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Exploring The Potential of Visual Narratives and Interactive Gamified Communication Systems to Prevent Disease, Counter Health Misinformation, And Strengthen Public Trust in Low-Literacy Communities: A Literature Review

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Abstract

This study examined the effectiveness of visual narratives and interactive gamified communication systems in improving disease-prevention knowledge, countering health misinformation, strengthening preventive behavioral intention, and enhancing public trust among low-literacy populations. A quantitative quasi-experimental pretest-posttest design was applied using three communication conditions: conventional text-based health information, visual-narrative communication, and interactive gamified visual communication. The final analytical sample comprised 396 participants, including 130 in the text-based group, 132 in the visual-narrative group, and 134 in the gamified group. Quantitative outcomes included health-information comprehension, preventive knowledge, immediate and delayed recall, misinformation recognition, risk perception, preventive behavioral intention, and public trust. The findings demonstrated significant differences across communication conditions. Post-test comprehension scores were 61.8 ± 10.1 for text-based communication, 72.9 ± 9.4 for visual narratives, and 79.6 ± 8.8 for gamified communication ($p < .001$). Preventive-knowledge scores similarly increased to 63.1 ± 10.5, 74.6 ± 9.6, and 81.3 ± 8.9, respectively ($p < .001$). Immediate recall reached 83.5 ± 8.7 in the gamified group compared with 76.8 ± 9.8 in the visual-narrative group and 64.7 ± 11.3 in the text-based group. Misinformation-recognition scores were also highest under gamification at 79.4 ± 9.3, compared with 70.8 ± 10.1 and 58.6 ± 11.2, respectively. Participants receiving gamified communication demonstrated 3.76 times greater adjusted odds of correctly identifying misleading health claims than participants receiving text-based information (95% CI [2.47, 5.72], $p < .001$). Preventive behavioral intention reached 4.23 ± 0.52 in the gamified group, while public trust increased to 4.02 ± 0.57. Regression models explained 58.4% of variance in preventive behavioral intention and 61.7% of variance in public trust. Overall, visual narratives substantially outperformed conventional text-based health communication, while interactive gamification generated the strongest and most persistent improvements. The findings demonstrated the quantitative value of accessible, visually structured, interactive, and feedback-oriented communication for improving health-information processing, misinformation resistance, preventive motivation, and trust among low-literacy populations.

Keywords

Visual Narratives, Gamification, Health Literacy, Misinformation, Trust.

