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Original Article

Risk Communication Gaps During Climate-Sensitive Disease Outbreaks: A Qualitative Study

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ABSTRACT

Background: Climate-sensitive disease outbreaks are increasingly shaped by rainfall, flooding, water insecurity, heat, sanitation disruption, and vector ecology, but community response also depends on how risk is communicated. Qualitative inquiry is needed to understand how people interpret warnings, assess trust, respond to uncertainty and misinformation, and judge whether recommended protective actions are feasible in everyday conditions. Objective: This study explored community perceptions of risk communication during climate-sensitive disease outbreak risk, focusing on message timing, clarity, trusted sources, misinformation, channel access, and feasibility of recommended protective actions. Methods: A qualitative descriptive study was conducted using 12 purposively varied participant accounts from adults exposed to communication about climate-sensitive disease risks. Participants included caregivers, workers, parents, older adults, community volunteers, young adults, a pregnant participant, a shopkeeper, a migrant worker, a local leader, a student, and a water-insecure resident. Data were analysed using reflexive thematic analysis, sensitised by Crisis and Emergency Risk Communication, Risk Communication and Community Engagement principles, and the Health Belief Model. Results: Six themes were identified: delayed warnings and weak preparedness signals; unclear explanation of the climate-disease connection; conflicting messages from official and informal sources; technical language and limited actionability; unequal access to trusted communication channels; and advice without feasible protective support. Participants' accounts suggested that response was shaped not only by awareness, but also by trust, practical understanding, language access, service visibility, household resources, and the credibility of messengers. Conclusion: Risk communication for climate-sensitive outbreaks should be timely, locally explained, coordinated across sectors, delivered through trusted and accessible channels, and linked with practical support such as safe water, vector control, clinic access, and household-level prevention guidance. Keywords: Risk communication; climate-sensitive diseases; disease outbreaks; public health communication; community engagement; misinformation; outbreak preparedness.

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INTRODUCTION

Climate-sensitive disease outbreaks are an increasing public health concern because changes in temperature, rainfall, flooding, drought, water insecurity, sanitation disruption, and vector ecology can alter the interaction between pathogens, vectors, environments, health systems, and communities. Diseases such as dengue, malaria, cholera, diarrhoeal infections, leptospirosis, and other environmentally mediated conditions are not only shaped by biological and ecological processes, but also by how risk is communicated before and during outbreaks. Communities must understand why risk is changing, what

protective actions are required, which symptoms indicate danger, where help is available, and how recommended actions can be realistically implemented within local household and service constraints. The World Health Organization has identified climate change as a major threat to health, with projected increases in the burden of malaria, diarrhoeal disease, malnutrition, heat-related illness, and other climate-associated conditions [1].

Vector-borne and waterborne diseases are particularly relevant to climate-sensitive risk communication because their risks are often linked to visible environmental changes, including rainfall, stagnant water, flooding, unsafe water storage, poor drainage, heat, and sanitation breakdown. Vector-borne disease transmission can be influenced by temperature, rainfall, humidity, breeding environments, and patterns of human exposure [2]. Global climate-health surveillance has also shown that climatic suitability for several pathogens and vectors has increased in many regions, strengthening the need for communication systems that can translate environmental warning signals into locally meaningful public guidance [3]. Dengue illustrates this challenge because household prevention, mosquito control, early recognition, and timely care-seeking are frequently emphasized in public health messaging, yet communities may not always receive these messages early enough or in sufficiently practical language [4]. Cholera and acute watery diarrhoeal disease raise similar communication challenges, particularly where flooding, unsafe water, displacement, and sanitation disruption increase exposure while households may lack the resources needed to act on water-safety advice [5].

Risk communication during climate-sensitive outbreaks cannot be understood as a simple transfer of technical information from authorities to communities. People interpret warnings through prior outbreak experience, trust in public institutions, religious and cultural beliefs, household decision-making structures, social media exposure, language access, work constraints, mobility, service availability, and the material resources needed to act. Instructions such as eliminating stagnant water, boiling water, covering containers, using mosquito protection, or visiting a clinic early may appear straightforward to health professionals but may be difficult for households facing unsafe drainage, unreliable water supply, informal employment, limited transport, language exclusion, or low confidence in public services. Climate vulnerability is therefore closely connected with communication vulnerability: those most exposed to disease risk may also be those least likely to receive timely, trusted, understandable, and feasible guidance [6].

