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Review

From Risk Visualization to Human-Centred Interfaces: A Scoping Review of Digital Technologies for Risk Communication

Mariagrazia Monaci [1], Elena Cattelino [1], Luca Scacchi [1], Andrea Guerra [2] and Enrico Vezzetti [3,*]

1 Department of Human and Social Sciences, Università della Valle d'Aosta—Université de la Vallée d'Aoste, Strada Cappuccini 2A, 11100 Aosta, Italy; e.cattelino@univda.it (E.C.); l.scacchi@univda.it (L.S.)
2 COSTECH (EA 2223), Université de Technologie de Compiègne (UTC), Centre de Recherche, Rue du Dr Schweitzer, 60203 Compiègne, France; andrea.guerra@utc.fr
3 Department of Management and Production Engineering, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129 Turin, Italy
* Correspondence: enrico.vezzetti@polito.it

Featured Application

The proposed human-centred framework can support the design and evaluation of digital risk communication interfaces by systematically aligning risk characteristics, representation modalities, interface technologies, interaction strategies, target users, and intended communication outcomes. It can be applied across domains such as healthcare, natural hazards, environmental risk, industrial safety, transport, and cybersecurity.

Abstract

Digital risk communication increasingly relies on interactive technologies to transform complex, uncertain, and probabilistic information into forms that can support human understanding and decision-making. Yet the literature is fragmented across application domains, technologies, and interaction paradigms. This scoping review maps how digital and interactive technologies are used to communicate, represent, visualize, or enable users to experience risk, with particular attention to the relationships among risk type, representation, interface, interaction, target users, and outcomes. Eligible sources described a human-facing digital or interactive risk communication solution, and study characteristics were charted using an eight-dimension taxonomy. Searches of Scopus, Web of Science Core Collection, and PubMed identified 457 records. After removing 119 duplicates, 338 unique records were screened; 258 were retained for eligibility assessment. The final synthesis included 199 studies after the removal of one retracted source, with 57 records excluded during eligibility adjudication and one report not retrieved. Data visualization was the most frequent interface family (n = 122), followed by VR/AR/XR and web/mobile interfaces (both n = 46). Healthcare/public health (n = 87) and natural hazards/disaster (n = 67) dominated the corpus, while interactive exploration was the most common interaction mode (n = 82). The synthesis shows that technology alone does not explain digital risk communication: effectiveness depends on how risk is represented, how users interact with the interface, who the users are, and which outcomes are targeted. A human-centred framework—Risk → Representation → Interface → Interaction → User → Outcome—is proposed to support the analysis, design, and iterative evaluation of future risk communication interfaces.

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1. Introduction

Risk communication is central whenever citizens, patients, professionals, or decision-makers must interpret information characterized by probability, uncertainty, and possible future consequences and translate it into appropriate decisions or behaviours. Risk communication is therefore not merely the transmission of technical information; it also depends on how recipients understand, evaluate, and use that information [1,2]. This challenge spans heterogeneous application domains, including healthcare and public health, natural and environmental hazards, industrial and occupational safety, transport, and cybersecurity. It is intensified by the fact that risk is often probabilistic, dynamic, multidimensional, or not directly observable, and by evidence that comprehension is influenced by the way probabilities and uncertainty are presented [3,4].

The development of digital technologies has substantially broadened the means available to address this problem. Traditional textual and numerical communication is increasingly complemented by graphical and interactive representations, maps and geovisualizations, dashboards, web and mobile applications, decision aids, virtual and augmented reality, conversational agents, and sensor-based interfaces. Domain-specific reviews have documented the growing use of artificial intelligence and virtual reality in doctor–patient risk communication, dashboards for public health data, and geovisualizations for environmental health hazards [5–7].

However, the increasing availability of digital technologies raises a fundamental design question: communication effectiveness cannot be inferred from the technology alone. Research on risk representation has shown that numerical, verbal, and visual formats may produce different levels of understanding, perception, and response, and that specific graphical design choices can alter how information is interpreted [3,8,9]. A dashboard, for example, may communicate risk through probabilities, charts, colours, maps, alert levels, or combinations of these elements. It may provide static information or allow users to explore alternative scenarios, receive contextual feedback, or access personalized content. Experimental evidence from data-based dashboards in animal-health management shows that traffic-light and sequential colour schemes can influence information recall and decision certainty [10].

The problem therefore extends beyond identifying which technologies are used for risk communication. It also requires understanding how risk is represented, through which interface, with what degree of interaction, for which user, and with what intended purpose. Recent HCI studies illustrate this point: interactive interfaces can support informed privacy decisions [11], visualizing the risk of accessibility barriers can influence route planning by people with mobility impairments [12], and augmented reality can make a dynamic risk field perceptible in real time during human–robot collaboration [13].

From this perspective, digital risk communication can be interpreted as a human-centred interface design problem. Technology is only one layer of the communication process; effectiveness emerges from the relationship among risk content, representational form, interface characteristics, interaction modality, and the characteristics of the intended user [4,11–13]. At least six dimensions therefore need to be considered jointly: the risk itself, the representation, the interface, the interaction, the user, and the intended outcome.

The existing literature nevertheless tends to focus on specific technologies or individual application domains. Reviews on AI and VR in surgical risk communication, public health dashboards, and geovisualizations for environmental hazards are important within their respective fields [5–7], but they make it difficult to identify design dimensions that are transferable across domains. A cross-domain synthesis is therefore needed to separate technology type from representation and interaction and to identify recurring human-centred design patterns.

Accordingly, this scoping review aims to

1. Identify the main application domains in which digital technologies are used for risk communication;
2. Classify the main interface families and risk representation modalities;
3. Analyze the interaction modes between users and systems;
4. Identify the main target users and communication outcomes;
5. Propose a human-centred framework describing the design process of risk communication interfaces through the sequence Risk → Representation → Interface → Interaction → User → Outcome.

The objective is therefore not only to map existing technologies but also to derive a conceptual structure that can support the design and evaluation of future human–machine interfaces for risk communication.

2. Materials and Methods

2.1. Review Design

A scoping review was conducted to identify, classify, and synthesize digital and interactive technologies used for risk communication across different application domains. Particular attention was paid to how risk information is represented and made accessible to users, the interface technologies through which it is delivered, and the forms of interaction enabled by those systems.

A scoping-review design was selected because of the breadth and heterogeneity of the field and the need to map concepts, approaches, and characteristics distributed across multiple application areas. The methodological approach was informed by the original scoping-study framework and subsequent methodological refinements [14–16]. The objective was not to quantitatively compare intervention effectiveness but to map the available solutions, identify their main characteristics, and derive cross-cutting analytical dimensions. This scoping review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) [17]. The review protocol was not prospectively registered.

2.2. Information Sources and Search Strategy

The bibliographic search used Scopus, Web of Science Core Collection, and PubMed to provide multidisciplinary coverage of research on risk communication and digital or interactive technologies. The final searches and database exports were completed on 10 August 2026. Across the three databases, 457 records were identified: 331 from Scopus, 50 from Web of Science, and 76 from PubMed. Database-specific syntax was adapted to each platform while preserving the same two-block conceptual structure. The first block captured risk communication and representation terms (“risk communication”, “risk information”, “risk visualization”, “risk visualisation”, “risk representation”, and “risk display”). The second block captured human–machine/human–computer interfaces and digital or interactive forms of risk presentation, including user and graphical interfaces, information/data/interactive visualization, geovisualization, dashboards, virtual/augmented/mixed/extended reality, conversational agents, and chatbots. Publications from 2018 onward were considered.

In Scopus, the terms were searched in titles, abstracts, and keywords (TITLE-ABS-KEY), with the restriction PUBYEAR > 2017. Equivalent database-specific field tags and date restrictions were used in Web of Science Core Collection and PubMed. To improve reproducibility, the complete database-specific search strategies are reported in Supplementary Table S1. The Scopus query is reproduced verbatim from the retained search history. For Web of Science Core Collection and PubMed, the literal historical search strings were not archived; therefore, database-specific queries were reconstructed from the retained term sets, search fields, publication date limits, language restriction, and original record counts used in the review. These reconstructed expressions are explicitly identified as such and are provided to enable replication of the implemented search logic without implying that they are verbatim exports of the original platform search histories. Table 1 summarizes the information sources, search fields, core search logic, and number of records retrieved from each database.

Table 1. Information sources and search framework.

Database	Primary Search Fields	Core Search Logic	Records
Scopus	Title, abstract, keywords	Risk communication/representation × HCI/interface/visualization technologies; PUBYEAR > 2017	331
Web of Science Core Collection	Topic fields	Equivalent two-block Boolean structure adapted to WoS syntax; 2018–2026	50
PubMed	Title/Abstract	Equivalent two-block Boolean structure adapted to PubMed syntax; 2018–10 August 2026	76

Note: The two conceptual search blocks were kept constant across databases, while field tags, platform-specific operators, and date restrictions were adapted to each database. Total records identified = 457.

2.3. Deduplication and Preliminary Screening

The 457 records were deduplicated before screening by comparing normalized DOI values and normalized titles. A total of 119 duplicate records were removed, leaving 338 unique records. Title-and-abstract screening then excluded 80 records. Title-and-abstract screening was independently performed by three reviewers (E.V., M.M., and A.G.); disagreements were resolved by discussion until consensus was reached. The remaining records were provisionally categorized as Include (n = 173) or Maybe (n = 85); both categories were retained for a more restrictive eligibility assessment, resulting in a corpus of 258 records.

2.4. Eligibility Criteria

Studies were considered eligible when they investigated, developed, evaluated, or applied a digital or interactive technology through which risk-related information was intentionally communicated, represented, visualized, or experienced by human users to support understanding, awareness, perception, decision-making, or behavioural response. For the purposes of this review, digital risk communication was operationally defined as the intentional human-facing mediation of risk-related information through a digital or interactive interface, whereby a risk, hazard, exposure, uncertainty, vulnerability, or potential consequence was made perceptible or actionable to a human recipient. General risk-assessment, prediction, optimization, or control systems were excluded when risk was only computed internally and was not explicitly communicated to a human user. Decision-support systems were eligible only when the interface explicitly represented or communicated risk information, rather than merely providing a recommendation or control output. Similarly, general data-visualization systems were eligible only when risk itself constituted an explicit communication object. Empirical and non-empirical contributions were eligible when they provided sufficient information on a concrete human-facing digital risk communication solution or on its design and evaluation. The search and eligibility assessment were restricted to publications in English. No restriction was imposed on study design; journal articles and conference contributions, as well as review/framework and protocol/planned-evaluation publications, were eligible when they met the substantive inclusion criteria. The English-language restriction was applied to ensure consistent screening and coding across the review team. The operational inclusion and exclusion criteria applied during eligibility assessment are summarized in Table 2.

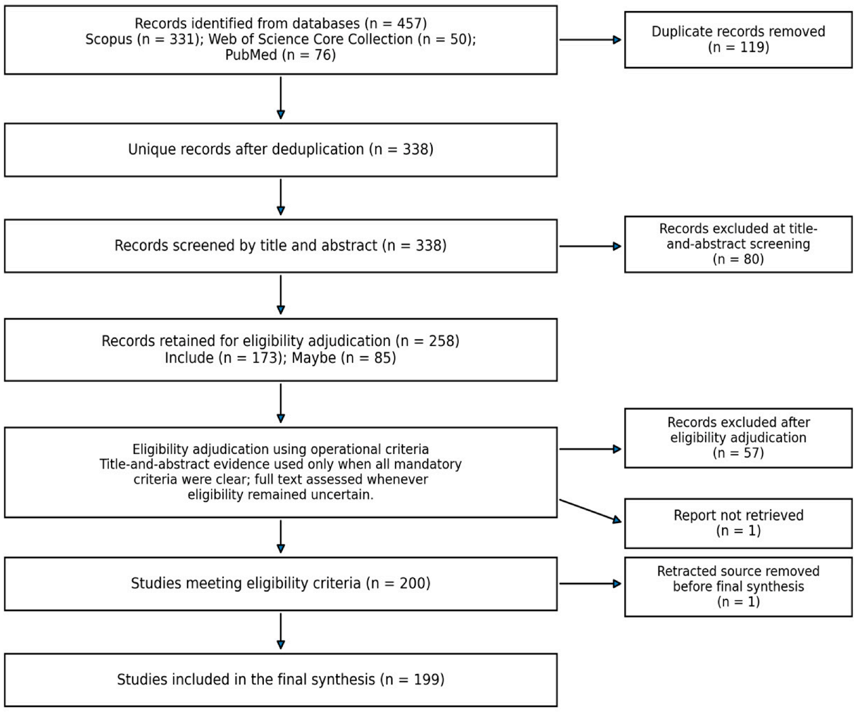
Table 2. Operational eligibility criteria used in the final screening stage.

Criterion	Include	Exclude
Risk content	A risk, hazard, exposure, uncertainty, vulnerability, or consequence is communicated to a human user.	Risk is only computed, predicted, modelled, or assessed without human-facing communication.
Technology/interface	A digital or interactive technology is used to present, visualize, explain, or enable experience of risk.	Technology is present but unrelated to risk communication or representation.
Human-facing function	The interface supports understanding, awareness, perception, decision-making, situational awareness, or protective response.	Risk perception is measured without a communication interface or intervention.
Communication object	The study concerns designed communication/representation of risk information.	The study only analyses discourse, messages, or communication content without a designed interface/intervention.
Transferability	For cross-domain or atypical applications, all preceding risk communication criteria are satisfied and the human-facing interface contains design characteristics that can be mapped to the review taxonomy.	General relevance to interface design alone is insufficient. Applications that do not satisfy the preceding human-facing risk communication criteria are excluded regardless of their potential transferability.

Transferability was therefore not used as an independent route to inclusion. It served only as a scope check for cross-domain applications after the substantive risk-content, technology/interface, human-facing function, and communication-object criteria had been satisfied.

2.5. Eligibility Assessment

The 258 retained records underwent stricter eligibility adjudication using the operational criteria in Table 2. A final eligibility decision based on title-and-abstract information alone was made only when the available information was sufficient to positively establish all mandatory inclusion criteria. Whenever any criterion remained uncertain—particularly the intentional human-facing function, the communication object, or cross-domain scope relevance—the full text was retrieved and assessed before a final decision was made. Lack of information in the title or abstract was not treated as evidence for exclusion. This conservative procedure was intended to minimize false exclusions while directing full-text assessment to records for which eligibility could not be established unambiguously from bibliographic information. Eligibility adjudication was independently performed by three reviewers (E.V., M.M., and A.G.), with any disagreements resolved through discussion until consensus was reached. The eligibility assessment resulted in 200 eligible studies and 57 excluded studies; one report could not be retrieved and therefore remained unresolved. Following eligibility assessment, one of the 200 eligible studies was identified as retracted and was removed from the evidence synthesis. The final analytical corpus therefore comprised 199 studies. The overall identification, screening, eligibility, and final inclusion process is summarized in Figure 1.



Note. The process followed PRISMA-ScR. One source initially meeting the eligibility criteria was subsequently identified as retracted and removed before the final evidence synthesis.