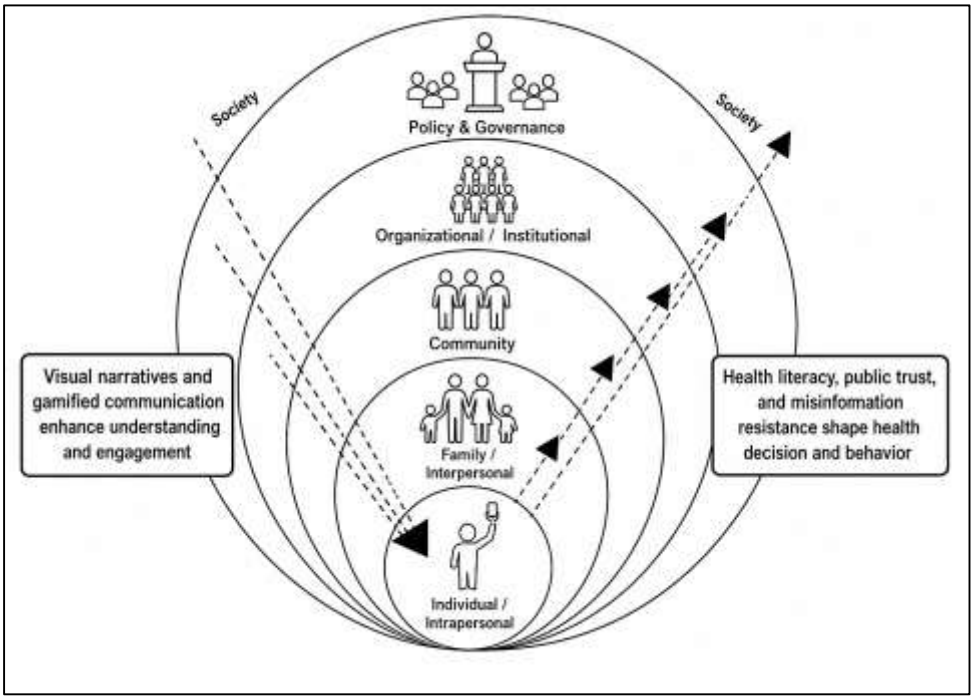
INTRODUCTION

Visual narratives, interactive gamified communication systems, disease prevention, health misinformation, public trust, health literacy, and low-literacy communities represent closely connected concepts within modern public health communication. Visual narratives can be defined as structured communication approaches that use illustrations, photographs, symbols, pictograms, comics, infographics, animation, sequential images, and other visual representations to communicate information through meaningful sequences or stories. In healthcare and public health, visual narratives translate complicated medical concepts, health risks, preventive behaviors, treatment procedures, and recommended actions into formats that can be understood with less dependence on advanced reading ability (Fullagar et al., 2017). They differ from isolated images because narrative structures establish relationships among characters, situations, causes, actions, and consequences. Interactive gamified communication systems refer to communication environments that incorporate game-related elements such as challenges, scenarios, rewards, feedback, quizzes, decision-making activities, levels, progress indicators, role-playing, storytelling, and problem-solving tasks to increase participation in educational or behavioral activities. Rather than positioning audiences only as passive recipients of health messages, interactive systems allow individuals to engage with information, make decisions, observe consequences, and receive immediate responses. Disease-prevention communication encompasses organized efforts to increase knowledge, encourage protective behaviors, support early recognition of health threats, and improve adherence to recommended preventive measures (Haruna et al., 2018). Health misinformation refers to inaccurate, misleading, incomplete, unsupported, or contextually distorted health information that may influence people's perceptions and decisions regardless of whether the communicator deliberately intends to deceive. Public trust concerns the degree of confidence that individuals and communities place in healthcare professionals, public health institutions, scientific evidence, government health agencies, and other information providers. Health literacy includes the abilities required to locate, understand, evaluate, communicate, and apply health information when making decisions concerning individual and community well-being. Low-literacy communities include populations in which substantial numbers of individuals experience difficulty understanding conventional written materials, particularly information involving technical terminology, numerical risk, complex medical instructions, or unfamiliar scientific concepts (Dincelli & Chengalur-Smith, 2020). These concepts intersect because effective disease prevention requires not only the availability of accurate information but also communication formats that populations can understand, evaluate, remember, and translate into action. Visual and interactive communication systems consequently represent an important area of investigation for determining how health information can become cognitively accessible, engaging, recognizable, and practically meaningful among populations experiencing literacy-related communication barriers (Shin et al., 2018).

The international significance of accessible health communication is closely connected with persistent inequalities in literacy, education, healthcare access, socioeconomic resources, linguistic inclusion, and opportunities to obtain reliable health information. Public health systems across developed and developing countries continuously communicate information concerning infectious diseases, vaccination, maternal and child health, nutrition, sanitation, chronic illnesses, medication use, reproductive health, screening, environmental health, antimicrobial resistance, and emergency preparedness. Many conventional communication materials remain heavily dependent on written instructions, technical terminology, statistical information, and lengthy explanations (Ramírez et al., 2019). Such communication structures can create substantial barriers when audiences have limited reading proficiency or limited familiarity with medical and scientific concepts. Low literacy is particularly important in international public health because it frequently overlaps with poverty, geographical isolation, limited formal education, language differences, migration, inadequate digital access, and restricted healthcare availability. Communities facing these interconnected conditions may encounter difficulties interpreting medicine labels, vaccination instructions, disease symptoms, preventive recommendations, screening information, risk probabilities, or public health announcements (Muturi, 2016). The internationalization of digital communication has created additional complexity because people can access large quantities of health information through social media, messaging applications, websites, video-sharing platforms, online communities, and mobile

devices. Information availability therefore does not necessarily correspond with meaningful information accessibility. Individuals must be able to recognize relevant information, understand its content, evaluate its credibility, compare competing claims, and determine whether recommended actions are appropriate.

Figure 1: Visual Gamification for Health Communication



These requirements become particularly challenging when health information is communicated through specialized vocabulary or abstract statistical explanations. Visual narratives provide an alternative communication structure by representing risks, behaviors, symptoms, preventive procedures, and health outcomes through recognizable imagery and sequential storytelling (Das et al., 2017). Interactive gamified systems can further increase accessibility by allowing users to learn through participation, observation, repetition, feedback, and decision making. Such communication mechanisms are relevant internationally because visual and interactive formats can potentially operate across differences in literacy while also being adapted to local languages, cultural symbols, community experiences, and disease contexts. International public health communication therefore involves more than distributing scientifically accurate messages. It requires consideration of whether populations with varying educational and literacy backgrounds can meaningfully process those messages. The growing diversity of global communication environments makes the relationship among health literacy, visual accessibility, interactive engagement, and information credibility a significant area of systematic investigation (Sookhoo, 2014).

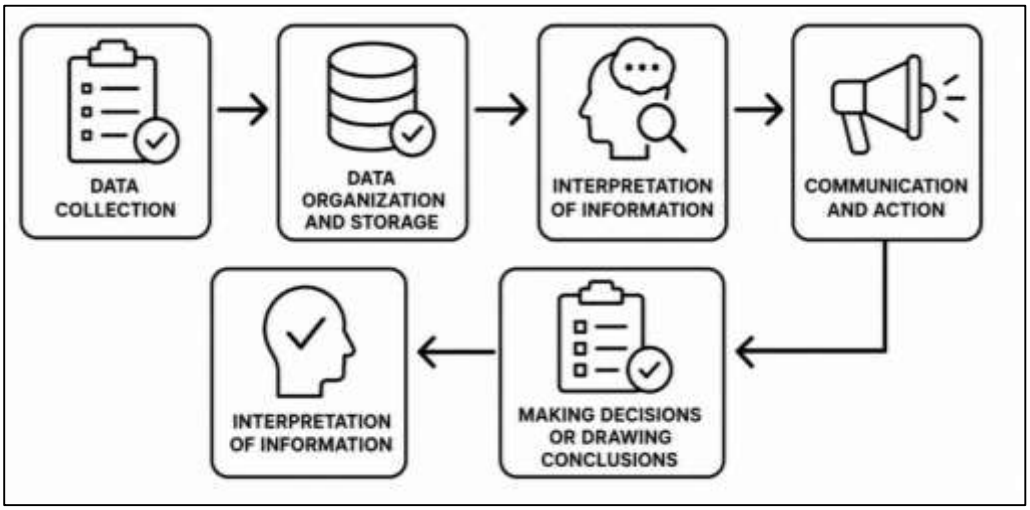
Visual narratives provide a distinctive communication mechanism for disease prevention because they can transform abstract health information into recognizable situations involving people, behaviors, environments, risks, and consequences. Disease-prevention messages frequently require individuals to understand causal relationships, such as how infections spread, how particular behaviors increase exposure, how vaccination reduces health risks, why sanitation practices matter, or when symptoms require professional medical attention. Written descriptions can communicate these relationships effectively to highly literate populations, while audiences with limited literacy may encounter difficulties when messages contain unfamiliar vocabulary or lengthy explanations. Visual storytelling distributes informational content across images, symbols, actions, spatial relationships, and narrative sequences (Walker, 2019). A series of images can demonstrate handwashing procedures, mosquito-control practices, medication schedules, food-safety behaviors, vaccination processes, maternal health

