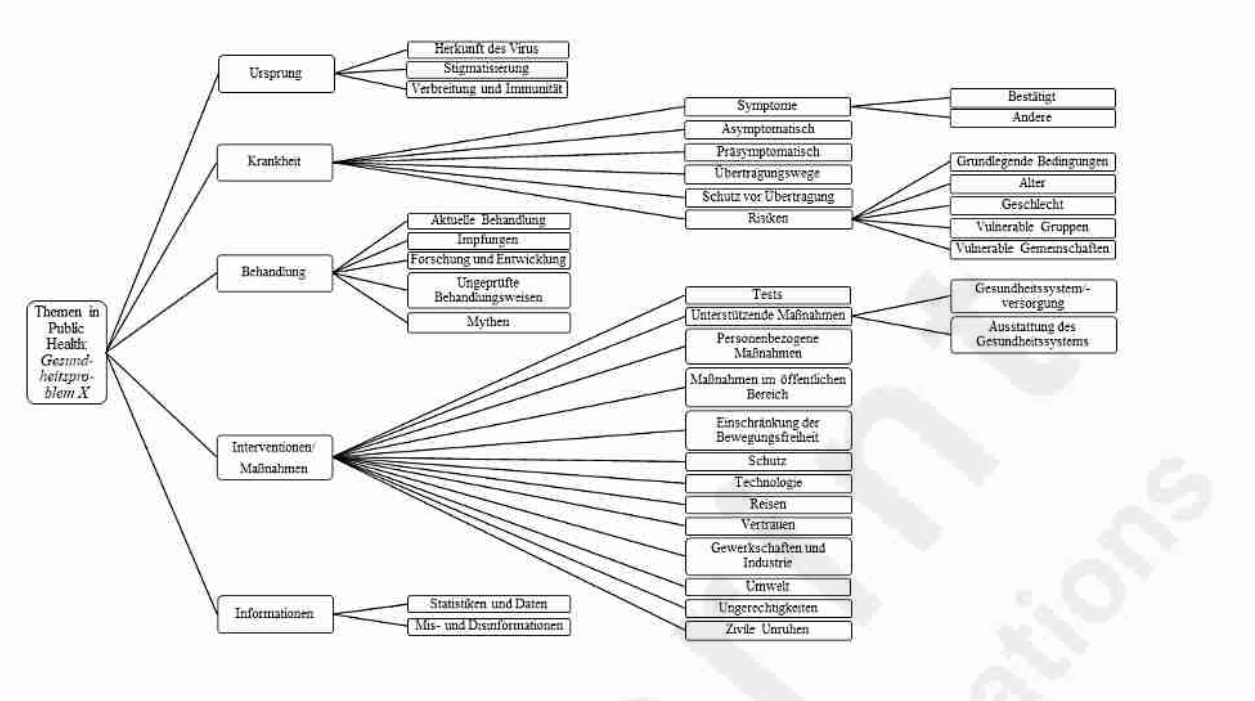
Supplemental material

Supplemental Table 1. Risk assessment of data protection requirement, based on the data protection questionnaire for new procedures for processing of personal data at the Robert Koch Institute (Version 03/2019).

Protection requirement	Description
low	Anonymous data
normal	Since any processing of personal data constitutes an interference with the fundamental rights of the data subject, the need for protection can never be lower than "normal." Consequently, only processing operations involving non-personal, i. e. anonymous, data can be less in need of protection.
high	The following processing scenarios, listed as examples, imply an intensity of intervention that may result in a higher than normal need for protection: - Processing of unchangeable personal data that can serve as an anchor for profiling for a lifetime or that can be assigned (e.g., biometric data, genetic data), - Dissemination of uniquely identifying, highly linkable data (e.g., lifetime health insurance number, tax ID), - Processing of data with potential impact on the image/reputation of the data subject, - Processing of data in a procedure with potential impact on the physical integrity of the data subject, - Processing of data that can realistically be expected to have an impact on the exercise of fundamental rights of a large number of data subjects (e.g., increasingly widespread, public video surveillance), - Risk of discrimination, stigmatization (e.g., becoming aware of HIV infection), - interference with particularly protected internal sphere of life of a data subject (e.g. sexual behaviour), - Personal health data
Very high	A very high need for protection is to be assumed if a person affected is directly dependent on the decisions or services of the organization for his or her existence and additional risks for the person affected are not noticeable.

Supplemental Figure 1. Taxonomy to systematically monitor key words in conversations related to public health issue X within thematic categories relevant to public health response. (German version; English version as Figure 1).



Supplemental Data. Full list of in- and exclusion of potential data sources for social listening.
See separate file.

Supplementary Files