Figure 1. PRISMA-ScR flow diagram of the study-selection process. Eligibility adjudication used title-and-abstract evidence only when all mandatory inclusion criteria could be established from the available information; targeted full-text assessment was performed whenever eligibility remained uncertain. Of the 200 studies meeting the eligibility criteria, one source was subsequently identified as retracted and removed prior to the final evidence synthesis, resulting in a final analytical corpus of 199 studies.

2.6. Data Extraction and Classification

For each study included in the final analytical corpus, bibliographic information and design-relevant characteristics were extracted. Data were charted using a standardized extraction framework corresponding to the eight analytical dimensions reported in Table 3. The final taxonomy comprised eight dimensions: Primary Domain, Risk Type, Interface Family, Representation Modality, Interaction Mode, Target User Group, Communication Purpose, and Evidence Type. Primary Domain, Risk Type, and Evidence Type were coded as single-label dimensions, while Interface Family, Representation Modality, Interaction Mode, Target User Group, and Communication Purpose were multi-label dimensions because one study could combine several technologies, representations, user groups, or communication purposes.

Data extraction and initial classification were distributed among three reviewers (E.V., M.M., and A.G.), each responsible for coding a subset of the included studies according to the taxonomy in Table 3.

Following distributed coding, a cross-check audit was conducted in which each of the three reviewers examined a sample of the classifications assigned by the other two, with all flagged or uncertain cases discussed jointly by E.V., M.M., and A.G. Classifications confirmed without modification during this process were rated high-confidence; those revised following discussion were rated medium-confidence; persistent disagreements after discussion would have been rated low-confidence.

The cross-check audit was initially conducted on the 200 studies meeting the eligibility criteria. Following removal of the retracted source, the final analytical dataset comprised 199 studies. After the audit, 194 records were rated high-confidence and five medium-confidence; no low-confidence classifications remained. The High/Medium confidence labels represent post-adjudication classification confidence and should not be interpreted as an inter-rater agreement statistic. A formal coefficient such as Cohen's or Fleiss' kappa was not calculated because initial study coding was distributed among the three reviewers rather than performed independently in parallel by all reviewers for the complete corpus. Consequently, a retrospective kappa calculated from consensus-adjudicated classifications would not provide a valid estimate of independent agreement. Coding reliability was instead supported through predefined category definitions, cross-checking of classifications, and consensus adjudication of all flagged or uncertain cases. The audited taxonomy was used for all quantitative results reported below. No formal critical appraisal of individual sources of evidence was performed, as the purpose of the scoping review was to map the characteristics and design patterns of the available evidence rather than to assess intervention effectiveness. Authors of the included sources were not contacted for additional or missing information.

Table 3. Analytical taxonomy used for study-level data extraction and synthesis.

Dimension	Purpose	Examples	Coding
Primary Domain	Main application context	Healthcare/public health; natural hazards; industrial safety; transport; environmental; cybersecurity	Single-label
Risk Type	Nature of the communicated risk	Clinical; epidemic; environmental exposure; natural hazard; privacy; occupational safety	Single-label
Interaction Mode	How the user engages with risk information	Static; interactive exploration; immersive; real-time; conversational; adaptive	Multi-label
Target User Group	Intended human recipient	Public; patient/caregiver; professional; operator; manager	Multi-label
Interface Family	Technological interface through which risk is communicated	Data visualization; dashboard; web/mobile; XR; geovisualization; chatbot; sensor display	Multi-label
Representation Modality	Form in which risk information is made perceptible	Graphical; numeric; textual; spatial; warning cue; immersive; multimodal	Multi-label
Communication Purpose	Intended cognitive, decision, or behavioural effect	Awareness; comprehension; decision support; protective action; training	Multi-label
Evidence Type	Type of evidence generated by the study	Empirical user/field study; observational study; prototype development; review/framework; protocol/planned evaluation	Single-label

2.7. Data Synthesis and Framework Development

Absolute frequencies and percentages were calculated for single-label dimensions using the 199 studies in the final analytical corpus as the denominator. For multi-label dimensions, frequencies indicate the number of studies in which each characteristic was present; totals therefore may exceed the number of included studies. A Domain × Interface Family matrix was constructed to examine how interface families were distributed across application contexts. The quantitative synthesis was complemented by qualitative comparison of recurring design relationships among risk representation, interface technology, interaction, users, and outcomes.

Framework development followed a three-step synthesis procedure. First, the eight taxonomy dimensions were examined according to whether they described the application context, a component of the human-facing communication process, the intended effect of communication, or a methodological characteristic of the evidence. Second, dimensions directly describing the communication process were mapped onto six design components: Risk Type → Risk; Representation Modality → Representation; Interface Family → Interface; Interaction Mode → Interaction; Target User Group → User; and Communication Purpose → Outcome. Third, cross-dimensional patterns and representative studies were examined to assess whether these components formed a coherent design sequence across application domains. Primary Domain was not incorporated as a framework component because it describes the context in which communication occurs rather than a functional element of the communication process. Evidence Type was likewise excluded because it characterizes how evidence was generated rather than how risk is communicated. Risk Type was mapped to Risk because it defines the substantive risk, hazard, exposure, uncertainty, vulnerability, or consequence that constitutes the object of communication. Communication Purpose was mapped to Outcome because it captures the intended cognitive, perceptual, decisional, or behavioural effect of the communication process; where studies directly measured such effects, these were interpreted as empirical instantiations of Outcome. The resulting framework was therefore derived from the analytical taxonomy and cross-dimensional synthesis rather than imposed a priori.

3. Results

3.1. Study Selection and General Characteristics

Following the removal of one retracted source, the final synthesis comprised 199 studies. Healthcare/public health was the largest application domain (n = 87; 43.7%), followed by natural hazards/disaster (n = 67; 33.7%). Industrial/occupational safety and transport/public safety each accounted for 10 studies (5.0%), environmental applications for nine (4.5%), cybersecurity/privacy for nine (4.5%), and other/cross-domain applications for seven (3.5%). The distribution by primary domain is shown in Figure 2.

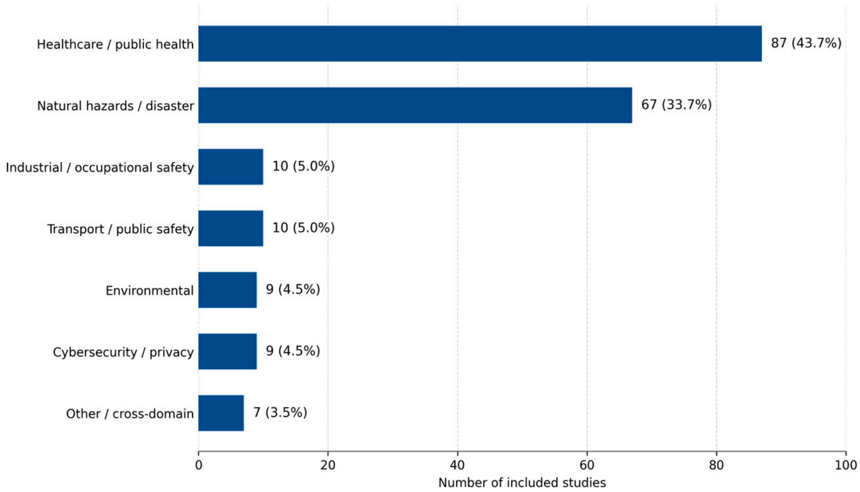


Figure 2. Distribution of the 199 included studies by primary application domain. Primary domain was coded as a mutually exclusive category.

Publication activity increased overall across the 2018–2026 period. The number of included studies rose from eight in 2018 to 33 in 2025 and 43 in 2026 (Figure 3). Because the final search was completed in August 2026, the 2026 count represents a partial publication year and should not be interpreted as a complete annual total. Study-level characteristics and classifications for all 199 included sources of evidence are provided in Supplementary Table S2.

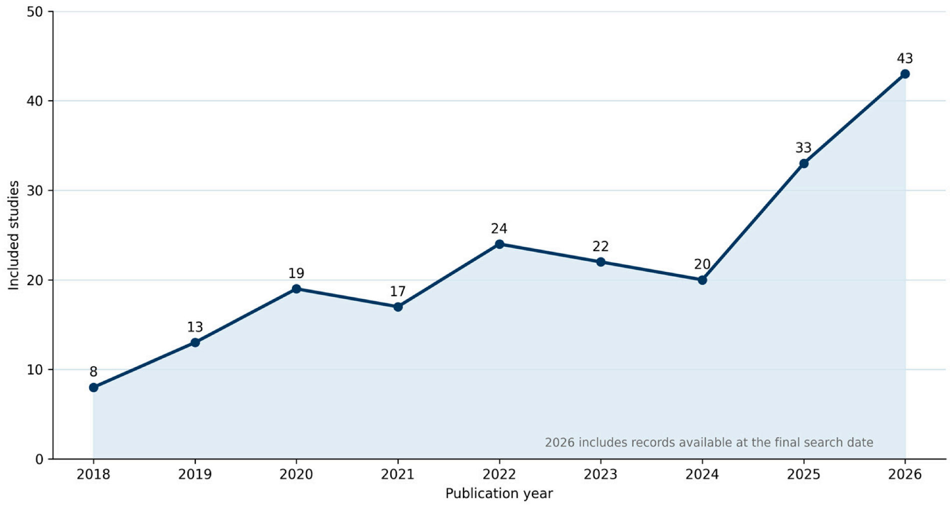


Figure 3. Publication trend of the included studies. The 2026 value reflects publications available up to the final search date in August 2026.

3.2. Interface and Technology Families

Data visualization was the dominant interface family, identified in 122 studies (61.3%). VR/AR/XR and web/mobile interfaces were each present in 46 studies (23.1%), followed by map/geovisualization (n = 35; 17.6%), conversational AI/chatbots (n = 26; 13.1%), and dashboards (n = 20; 10.1%). Decision aids/risk calculators were identified in 14 studies (7.0%), other digital interfaces in 13 studies (6.5%), multimodal/haptic interfaces in eight (4.0%), and sensor/ambient displays in three (1.5%). These categories were multi-label and therefore are not mutually exclusive (Figure 4).

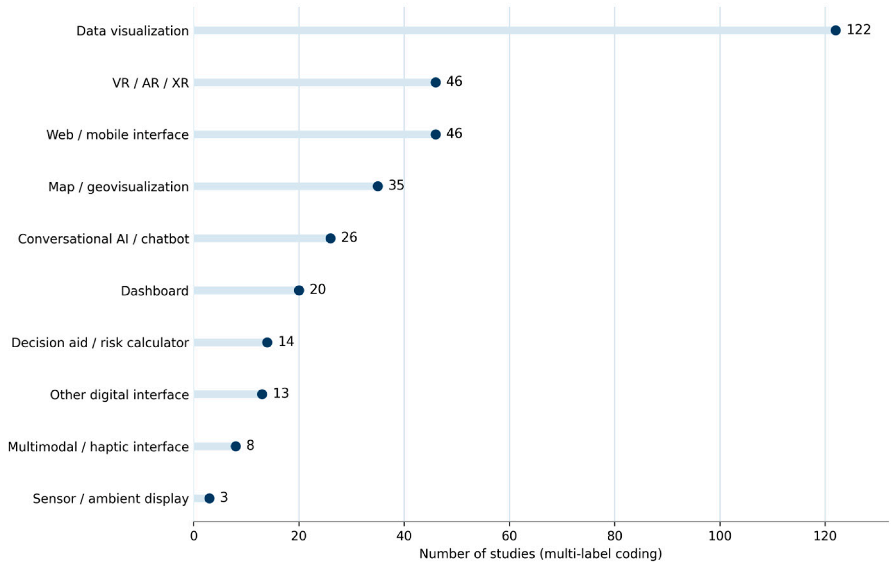


Figure 4. Interface and technology families identified in the included studies. Counts are multi-label; a study may contribute to more than one category.

3.3. Cross-Domain Interface Patterns

Interface adoption differed across application domains. In healthcare/public health, data visualization was the most frequent family (n = 50), followed by web/mobile interfaces (n = 23) and conversational AI/chatbots (n = 18). Natural-hazard/disaster applications showed a different profile, combining data visualization (n = 46), VR/AR/XR (n = 33), and map/geovisualization (n = 22). This reflects the importance of spatial and scenario-based communication in disaster contexts. The complete domain × interface matrix is shown in Figure 5, while Table 4 provides exact counts for the six most prevalent interface families.

Table 4. Distribution of the six most prevalent interface families across primary application domains.

Dimension	Data Vis.	VR/AR/XR	Web/Mobile	Map/Geovis.	Conv. AI	Dashboard
Healthcare/public health	50	7	23	6	18	11
Natural hazards/disaster	46	33	15	22	3	5
Industrial/occupational safety	8	3	1	2	0	2
Transport/public safety	7	1	3	5	0	0
Environmental	4	1	2	0	3	0
Cybersecurity/privacy	3	0	1	0	1	0
Other/cross-domain	4	1	1	0	1	2

Note: Cells report multi-label counts. Because one system can combine multiple interface families, row totals may exceed the number of studies assigned to that domain.

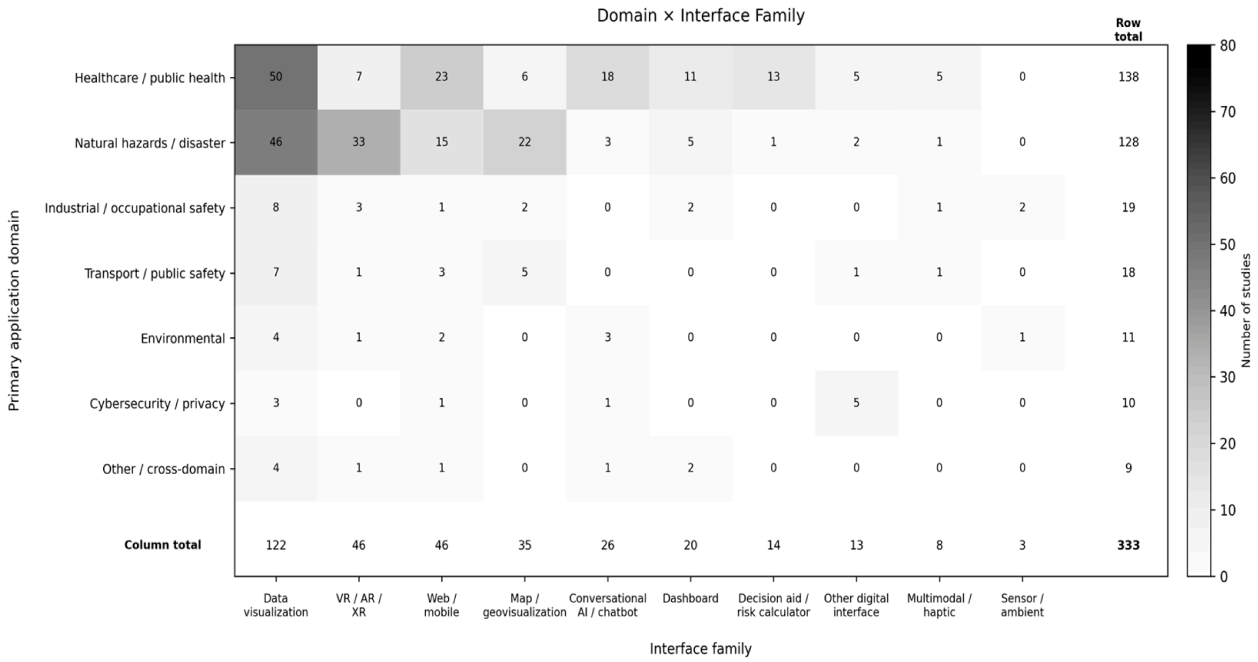


Figure 5. Heatmap of the Domain × Interface Family matrix. Cells report multi-label study counts; marginal totals refer to interface-family assignments and may therefore exceed the number of unique studies.