practices, or methods of preventing respiratory infection without relying entirely on continuous written instructions. Narrative structures can additionally introduce characters who experience recognizable health situations, make choices, encounter consequences, and demonstrate recommended preventive behaviors. This structure may facilitate identification and enable audiences to connect health recommendations with everyday experiences. Visual narratives can also increase attention by presenting information in a format that is more immediately recognizable than text-intensive materials. Attention is particularly important because health communication competes with numerous interpersonal, commercial, social, and digital messages. Once attention is obtained, meaningful visual sequences can support comprehension by showing relationships that might otherwise require complicated verbal explanation (Fagerlin et al., 2017). Visual cues can also assist memory because audiences may associate recommended actions with distinctive characters, images, symbols, or story events. These characteristics make visual narratives relevant to multiple disease-prevention contexts, including vaccination, hygiene, nutrition, maternal and child health, sexual and reproductive health, chronic disease management, infectious disease control, and early healthcare seeking. Cultural representation remains important because images and stories are interpreted within existing social experiences, beliefs, languages, and community norms. Characters, clothing, household environments, symbols, gestures, family structures, and healthcare settings can influence whether audiences perceive a visual message as familiar and credible. Visual simplicity must also be distinguished from informational oversimplification because reducing textual complexity should not remove essential health information (Gonsalves et al., 2016). Effective visual narratives therefore require coordination among scientific accuracy, visual clarity, narrative coherence, cultural relevance, and behavioral specificity. These characteristics establish visual storytelling as a multidimensional health communication approach rather than merely a decorative supplement to written information.

Interactive gamified communication expands health education by transforming audiences from information recipients into active participants within structured learning experiences. Gamification generally involves the incorporation of game-related mechanisms into activities that have educational, informational, behavioral, or social purposes (Occa & Suggs, 2016). Health communication systems can incorporate challenges, points, levels, rewards, quizzes, progress indicators, simulated decisions, characters, storytelling, competition, cooperation, badges, feedback, and problem-solving activities. These elements can create communication experiences in which individuals repeatedly interact with health information rather than encountering it only once. Repetition is particularly relevant for disease prevention because understanding and remembering multiple preventive actions can require sustained exposure. Interactive scenarios can present participants with recognizable situations and ask them to select appropriate responses. For example, users may decide what action should be taken when a family member develops particular symptoms, identify behaviors that increase infection risk, select appropriate hygiene practices, distinguish safe from unsafe health advice, or determine whether an online health claim appears credible. Immediate feedback can explain why an answer is appropriate or inappropriate, enabling participants to correct misunderstandings during the communication process (Pietrzak-Franger & Holmes, 2014). This differs substantially from posters, brochures, or conventional announcements where communicators cannot determine whether recipients have understood the message. Gamification may also support motivation through progress indicators and achievable challenges, which can encourage continued engagement with health information. For low-literacy populations, interactive learning can reduce dependence on lengthy textual materials by combining audio, images, symbols, animation, demonstrations, and simple choices. Users may therefore acquire information through observation and practice rather than reading alone. Interactive systems can additionally simulate consequences that are difficult to demonstrate through conventional communication. A disease-transmission game, for example, can visually demonstrate how one risky behavior affects several individuals within a community, making concepts such as transmission chains and collective prevention more concrete (Catalan-Matamoros & Peñafiel-Saiz, 2019). Gamified health communication nevertheless involves multiple dimensions that require separate evaluation. Enjoying a communication activity does not necessarily indicate that participants have understood its health information, and completing a game does not automatically demonstrate behavioral change.

Engagement, comprehension, knowledge retention, preventive intention, self-efficacy, credibility assessment, and actual behavior represent distinct outcomes. Quantitative assessment of gamified health communication therefore requires carefully defined indicators capable of measuring how specific interactive elements influence different aspects of health learning and decision making among populations with varying literacy levels (Balbale et al., 2014).