Existing climate-health literature shows that disease risk emerges through interactions between environmental change and social conditions, rather than through climate factors alone. Climate can influence vector breeding, pathogen survival, water contamination, and exposure patterns, but the final outbreak burden is also shaped by housing, sanitation, poverty, mobility, water infrastructure, and health service capacity [7,8]. Broader infectious disease literature similarly cautions against treating climate as the sole explanation for outbreaks because governance, infrastructure, and social vulnerability strongly influence both exposure and response [9]. Public health communication must therefore explain climate-related pathways without obscuring local material realities. Messages that focus only on “climate change” or “seasonal disease risk” may fail if they do not explain the specific household-level mechanisms through which rainfall, heat, flooding, or water insecurity become disease risks [10,11].

Emergency risk communication guidance emphasizes timeliness, transparency, credibility, empathy, practical advice, and two-way engagement with affected communities [12,13]. The Crisis and Emergency Risk Communication model highlights the need to be first, accurate, credible, empathetic, action-oriented, and respectful during public health emergencies [14]. Risk Communication and Community Engagement approaches further stress the importance of social listening, trusted local messengers, accessible channels, community feedback, and coordination between communication and services [15,16]. These principles are especially important for climate-sensitive outbreaks because authorities may need to communicate probabilistic or early-warning risk before case numbers rise sharply or before causal pathways are fully visible to the public.

Misinformation and conflicting messages further complicate outbreak communication. Rumours become more persuasive when official information is delayed, technical, inconsistent, or disconnected from people's lived realities. Evidence on misinformation correction suggests that responses are more effective when they are timely, specific, linked to trusted sources, and accompanied by an alternative explanation that fills the gap left by the false claim [17]. Studies on COVID-19 misinformation have shown that people often assess risk through competing information streams from government sources, media, social networks, and informal contacts, with source credibility playing a central role in interpretation and action [18]. Preventive approaches such as prebunking, media literacy, social listening, and community-based explanation may therefore be necessary before and during climate-sensitive outbreak periods [19].

The Health Belief Model provides a useful lens for understanding why people may or may not act on outbreak messages because perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy influence health behaviour [20,21]. However, in climate-sensitive outbreaks, barriers are not only cognitive or attitudinal. They may include lack of safe water containers, poor drainage, unaffordable transport, clinic waiting times, language marginalisation, insecure work, limited household authority, or mistrust created by previous institutional failure [22]. For this reason, the present study used a qualitative approach guided by a SPIDER logic: the sample comprised community members with varied exposure to outbreak communication; the phenomenon of interest was the experience and interpretation of risk communication during climate-sensitive disease risk; the design used semi-structured qualitative interviews; the evaluation focused on timing, clarity, trust, uncertainty, misinformation, channel access, and feasibility of protective action; and the research type was qualitative thematic inquiry. This approach was appropriate because the study sought to understand meanings, perceptions, practical barriers, and service experiences rather than estimate prevalence or test statistical associations.

This qualitative study examined how community members received, interpreted, trusted, and acted upon risk communication during climate-sensitive disease outbreak risk. Specifically, it explored perceptions of warning timing, explanations of climate-disease links, trusted and conflicting information sources, misinformation and uncertainty, access to communication channels, and the feasibility of recommended protective actions. By identifying communication gaps from the perspective of affected or at-risk community members, the study aimed to inform more timely, locally relevant, equitable, and actionable outbreak communication strategies.

Methodology

This study used a qualitative descriptive design to explore how community members experienced, interpreted, and responded to risk communication during climate-sensitive disease outbreak risk. A qualitative design was appropriate because the study aimed to examine perceptions, meanings, trust, uncertainty, message clarity, and feasibility of recommended protective actions rather than measure prevalence or test statistical relationships. Qualitative description was selected because it allows a direct but analytically useful account of participants' experiences in public health and healthcare contexts while remaining close to participants' language and practical concerns [23,24]. The study was guided by Crisis and Emergency Risk Communication, Risk Communication and Community Engagement principles, and the Health Belief Model, which sensitised the analysis to message timing, clarity, credibility, empathy, trusted channels, perceived susceptibility and severity, perceived barriers, cues to action, and self-efficacy [12-14,20-22].

The study was conducted in an urban and peri-urban community context where adults had been exposed to public or informal messages about disease risk associated with rainfall, flooding, water conditions, mosquitoes, heat, or other climate-sensitive environmental triggers. The setting was selected because climate-sensitive outbreak risks require communities to interpret both environmental warning signs and public health instructions. The manuscript should specify the exact country, city or district, data collection period, dominant outbreak concern, and recruitment locations to strengthen transferability and reporting completeness. Participants were eligible if they were adults who had received, discussed, or acted upon

communication related to climate-sensitive disease risk, including messages about mosquito control, water safety, symptom recognition, care-seeking, household prevention, or community-level preparedness. Participants were excluded if they were unable to provide informed consent or had no exposure to relevant outbreak or risk communication.