3.4. Risk Representation Modalities

Graphical/visual representation was the most frequent modality (n = 145; 72.9%). Textual/conversational representations were present in 49 studies (24.6%), immersive/spatial overlays in 47 (23.6%), spatial/map-based representations in 36 (18.1%), alert/warning cues in 34 (17.1%), numeric/probabilistic representations in 29 (14.6%), and multimodal representations in 28 (14.1%). A small residual category combined visual and textual information without a more specific dominant representation (n = 4; 2.0%). These findings reinforce the distinction between interface technology and representation modality: the same technological interface can encode risk through different visual, textual, numeric, spatial, or multimodal forms.

3.5. Interaction Modes

Interactive exploration was the most common interaction mode (n = 82; 41.2%). Static/one-way presentation remained substantial (n = 50; 25.1%), followed by immersive/experiential interaction (n = 45; 22.6%), real-time feedback (n = 29; 14.6%), conversational interaction (n = 26; 13.1%), and adaptive/personalized interaction (n = 22; 11.1%). The corpus therefore spans a continuum from unidirectional presentation to exploration, simulation, dialogue, and adaptive feedback.

3.6. Target Users, Communication Purposes, and Evidence Types

Citizens or members of the general public were the most frequent target group (n = 142; 71.4%). Decision-makers/managers appeared in 35 studies (17.6%), patients/caregivers in 32 (16.1%), healthcare/public health professionals in 25 (12.6%), and workers/operators in 14 (7.0%). Target-user categories were multi-label because some systems were designed for multiple stakeholder groups.

Behaviour/protective action was coded in 107 studies (53.8%), decision support in 100 (50.3%), understanding/comprehension in 84 (42.2%), and awareness/risk perception in 81 (40.7%). Training/experiential learning appeared in 16 studies (8.0%), monitoring/situational awareness in 12 (6.0%), and generic risk-information communication in six (3.0%).

The evidence base was predominantly empirical: 109 studies (54.8%) were empirical user or field studies, 53 (26.6%) were applied/observational studies, and 34 (17.1%) focused on system or prototype development. Two studies (1.0%) were classified as review/framework syntheses and one (0.5%) as a protocol/planned evaluation. The complete set of 199 included studies is cited collectively in References [10–13,18–212]. To provide an integrated overview of the corpus, Table 5 summarizes the most frequently identified categories across the main analytical dimensions.

Table 5. Summary of the main characteristics of the 199 included studies.

Dimension	Most Frequent Categories
Primary application domain	Healthcare/Public Health: 87 (43.7%); Natural Hazards/Disaster: 67 (33.7%); Industrial/Occupational Safety: 10 (5.0%); Transport/Public Safety: 10 (5.0%); Environmental: 9 (4.5%)
Interface family	Data Visualization: 122 (61.3%); VR/AR/XR: 46 (23.1%); Web/Mobile Interface: 46 (23.1%); Map/Geovisualization: 35 (17.6%); Conversational AI/Chatbot: 26 (13.1%)
Representation modality	Graphical/Visual: 145 (72.9%); Textual/Conversational: 49 (24.6%); Immersive/Spatial Overlay: 47 (23.6%); Spatial/Map-based: 36 (18.1%)
Interaction mode	Interactive Exploration: 82 (41.2%); Static/One-way Presentation: 50 (25.1%); Immersive/Experiential: 45 (22.6%); Real-time Feedback: 29 (14.6%)
Target user group	General Public/Citizens: 142 (71.4%); Decision Makers/Managers: 35 (17.6%); Patients/Caregivers: 32 (16.1%); Healthcare/Public Health Professionals: 25 (12.6%)
Communication purpose	Behaviour/Protective Action: 107 (53.8%); Decision Support: 100 (50.3%); Understanding/Comprehension: 84 (42.2%); Awareness/Risk Perception: 81 (40.7%)
Evidence type	Empirical User/Field Study: 109 (54.8%); Applied/Observational Study: 53 (26.6%); System/Prototype Development: 34 (17.1%)

Note: Primary application domain and evidence type are single-label dimensions. Interface family, representation modality, interaction mode, target user group, and communication purpose are multi-label dimensions; therefore, percentages within these dimensions are not mutually exclusive and their totals may exceed 100%.

3.7. From Risk Information Delivery to Risk Interaction

Across the corpus, interface technologies supported different modes of engagement with risk information, ranging from static presentation to interactive exploration, immersive experience, real-time feedback, conversational exchange, and adaptive communication. These modes should be interpreted as alternative design configurations rather than as a hierarchy of effectiveness. Their implications for human-centred risk communication are discussed in Section 4.3.

3.8. Cross-Domain Synthesis and Human-Centred Framework

The cross-domain analysis showed that classifying technologies alone was insufficient to describe how risk is communicated. The same risk information can be represented in different forms; the same representation can be implemented through different interfaces; the same interface can support different interaction modes; and the appropriateness of each configuration depends on both the intended user and the outcome. The mapping between the eight review-taxonomy dimensions and the six components of the proposed framework is made explicit in Table 6.

Table 6. Traceability from the review taxonomy to the proposed human-centred framework.

Review Taxonomy Dimension	Framework Role	Framework Component	Rationale
Primary Domain	Application context	Contextual variable, not a framework component	Identifies where risk communication occurs but does not describe a functional step in the communication process
Risk Type	Nature/content of communicated risk	Risk	Defines what risk, hazard, exposure, uncertainty, or consequence must be communicated
Representation Modality	Perceptual encoding	Representation	Defines how risk information is made perceptible
Interface Family	Technological artefact/channel	Interface	Defines the digital technology through which the representation is delivered
Interaction Mode	Mode of engagement	Interaction	Defines how the recipient engages with risk information
Target User Group	Intended recipient	User	Defines who interprets and acts on the communicated
Communication Purpose	Intended cognitive/decisional/behavioural effect	Outcome	Provides the taxonomy-level proxy for the outcome sought by the communication process
Evidence Type	Methodological/evidentiary descriptor	Methodological variable, not a framework component	Describes how evidence is generated rather than how communication is designed

Note: Table 6 makes explicit that the six framework components do not correspond to an arbitrary subset of the taxonomy. Rather, they represent those dimensions that describe the functional human-facing communication chain, whereas Primary Domain and Evidence Type provide contextual and methodological descriptors, respectively.

To further examine the relationships underlying the framework, three complementary cross-dimensional analyses were conducted: Risk Type × Representation Modality, Interface Family × Interaction Mode, and Target User Group × Communication Purpose (Supplementary Tables S3–S5). These analyses were selected because they connect conceptually adjacent components of the proposed framework and complement the Domain × Interface Family analysis reported above. The matrices show recurring associations rather than causal dependencies. For example, natural-hazard/disaster risks were frequently paired with immersive/spatial overlays (n = 31) and spatial/map-based representations (n = 19); VR/AR/XR interfaces were overwhelmingly associated with immersive/experiential interaction (n = 45), whereas conversational AI/chatbots were associated with conversational interaction (n = 26); and citizen/public-oriented systems most frequently targeted behaviour/protective action (n = 83) and awareness/risk perception (n = 73). These patterns support the interpretation that representation, interaction, and communication purpose are configured in relation to risk type, interface technology, and intended user rather than functioning as independent design choices.

Representative studies illustrate the same chain at study level. Privacy decision interfaces connect privacy risk to visual representation, interactive exploration, citizen users, and informed decision support [11]. Navigation interfaces for people with mobility impairments communicate probabilistic accessibility risks through map-based representations that users explore to support route decisions [12]. In industrial human–robot collaboration, dynamic risk estimates can be represented spatially and communicated through real-time or augmented interfaces to support situational awareness and protective response [13]. These examples illustrate how the framework links dimensions that were coded separately in the taxonomy but coexist within individual risk communication systems.

These relationships led to the synthesis represented by the sequence Risk → Representation → Interface → Interaction → User → Outcome. The framework is a conceptual synthesis derived from the scoping review rather than a validated causal model. Although the six dimensions are represented sequentially to make their analytical roles explicit, the synthesis also suggests an iterative relationship in which outcome evaluation can inform the refinement of earlier design choices (Figure 6).

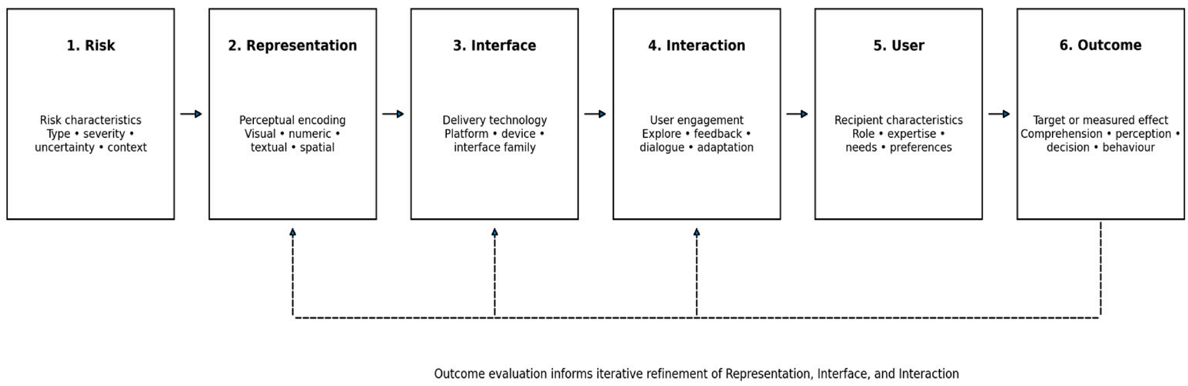


Figure 6. Human-centred framework for digital risk communication. Risk communication interfaces are designed by aligning risk content, representation, interface, interaction, and user characteristics with intended outcomes. Outcome evaluation provides evidence that informs the iterative refinement of representation, interface, and interaction choices.

4. Discussion

4.1. From Technology to Human-Centred Risk Communication Design

Across domains, the main implication of the synthesis is the need to distinguish the technological interface from the representational and interaction choices implemented through it. The same interface family may communicate risk using different visual, numeric, spatial, textual, or multimodal forms and may enable substantially different modes of user engagement. This distinction provides the conceptual basis for the framework developed in Section 3.8.

4.2. Risk Representation as a Design Variable

Probabilities, exposure levels, uncertainty, vulnerability, and future consequences often require mediation before they can be perceived and interpreted. Graphs, colours, icons, maps, indicators, warnings, text, three-dimensional scenes, and multimodal combinations are not merely esthetic alternatives; they can change salience, comprehension, and downstream decisions [3,4,8,9]. Experimental dashboard research illustrates this directly: colour schemes and alert configurations can alter information retention and decision certainty even when the underlying risk data remain unchanged [10]. Representation should therefore be considered an explicit design variable rather than a final formatting step applied after risk estimation.

4.3. From Presentation to Interaction with Risk

The prevalence of interactive exploration, immersive experiences, real-time feedback, conversational interaction, and personalization indicates that the recipient is increasingly more than a passive receiver of a message. Privacy decision interfaces allow users to actively explore a privacy–utility trade-off [11]; accessible navigation interfaces visualize the probability of encountering barriers and thereby influence route planning [12]; and augmented-reality systems can superimpose a dynamic risk field on the physical workspace during human–robot collaboration [13]. The continuum present → explore → experience → interact → adapt therefore captures different design possibilities, although it should not be interpreted as an automatic hierarchy of effectiveness.

4.4. Spatial and Immersive Dimensions of Risk

VR/AR/XR technologies were particularly concentrated in natural-hazard and disaster applications, suggesting that their value is closely related to the spatial nature of the communicated risk. Position, distance, extent, and the relationship between the user and the environment can be turned into directly perceptible components of communication. Realistic interactive flood visualizations, for example, can make possible consequences more concrete and spatially contextualized [18]. A similar principle appears in industrial AR, where risk is overlaid on the operational environment rather than represented on a separate display [13]. Immersion is therefore best understood not simply as technological novelty but as one strategy for spatial risk representation and experiential communication. An adjacent research stream addresses the downstream conversion of perceived hazards into safe robotic action. Xing et al. [213], for example, formulate mobile-manipulator motion planning as a hierarchical quadratic-programming problem integrating physical constraints, trajectory tracking, obstacle avoidance, and manipulability optimization. This work lies outside the eligibility scope of the present review because its primary objective is robot motion control rather than intentional human-facing risk communication. Nevertheless, it helps situate risk communication within a broader perception–representation–response continuum: in human–robot settings, the communication interface can constitute the human-facing layer through which assessed risk becomes perceptible and actionable, while control-oriented planning governs the robot's safe response.

4.5. Personalization, Adaptivity, and Context

Personalizing a risk estimate is not equivalent to personalizing risk communication. Numeracy and the ability to interpret visual representations influence the comprehension of probabilistic information [3,4,8], and privacy decision-interface research shows that individual characteristics such as numeracy and need for cognition affect interface use and decision behaviour [11]. Future systems may therefore need to adapt not only which risk value is communicated but also how that value is represented. Numeracy, expertise, digital literacy, role, context, and time pressure could become inputs for selecting representational format, information density, interaction mode, and level of explanation.

4.6. From Information to Outcome

The reviewed studies target outcomes that extend well beyond information availability, including awareness, risk perception, comprehension, decision support, behavioural intention, and protective action. Experimental evidence shows that improvements in comprehension do not necessarily produce equivalent effects on perception or behaviour [8,9]. Participatory sensing of indoor air quality provides a clear example: real-time feedback increased awareness of air pollution, yet did not produce an equivalent increase in perceived self-efficacy for controlling exposure [19]. Usability and communication effectiveness should therefore not be treated as interchangeable constructs. Evaluation should distinguish interaction-level, cognitive, perceptual, decisional, and behavioural outcomes.

4.7. The Role of the User

The heterogeneity of target users further supports a human-centred approach. Citizens, patients, professionals, operators, and managers differ in expertise, responsibility, numeracy, time constraints, and information needs. Evidence on visual aids indicates that representational effectiveness varies with user capabilities [8], while included studies demonstrate the importance of designing interfaces around the decision context and the abilities of the intended user [11,12]. The user should therefore be treated as an active design dimension that influences representation and interaction choices, not merely as the final destination of an information pipeline.