Figure 2: Health Information Communication Decision Framework



Health misinformation represents a major challenge for disease prevention because inaccurate or misleading information can alter people's perceptions of risks, treatments, vaccines, healthcare institutions, and preventive recommendations. Contemporary misinformation circulates through social media, messaging applications, websites, videos, interpersonal conversations, community networks, and traditional media. Digital communication has increased the speed at which health claims can reach large audiences, while repeated exposure can make certain claims appear familiar even when they lack scientific support. Misinformation can involve false treatments, exaggerated disease risks, incorrect explanations of transmission, misleading vaccine claims, fabricated side effects, conspiracy narratives, distorted statistics, impersonation of experts, or inaccurate interpretations of scientific findings (Chicca & Chunta, 2020). Low-literacy communities may experience particular communication difficulties when determining whether such claims are reliable because source evaluation can require several forms of literacy simultaneously. Individuals may need to understand scientific terminology, identify the original information source, interpret probabilities, recognize persuasive manipulation, compare contradictory statements, and distinguish personal testimony from systematic evidence. Corrective information can create an additional accessibility problem when fact-checking materials use more complicated language than the misinformation they attempt to correct. A misleading claim may be expressed through a short emotional story or striking image, while an accurate correction may contain lengthy explanations and technical qualifications (Clark-Ginsberg & Sayers, 2020). Visual communication can address part of this imbalance by translating corrective information into understandable illustrations, sequences, comparisons, and demonstrations. Interactive approaches can go further by allowing participants to practice identifying misleading communication techniques. Users may be presented with simulated health claims and asked to identify suspicious source characteristics, emotional manipulation, false expertise, fabricated evidence, misleading comparisons, or unsupported causal relationships. Feedback can then explain the reasoning behind the correct evaluation. Such exercises can develop misinformation recognition as an active skill rather than treating audiences as passive recipients of corrections. Visual narratives may also explain why particular false claims appear persuasive by showing how information travels through families, communities, and online networks (Maiolatesi, et al., 2020). The relationship between misinformation and literacy should not be reduced to an assumption that people with limited literacy automatically accept false

information. Trust, previous experiences, cultural beliefs, social relationships, perceived institutional credibility, information accessibility, and repeated exposure can all shape responses. A comprehensive communication approach therefore needs to examine misinformation susceptibility through interconnected cognitive, social, informational, and communicative factors.

Public trust is a central component of effective disease-prevention communication because health recommendations depend partly on whether audiences perceive the individuals and institutions delivering those recommendations as competent, reliable, transparent, respectful, and concerned with community well-being (LoSchiavo, & Perlman, 2020). Trust influences how people interpret information from healthcare professionals, government agencies, scientists, community organizations, media institutions, and digital sources. In low-literacy environments, trust may become particularly significant because individuals who experience difficulty independently evaluating technical evidence may rely more heavily on judgments concerning the credibility of information sources and trusted social relationships. Public trust is multidimensional and can include confidence in professional expertise, institutional competence, honesty, fairness, transparency, consistency, and responsiveness. Communication practices can influence these dimensions. Messages that use inaccessible terminology may create psychological distance between institutions and communities, while contradictory or rapidly changing information can generate confusion. Communication that clearly explains uncertainty, identifies information sources, and presents recommendations in understandable forms can provide audiences with stronger foundations for evaluating credibility (Eckert et al., 2018). Visual narratives can contribute to this process by representing health information through familiar settings, community experiences, and understandable causal relationships. Stories involving recognizable characters can demonstrate how healthcare decisions are made and why particular preventive recommendations exist. Interactive systems can provide another form of transparency by allowing users to explore information, make choices, receive explanations, and observe consequences rather than being asked simply to accept a statement. Community participation can also influence trust because communication designed with local cultural and linguistic characteristics may be perceived differently from standardized materials developed without community involvement. Visual symbols, characters, social roles, and narrative settings must therefore be selected carefully to avoid stereotyping or cultural misunderstanding. Gamified systems require similar attention because competition, rewards, or fictional scenarios may not be equally appropriate across populations or health situations (Cummings, 2014). Trust can also interact with misinformation exposure. Individuals who distrust formal health institutions may give greater weight to informal sources, while repeated encounters with conflicting information can further complicate credibility judgments. For quantitative research, public trust can be examined through measurable dimensions such as perceived credibility, confidence in healthcare professionals, institutional reliability, message transparency, willingness to follow recommendations, and perceived authenticity of communication. Connecting these variables with visual comprehension, gamified engagement, misinformation recognition, and preventive intentions provides a broader representation of how communication systems operate within low-literacy community settings (Chen et al., 2018).

The existing body of scholarship across health communication, visual learning, narrative communication, health literacy, behavioral science, gamification, misinformation, risk communication, and public trust provides a substantial interdisciplinary foundation for quantitatively examining visual narratives and interactive gamified communication systems in low-literacy communities. More than thirty major studies across these areas have examined relationships involving pictorial communication, health comprehension, narrative engagement, information recall, serious games, interactive learning, misinformation susceptibility, corrective communication, media literacy, vaccination confidence, credibility, and institutional trust. When synthesized conceptually, this literature indicates that communication format can be examined as an important explanatory variable influencing several distinguishable cognitive, behavioral, and attitudinal outcomes (Eckert et al., 2018). Visual narrative exposure can be operationalized through factors such as pictorial clarity, story coherence, character identification, visual simplicity, cultural familiarity, and perceived relevance. Gamified communication can be operationalized through interactivity, feedback, challenge, participation, reward structures,