Twelve participants were included and were assigned anonymised codes from P01 to P12. Participants represented a purposively varied sample, including caregivers, informal workers, parents of school-age children, older adults, community volunteers, young adults, pregnant participants, small shopkeepers, migrant workers, local leaders, students, and residents experiencing water insecurity. Purposive sampling was used to capture diversity in information sources, trusted messengers, household decision-making positions, language and channel access, water and work constraints, and practical capacity to act on recommended protective measures. The sample was not intended to be statistically representative; instead, it was designed to generate information-rich accounts relevant to the study aim. Recruitment procedures should be reported explicitly, including who approached potential participants, where they were approached, whether any participants refused, and whether recruiters had any service or authority relationship with participants.

Data were collected through semi-structured individual interviews focused on outbreak messages, warning timing, trusted sources, unclear or inconsistent information, explanations of climate-disease relationships, rumours and misinformation, media and interpersonal communication channels, household decision-making, and the feasibility of recommended protective behaviours. The interview guide was developed from the study objectives and sensitising frameworks, while allowing participants to introduce unanticipated experiences and concerns. For reproducibility, the manuscript should state whether the guide was piloted, the language used during interviews, whether interviews were audio-recorded with permission, the approximate duration of interviews, the interview location, privacy arrangements, whether field notes were taken, and whether repeat interviews were conducted. Where translation was required, the translation process should be described, including how meaning was preserved across transcription and translation.

Data were anonymised and organised using participant codes before analysis. Audio-recorded interviews, where used, should be transcribed verbatim; if notes rather than recordings were used, the manuscript should state this clearly and describe how accuracy was maintained. Transcripts or interview records should be de-identified before analysis, with removal of names, exact addresses, and other identifying information. Data storage procedures should include password protection, restricted access to the research team, and secure retention according to institutional requirements. If interviews were translated into English for analysis, the manuscript should specify whether translation was performed by bilingual researchers, whether selected extracts were checked against the original language, and how culturally specific meanings were retained.

The research team used reflexive thematic analysis to identify patterns of meaning across the participant accounts [25,26]. Analysis involved repeated familiarisation with the data, initial coding, grouping of related codes, development of candidate themes, review of theme boundaries, definition and naming of themes, and analytic writing. The three sensitising frameworks helped guide attention to communication timing, clarity, trust, credibility, uncertainty, channel access, perceived risk, barriers, and self-efficacy, but coding remained open to inductive meanings emerging from participants' accounts. To improve analytic transparency, the manuscript should report how many researchers coded the data, whether coding was conducted independently or collaboratively, whether a codebook was developed, how coding disagreements or interpretive differences were resolved, whether qualitative software or manual matrices were used, and how an audit trail of coding and theme-development decisions was maintained.

Sample adequacy was considered using the principle of information power rather than statistical sample-size calculation [27]. The sample of 12 participants was considered appropriate if the study aim was sufficiently focused, the participants had direct experience of relevant outbreak communication, the accounts were information-rich, and later interviews repeated the main communication gaps without

generating new theme-level patterns. If the authors claim saturation, they should specify the type of saturation assessed, such as code saturation or meaning saturation, and indicate when it was reached. If saturation was not formally assessed, the manuscript should avoid overstating saturation and instead state that sample adequacy was judged through information power and recurrence of major analytic patterns.

Trustworthiness was addressed through credibility, dependability, confirmability, and transferability [28-30]. Credibility was supported by using participant quotations, comparing accounts across varied participant roles, and linking themes to the study questions. Dependability should be strengthened by documenting analytic decisions, coding revisions, and theme development in an audit trail. Confirmability should be supported through reflexive notes that record researcher assumptions and interpretation decisions. Transferability should be improved by providing sufficient contextual detail about the study setting, participant characteristics, outbreak-risk context, and communication environment. If member checking, peer debriefing, triangulation, or negative-case analysis was conducted, this should be stated explicitly; if not, the manuscript should acknowledge this as a limitation rather than imply that all trustworthiness procedures were used.

Reflexivity was an important consideration because researchers' assumptions about public health communication, institutional credibility, misinformation, and community responsibility could influence data interpretation. The manuscript should state the roles and backgrounds of the interviewer and analysts, whether they had prior relationships with participants, and how potential bias was managed. Reflexive practice may include post-interview notes, team discussion of assumptions, comparison of alternative interpretations, and attention to deviant or contrasting cases. These details are necessary for COREQ and SRQR alignment and for allowing readers to judge how researcher position may have shaped the findings.