4.8. A Human-Centred Framework for Digital Risk Communication

The proposed framework—Risk → Representation → Interface → Interaction → User → Outcome—separates six layers that are often conflated in technology-centred descriptions. Risk defines what is to be communicated; Representation defines how it is made perceptible; Interface defines the technological artefact through which it is delivered; Interaction defines how the user engages with the information; User introduces the characteristics and role of the recipient; and Outcome defines the cognitive, perceptual, decisional, or behavioural effect being pursued or measured. The main value of the framework is therefore analytical and design-oriented: it makes explicit that selecting a technology does not by itself specify an effective communication solution. To clarify its positioning relative to existing approaches, Table 7 compares the proposed framework with representative perspectives on risk communication, risk representation, and digital risk-interface research.

Although represented as a sequence for analytical clarity, the framework should not be interpreted as a strictly linear design process. Rather, the six dimensions are interdependent and should be iteratively aligned throughout the design and evaluation process. In particular, evidence concerning user interaction and communication outcomes can feed back into the selection or refinement of representation modalities, interface characteristics, and interaction strategies.

Feedback and learning therefore represent a transversal component of the framework rather than an additional sequential stage. Evaluation of comprehension, decision quality, behavioural response, usability, or other relevant outcomes can provide evidence for redesigning earlier components of the communication process. For example, insufficient comprehension may require modification of the representation modality, whereas interaction difficulties may indicate the need to reconsider the interface or interaction strategy. The framework thus supports an iterative human-centred design cycle in which communication solutions are progressively refined on the basis of outcome evaluation.

Table 7. Relationship between the proposed framework and representative existing approaches to risk communication and digital risk-interface research.

Representative Approach	Main Emphasis	Limitation Relative to Present Objective	Contribution of Proposed Framework
General risk communication process [1,2]	Communication process, trust, message and response	Does not explicitly decompose contemporary digital interfaces	Adds explicit Representation, Interface and Interaction layers
Risk-format and uncertainty research [3,4,8,9]	Numerical, verbal and visual representation; comprehension	Primarily representation-centred	Connects representation to technology, interaction, users and outcomes
AI/VR doctor–patient risk communication [5]	Specific technologies in healthcare	Domain- and technology-specific	Provides a cross-domain structure independent of a particular technology
Public health dashboards [6]	Dashboard design and public health information	Interface-family specific	Separates dashboard technology from representation and interaction
Environmental geovisualization [7]	Spatial risk representation	Primarily spatial/environmental	Generalizes representation–interface relationships across domains
Present framework	Risk → Representation → Interface → Interaction → User → Outcome	Conceptual synthesis requiring empirical validation	Cross-domain decomposition of the human-facing digital risk communication process with iterative feedback from Outcome

The proposed framework should therefore not be interpreted as replacing these approaches or as being intrinsically superior to them. Its contribution is complementary: it provides a cross-domain design-oriented decomposition that explicitly distinguishes risk content, representational encoding, technological interface, interaction, recipient, and intended outcome—dimensions that are frequently examined separately in existing domain- or technology-specific literature.

The framework should not be interpreted as a validated causal model. Rather, it is a conceptual synthesis generated from the taxonomy and cross-domain patterns observed in the review. Its relationships should be tested empirically in future work, including whether particular combinations of representation and interaction are consistently better suited to specific risk types, user groups, or decision contexts.

4.9. Implications for Interface Design and Evaluation

Several practical implications follow from the synthesis. First, design should begin with the risk characteristics and the intended outcome rather than with the available technology. Second, representation should be treated as an explicit and testable design variable: colour, scale, dimensionality, probability format, uncertainty representation, icons, and level of detail can all affect interpretation. Third, interactivity should be introduced when it serves a communication function—such as comparing alternatives, exploring scenarios, understanding causal relationships, or contextualizing consequences—rather than as an end in itself. Fourth, personalization should progressively extend from individualized risk estimates to individualized communication strategies. Finally, evaluation metrics should match the intended outcome: an interface intended to support protective action should not be evaluated only through usability, and an interface intended to improve comprehension should include direct measures of understanding. These evaluation results should subsequently inform iterative redesign. In this sense, Outcome is not merely the endpoint of the framework but also a source of evidence for reconsidering earlier design choices concerning Representation, Interface, and Interaction.

4.10. Limitations and Future Research

This review has several limitations. First, the field is characterized by substantial terminological heterogeneity. Terms such as risk communication, risk visualization, warning system, decision support, situational awareness, and risk information can describe partially overlapping phenomena; consequently, relevant studies may use terminology not fully captured by the search concepts. Second, the exact Scopus query was retained, whereas the literal historical search strings for Web of Science Core Collection and PubMed were not archived. To improve reproducibility, database-specific expressions for these two sources were reconstructed from the retained term sets, search fields, date limits, language restriction, and original record counts and are reported in Supplementary Table S1. These reconstructed expressions reproduce the implemented search logic but cannot be verified as verbatim exports of the original platform search histories.

Third, several analytical dimensions were intentionally multi-label. This better reflects the composite nature of contemporary interfaces but means that category frequencies are not additive and should not be interpreted as mutually exclusive distributions. Fourth, the evidence base is methodologically heterogeneous, ranging from controlled user studies to field implementations and prototype-development papers. The review can therefore identify recurring technologies and design patterns, but it cannot establish a hierarchy of effectiveness among interface families. Finally, the proposed framework requires empirical validation. Future studies should test relationships among Risk, Representation, Interface, Interaction, User, and Outcome and examine when adaptive, context-aware, and multimodal interfaces provide measurable benefits over simpler forms of communication. The review was restricted to English-language publications, which may have resulted in the exclusion of relevant evidence published in other languages. Funding information for individual included sources was not systematically charted and therefore could not be synthesized.

5. Conclusions

This scoping review synthesized 199 studies on digital and interactive technologies for risk communication and identified a highly heterogeneous landscape of application domains, interfaces, representation modalities, interaction modes, target users, and communication purposes. Healthcare/public health and natural-hazard/disaster applications dominate the literature, while data visualization is the most widespread interface family.

The evidence nevertheless points beyond a technology-centred interpretation. The reviewed corpus spans static information delivery, interactive exploration, immersive experiences, conversational systems, real-time feedback, and adaptive communication. These modes should be interpreted as alternative design configurations rather than as evidence of a universal temporal progression or hierarchy of effectiveness. The same technological family can communicate risk through very different numerical, visual, spatial, textual, or multimodal representations and can support different degrees of interaction.

The main conceptual contribution of the review is therefore the distinction among six interdependent design layers summarized by the framework Risk $\rightarrow$ Representation $\rightarrow$ Interface $\rightarrow$ Interaction $\rightarrow$ User $\rightarrow$ Outcome. The framework emphasizes that digital risk communication should be designed by aligning the characteristics of the risk with an appropriate representation, technological interface, interaction strategy, intended user, and target outcome.

Taken together, the review supports a cross-domain, human-centred interpretation of digital risk communication in which technology selection is only one component of a broader design configuration. Future research should test which combinations of risk representation, interface technology, interaction mode, and user characteristics are associated with specific cognitive, decisional, and behavioural outcomes.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/app16189058/s1, Table S1: Electronic search strategies for Scopus, Web of Science Core Collection, and PubMed; Table S2: Study-level characteristics and analytical classification of the 199 included sources of evidence; Table S3: Risk Type × Representation Modality matrix; Table S4: Interface Family × Interaction Mode matrix; Table S5: Target User Group × Communication Purpose matrix; Section S1: Deduplication, screening, and eligibility audit. The completed PRISMA-ScR checklist is provided as a separate supplementary file.

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Abbreviations

The following abbreviations are used in this manuscript:

AI	Artificial intelligence
AR	Augmented reality
HCI	Human–computer interaction
HMI	Human–machine interface
PRISMA-ScR	Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews
VR	Virtual reality
XR	Extended reality

References

1. Fischhoff, B. Risk perception and communication unplugged: Twenty years of process. *Risk Anal.* **1995**, *15*, 137–145. [CrossRef] [PubMed]
2. World Health Organization. *Communicating Risk in Public Health Emergencies: A WHO Guideline for Emergency Risk Communication (ERC) Policy and Practice*; World Health Organization: Geneva, Switzerland, 2017.
3. Lipkus, I.M. Numeric, verbal, and visual formats of conveying health risks: Suggested best practices and future recommendations. *Med. Decis. Mak.* **2007**, *27*, 696–713. [CrossRef] [PubMed]
4. Spiegelhalter, D.; Pearson, M.; Short, I. Visualizing uncertainty about the future. *Science* **2011**, *333*, 1393–1400. [CrossRef] [PubMed]

5. Antel, R.; Abbasgholizadeh-Rahimi, S.; Guadagno, E.; Harley, J.M.; Poenaru, D. The use of artificial intelligence and virtual reality in doctor-patient risk communication: A scoping review. *Patient Educ. Couns.* **2022**, *105*, 3038–3050. [CrossRef] [PubMed]
6. Schulze, A.; Brand, F.; Geppert, J.; Böl, G.-F. Digital dashboards visualizing public health data: A systematic review. *Front. Public Health* **2023**, *11*, 999958. [CrossRef] [PubMed]
7. Slavik, C.E.; Fish, C.; Peters, E. Using geovisualizations to educate the public about environmental health hazards: What works and why. *Curr. Environ. Health Rep.* **2024**, *11*, 453–467. [CrossRef] [PubMed]
8. Garcia-Retamero, R.; Cokely, E.T. Communicating health risks with visual aids. *Curr. Dir. Psychol. Sci.* **2013**, *22*, 392–399. [CrossRef]
9. Okan, Y.; Stone, E.R.; Bruine de Bruin, W. Designing graphs that promote both risk understanding and behavior change. *Risk Anal.* **2018**, *38*, 929–946. [CrossRef] [PubMed]
10. Bearth, A.; Carmo, L.P.; Silva de Oliveira, V.H.; Correia-Gomes, C.; Boerlage, A. Designing a data-based dashboard for decision making in animal farming: Traffic lights vs. sequential colours. *Comput. Electron. Agric.* **2026**, *240*, 111217. [CrossRef]
11. Franzen, D.; Müller-Birn, C.; Wegwarth, O. Communicating the privacy-utility trade-off: Supporting informed data donation with privacy decision interfaces for differential privacy. *Proc. ACM Hum.-Comput. Interact.* **2024**, *8*, 32. [CrossRef]
12. Anisha, S.A.; Kirkham, R. Investigating user risk attitudes in navigation systems to support people with mobility impairments. In *Proceedings of the 34th Australian Conference on Human-Computer Interaction (OzCHI '22), Canberra, Australia, 29 November–2 December 2022*; Association for Computing Machinery: New York, NY, USA, 2022. [CrossRef]
13. Liu, Z.; Wang, X.; Cai, Y.; Xu, W.; Liu, Q.; Zhou, Z.; Pham, D.T. Dynamic risk assessment and active response strategy for industrial human-robot collaboration. *Comput. Ind. Eng.* **2020**, *141*, 106302. [CrossRef]
14. Arksey, H.; O'Malley, L. Scoping studies: Towards a methodological framework. *Int. J. Soc. Res. Methodol.* **2005**, *8*, 19–32. [CrossRef]
15. Levac, D.; Colquhoun, H.; O'Brien, K.K. Scoping studies: Advancing the methodology. *Implement. Sci.* **2010**, *5*, 69. [CrossRef] [PubMed]
16. Peters, M.D.J.; Godfrey, C.M.; Khalil, H.; McInerney, P.; Parker, D.; Soares, C.B. Guidance for conducting systematic scoping reviews. *Int. J. Evid.-Based Healthc.* **2015**, *13*, 141–146. [CrossRef] [PubMed]
17. Tricco, A.C.; Lillie, E.; Zarin, W.; O'Brien, K.K.; Colquhoun, H.; Levac, D.; Moher, D.; Peters, M.D.J.; Horsley, T.; Weeks, L.; et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and explanation. *Ann. Intern. Med.* **2018**, *169*, 467–473. [CrossRef] [PubMed]
18. Kuser Olsen, V.B.; Momen, B.; Langsdale, S.M.; Galloway, G.E.; Link, E.; Brubaker, K.L.; Ruth, M.; Hill, R.L. An approach for improving flood risk communication using realistic interactive visualisation. *J. Flood Risk Manag.* **2018**, *11*, S783–S793. [CrossRef]
19. Boso, À.; Álvarez, B.; Oltra, C.; Garrido, J.; Muñoz, C.; Hofflinger, Á. Out of sight, out of mind: Participatory sensing for monitoring indoor air quality. *Environ. Monit. Assess.* **2020**, *192*, 104. [CrossRef] [PubMed]
20. Sanni, T.; Liu, Z.; Lee, J.; Song, W.; Liu, J.; Shi, Y. Investigating the Impacts of Different Warning Modalities on Individual's Risk Perception and Response Behaviors Through a Virtual Reality Experiment. In *Proceedings of the Human Factors and Ergonomics Society*; SAGE Publications: Thousand Oaks, CA, USA, 2024; pp. 1174–1175. [CrossRef]
21. Anniés, J.; Papathanasiou, C.; Knudsen, S.; De Vito, P.; Sampson, O.; Michalis, P.; Karagiannidis, L.; Amditis, A.; Barbagelata, M.; Mandri, E.; et al. Participative Technology Development of ICT tools for Risk Communication and Disaster Management. In *Proceedings of the ACM International Conference Proceeding Series*; Association for Computing Machinery: New York, NY, USA, 2023; pp. 564–567. [CrossRef]
22. Nietch, C.T.; Gains-Germain, L.; Lazorchak, J.; Keely, S.P.; Youngstrom, G.; Urichich, E.M.; Astifan, B.; Dasilva, A.; Mayfield, H. Development of a Risk Characterization Tool for Harmful Cyanobacteria Blooms on the Ohio River. *Water* **2022**, *14*, 644. [CrossRef] [PubMed]
23. Binion, K.; Miller, A.; Misseri, R.; Kaefer, M.; Longtin, K.; Carroll, A.; Wiehe, S.E.; Chan, K.H. Ask the parents: Testing the acceptability and usability of a hypospadias decision aid. *J. Pediatr. Urol.* **2022**, *18*, 170.e1–170.e9. [CrossRef] [PubMed]
24. Pratheek, H.; Kumar, S.; Siddeshwar, S.N.; Yohima Shetty, M.; Shetty, A. Early Paddy Disease Detection & Sustainable Farming for South Indian Farmers. In *Proceedings of the 2026 International Conference on Artificial Intelligence and Data Engineering, AIDE 2026—Proceedings*; IEEE: Piscataway, NJ, USA, 2026; pp. 123–127. [CrossRef]
25. Gentile, R.; Deshpande, T.; Ozer, E.; Amatya, S.; Shrestha, N.; Guragain, R.; Pelling, M.; Sinclair, H. Tomorrow's Cities risk agreement approach: Utilising the analytical, communication and convening power of science for inclusive, risk-sensitive urban planning. *Int. J. Disaster Risk Reduct.* **2025**, *128*, 105659. [CrossRef]
26. Clini, P.; Nespeca, R.; Angeloni, R.; Ferretti, U. Above-Ground and Underground Architectural Heritage Documentation: A Scan-to-HBIM-to-XR Approach for Historic Centres. In *Proceedings of the International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences—ISPRS Archives*; Copernicus Publications: Göttingen, Germany, 2025; pp. 345–351. [CrossRef]