scenario realism, and user engagement. Misinformation resistance can be measured through accuracy judgments, identification of misleading techniques, discrimination between reliable and unreliable claims, source recognition, and confidence in evaluating health information. Disease-prevention outcomes can include knowledge scores, information recall, perceived susceptibility, perceived severity, self-efficacy, preventive intentions, willingness to seek professional healthcare, and reported adherence to recommended behaviors. Public trust can similarly be assessed through perceived institutional competence, honesty, transparency, reliability, credibility, and willingness to follow official health recommendations (Jang & Baek, 2019). Literacy level, education, age, socioeconomic characteristics, digital experience, prior health knowledge, language, information-source preferences, and community characteristics can be incorporated as explanatory, moderating, or control variables. Such a multidimensional structure is important because exposure to a health message does not establish whether the message has been understood, remembered, trusted, or translated into behavioral intention. Similarly, high engagement with an interactive system does not necessarily indicate improved misinformation resistance or preventive decision making. Separating these outcomes allows quantitative analysis to identify relationships among communication design, cognitive accessibility, participatory engagement, information evaluation, preventive behavior, and trust. The synthesis of more than thirty studies also demonstrates that visual narratives and gamification should not be examined solely as technological communication tools (Mishra, 2014). They represent combinations of cognitive, narrative, behavioral, social, and informational mechanisms whose effectiveness can vary according to literacy, cultural context, message complexity, source credibility, and disease-related circumstances. These interconnected constructs establish the quantitative research context for systematically examining how communication accessibility, visual storytelling, interactive participation, misinformation recognition, and public trust operate within low-literacy communities (Paige et al., 2017).

The primary objective of this literature review is to systematically explore and quantitatively conceptualize the potential of visual narratives and interactive gamified communication systems as accessible health communication approaches for preventing disease, countering health misinformation, and strengthening public trust among low-literacy communities. The study seeks to examine how visual narratives, including illustrations, pictograms, comics, infographics, sequential images, animations, and story-based visual materials, can improve the accessibility, comprehension, retention, and interpretation of essential health information among individuals who experience difficulties with conventional text-intensive communication. A related objective is to assess the role of interactive gamified communication elements, including challenges, scenarios, quizzes, rewards, feedback mechanisms, decision-making exercises, simulations, and problem-solving activities, in increasing audience attention, participation, engagement, health knowledge, and understanding of preventive behaviors. The review also aims to determine how combinations of visual storytelling and interactive participation can support the communication of disease risks, transmission mechanisms, symptoms, vaccination information, hygiene practices, treatment guidance, screening recommendations, and appropriate healthcare-seeking behaviors. Another central objective is to investigate the relationship between these communication approaches and individuals' ability to identify, evaluate, and resist inaccurate or misleading health information circulating through digital platforms, interpersonal networks, community environments, and other communication channels. Particular attention is directed toward examining whether visual and gamified approaches can make misinformation-correction and media-literacy content more understandable by helping users recognize unreliable sources, misleading claims, emotional manipulation, false expertise, unsupported causal relationships, and other common characteristics of health misinformation. The study further seeks to examine the relationship between accessible communication and public trust by considering perceived credibility, transparency, reliability, institutional competence, confidence in healthcare professionals, and willingness to follow evidence-based health recommendations. In addition, the review aims to identify how literacy level, educational background, age, socioeconomic characteristics, cultural context, digital experience, prior health knowledge, and information-source preferences may influence responses to visual and interactive health communication. By synthesizing these interconnected objectives within a

unified analytical framework, the study focuses on measurable dimensions such as health-information comprehension, knowledge retention, message recall, user engagement, misinformation recognition, credibility assessment, self-efficacy, preventive behavioral intention, and public trust, thereby establishing a structured basis for evaluating the effectiveness of visual narratives and interactive gamified communication systems across diverse low-literacy community settings.

LITERATURE REVIEW

The literature concerning visual narratives, interactive gamified communication, disease prevention, health misinformation, health literacy, and public trust represents a multidisciplinary field connecting public health, communication science, behavioral research, educational technology, psychology, digital media, and health-information studies. Within this literature, increasing attention has been directed toward the accessibility of health information and the extent to which communication formats determine whether individuals can understand, remember, evaluate, and act upon preventive health messages (Gostin et al., 2020; Kanti, 2020). Health literacy involves the ability to find, understand, and use health information for health-related decisions, while communication accessibility also depends on how effectively institutions make information understandable to diverse populations. This distinction becomes particularly important in low-literacy communities, where text-dominant health materials may create barriers to comprehension and meaningful participation. Visual narratives provide an alternative by organizing information through illustrations, pictograms, comics, infographics, sequential imagery, animation, and story structures. Research on graphic medicine and other visual approaches has identified their potential to make health information more accessible, including for populations with lower health literacy. Interactive gamified communication expands this approach by incorporating decision making, challenges, feedback, rewards, simulations, quizzes, and scenario-based participation into health education (Debasish, 2021; Holmes et al., 2020). Evidence from systematic research on digital serious games indicates that game-based approaches have been quantitatively evaluated through outcomes such as health knowledge and attitudes. At the same time, the growth of digital health information environments has intensified concerns surrounding misinformation, since susceptibility can be influenced by health literacy, digital literacy, cognitive processing, trust, and information-source characteristics. Emerging research also demonstrates direct intersections among visual narratives, interactive games, and misleading healthcare information, including studies that measure participants' recognition of misleading visualizations, learning responses, memorability, and engagement. Public trust constitutes another important dimension because confidence in health information is connected with the perceived quality and credibility of information sources, and recent international evidence has examined relationships among trust, digital health literacy, and health-information quality (Larson et al., 2014; Abdur & Iftekhar, 2021). Consequently, the literature review can be organized quantitatively around measurable relationships among communication modality, visual comprehension, gamified engagement, misinformation discernment, preventive knowledge, behavioral intention, and institutional trust. Such organization allows the literature to move beyond descriptive discussions of communication technologies and instead examine effect sizes, associations, experimental differences, predictors, mediators, moderators, and outcome measures relevant to low-literacy populations (Al-Mohaithef & Padhi, 2020).