Ethical approval was obtained from the Department of Epidemiology, Universitas Prima Indonesia. Participation was voluntary, and informed consent was obtained before data collection. The manuscript should clarify whether consent was written or verbal, whether permission for audio recording was obtained, and how participants were informed of their right to decline questions or withdraw. Participant anonymity was protected through code numbers and removal of identifying information from transcripts, tables, and quotations. Because outbreak communication can involve fear, misinformation, institutional mistrust, and potentially vulnerable participants, the ethical approach should also describe how privacy, confidentiality, and participant comfort were maintained during interviews.

FINDINGS

Analysis of the 12 participant accounts generated six interrelated themes describing how community members received, interpreted, trusted, and acted upon risk communication during climate-sensitive disease outbreak risk. The themes were: delayed warnings and weak preparedness signals; unclear explanation of the climate-disease connection; conflicting messages from official and informal sources; technical language and limited actionability; unequal access to trusted communication channels; and advice that was not supported by feasible protective resources. These themes indicate that communication gaps were not isolated message failures, but reflected broader misalignment between institutional communication, community interpretation, trusted channels, and household capacity to act.

Because the dataset comprised 12 individual participant accounts rather than focus group discussions or district-level sampling, the results are presented using structured qualitative magnitude language rather than statistical frequency. The terms "prominent," "recurring," and "participant-specific" are used to indicate analytic weight based on recurrence across accounts, relevance to the research question, and depth of supporting narratives. These terms should not be interpreted as quantitative prevalence estimates.

Delayed warnings and weak preparedness signals were a prominent concern among participants whose accounts described official messages as arriving after community concern had already emerged. This

pattern was especially visible in the accounts of participants who observed local environmental risks, such as fever clusters or standing water, before receiving formal advice. The issue was not only that warnings were late, but that late communication reduced the perceived preparedness and responsiveness of authorities. For participants such as the local leader and shopkeeper, community observation appeared to move faster than formal alerts. This suggests that climate-sensitive outbreak communication should be triggered not only by confirmed case escalation but also by early environmental signals that are visible to residents, including heavy rainfall, stagnant water, drainage failure, flooding, water contamination, and increased mosquito presence.

Table 1. Theme matrix showing communication gaps across participant groups and illustrative quote IDs

Theme	Caregivers, parents, pregnant participant, and older adult	Workers, shopkeeper, migrant worker, and water-insecure resident	Community volunteer and local leader	Student or young adult	Evidence pattern and illustrative quote IDs
Delayed warnings and weak preparedness signals	Present where families needed earlier clarification before taking protective action	Present where visible environmental risk preceded official alerts	Prominent among local actors expected to support community response	Not primary but related to later uncertainty	Recurring across accounts that described formal communication as reactive rather than anticipatory; quote IDs: P01, P08, P10
Unclear explanation of the climate-disease connection	Prominent among parents and family decision-makers needing practical causal explanation	Present where climate messages did not connect with water, work, or environmental constraints	Not primary but relevant to local explanation duties	Present where general online climate information did not translate into local disease risk	Recurring across accounts that showed difficulty connecting rainfall, climate, mosquitoes, water contamination, and disease; quote IDs: P03, P06
Conflicting messages from authorities and informal sources	Present where families received multiple competing instructions	Present where informal networks influenced interpretation	Prominent among community intermediaries expected to relay advice	Present where official pages and peer discussions produced doubt	Recurring across accounts involving health teams, municipal agencies, media, neighbours, and social media; quote IDs: P05, P06, P11
Technical language and limited actionability	Prominent among older adults, caregivers, and pregnant participants needing clear danger signs	Present where advice did not translate into feasible household or work decisions	Less explicit but relevant for community-level explanation	Present where technical online messages required interpretation	Recurring in accounts where disease terminology or general advice did not guide immediate household decisions; quote IDs: P04, P07
Unequal access to trusted communication channels	Present where families relied on nurses, schools, midwives, or local workers	Prominent among migrant and water-insecure participants affected by language, channel, and resource exclusion	Present where local leaders acted as intermediaries	Present where digital sources were available but inconsistent	Recurring across accounts showing that posting a message did not ensure meaningful reach; quote IDs: P09, P12
Advice without feasible protective support	Present where household-level advice required resources or family cooperation	Prominent among informal workers, shopkeepers, and water-insecure residents facing material constraints	Present where local response required municipal or service support	Less explicit but related to trust in official advice	Prominent in accounts where participants did not reject advice but struggled to act because of water, containers, work, cost, drainage, or vector-control limitations; quote IDs: P02, P08, P12