27. Karthiyayini, J.; Nisarga, H.N.; Mythri, R.; Prarthana, R.; Haudakari, K. EarthPulse: An Open Source Climate and Disaster Data Integration Platform. In Proceedings of the 2026 International Conference on Intelligent and Innovative Technologies in Computing, Electrical and Electronics, IITCEE, Bangalore, India, 22–23 January 2026. [CrossRef]
28. Harman, J.L.; Weinhardt, J.M.; Beck, J.W.; Mai, I. Interpreting time-series COVID data: Reasoning biases, risk perception, and support for public health measures. *Sci. Rep.* **2021**, *11*, 15585. [CrossRef] [PubMed]
29. Navarro, O.; Naud, A.; Verhulst, E.; Fleury-Bahi, G.; Besnard, J.; Allain, P.; Provitolo, D.; Boudoukha, A.H. Effect of contextual and dispositional variables on protective behaviours in the face of imminent risk, as analysed using the virtual simulation of a tsunami. *Acta Psychol.* **2026**, *268*, 107331. [CrossRef] [PubMed]
30. Lopes, S.I.; Nunes, L.J.R.; Curado, A. Designing an indoor radon risk exposure indicator (Irrei): An evaluation tool for risk management and communication in the iot age. *Int. J. Environ. Res. Public Health* **2021**, *18*, 7907. [CrossRef] [PubMed]
31. Jeffery, A.D.; Reale, C.; Faiman, J.; Borkowski, V.; Beebe, R.; Matheny, M.E.; Anders, S. Inpatient nurses' preferences and decisions with risk information visualization. *J. Am. Med. Inform. Assoc.* **2024**, *31*, 61–69. [CrossRef] [PubMed]
32. Atasoy, G.; Ertaymaz, U.; Dikmen, I.; Talat Birgonul, M. Empowering Risk Communication: Use of Visualizations to Describe Project Risks. *J. Constr. Eng. Manag.* **2022**, *148*, 04022015. [CrossRef]
33. Zhou, S.; Murali, P.; Underhill-Blazey, M.; Bickmore, T. Cancer genetic counseling by humanoid robot: Modeling multimodal communication of health risk. In *Proceedings of the ACM/IEEE International Conference on Human-Robot Interaction*; Association for Computing Machinery: New York, NY, USA, 2020; pp. 543–545. [CrossRef]
34. Amer, Y.; Ul Haque, E.; Rong, Z.; Khan, M.M.H. Understandability of the Technology and Benefit May Not Be Enough to Nudge Users: An Exploratory Study in the Context of FIDO2 Adoption Behavior. In *Proceedings—2025 IEEE 49th Annual Computers, Software, and Applications Conference, COMPSAC*; IEEE: Piscataway, NJ, USA, 2025; pp. 607–618. [CrossRef]
35. Yuan, Z.; Shi, Z.; Wang, Z. The Real-Time Support Role of Augmented Reality Technology in Shared Decision-Making in Neurosurgery Under the SEGUE Framework: Randomized Controlled Trial. *J. Med. Internet Res.* **2026**, *28*, e87198. [CrossRef] [PubMed]
36. Wu, F.; Li, X.; Zeng, Y.; Tang, Y.; Xiao, Z.; Yang, S.; Wu, K.; Liu, S.; Li, A. A Guideline-Concordant Chatbot Framework for Structured Colorectal Cancer Screening: Multistage Feasibility Study. *J. Med. Internet Res.* **2026**, *28*, e93042. [CrossRef] [PubMed]
37. Walwema, J. The WHO Health Alert: Communicating a Global Pandemic with WhatsApp. *J. Bus. Tech. Commun.* **2021**, *35*, 35–40. [CrossRef]
38. Bickmore, T.; Blain, M.; Underhill, M. Promoting Family Communication for Cascade Cancer Genetic Testing with Relational Agent Role-Play: Quasi-Experimental Study. *JMIR Form. Res.* **2026**, *10*, e87623. [CrossRef] [PubMed]
39. Dikmen, I.; Hartmann, T. Seeing the risk picture: Visualization of project risk information. In *Proceedings of the EG-ICE 2020 Workshop on Intelligent Computing in Engineering, Proceedings, Online, 1–4 July 2020*; Universitätsverlag der TU Berlin: Berlin, Germany, 2020; pp. 383–392.
40. Yin, S.; Yan, X.; Yin, M.; Zhang, L. Visual Analysis of Urban Block Risk Based on Bayesian Network—Taking Traffic as an Example. In *Proceedings of Journal of Physics: Conference Series*; IOP Publishing: Bristol, UK, 2022. [CrossRef]
41. Chen, A.S.; Khoury, M.; Vamvakeridou-Lyroudia, L.; Stewart, D.; Wood, M.; Savic, D.A.; Djordjevic, S. 3D visualisation tool for improving the resilience to urban and coastal flooding in Torbay, UK. In *Proceedings of the Procedia Engineering*; Elsevier B.V.: Amsterdam, The Netherlands, 2018; pp. 809–815. [CrossRef]
42. Felgendreff, L.; Siegers, R.; Otten, L.; Betsch, C. Infographics on risks associated with COVID-19 and the willingness to get the AstraZeneca vaccine: Two randomized online experiments. *BMC Public Health* **2024**, *24*, 529. [CrossRef] [PubMed]
43. Kandel, S.; Stumpf, A.C.; Joshi, A.; Sharma, S.; Taylor, L.E.; Jefferson, A.J.; Kenney, M.A. Comparing Flood Inundation Map Features and Diagnosing Decision Support Design Challenges. *Hydrol. Process.* **2026**, *40*, e70362. [CrossRef]
44. Hollister, B.M.; Schopp, E.M.; Telaak, S.H.; Buscetta, A.J.; Dolwick, A.P.; Fortney, C.J.; Bonham, V.L.; Persky, S. Educational considerations based on medical student use of polygenic risk information and apparent race in a simulated consultation. *Genet. Med.* **2022**, *24*, 2389–2398. [CrossRef] [PubMed]
45. Zhou, S.; Bickmore, T. Automating Cancer Genetic Counseling with an Adaptive Pedagogical Agent. In Proceedings of the Conference on Human Factors in Computing Systems—Proceedings, Virtual, 8–13 May 2021. [CrossRef]
46. Tsujimoto, R.; Fukuda, T.; Yabuki, N. Server-enabled mixed reality for flood risk communication: On-site visualization with digital twins and multi-client support. *Environ. Model. Softw.* **2024**, *177*, 106054. [CrossRef]
47. Padilla, L.; Fygenson, R.; Castro, S.C.; Bertini, E. Multiple Forecast Visualizations (MFVs): Trade-offs in Trust and Performance in Multiple COVID-19 Forecast Visualizations. *IEEE Trans. Vis. Comput. Graph.* **2023**, *29*, 12–22. [CrossRef] [PubMed]
48. Zare-Harofteh, A.; Kramer, S.J.; Huang, S.; Scarborough, C.R.; Besong, K.; Kumar, N.; Brown, T.; Hosseinpour, F. SmokePath Explorer–a data driven smoke management tool to support prescribed fire planning in California, USA. *J. Air Waste Manag. Assoc.* **2025**, *75*, 932–952. [CrossRef] [PubMed]
49. Frank, A.L.; Baldwin, J.; Browning, M.H.E.M.; Yuan, S.; Ahn, S.J. Learning the dangers of storm surges in virtual reality: Coastal leaders' attitudes toward VR as a risk communication tool. *Environ. Educ. Res.* **2026**, *32*, 550–568. [CrossRef]

50. Jubur, M. User-Centric Risk Communication for Password Managers: A Framework for Adaptive Alerts and Onboarding. In *Proceedings of the 2025 11th International Conference on Computer Technology Applications, ICCTA*; IEEE: Piscataway, NJ, USA, 2025; pp. 19–24. [CrossRef]
51. Hochstenbach, L.M.J.; Determann, D.; Fijten, R.R.R.; Bloemen-van Gurp, E.J.; Verwey, R. Taking shared decision making for prostate cancer to the next level: Requirements for a Dutch treatment decision aid with personalized risks on side effects. *Internet Interv.* **2023**, *31*, 100606. [CrossRef] [PubMed]
52. Danforth, C.G.; Portier, C.; Ensor, K.B.; Hopkins, L.; Evans, B.; Quist, A.J.L.; McGraw, K.E.; Craft, E. Development and demonstration of a data visualization platform of short-term guidelines for ambient air levels of benzene during disaster response in Houston, Texas. *Integr. Environ. Assess. Manag.* **2024**, *20*, 533–546. [CrossRef] [PubMed]
53. Farkas, K.; Kaya, D.; Maal-Bared, R.; Al-Mustapha, A.I.; Tandukar, S.; Keenum, I.; Gunnar, T.; Bivins, A.; J Wade, M.; Bibby, K.; et al. Communicating wastewater-based surveillance data to drive action. *J. Water Health* **2025**, *23*, 1095–1108. [CrossRef] [PubMed]
54. Shaffer, V.A.; Duan, S.; Weiger, P.; Bobo, M.; Canfield, S.M.; Rolbiecki, A.; Geleto, T.M.; Martinez, W.; Koopman, R.; Dorr, D. The effect of adding visual summaries to data visualizations on patient judgments of hypertension control. *JAMIA Open* **2026**, *9*, ooag034. [CrossRef] [PubMed]
55. Vromans, R.D.; Bol, N.; van Wezel, M.M.C.; Krahmer, E.J. "R" you getting this? Factors contributing to the public's understanding, evaluation, and use of basic reproduction numbers for infectious diseases. *BMC Public Health* **2024**, *24*, 1209. [CrossRef] [PubMed]
56. Xu, Y.; Li, M.; Huang, G.; Liu, Q.; Zou, X.; Xu, X.; Guo, Z.; Li, C.; Lai, G. BIM-Based Integration and Visualization Management of Construction Risks in Water Pumping Station Projects. *Buildings* **2025**, *15*, 3573. [CrossRef]
57. Song, Y.; Jiang, Q.; Chen, W.; Zhuang, X.; Ma, G. Pedestrians' road-crossing behavior towards eHMI-equipped autonomous vehicles driving in segregated and mixed traffic conditions. *Accid. Anal. Prev.* **2023**, *188*, 107115. [CrossRef] [PubMed]
58. Ramos, C.D.; Clamor, W.L.; Aligaya, C.D.; Te, K.N.; Espiritu, M.R.; Gonzales, J.P. A Disaster Management System on Mapping Health Risks from Agents of Disasters and Extreme Events. In *Proceedings of the Advances in Intelligent Systems and Computing*; Springer Nature: Cham, Switzerland, 2021; pp. 523–537. [CrossRef]
59. Al-nuwaiser, W.M. Effect of visual imagery in COVID-19 social media posts on users' perception. *PeerJ Comput. Sci.* **2022**, *8*, e1153. [CrossRef] [PubMed]
60. Ishida, K. Recognition of risk information—Adaptation of J. Bertin's ordinal matrix for social communication. In Proceedings of the PSAM 2018—Probabilistic Safety Assessment and Management, Los Angeles, CA, USA, 16–21 September 2018.
61. Chen, J.; Hong, W.; Tian, X.; Wang, W.; Sun, Y. Association of Triglyceride-to-HDL Cholesterol Ratio with Osteoarthritis: Multicenter Evidence and Application of an Interactive Risk Visualization Tool. *J. Inflamm. Res.* **2026**, *19*, 604881. [CrossRef] [PubMed]
62. Januszewski, A.S.; Greene, C.D. An online visualization tool for exploring crime patterns around U.S. counties and postsecondary institutions. *J. Am. Coll. Health* **2026**, *74*, 1888–1893. [CrossRef] [PubMed]
63. Macchione, F.; Costabile, P.; Costanzo, C.; De Santis, R. Moving to 3-D flood hazard maps for enhancing risk communication. *Environ. Model. Softw.* **2019**, *111*, 510–522. [CrossRef]
64. Lempert, R.J.; Busch, L.; Brown, R.; Patton, A.; Turner, S.; Schmidt, J.; Young, T. Community-Level, Participatory Co-Design for Landslide Warning with Implications for Climate Services. *Sustainability* **2023**, *15*, 4294. [CrossRef]
65. Pascual-Presa, N.; Fernández-Pichel, M.; Losada, D.E.; García-Orosa, B. Web Search or Conversation with an Artificial Intelligence? Analysis of Misinformation and Relevance in the Case of Radon Gas. *Prof. Inf.* **2024**, *33*, e330220. [CrossRef]
66. Ndemera, I.; Hsieh, Y.-T.S.; Chirwa, K.; Ngwira, S.; Denny, A.; Wu, T.S.J.; Lee, H.-Y.; Chirambo, G.B.; Yosefe, S.L.; Chilima, B.; et al. Describing a National Chatbot Deployed by the Ministry of Health in Malawi During the COVID-19 Pandemic: Retrospective Data Analysis. *J. Med. Internet Res.* **2026**, *28*, e80960. [CrossRef] [PubMed]
67. Cheng, Y.-C. Global Information Sharing on Social Media under the COVID-19 Risk: Analysis of Hyperlinks and Contents on Twitter. *Mass Commun. Res.* **2023**, 113–173. [CrossRef]
68. Hamilton, J.G.; Genoff Garzon, M.; Shah, I.H.; Cadet, K.; Shuk, E.; Westerman, J.S.; Hay, J.L.; Offit, K.; Robson, M.E. Illustrating Cancer Risk: Patient Risk Communication Preferences and Interest regarding a Novel BRCA1/2 Genetic Risk Modifier Test. *Public Health Genom.* **2020**, *23*, 6–19. [CrossRef] [PubMed]
69. Sanni, T.O.; Chen, J.; Shao, W.; Liu, J.; Shi, Y. Investigating the feasibility of adopting virtual reality as a method for natural hazard risk communication. *Int. J. Disaster Risk Reduct.* **2025**, *119*, 105296. [CrossRef]
70. Fallon, K.M.; Bernhardt, J.; Martin, F. Corrientes marinas: Evaluating spanish rip current communications through beach signs and virtual reality. *Weather Clim. Soc.* **2025**, *17*, 805–816. [CrossRef]
71. Zhang, W.; Zhang, Z.; Wang, T.; Nong, T.; Ma, Y.; Lee, E.W.M.; Shi, M. Effects of risk information on pedestrian evacuation during fire emergencies: Virtual experiments and survey. *Phys. A Stat. Mech. Its Appl.* **2024**, *656*, 130232. [CrossRef]