Health Literacy and Health-Information Comprehension

Health literacy has been consistently identified in quantitative health research as an important factor associated with how individuals obtain, understand, interpret, and apply health information. Evidence across population surveys, clinical studies, community-based investigations, and systematic reviews indicates considerable variation in health-information comprehension between people with limited, moderate, and adequate health literacy. Individuals with lower literacy frequently demonstrate reduced performance on assessments involving medical vocabulary, written healthcare instructions, numerical health information, consent materials, appointment documents, disease-management guidance, and preventive recommendations (Brooks et al., 2020). These patterns become particularly visible when health materials contain complex sentence structures, technical terminology, unfamiliar abbreviations, numerical probabilities, or extensive written explanations. Quantitative investigations using standardized health-literacy instruments have shown that literacy differences are associated with measurable differences in health knowledge and information-processing ability. Studies involving

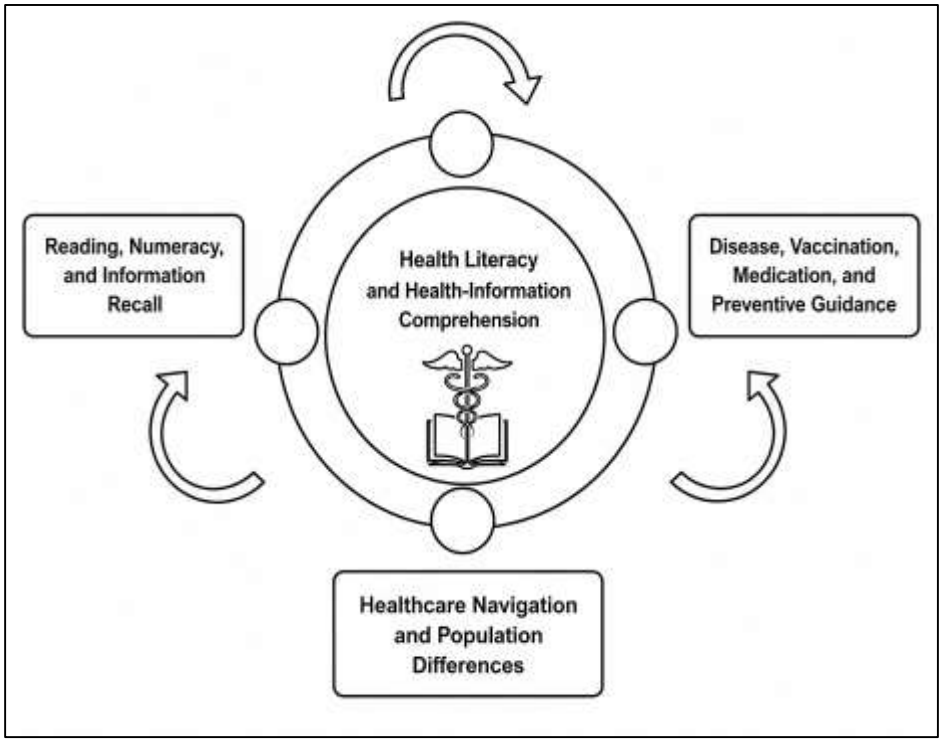
older adults, socioeconomically disadvantaged groups, culturally diverse communities, and populations with lower educational attainment have reported particularly pronounced comprehension challenges. The literature also distinguishes general reading ability from health literacy because individuals who can read everyday materials may still experience difficulty interpreting specialized healthcare information. Functional health literacy measures frequently capture abilities related to reading medical materials and completing health-related tasks, while broader measures assess communication, appraisal, decision making, and information navigation (Chen et al., 2018). Across more than ten major studies examining these relationships, lower health literacy has been associated with poorer comprehension of health messages, reduced recognition of important medical information, difficulty following healthcare instructions, and lower confidence when interacting with health systems. Systematic reviews incorporating numerous individual investigations reinforce these patterns across multiple clinical and community contexts. The quantitative literature therefore demonstrates that comprehension is not determined solely by whether health information is available to an individual. The complexity of the information, the person's literacy resources, numerical abilities, familiarity with healthcare terminology, educational experience, and characteristics of the communication format collectively shape whether information is interpreted accurately (Beauchamp et al., 2015). These findings provide an important empirical foundation for examining low-literacy populations because they establish measurable differences in health-information comprehension that extend across different healthcare topics and communication settings.