Unclear explanation of the climate-disease connection was a recurring theme, particularly among participants who received general references to weather, rain, flooding, or climate but did not receive a practical explanation of how these conditions produced disease risk. Participants did not necessarily reject climate-related messages; rather, they needed them to be translated into locally observable mechanisms. The parent's question about how "rain becomes disease" illustrates the gap between technical risk framing and household-level understanding. Climate-sensitive communication therefore needs to move beyond broad warnings and explain specific pathways: rainfall may create mosquito breeding sites, flooding may contaminate water, unsafe storage may increase diarrhoeal disease risk, and heat or disrupted services may affect exposure and care-seeking. Without this practical explanation, disease risk may be normalised as seasonal illness rather than understood as a preventable outbreak threat.

Table 2. Representative quotation table linking themes, subthemes, and participant accounts

Theme	Subtheme	Representative quotation	Participant label	Interpretive meaning
Delayed warnings and weak preparedness signals	Official messages arrived after local concern had already developed	"By the time the official message came, people were already talking about fever in three streets."	P10, local leader	The warning was experienced as reactive rather than preventive, reducing confidence in preparedness communication.

Theme	Subtheme	Representative quotation	Participant label	Interpretive meaning
Delayed warnings and weak preparedness signals	Visible environmental risks were not converted into early alerts	"The water was standing in the market area, but the warning came later."	P08, small shopkeeper	Participants noticed environmental risk before formal communication, suggesting a gap between local observation and institutional warning.
Unclear explanation of the climate-disease connection	Climate was mentioned without a practical disease pathway	"They said the weather made it worse, but nobody explained how rain becomes disease."	P03, parent of school-age children	Participants needed concrete explanations linking rainfall, standing water, mosquitoes, contamination, and disease transmission.
Unclear explanation of the climate-disease connection	General climate information did not translate into local action	"Online they talk about climate, but here we need to know if dirty water or mosquitoes will make us sick."	P06, young adult	Abstract climate messaging was less useful than locally grounded risk explanation.
Conflicting messages from authorities and informal sources	Agencies communicated inconsistent priorities	"The health team said one thing, the municipality said another, and people asked which one was true."	P05, community volunteer	Inconsistent official communication weakened credibility and delayed action.
Conflicting messages from authorities and informal sources	Social media rumours competed with official information	"On social media, one post said it was dangerous and another said it was only normal fever."	P06, young adult	Contradictory digital information increased hesitation and uncertainty.
Technical language and limited actionability	Symptoms and danger signs were not explained in household language	"They used names of symptoms, but I did not know which sign meant I should go to hospital."	P04, older adult	Technical terminology did not help participants identify when urgent care was needed.
Technical language and limited actionability	Instructions were correct but not easy to apply	"The midwife explained some things, but the words were difficult, so I followed only what I understood."	P07, pregnant participant	Partial understanding led to selective adherence rather than full protective action.
Unequal access to trusted communication channels	Language barriers delayed access to formal alerts	"The message was not in my language, so I heard it later from another worker."	P09, migrant worker	Communication access was unequal, especially for linguistically marginalised participants.
Unequal access to trusted communication channels	Trusted intermediaries were needed to interpret messages	"When the health worker explained it at home, then I understood what to do."	P12, water-insecure resident	Door-to-door or interpersonal explanation improved comprehension where formal channels were insufficient.
Advice without feasible protective support	Protective advice assumed unavailable household resources	"They told us to keep water covered, but sometimes we do not even have proper containers."	P12, water-insecure resident	Advice lost feasibility when it ignored resource constraints.
Advice without feasible protective support	Work and livelihood demands limited action	"They told us to attend the meeting, but I could not leave work, and water is also not always available."	P02, informal worker	Communication did not account for livelihood constraints and unstable water access.

Conflicting messages from official and informal sources were reported across accounts involving health teams, municipal agencies, neighbours, social media, school notices, and online sources. This theme was particularly important because participants were not simply comparing correct information with misinformation; they were often trying to reconcile multiple partial messages from different sources. The community volunteer's account showed how uncoordinated communication from health and municipal actors created uncertainty about which instruction should be followed. The young adult's account further showed how social media intensified doubt when official guidance was not timely, consistent, or sufficiently explanatory. These findings indicate that risk communication during climate-sensitive outbreaks requires coordination across health, municipal, water, sanitation, school, and local government actors, with shared messages that clarify both household responsibilities and service-level actions.