72. Turer, R.W.; Gradwohl, S.C.; Stassun, J.; Johnson, J.; Slagle, J.M.; Reale, C.; Beebe, R.; Nian, H.; Zhu, Y.; Albert, D.; et al. User-Centered Design and Implementation of an Interoperable FHIR Application for Pediatric Pneumonia Prognostication in a Randomized Trial. *Appl. Clin. Inform.* **2024**, *15*, 556–568. [CrossRef] [PubMed]
73. Hoogestraat, A.T.; Schmitz, T.; Voigt, A.; Baumgartl, T.; Müller, F.; Biermann, P.; von Landesberger, T.; Wulff, A. Developing a User-Centric System for Hospital-Onset Bacteremia Risk Assessment and Visualization: An Integrated Requirements Analysis Approach. In *Proceedings of the Studies in Health Technology and Informatics*; IOS Press: Amsterdam, The Netherlands, 2025; pp. 51–56. [CrossRef] [PubMed]
74. Li, L.; Liu, Z.; Wang, X.; Zhang, X.; Wang, L. PregnancyLine: A Visual Analysis System for Pregnancy Care and Risk Communication. *IEEE Access* **2022**, *10*, 111493–111506. [CrossRef]
75. Dai, F.; Olorunfemi, A.; Peng, W.; Cao, D.; Luo, X. Can mixed reality enhance safety communication on construction sites? An industry perspective. *Saf. Sci.* **2021**, *133*, 105009. [CrossRef]
76. Olorunfemi, A.; Dai, F.; Tang, L.; Yoon, Y. Three-dimensional visual and collaborative environment for jobsite risk communication. In *Proceedings of the Construction Research Congress 2018: Safety and Disaster Management—Selected Papers from the Construction Research Congress*; American Society of Civil Engineers: Reston, VA, USA, 2018; pp. 345–355. [CrossRef]
77. Ponnada, S. Reimagining the COVID-19 digital experience: The value of user empowerment and accessibility in risk communication. In Proceedings of the SIGDOC 2020—Proceedings of the 38th ACM International Conference on Design of Communication, Virtual, 3–4 October 2020. [CrossRef]
78. Li, W.; Zhu, J.; Haunert, J.-H.; Fu, L.; Zhu, Q.; Dehbi, Y. Three-dimensional virtual representation for the whole process of dam-break floods from a geospatial storytelling perspective. *Int. J. Digit. Earth* **2022**, *15*, 1637–1656. [CrossRef]
79. Chen, X.; Ke, J.; Flynn, L.; Parmigiani, G.; Braun, D. Web-Based User Interface for Fam3PRO: A Multigene, Multicancer Risk Prediction Model for Families with Cancer History. *JCO Clin. Cancer Inform.* **2026**, *10*, e2500332. [CrossRef] [PubMed]
80. Chama, B.; Mazzeo, A. Intelligent Systems, Linguistic Bias, and Health Communication in Dubai: A Critical Study of AI Reliability Across Arabic and Gulf Dialects. In Proceedings of the 2026 International Conference on Integrated Intelligence and Cognitive Engineering, ICIICE, Dubai, United Arab Emirates, 18–19 April 2026. [CrossRef]
81. Knapstad, T.; Njå, O. Long-term learning effects of structured risk communication targeting safe behaviour in road tunnels. *Transp. Res. Part F Traffic Psychol. Behav.* **2026**, *120*, 103644. [CrossRef]
82. Denda, M.; Fujikane, M. Development of a virtual flood experience system and its suitability as a flood risk communication tool. In *Proceedings of the International Association of Hydrological Sciences*; Copernicus GmbH: Göttingen, Germany, 2024; pp. 21–26. [CrossRef]
83. Vasnier, J.-M.; Yaacob, N. Applying the technology acceptance model to risk communication dashboards: A case study. *J. Model. Manag.* **2026**, 1–23. [CrossRef]
84. Helten, C.; Wolf, P. Scout: Runtime Risk Modeling and Visual Safety Feedback for Human-Aware Robots. In *Proceedings of the 2026 IEEE Engineering Reliable Autonomous Systems, ERAS*; IEEE: Piscataway, NJ, USA, 2026; pp. 90–95. [CrossRef]
85. Bica, M.; Demuth, J.L.; Dykes, J.E.; Palen, L. Communicating hurricane risks: Multi-method examination of risk imagery diffusion. In Proceedings of the Conference on Human Factors in Computing Systems—Proceedings, Glasgow, Scotland, UK, 4–9 May 2019. [CrossRef]
86. Cosgrove, S. Responsive data visualization: The national weather service and the representation of risk. In Proceedings of the SIGDOC 2018—36th ACM International Conference on the Design of Communication, Milwaukee, WI, USA, 3–5 August 2018. [CrossRef]
87. Foraker, R.; Phommasathit, C.; Clevenger, K.; Lee, C.; Boateng, J.; Shareef, N.; Politi, M.C. Using the sociotechnical model to conduct a focused usability assessment of a breast reconstruction decision tool. *BMC Med. Inform. Decis. Mak.* **2023**, *23*, 140. [CrossRef] [PubMed]
88. Stempel, P.J.; Becker, A. Is it scientific? Viewer perceptions of storm surge visualizations. *Cartographica* **2021**, *56*, 120–136. [CrossRef]
89. Ariks, M.Y.; Aini Rakhmawati, N. Requirements Analysis for Risk Communication Systems with Design Thinking in Mining Operations. In Proceedings of the 2023 5th International Conference on Cybernetics and Intelligent Systems, ICORIS, Pangkalpinang, Indonesia, 6–7 October 2023. [CrossRef]
90. Tomsho, K.S.; Polka, E.; Chacker, S.; Queeley, D.; Alvarez, M.; Scammell, M.K.; Emmons, K.M.; Rudd, R.E.; Adamkiewicz, G. A process for creating data report-back tools to improve equity in environmental health. *Environ. Health A Glob. Access Sci. Source* **2022**, *21*, 67. [CrossRef] [PubMed]
91. Martelo, R.; Ahmadiyehyazdi, K.; Wang, R.-Q. Towards democratized flood risk management: An advanced AI assistant enabled by GPT-4 for enhanced interpretability and public engagement. *Environ. Model. Softw.* **2026**, *197*, 106821. [CrossRef]
92. Zhang, Z.; Jian, S.; Wang, Y.; Tong, M. Enhancing Safety of Large Autonomous Vehicles via Risk Visualization eHMI Under Low Visibility: A Multi-Scenario Study. In *Proceedings of the Communications in Computer and Information Science*; Springer Nature: Cham, Switzerland, 2026; pp. 216–226. [CrossRef]

93. Kuster, F.; Ruginski, I.T.; Fabrikant, S.I. How does your viewing perspective matter for decision-making with flood risk maps?*. *Cartogr. Geogr. Inf. Sci.* **2023**, *50*, 562–573. [CrossRef]
94. Chande, A.; Lee, S.; Harris, M.; Nguyen, Q.; Beckett, S.J.; Hilley, T.; Andris, C.; Weitz, J.S. Real-time, interactive website for US-county-level COVID-19 event risk assessment. *Nat. Hum. Behav.* **2020**, *4*, 1313–1319. [CrossRef] [PubMed]
95. Kollozu, S.; Keesara, V.R.; Loukika, K.N.; Sridhar, V. Harnessing social media data and geospatial tools for flood hazard and risk assessment. *Environ. Model. Softw.* **2026**, *199*, 106914. [CrossRef]
96. Jie, Z.; Lugtenberg, G.; Zhang, R.; Teubert, A.; Fujisawa, M.; Uchiyama, H.; Kiyokawa, K.; Butaslac, I.; Sawabe, T.; Kato, H. Application of Transitional Mixed Reality Interfaces: A Co-Design Study with Flood-Prone Communities. *IEEE Trans. Vis. Comput. Graph.* **2025**, *31*, 9889–9898. [CrossRef] [PubMed]
97. Holt, J.; Lamm, A.J.; Gibson, K.; Lamm, K.; Ellis, J.D.; Rumble, J.N. Animating science communication: Measuring U.S. consumers' recall about genetic modification with animated infographics. *J. Appl. Commun.* **2020**, *104*, 4. [CrossRef]
98. Rainear, A.M.; Lachlan, K.A.; Fishlock, J. Exploring retention and behavioral intentions when using social robotics to communicate a weather risk. *Comput. Hum. Behav.* **2019**, *90*, 372–379. [CrossRef]
99. Weeks, R.; Sangha, P.; Cooper, L.; Sedoc, J.; White, S.; Gretz, S.; Toledo, A.; Lahav, D.; Hartner, A.-M.; Martin, N.M.; et al. Usability and Credibility of a COVID-19 Vaccine Chatbot for Young Adults and Health Workers in the United States: Formative Mixed Methods Study. *JMIR Hum. Factors* **2023**, *10*, e40533. [CrossRef] [PubMed]
100. Sanni, T.O.; Kuang, B.; Chen, J.; Shao, W.; Liu, M.; Liu, J.; Shi, Y. Exploring the Feasibility of Adopting Virtual Reality as an Alternative Risk Communication Method for Natural Hazards. In *Proceedings of the Computing In Civil Engineering 2024: Building Information Modeling, Digital Twins, and Simulation and Visualization—Selected Papers from the ASCE International Conference on Computing in Civil Engineering*; American Society of Civil Engineers: Reston, VA, USA, 2024; pp. 234–244. [CrossRef]
101. Morin, J.; Lucas-Smith, M.; Walshe, R.; Perales, C.; Anfrus, L.; Donovan, A.; Bono, L.; Bigam, L.; Gallant, L.; Amigo, Á. Volcano Voices, a cost-effective tool to collect and share narratives on the environment. An example from Chaitén, Chile. *Int. J. Disaster Risk Reduct.* **2026**, *133*, 105908. [CrossRef]
102. Jiang, Y.; Xu, X.; Tong, Y. Intelligent Adaptive Digital Twin-Based Early Warning System for Construction. In Proceedings of the International Conference on Intelligent Communication Networks and Computational Techniques, ICICNCT, Bidar, India, 5–6 September 2025. [CrossRef]
103. Laefer, D.F.; O'Keeffe, E.; Chandna, K.; Hertz, K.; Zhu, J.; Lejano, R.; Vo, A.V.; Bertolotto, M.; Ofterdinger, U. Low-Cost, LiDAR-Based, Dynamic, Flood Risk Communication Viewer. *Remote Sens.* **2025**, *17*, 592. [CrossRef]
104. Kwon, B.C.; VanDam, C.; Chiuve, S.E.; Choi, H.W.; Entler, P.; Tan, P.-N.; Huh-Yoo, J. Improving heart disease risk through quality-focused diet logging: Pre-post study of a diet quality tracking app. *JMIR mHealth uHealth* **2020**, *8*, e21733. [CrossRef] [PubMed]
105. Tommasi, P.; Deparis, S.; Pascale, A. HWProfile UI: Facilitating the exploration of a patient centered risk model. In Proceedings of the 2019 IEEE International Conference on Healthcare Informatics, ICHI, Xi'an, China, 10–13 June 2019. [CrossRef]
106. Witt, J.K.; Dhami, M.K. Visual Organization of Icon Arrays Affects Bayesian Reasoning and Risk Judgments. *J. Appl. Res. Mem. Cogn.* **2022**, *12*, 241–254. [CrossRef]
107. Balbin, C.A.; Stevens, L.; Dalrymple, R.; Tiase, V.L.; Kaphingst, K.A.; Stevens, E.R.; Kukhareva, P.V.; Caverly, T.J.; Fiol, G.D.; Mann, D.; et al. MyLungHealth, a Patient-Facing Education Tool for Lung Cancer Screening: Qualitative User-Centered Design Study. *JMIR Form. Res.* **2026**, *10*, e83033. [CrossRef] [PubMed]
108. Decker, H.; Trang, K.; Ramirez, J.; Colley, A.; Pierce, L.; Coleman, M.; Bongiovanni, T.; Melton, G.B.; Wick, E. Large Language Model-Based Chatbot vs Surgeon-Generated Informed Consent Documentation for Common Procedures. *JAMA Netw. Open* **2023**, *6*, e2336997. [CrossRef] [PubMed]
109. Marchezini, V.; Porto de Albuquerque, J.; Pitidis, V.; Rudorff, C.M.; Lima-Silva, F.; Klonner, C.; Martins, M.H.M. Flood risk governance in Brazil and the UK: Facilitating knowledge exchange through research gaps and the potential of citizen-generated data. *Disaster Prev. Manag. Int. J.* **2022**, *31*, 30–44. [CrossRef]
110. Tomkins, A.; Lange, E. Interactive landscape design and flood visualisation in augmented reality. *Multimodal Technol. Interact.* **2019**, *3*, 43. [CrossRef]
111. Crispi, V.; Peat, S.; Bolton, W.S.; Chapman, S.; Rousseau, N.; Mushtaq, F.; Mathew, R.K. Mixed reality with 3D brain imaging for patient consultation in neurosurgery: An IDEAL stage 2a feasibility study. *J. Neuro-Oncol.* **2025**, *174*, 143–156. [CrossRef] [PubMed]
112. Zhou, S.; Bickmore, T. A Virtual Counselor for Breast Cancer Genetic Counseling: Adaptive Pedagogy Leads to Greater Knowledge Gain. In Proceedings of the Conference on Human Factors in Computing Systems—Proceedings, New Orleans, LA, USA, 30 April–5 May 2022. [CrossRef]
113. Richards, D.P. An Ethic of Constraint: Citizens, Sea-Level Rise Viewers, and the Limits of Agency. *J. Bus. Tech. Commun.* **2019**, *33*, 292–337. [CrossRef]