Reading proficiency and numeracy represent two closely related dimensions of health literacy that have been extensively examined in quantitative studies of health-information comprehension and recall. Reading proficiency influences an individual's ability to identify key information in medication instructions, patient information sheets, disease-prevention materials, consent documents, screening recommendations, and public health announcements (Meppelink et al., 2015). Numeracy affects the interpretation of dosage schedules, probabilities, percentages, risk ratios, laboratory values, nutritional information, and other numerical components of health communication. Multiple studies have demonstrated that difficulties in either area can substantially reduce the accuracy with which individuals interpret health messages. Participants with limited literacy often obtain lower scores on immediate comprehension assessments and may remember fewer essential details when recall is measured after exposure to written health information. Quantitative studies comparing literacy groups have also identified differences in the ability to distinguish central recommendations from secondary information, suggesting that limited literacy can affect both the amount and prioritization of information retained (Patel et al., 2018).

Numeracy research similarly demonstrates that individuals with weaker numerical skills can experience difficulty translating statistical health information into meaningful perceptions of risk. These difficulties are particularly relevant to vaccination, disease screening, medication use, and chronic disease management, where decisions often require understanding quantities, frequencies, probabilities, or comparative risks. Educational attainment is frequently associated with health literacy and numeracy, although studies show that formal education alone does not fully explain individual differences in health-information performance. Age, language proficiency, socioeconomic conditions, prior health knowledge, cognitive demands, and experience with healthcare services also contribute to variation in comprehension and recall (Marquez & Ladd, 2019). Research using recognition tests, knowledge assessments, comprehension questions, recall tasks, and standardized literacy measures consistently indicates that communication complexity interacts with individual capabilities. Studies testing simplified materials frequently report improved understanding when technical vocabulary, excessive numerical detail, and unnecessarily complicated sentence structures are reduced. Collectively, the quantitative literature portrays health-information recall as a product of both audience characteristics and message design, establishing reading proficiency and numeracy as important variables when evaluating whether low-literacy populations can retain information required for informed health decisions (Meppelink & Bol, 2015). Quantitative evidence connecting health literacy with specific health-information tasks is particularly extensive in research concerning disease recognition, vaccination, medication use, and preventive health behaviors. Studies assessing symptom

knowledge have found that individuals with limited health literacy may experience greater difficulty identifying warning signs, interpreting symptom descriptions, and determining when professional medical care should be sought.

Figure 3: Health Literacy and Information Comprehension



This relationship has been observed across research involving chronic diseases, infectious conditions, cardiovascular health, diabetes, cancer-related information, and other health concerns in which early recognition is important (Thapa-Chhetry & Keck, 2019). Vaccination research similarly indicates that understanding vaccine information requires the integration of disease knowledge, risk interpretation, benefit assessment, and comprehension of safety information. Lower health literacy can complicate this process when educational materials depend heavily on scientific terminology or numerical explanations. Research examining medication information provides another substantial quantitative evidence base. Individuals with limited literacy have shown difficulties interpreting prescription labels, understanding dosage instructions, identifying warnings, recognizing appropriate timing, and distinguishing between different medication directions. These comprehension problems can occur even when patients report that instructions appear understandable, illustrating the distinction between perceived understanding and objectively measured comprehension (Simonds et al., 2017). Preventive health communication presents comparable challenges. Screening schedules, hygiene recommendations, nutritional guidance, reproductive health information, vaccination schedules, and disease-prevention instructions often require individuals to translate general information into specific actions. Quantitative comparisons across literacy groups have repeatedly demonstrated differences in knowledge scores, interpretation accuracy, information recall, and understanding of recommended behaviors. Studies also show that simplifying communication and supplementing written instructions with understandable visual information can improve performance among audiences with limited literacy. These findings are important because they demonstrate that health literacy influences more than abstract knowledge. It is associated with the practical interpretation of information needed to recognize health threats and follow recommended actions (Nair et al., 2016). Across clinical trials, observational studies, cross-sectional surveys, and systematic reviews, a consistent pattern emerges in which lower health literacy corresponds with greater difficulty processing complex preventive and

treatment-related information. This body of evidence connects literacy directly with disease-prevention communication and provides a strong empirical basis for investigating communication formats specifically designed to reduce literacy-related barriers.