Technical language and limited actionability emerged where participants understood that a warning had been issued but could not convert the message into immediate decisions. This was especially evident in accounts from participants who needed clear symptom thresholds, danger signs, service instructions, or household priorities. The older adult's account showed that naming symptoms was insufficient if the message did not explain which signs required urgent care. The pregnant participant's account suggested that technically correct instructions may lead to selective adherence when language is difficult or poorly explained. Effective qualitative interpretation of this theme shows that public health messages must answer practical questions: what is the risk, who is most vulnerable, what should be done today, when should care be sought, where should people go, and what support is available.

Unequal access to trusted communication channels was a recurring finding across participant accounts. The manuscript showed that participants relied on diverse sources, including radio, television, WhatsApp groups, neighbours, school notices, nurses, midwives, co-workers, local leaders, community health

workers, and official online pages. However, access to a channel did not necessarily mean access to a trusted or understandable message. The migrant worker's account highlighted language exclusion, while the water-insecure resident's account showed the value of interpersonal explanation by a health worker. This theme indicates that communication reach should not be measured only by whether a message was posted or broadcast. Reach must include language, literacy, work timing, migration status, gendered access to information, digital access, and availability of trusted messengers who can interpret messages in practical terms.

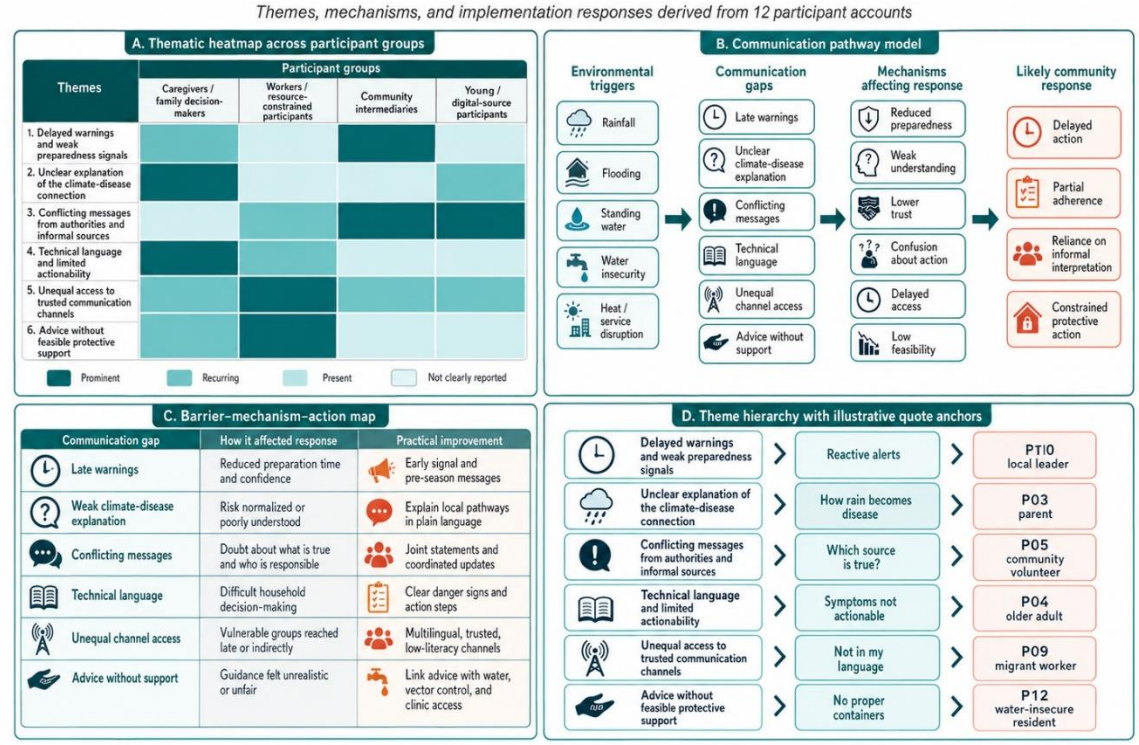

Figure 1 Qualitative synthesis of risk communication gaps during climate-sensitive disease outbreak risk: themes, mechanisms, and implementation responses.