114. Dong, J.; Han, S.; Guan, C.; Pi, J.; Wang, N.; Wang, Z.; Lee, J. Radiogenesis: Designing a Serious Game for Radiation Safety Education Through the Integration of the Design-Play-Experience Framework and Social Cognitive Theory. In *Proceedings of the CHI PLAY Companion 2025—Companion Proceedings of the Annual Symposium on Computer-Human Interaction in Play*; Association for Computing Machinery: Pittsburgh, PA, USA, 2025; pp. 139–147. [CrossRef]
115. Naughton, C.C.; Holm, R.H.; Lin, N.J.; James, B.P.; Smith, T. Online dashboards for SARS-CoV-2 wastewater data need standard best practices: An environmental health communication agenda. *J. Water Health* **2023**, *21*, 615–624. [CrossRef] [PubMed]
116. St. John, M.F.; Gustafson, W.; Martin, A.; Moore, R.A.; Korkos, C.A. Risk Surface: A Visualization of Data Sharing Risk for Enterprise Users. *Proc. Hum. Factors Ergon. Soc.* **2019**, *63*, 297–301. [CrossRef]
117. Kandel, J.; Liu, J.; Wang, A.Z.; Tseng, C.; Szafir, D.A. Graphical Perception of Icon Arrays versus Bar Charts for Value Comparisons in Health Risk Communication. *IEEE Trans. Vis. Comput. Graph.* **2026**, *32*, 780–790. [CrossRef] [PubMed]
118. Gmelch, P.; Lejano, R.; O'Keeffe, E.; Laefer, D.F.; Drell, C.; Bertolotto, M.; Ofterdinger, U.; McKinley, J. The case for low-cost, personalized visualization for enhancing natural hazard preparedness. In *Proceedings of the International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences—ISPRS Archives*; Copernicus Publications: Göttingen, Germany, 2020; pp. 37–44.
119. Hong, S.J. What drives AI-based risk information-seeking intent? Insufficiency of risk information versus (Un)certainty of AI chatbots. *Comput. Hum. Behav.* **2025**, *162*, 108460. [CrossRef]
120. Oviedo-Trespalacios, O.; Peden, A.E.; Cole-Hunter, T.; Costantini, A.; Haghani, M.; Rod, J.E.; Kelly, S.; Torkamaan, H.; Tariq, A.; David Albert Newton, J.; et al. The risks of using ChatGPT to obtain common safety-related information and advice. *Saf. Sci.* **2023**, *167*, 106244. [CrossRef]
121. Retchless, D.; Fish, C.; Thatcher, J. Climate change communication beyond the digital divide: Exploring cartography's role and privilege in climate action. *J. Environ. Media* **2022**, *3*, 101–123. [CrossRef]
122. Terfurth, L.; Heidenreich, A.; Glunz, E.; Kox, T.; Gerhold, L. Troubled water: Enhancing flood preparedness with eXtended reality. *Comput. Hum. Behav. Rep.* **2026**, *22*, 101004. [CrossRef]
123. Castrejon, D.J.; Wang, C.; Osmak, D.; Kukadiya, B.; Liu, L.; Giraldo, M.; Jiang, X. Machine Learning-based California Wildfire Risk Prediction and Visualization. In *Proceedings—22nd IEEE International Conference on Machine Learning and Applications, ICMLA*; IEEE: Piscataway, NJ, USA, 2023; pp. 1212–1217. [CrossRef]
124. Qian, X. Examining Preferences for Human vs. AI Sources in Online Health Information Seeking: Integrating the RISP and Source Credibility Perspectives. *Health Commun.* **2026**, 1–13. [CrossRef] [PubMed]
125. Toda, M.; Chakradhar, S.; Debnath, B.; Cosatto, E.; Senzaki, K.; Sankaradas, M.; Min, M.R. Rapid Disaster Situational Awareness Through the Integration of Satellite Image Analysis and LLM. *NEC Tech. J.* **2025**, *18*.
126. Marcum, C.S.; Goldring, M.R.; McBride, C.M.; Persky, S. Modeling Dynamic Food Choice Processes to Understand Dietary Intervention Effects. *Ann. Behav. Med.* **2018**, *52*, 252–261. [CrossRef] [PubMed]
127. Yu, H.; Shedge, K.; Mohamed, N.; Samak, N.; Binsad, W.; Bhosale, S.; Kim, E.; Kondvilkar, S.; Riener, A. AwareDoor: Enhancing Vehicle-Exit Safety via Multimodal Risk Communication. In *Proceedings of the Adjunct Conference Proceedings—17th International ACM Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI*; Association for Computing Machinery: New York, NY, USA, 2025; pp. 345–348. [CrossRef]
128. Tjaden, N.; Geeraedts, F.; Kioko, C.; Riezebos-Brilman, A.; Al Naiemi, N.; Blanford, J.; de Jong, N.B. The power of interactive maps for communicating spatio-temporal data to health professionals. *Geospat. Health* **2024**, *19*, 1296. [CrossRef] [PubMed]
129. Díaz Ferreyra, N.E.; Kroll, T.; Aïmeur, E.; Stieglitz, S.; Heisel, M. Preventative nudges: Introducing risk cues for supporting online self-disclosure decisions. *Information* **2020**, *11*, 399. [CrossRef]
130. Macchione, F.; Costabile, P.; Costanzo, C.; De Santis, R. Fully-hydrodynamic modelling supporting flood hazard assessment and communication: A reference framework. *Ital. J. Eng. Geol. Environ.* **2018**, *2018*, 101–121. [CrossRef]
131. Chockalingam, S.; Pirbhulal, S.; Abie, H. Improving Security and Privacy of Cognitive Digital Twins Through Dynamic Consent for Healthcare and Resilient Societies. In *Proceedings of the Lecture Notes in Computer Science*; Springer Nature: Cham, Switzerland, 2026; pp. 293–305. [CrossRef]
132. Rauer-Zechmeister, S.; Cornel, D.; Sadransky, B.; Horváth, Z.; Konev, A.; Buttinger-Kreuzhuber, A.; Heidrich, R.; Blöschl, G.; Gröller, E.; Waser, J. HORA 3D: Personalized Flood Risk Visualization as an Interactive Web Service. *Comput. Graph. Forum* **2024**, *43*, e15110. [CrossRef]
133. Wang, S.; Xue, Y.; Wang, D.; Li, R. Enhancing Situation Awareness in Digital Healthcare: A Visual Analytics Framework for Integrated Network and Data Security Governance. *Int. J. Hum.-Comput. Interact.* **2026**, 1–24. [CrossRef]
134. Cheng, T.H. Designing Dialogic Disclaimers: Principles for Ethical Conversational Design in LLM Interfaces. In Proceedings of the CUI 2025—Proceedings of the 2025 ACM Conference on Conversational User Interfaces, Waterloo, ON, Canada, 8–10 July 2025. [CrossRef]

135. Tibbels, N.; Dosso, A.; Allen-Valley, A.; Benie, W.; Fordham, C.; Brou, J.A.; Nana, M.; Zounneme, V.; Silué, K.F.; Kamara, D.; et al. Real-time tracking of COVID-19 rumors using community-based methods in Côte d'Ivoire. *Glob. Health Sci. Pract.* **2021**, *9*, 355–364. [CrossRef] [PubMed]
136. Fernández, N.M.; Barcia, E.L. Evaluation of infographics during the first year of the pandemic in 'El País Digital' (2020–2021). *Index. Comun.* **2022**, *12*, 177–204. [CrossRef]
137. Li, J.; Prillard, O.; Klonteig, S.; Hoffmann, V. Development of a digital tool for showing test results from cervical cancer screening. In *Proceedings of the International Conferences on Big Data Analytics, Data Mining and Computational Intelligence 2025, BigDaCI, Lisbon, Portugal, 23–25 July 2025*; Connected Smart Cities 2025 and e-Health 2025, EH 2025—Part of the Multi Conference on Computer Science and Information Systems 2025; IADIS Press: Lisbon, Portugal, 2025; pp. 192–199.
138. Schömbs, S.; Goncalves, J.; Johal, W. "i can feel the risks by looking at the robot face": Communicating Risk through a Physical Agent. In *Proceedings of the DIS 2025—Proceedings of the 2025 ACM Designing Interactive Systems Conference*; Association for Computing Machinery: New York, NY, USA, 2025; pp. 236–252. [CrossRef]
139. Sledge, D.; Thomas, H.F. Risk communication and large language models. *Risk Hazards Crisis Public Policy* **2025**, *16*, e12303. [CrossRef]
140. Oh, J.; Kang, J.; Kim, Y. Communicating Environmental Risks in Virtual Reality: The Effects of Spatial and Concentration Cues on Responses to Particulate Matter. *Presence Teleoperators Virtual Environ.* **2026**, *35*, 285–303. [CrossRef]
141. Rydvanskiy, R.; Hedley, N. 3D geovisualization interfaces as flood risk management platforms: Capability, potential, and implications for practice. *Cartographica* **2020**, *55*, 281–290. [CrossRef]
142. Gisladottir, U.; Nakikj, D.; Jhunjhunwala, R.; Panton, J.; Brat, G.; Gehlenborg, N. Effective Communication of Personalized Risks and Patient Preferences During Surgical Informed Consent Using Data Visualization: Qualitative Semistructured Interview Study with Patients After Surgery. *JMIR Hum. Factors* **2022**, *9*, e29118. [CrossRef] [PubMed]
143. DeVasto, D. Toward Rhetorically Infused Methods for Relational Network Modeling: The Visualization of Agency in Seismic Risk Visuals. *Tech. Commun. Q.* **2024**, *33*, 122–139. [CrossRef]
144. Molan, S.; Weber, D.; Kor, M. Understanding the intention to stay and defend during a bushfire: An application of virtual reality to improve awareness of predictors associated with behavioural response. *Int. J. Disaster Risk Reduct.* **2023**, *84*, 103444. [CrossRef]
145. Ebert, N.; Fischer-Hübner, S.; Human, S.; Kitkowska, A.; Kollnig, K.; Mitrović, J.; Pan, S.; Schaltegger, T.; Schaub, F.; Smullen, D.; et al. From procedures to peril: Towards risk transparency in information privacy for users. *Telecommun. Policy* **2026**, *50*, 103195. [CrossRef]
146. Permatasari, R.; Kartika, D.S.Y.; Daffa, M.; Najaf, A.R.E.; Sisephaputra, B.; Lukman, N. Unveiling Patterns: Utilizing Folium for Visualizing Clustered Criminal Acts Distribution in Surabaya City. In Proceedings of the IEEE 9th Information Technology International Seminar, ITIS, Batu Malang, Indonesia, 18–20 October 2023. [CrossRef]
147. Carro, G.; Schalm, O.; Jacobs, W.; Demeyer, S. Exploring actionable visualizations for environmental data: Air quality assessment of two Belgian locations. *Environ. Model. Softw.* **2022**, *147*, 105230. [CrossRef]
148. Amoozegar, J.B.; Williams, P.; Giombi, K.C.; Richardson, C.; Shenkar, E.; Watkins, R.L.; O'Donoghue, A.C.; Sullivan, H.W. Consumer Engagement with Risk Information on Prescription Drug Social Media Pages: Findings From In-Depth Interviews. *J. Med. Internet Res.* **2025**, *27*, e67361. [CrossRef] [PubMed]
149. Heyer, T.; Hammoudi, H.; Zimmermann, R.; Backhaus, L.; Stamm, J.; Schilling, A.; Trometer, S.t. Flood risk analysis and communication using digital twins of urban areas. In *Proceedings of the River Flow 2020—Proceedings of the 10th Conference on Fluvial Hydraulics*; CRC Press: Leiden, The Netherlands, 2020; pp. 1409–1414.
150. Momenipour, A.; Rojas-Murillo, S.; Murphy, B.; Pennathur, P.; Pennathur, A. Usability of state public health department websites for communication during a pandemic: A heuristic evaluation. *Int. J. Ind. Ergon.* **2021**, *86*, 103216. [CrossRef] [PubMed]
151. Jin, A.-B.; Ma, C.; Zhao, Y.-Q.; Wang, H.-K.; Li, Z.-H. Risk Visualization in Mining Processes Based on 3Dmine-3DEC Data Interoperability. *Appl. Sci.* **2026**, *16*, 816. [CrossRef]
152. Horwell, C.J.; Elias, T.; Covey, J.; Bhandari, R.; Truby, J. Perceptions of volcanic air pollution and exposure reduction practices on the Island of Hawai'i: Working towards socially relevant risk communication. *Int. J. Disaster Risk Reduct.* **2023**, *95*, 103853. [CrossRef]
153. Knapstad, T.; Dettweiler, U.; Jenssen, G.D.; Njå, O. Effects of structured risk communication on road users' evacuation behaviour in the event of a tunnel fire—Results from a virtual reality simulation experiment. *Transp. Res. Interdiscip. Perspect.* **2026**, *37*, 101965. [CrossRef]
154. Scheerer, F.; Pohl, V.; Angerbauer, K.; Böhl, D.; Sedlmair, M. Beyond Entertainment: Virtual Reality as a Tool for Engaging Insurance Risk Communication. In *Proceedings of the Communications in Computer and Information Science*; Springer Nature Switzerland AG: Cham, Switzerland, 2026; pp. 81–90. [CrossRef]
155. Sobowale, K.; Hilliard, H.; Ignaszewski, M.J.; Chokroverty, L. Real-time communication: Creating a path to COVID-19 public health activism in adolescents using social media. *J. Med. Internet Res.* **2020**, *22*, e21886. [CrossRef] [PubMed]

156. Fang, H.; Du, X.; Sun, Y.; Yang, N. Risk perception evaluation of epidemic maps using event-related potentials. *Cartogr. Geogr. Inf. Sci.* **2025**, *52*, 142–159. [CrossRef]
157. Friedrich, M.; Kuls, J.; Findeisen, M.; Peinecke, N. HMI Design for Explainable Machine Learning Enhanced Risk Detection in Low-Altitude UAV Operations. In Proceedings of the AIAA/IEEE Digital Avionics Systems Conference, Barcelona, Spain, 1–5 October 2023. [CrossRef]
158. Li, Z.; Xu, R.; Huang, W.; Zhou, S.; Xu, Z.; Liu, Y.; Xing, Y.; Yang, Z.; Huang, J.; Chen, B.; et al. Developing a Community-Specific Daily Weather Health Risk Index Across Australia Using Explainable Machine Learning. *Environ. Sci. Technol.* **2025**, *59*, 24268–24278. [CrossRef] [PubMed]
159. Amidon, T.R.; Nielsen, A.C.; Pflugfelder, E.H.; Richards, D.P.; Stephens, S.H. Visual Risk Literacy in "Flatten the Curve" COVID-19 Visualizations. *J. Bus. Tech. Commun.* **2021**, *35*, 101–109. [CrossRef]
160. DeVasto, D. Agency visualized: Connecting relational network modeling and communication design. In Proceedings of the SIGDOC 2018—36th ACM International Conference on the Design of Communication, Milwaukee, WI, USA, 3–5 August 2018. [CrossRef]
161. Michaud, M.S.; Sutton, J.; Berry, K.L.; Obermeier, H.B.; Sheridan, H.; Cox, G.E.; Rafizadeh, C.M.; Olivas, S.; Johnson, N.; Krocak, M.J.; et al. NextGen TV and Advanced Emergency Alerting: The Future of TV Warnings and Alerts. *Bull. Am. Meteorol. Soc.* **2025**, *106*, E1489–E1497. [CrossRef]
162. Choi, B.C.K.; Manuel, D.G. The Canadian Health Clock and health calculators. *Can. J. Public Health* **2020**, *111*, 726–736. [CrossRef] [PubMed]
163. Chan, Y.-L.; Tsai, M.-H.; Chan, H.-Y. EDM: An ensemble decision method for introducing meteorological forecast uncertainty into the disaster response decision process. *Int. J. Disaster Risk Reduct.* **2022**, *72*, 102848. [CrossRef]
164. Simpson, M.; Padilla, L.; Keller, K.; Klippel, A. Immersive storm surge flooding: Scale and risk perception in virtual reality. *J. Environ. Psychol.* **2022**, *80*, 101764. [CrossRef]
165. Yi, Y.; Kaiser-Jackson, L.; Bather, J.R.; Goodman, M.S.; Chavez-Yenter, D.; Bradshaw, R.L.; Chambers, R.L.; Espinel, W.F.; Hess, R.; Mann, D.M.; et al. Bridging Technology and Pretest Genetic Services: Quantitative Study of Chatbot Interaction Patterns, User Characteristics, and Genetic Testing Decisions. *J. Med. Internet Res.* **2025**, *27*, e73391. [CrossRef] [PubMed]
166. Liu, K.; Yuan, Z.; Xin, X.; Zhang, J.; Wang, W. Conflict detection method based on dynamic ship domain model for visualization of collision risk Hot-Spots. *Ocean Eng.* **2021**, *242*, 110143. [CrossRef]
167. Kirabo, L.; Namara, M.; McNeese, N. The Power of the Blue Tick: Ugandans' experiences and engagement on Twitter at the onset of the COVID-19 pandemic. In *Proceedings of the ACM International Conference Proceeding Series*; Association for Computing Machinery: New York, NY, USA, 2021; pp. 84–93. [CrossRef]
168. Banno, T.; Kawada, K.; Takenawa, M.; Denda, M.; Aizawa, K. Realistic Virtual Flood Experience System Using 360° Videos and 3D City Models Constructed from Building Footprints. In *Proceedings of the ICMR 2026—Proceedings of the 16th ACM International Conference on Multimedia Retrieval*; Association for Computing Machinery: New York, NY, USA, 2026; pp. 2867–2871. [CrossRef]
169. Demuth, J.L.; Wilhelmi, O.V.; Morss, R.E.; Walpole, H.D.; Chamberlain, B.C.; Boehnert, J.; Laidlaw, E.K. The Roles of Place Attachment and Geovisualizations on Hurricane Storm Surge Risk Perceptions and Behavioral Intentions. *Risk Anal.* **2026**, *46*, e70283. [CrossRef] [PubMed]
170. Fansher, M.; Walls, L.; Hao, C.; Subramonyam, H.; Boduroglu, A.; Shah, P.; Witt, J.K. Narrative visualizations: Depicting accumulating risks and increasing trust in data. *Cogn. Res. Princ. Implic.* **2025**, *10*, 7. [CrossRef] [PubMed]
171. Semmens, K.; Carr, R.H.; Montz, B.; Maxfield, K.; Painter, P.; Nelson, J.A.; Bright, D.; Bower, E.; King, A. Integrating End-User Feedback to Inform Development of a New Urban Rain Rate Dashboard Product. *Bull. Am. Meteorol. Soc.* **2026**, *107*, E753–E769. [CrossRef]
172. Pintilie, T.; Dobre, C.; Streche, R.; Danila, A.; Suciu, G. An Integrated Geospatial Platform for Climate Risk Visualization of Transport and Energy Infrastructure. In *Proceedings of the 18th International Conference on Electronics, Computers and Artificial Intelligence, ECAI*; IEEE: Piscataway, NJ, USA, 2026. [CrossRef]
173. Norman, M.L.P.; Bao, J.A.; Kurniasari, T.; Skurka, C. Posting environmental risk: Communicating with numerical and nonnumerical messaging across information modalities. *Risk Anal.* **2025**, *45*, 1971–1983. [CrossRef] [PubMed]
174. Wilhelmi, O.V.; Chamberlain, B.C.; Morss, R.E.; Demuth, J.L.; Walpole, H.D.; Boehnert, J.; Gambill, J.M.; Lazrus, H.; Dobson, J.G. Integrating Place and Sense of Place into Geovisualizations of Hurricane Storm Surge Risk. *Weather Clim. Soc.* **2023**, *15*, 1029–1047. [CrossRef]
175. Zhou, S.; Bickmore, T. A virtual counselor for genetic risk communication. In *Proceedings of the Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*; Springer Nature: Cham, Switzerland, 2019; pp. 374–378. [CrossRef]
176. Fan, Z.; Lei, J.; Shi, W.; Lin, Y.; Wang, Q.; Bao, L. Can AI chatbots accurately provide information on orthodontic risks? *Angle Orthod.* **2025**, *95*, 483–489. [CrossRef] [PubMed]