Panel A: Thematic Heatmap. Display the six major themes among participant groups using qualitative intensity categories like "prominent," "recurring," "present," or "not clearly reported." Participants may be caregivers/family decision-makers, workers/resource-constrained participants, community intermediaries, or young/digital-source participants. If defensible theme frequency tallies are not available, utilize presence/absence or qualitative magnitude instead. Panel B: The Communication Pathway Model. Show how climate-sensitive environmental triggers lead to communication gaps and community response. The suggested flow is as follows: rainfall, flooding, standing water, and water insecurity lead to delayed or unclear messaging, trust, understanding, access, and feasibility barriers, and delayed, partial, or limited protective action. Panel C: The Barrier-Mechanism-Action Map. Map each communication gap to the process that influenced reaction and the practical solution required. For example: delayed warnings → reduced preparation time → early signal/pre-season messages; technical language → poor household decision-making → plain-language danger signs and action steps; unsupported advice → low feasibility → link messages with water, containers, vector control, and clinic access. Panel D (optional): Theme Hierarchy or Quote-Based Summary. Display the theme hierarchy: theme → subtheme → quote ID for illustration. Use participant identifiers like P03 parent, P09 migrant worker, or P12 water-insecure resident. Avoid extended quotations in the figure; instead, use short quote IDs and explain entire quotations in the accompanying table.

Advice without feasible protective support was one of the strongest implementation-relevant themes. Participants often did not dismiss official advice because they believed it was false; rather, they described difficulty acting on advice that assumed resources they did not have. The water-insecure participant's account about lacking proper containers and the informal worker's account about work constraints show that household recommendations can become unrealistic when they are not accompanied by material and

service support. This theme was especially evident among participants facing water insecurity, informal employment, market exposure, or inadequate vector-control support. The finding suggests that risk communication should link advice with enabling conditions, including clean water access, safe containers, chlorine, waste removal, drainage response, vector-control services, clinic hours, transport guidance, and locally available support mechanisms.

Across themes, the analysis suggests that poor community response should not be interpreted as lack of awareness alone. Participants' accounts showed that action depended on whether messages were timely, understandable, consistent, trusted, accessible, and feasible. The strongest cross-cutting contrast was between communication as information and communication as enabled action. Messages that only instructed households what to do were less useful when they did not explain why the action mattered, who should act first, what services were available, and how households with limited resources could realistically comply. These findings support a shift from one-way outbreak messaging toward anticipatory, locally explained, equity-sensitive, and service-linked communication.

DISCUSSION

This qualitative study suggests that risk communication gaps during climate-sensitive disease outbreak risk were experienced as relational, practical, and structural failures rather than as simple deficits in public awareness. Participants did not describe communication problems only in terms of whether information was available; they described whether messages arrived early enough, whether the link between climate and disease was understandable, whether different sources were consistent, whether technical language could be translated into household decisions, whether trusted channels were accessible, and whether recommended actions were feasible with available resources. This interpretation aligns with emergency risk communication and community engagement principles, which emphasize timeliness, credibility, empathy, practical guidance, and two-way engagement rather than one-directional information delivery [12-16].

The theme of delayed warnings indicates the need to move from reactive outbreak announcements toward anticipatory communication linked to environmental and surveillance signals. In climate-sensitive outbreaks, visible local conditions such as heavy rainfall, standing water, flooding, unsafe water storage, heat, or sanitation disruption may appear before formal outbreak escalation. Participants' accounts suggested that communities noticed environmental risk before receiving official guidance, which may reduce confidence in public preparedness. Risk communication therefore needs to explain early warning signals before disease becomes widespread. This does not require overstatement or certainty; rather, it requires transparent communication that acknowledges uncertainty while explaining why precautionary action is recommended.

The unclear explanation of the climate-disease connection shows that broad references to weather, rainfall, flooding, or climate are insufficient unless they are translated into locally observable disease pathways. Participants needed practical explanations of how rain can create mosquito breeding sites, how flooding can contaminate water, how water insecurity can lead to unsafe storage, and how disrupted services can delay care-seeking. The literature on climate-sensitive infectious diseases similarly shows that climate interacts with vector ecology, water systems, sanitation, housing, and health-service capacity rather than acting as an isolated cause [7-11]. Communication should therefore avoid both excessive technicality and oversimplification. Effective messages should connect environmental triggers with household-level actions in plain language.

Conflicting messages from official and informal sources weakened credibility and increased uncertainty. Participants' accounts suggested that confusion did not arise only from misinformation, but also from fragmented institutional communication. Health teams, municipal actors, schools, workplaces, informal networks, and digital platforms may each communicate partial information, leaving communities uncertain about what is true and who is responsible. This finding supports the need for coordinated risk communication across health, water, sanitation, drainage, waste management, education, meteorology,

and local government actors. Joint briefing notes, shared risk levels, consistent terminology, service updates, and pre-briefing of community intermediaries may reduce confusion and improve trust.

Technical language and limited actionability were important barriers because technically correct messages did not always help participants make immediate decisions. Participants needed clear answers to practical questions: what is the risk, who is most vulnerable, what should be done today, what symptoms are danger signs, where should care be sought, and what support is available. The Health Belief Model helps explain this pattern because cues to action and self-efficacy are necessary for protective behaviour, but the findings also show that barriers were often structural rather than purely cognitive [20-22]. Messages that ask households to remove stagnant water, boil water, cover containers, or seek care early may be ineffective when households lack containers, safe water, money for transport, time away from work, or trust in available services.

Unequal access to trusted communication channels highlights the importance of communication equity. Participants relied on diverse sources, including radio, television, WhatsApp groups, neighbours, school notices, health workers, midwives, co-workers, community leaders, and official pages. However, message dissemination did not guarantee message access. Language, literacy, migration status, age, work schedules, digital access, gendered information pathways, and trust in the messenger shaped whether communication became understandable and actionable. This finding supports the use of multilingual, low-literacy, interpersonal, radio-based, workplace-based, school-based, and door-to-door communication strategies, especially for groups that may be reached late through formal digital channels.

Advice without feasible protective support was one of the most implementation-relevant themes. Participants did not necessarily reject official guidance; rather, they described difficulty implementing advice that assumed resources unavailable to them. This is particularly important in climate-sensitive disease outbreaks because household-level prevention often depends on material conditions such as water containers, drainage, waste removal, vector-control services, transport, clinic access, and affordable care. Communication that ignores these constraints may appear unfair or unrealistic. Risk messages should therefore distinguish between what households can do, what services will do, where support can be accessed, what remains uncertain, and how residents can report barriers. Linking communication with visible service action may improve credibility more effectively than repeated instruction alone.

The findings have practical implications for outbreak preparedness. Public health agencies should develop pre-season and early-signal message libraries for dengue, malaria, cholera, diarrhoeal disease, leptospirosis, heat-related illness, and other climate-sensitive risks. These messages should include plain-language climate-disease pathways, household action steps, danger signs, service locations, uncertainty statements, and feedback mechanisms. Communication drills should include health, municipal, meteorological, water, sanitation, school, and community actors so that messages can be approved, translated, disseminated, and explained quickly. Trusted intermediaries such as community health workers, midwives, school staff, local leaders, and workplace contacts should be briefed early because they often translate institutional warnings into practical household guidance.

The findings also suggest that misinformation should be treated as both a communication problem and a symptom of weak communication systems. Rumours become more persuasive when official messages are delayed, inconsistent, overly technical, or disconnected from lived conditions. Corrective communication should therefore be accompanied by social listening, prebunking of predictable false claims, and locally trusted explanation. Evidence from misinformation research indicates that corrections are more effective when they are timely, specific, source-linked, and accompanied by a coherent alternative explanation [17-19]. In climate-sensitive outbreaks, this means explaining not only that a rumour is false, but also what is happening environmentally, why risk has changed, what protective actions are realistic, and where help can be obtained.

Several limitations should be considered. The study is based on 12 qualitative participant accounts and is not intended to estimate prevalence or produce statistical generalisation. The findings represent

perceptions and experiences of communication rather than independently verified behavioural change or outbreak outcomes. The setting is described broadly, and future versions of the manuscript should provide more detail on country, locality, recruitment site, disease context, data collection dates, language, and interviewer role to improve transferability. Social desirability may have influenced how participants described their responses to official messages. Recall bias may also have affected accounts of message timing, source trust, and protective action. If interviews were translated, some meaning may have been altered during translation. The manuscript should also clarify whether participants were recruited through community or health-system intermediaries, because this could affect what they felt comfortable reporting.

Despite these limitations, the study contributes useful qualitative insight into why climate-sensitive outbreak messages may fail to become protective action. The findings suggest that communication should not be evaluated only by whether information was sent, but by whether communities received it in time, understood it, trusted it, could access it through appropriate channels, and had the resources needed to act. This shifts the focus from message dissemination alone toward communication as an enabling component of outbreak preparedness and climate adaptation.

CONCLUSION

This qualitative study suggests that community-perceived risk communication gaps during climate-sensitive disease outbreak risk were shaped by delayed warnings, unclear climate-disease explanations, inconsistent sources, technical language, unequal access to trusted channels, and advice that did not match household resources. Participants' accounts indicated that communication was more acceptable and actionable when it was timely, locally explained, delivered through trusted messengers, and linked with practical support such as safe water, vector control, clinic access, and household-level prevention guidance. Public health authorities should strengthen early-warning communication, use plain-language explanations of local environmental disease pathways, coordinate messages across sectors, monitor rumours, and ensure that protective advice is accompanied by feasible service support. The findings should be interpreted as qualitative evidence on perceived communication mechanisms and implementation conditions rather than as evidence of population-level behavioural change or outbreak impact.

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