177. Zou, Y.; Danino, S.; Sun, K.; Schaub, F. You 'might' be affected: An empirical analysis of readability and usability issues in data breach notifications. In Proceedings of the Conference on Human Factors in Computing Systems, Proceedings, Glasgow, Scotland, UK, 4–9 May 2019. [CrossRef]
178. Stathis, G.; Trantas, A.; Biagioni, G.; van den Herik, J. Risk Visualisation for Trustworthy Intelligent Contracts. In Proceedings of the 21st International Industrial Simulation Conference, ISC, Valletta, Malta, 31 May–2 June 2023; pp. 53–57.
179. Kawai, Y. Integration of Disaster Risk and Shelter Information into a 3D Urban Model for Intuitive Evacuation Planning in Yokohama City. In *Proceedings of the HAI 2025—Proceedings of the 13th International Conference on Human-Agent Interaction*; Association for Computing Machinery: New York, NY, USA, 2026; pp. 384–385. [CrossRef]
180. Richter, R.; Giroldi, E.; Jansen, J.; Van Der Weijden, T. A qualitative exploration of clinicians' strategies to communicate risks to patients in the complex reality of clinical practice. *PLoS ONE* **2020**, *15*, e0236751. [CrossRef] [PubMed]
181. Applen, J.D. Risk Assessment, Enacting Roles, and Presenting Epidemiological Data. In *Proceedings of the 39th ACM International Conference on the Design of Communication: Building Coalitions. Worldwide, SIGDOC*; Association for Computing Machinery: New York, NY, USA, 2021; pp. 365–366. [CrossRef]
182. Rouyard, T.; Leal, J.; Salvi, D.; Baskerville, R.; Velardo, C.; Gray, A. An Intuitive Risk Communication Tool to Enhance Patient–Provider Partnership in Diabetes Consultation. *J. Diabetes Sci. Technol.* **2022**, *16*, 988–994. [CrossRef] [PubMed]
183. Liu, D.; Xu, Z.; Fan, C.; Zhou, Y. Development of fire risk visualization tool based on heat map. *J. Loss Prev. Process Ind.* **2021**, *71*, 104505. [CrossRef]
184. Rashdan Mahmood, M.; Panwar, M.K. Real time data analytics for process safety governance-case study. In *Proceedings of the Society of Petroleum Engineers—Abu Dhabi International Petroleum Exhibition and Conference, ADIP*; Society of Petroleum Engineers: Richardson, TX, USA, 2019.
185. Persky, S.; Hollister, B.M.; Martingano, A.J.; Dolwick, A.P.; Telaak, S.H.; Schopp, E.M.; Bonham, V.L. Assessing Bias Toward a Black or White Simulated Patient with Obesity in a Virtual Reality-Based Genomics Encounter. *Cyberpsychology Behav. Soc. Netw.* **2024**, *27*, 815–823. [CrossRef] [PubMed]
186. Liang, J.; Abgaz, Y.; Brenan, R. A framework for generating aviation risk information mobile user interfaces from knowledge graphs. In *Proceedings of the CEUR Workshop Proceedings, Galway, Ireland, 5–6 December 2019*; CEUR-WS: Aachen, Germany, 2019; pp. 329–340.
187. Zheng, K.; Luo, J.; Yan, Y. An Interactive Design Solution for Sleep Persuasion Based on Health Risk Visualization. In *Proceedings of the Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*; Springer Nature: Cham, Switzerland, 2023; pp. 197–210. [CrossRef]
188. Edgeley, C.M.; Cannon, W.H.; Pearse, S.; Kosović, B.; Pfister, G.; Kumar, R. Five social and ethical considerations for using wildfire visualizations as a communication tool. *Fire Ecol.* **2024**, *20*, 45. [CrossRef]
189. Mol, J.M.; Wouter Botzen, W.J.; Blasch, J.E. After the virtual flood: Risk perceptions and flood preparedness after virtual reality risk communication. *Judgm. Decis. Mak.* **2022**, *17*, 189–214. [CrossRef]
190. Li, Z.; Shen, Y.; Huang, L.; Yin, M. Visual Analysis of Urban Block Risk in Extreme Low Temperature Weather Based on Bayesian Network. In *Proceedings of the ACM International Conference Proceeding Series*; Association for Computing Machinery: New York, NY, USA, 2021; pp. 138–143. [CrossRef]
191. Garza, K.B.; Yang, H.; Richardson, A.; Seals, C.; Hawkins, G.; Rose, C.G.; Nowell, W.B.; Gavigan, K.; Stewart, P.; Fraenkel, L.; et al. Acceptance of Virtual Reality Among Adults with Rheumatologic Conditions. *J. Med. Ext. Real.* **2024**, *1*, 282–289. [CrossRef] [PubMed]
192. Quagliarini, E.; de Fino, M.; Cantatore, E.; Fatiguso, F.; Bernardini, G. Risk resilience in historic urban environments: A user-centred approach. *TECHNE—J. Technol. Archit. Environ.* **2026**, *2026*, 207–219. [CrossRef]
193. Kamihara, J.; Fisher, L.; Schienda, J.; Vanderwall, R.; Snir, M.; Snir, G.; Simmons, E.; Khalaj, A.; Goler, E.; Hamilton, K.V.; et al. Development and pilot testing of AYA-RISE, a risk information and screening education intervention for adolescents and young adults with cancer risk syndromes. *Fam. Cancer* **2026**, *25*, 11. [CrossRef] [PubMed]
194. Persky, S.; Yaremych, H.E.; Goldring, M.R.; Ferrer, R.A.; Rose, M.K.; Hollister, B.M. Investigating the Efficacy of Genetic, Environmental, and Multifactorial Risk Information When Communicating Obesity Risk to Parents of Young Children. *Ann. Behav. Med.* **2021**, *55*, 720–733. [CrossRef] [PubMed]
195. Zhang, J.; Wang, Y.; Wanta, W.; Zheng, Q.; Wang, X. Reactions to geographic data visualization of infectious disease outbreaks: An experiment on the effectiveness of data presentation format and past occurrence information. *Public Health* **2022**, *202*, 106–112. [CrossRef] [PubMed]
196. Hong, S.J. Developing and testing an AI-based risk information-seeking model (ARISM): A structural equation modeling approach. *Inf. Commun. Soc.* **2026**, 1–23. [CrossRef]
197. Ozdemir, M.; Gulec, A. Role-based evaluation of artificial intelligence chatbot responses in orthodontic emergency scenarios: Accuracy, readability, understandability, and patient-oriented communication. *BMC Oral Health* **2026**, *26*, 1419. [CrossRef] [PubMed]

198. Raffel, L.; Bours, P.; Komandur, S. Attention! Designing a Target Group-Oriented Risk Communication Strategy. In *Proceedings of the Communications in Computer and Information Science*; Springer Nature: Cham, Switzerland, 2020; pp. 597–604. [CrossRef]
199. Sasaki, S.; Kiyoki, Y.; Sarkar-Swaisgood, M.; Wijitdechakul, J.; Rachmawan, I.E.W.; Srivastava, S.; Shaw, R.; Veesommai, C. 5D World Map System for Disaster-Resilience Monitoring from Global to Local: Environmental AI System for Leading SDG 9 and 11. In *Proceedings of the Frontiers in Artificial Intelligence and Applications*; IOS Press: Amsterdam, The Netherlands, 2019; pp. 306–323. [CrossRef]
200. Stellamanns, J.; Dahal, K.; Schillmoeller, Z. Communicating Risks with Interactive Visualisations and Reflective Tasks A Mixed-Methods Evaluation of a Mammography Screening Decision Aid. *Eur. J. Health Commun.* **2025**, *6*, 27–59. [CrossRef]
201. Raphael, D.B.; Russell, N.S.; Immink, J.M.; Westhoff, P.G.; Stenfert Kroese, M.C.; Stam, M.R.; van Maurik, L.M.; van den Bongard, H.J.G.D.; Maduro, J.H.; Sattler, M.G.A.; et al. Risk communication in a patient decision aid for radiotherapy in breast cancer: How to deal with uncertainty? *Breast* **2020**, *51*, 105–113. [CrossRef] [PubMed]
202. Nozaki, N.; Kawabe, Y.; Oono, M.; Kitamura, K.; Yamanaka, T.; Nishida, Y. Three-Dimensional Situational Awareness for Everyday Safety: Integration of Epidemiological Data and Three-Dimensional Spatial and Behavioral Data. In *Proceedings of the Conference Proceedings—IEEE International Conference on Systems, Man and Cybernetics*; IEEE: Piscataway, NJ, USA, 2025; pp. 4879–4885. [CrossRef]
203. Wishart, M.; Miller, A.; Ferrante, F. Leveraging Advanced Visualization Capabilities for Improved Risk Communication and Decision-Making using Probabilistic Risk Assessment Models. In *Proceedings of the 18th International Probabilistic Safety Assessment and Analysis, PSA*; American Nuclear Society: La Grange Park, IL, USA, 2023; pp. 141–149. [CrossRef]
204. Twomlow, A.; Grainger, S.; Cieslik, K.; Paul, J.D.; Buytaert, W. A user-centred design framework for disaster risk visualisation. *Int. J. Disaster Risk Reduct.* **2022**, *77*, 103067. [CrossRef]
205. Li, N.; Molder, A.L. Can scientists use simple infographics to convince? Effects of the "flatten the curve" charts on perceptions of and behavioral intentions toward social distancing measures during the COVID-19 pandemic. *Public Underst. Sci.* **2021**, *30*, 09636625211038719. [CrossRef] [PubMed]
206. van Baal, S.T.; Le, S.T.T.; Fatehi, F.; Verdejo-Garcia, A.; Hohwy, J. Testing behaviour change with an artificial intelligence chatbot in a randomized controlled study. *J. Public Health Policy* **2024**, *45*, 506–522. [CrossRef] [PubMed]
207. Kopacz, A.; Banerski, G.; Biele, C. Cognitive and visual processing of 3D enhanced disaster risk communication video. *Int. J. Disaster Risk Reduct.* **2022**, *75*, 102971. [CrossRef]
208. Roosan, D.; Li, Y.; Law, A.; Truong, H.; Karim, M.; Chok, J.; Roosan, M. Improving Medication Information Presentation Through Interactive Visualization in Mobile Apps: Human Factors Design. *JMIR mHealth uHealth* **2019**, *7*, e15940. [CrossRef] [PubMed]
209. Bica, M.; Weinberg, J.; Palen, L. Achieving Accuracy through Ambiguity: The Interactivity of Risk Communication in Severe Weather Events. *Comput. Support. Coop. Work J. Collab. Comput. Work Pract.* **2020**, *29*, 587–623. [CrossRef]
210. Zhu, J.; Zhang, J.B.; Zhu, Q.; Li, W.L.; Wu, J.L.; Guo, Y.K. A knowledge-guided visualization framework of disaster scenes for helping the public cognize risk information. *Int. J. Geogr. Inf. Sci.* **2024**, *38*, 626–653. [CrossRef]
211. van Mierlo, R.; Scheenstra, B.; Verbeek, J.; Bruninx, A.; Kalendralis, P.; Bermejo, I.; Dekker, A.; van 't Hof, A.; Spreeuwenberg, M.; Hochstenbach, L. Optimizing Cardiovascular Risk Management in Primary Care Using a Personalized eCoach Solution Enhanced by an Artificial Intelligence-Driven Clinical Prediction Model: Protocol from the Coronary Artery Disease Risk Estimation and Early Detection Consortium. *JMIR Res. Protoc.* **2025**, *14*, e66068. [CrossRef] [PubMed]
212. Tessema, T.; Shahezian, M.; Vasquez, H.; Rosella, L.; Donmez, B. Uncertainty displays in pandemic dashboards: A review of COVID-19 use cases. *Front. Digit. Health* **2026**, *8*, 1869108. [CrossRef] [PubMed]
213. Xing, H.; Xu, Y.; Chen, J.; Li, W.; Liu, Y.; Xie, Y.; Ding, L. Multi-objective optimization with priority-based execution for mobile manipulators: An HQP approach integrating adaptive motion planning and obstacle avoidance. *Robot. Auton. Syst.* **2026**, *201*, 105457. [CrossRef]