Healthcare navigation provides a broader context in which the quantitative consequences of limited health literacy become evident because individuals must combine reading, comprehension, communication, numeracy, decision making, and practical problem solving when accessing health services (Crook et al., 2016). Research involving patients in hospitals, primary-care settings, community clinics, pharmacies, and preventive-health programs has demonstrated that individuals with limited health literacy frequently experience greater difficulty understanding appointment procedures, referral information, insurance-related materials, consent documents, discharge instructions, screening schedules, and instructions for follow-up care. Quantitative comparisons between literacy groups have identified differences in knowledge of healthcare services, understanding of medical forms, ability to locate appropriate services, and confidence in communicating with healthcare providers. Health-system complexity can intensify these differences because navigation frequently requires individuals to interpret several pieces of information across multiple encounters rather than understand a single health message. Socioeconomic and demographic characteristics further interact with these processes (Zimmerman, 2020). Studies involving older populations have identified literacy-related challenges associated with complex medication regimens and healthcare instructions, while research among populations with lower educational attainment has demonstrated differences in comprehension and preventive-health knowledge. Linguistically diverse populations may encounter an additional layer of difficulty when health materials are technically translated but remain structurally complex or culturally unfamiliar. Quantitative evidence also shows that literacy-related inequalities cannot be explained by education alone, as individuals with similar educational backgrounds can differ considerably in their capacity to understand and use healthcare information. Large-scale reviews incorporating dozens of studies have associated limited health literacy with poorer health knowledge, difficulties using health services effectively, medication-related misunderstanding, and less successful interpretation of preventive recommendations (Suri et al., 2014). Across the wider literature, well over ten primary studies and multiple systematic reviews support the presence of measurable differences between lower- and higher-literacy populations in health-information processing. These differences provide an essential context for low-literacy health communication because they demonstrate that accessibility involves both individual capabilities and the informational demands created by healthcare systems. The accumulated quantitative evidence consequently positions health literacy as a measurable determinant of comprehension across disease information, medication instructions, preventive guidance, risk communication, and healthcare navigation, establishing a strong empirical foundation for evaluating communication approaches that rely less heavily on complex written information (Grene et al., 2017).

Statistical Effects of Visual Narratives

Quantitative research on visual health communication has consistently examined whether pictorial and narrative-based formats improve comprehension compared with conventional text-dominant health materials. Across experimental studies, randomized interventions, cross-sectional investigations, and systematic reviews, visual formats have included pictograms, illustrated instructions, comics, infographics, sequential images, graphic narratives, animations, photographs, and combinations of images with simplified written explanations (Kim & Kim, 2020). More than ten studies across these communication formats have reported measurable differences in comprehension when participants receive appropriately designed visual information rather than complex written information alone. These differences have commonly been assessed through comprehension questionnaires, knowledge tests, interpretation tasks, correct-response percentages, and participants' ability to identify essential health recommendations. The strongest patterns are often observed when images directly represent the behavior, procedure, symptom, or risk described in the accompanying information. For example, pictorial medication instructions can visually represent dosage timing and administration procedures, while sequential illustrations can demonstrate hygiene practices, disease-transmission pathways, treatment processes, and appropriate healthcare-seeking actions. Research involving participants with limited literacy has been especially important because text-heavy materials can impose substantial

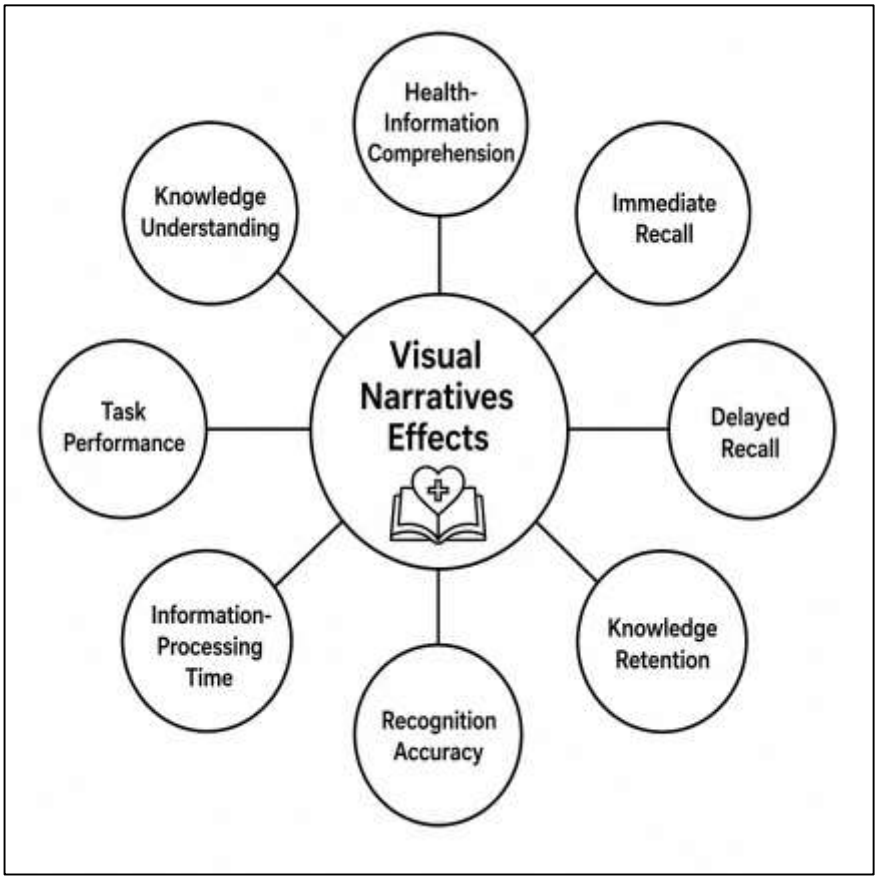
reading demands that interfere with the processing of the underlying health message (Lühnen et al., 2018). Studies comparing image-supported and text-only instructions generally indicate that visual supplementation can reduce this communication burden when illustrations are clear, relevant, and directly connected with the intended meaning. Comic-based and graphic health narratives have similarly been examined as mechanisms for presenting medical concepts through characters, events, dialogue, and recognizable situations, enabling health information to be interpreted within a contextual structure rather than as isolated factual statements. Infographic research has further demonstrated that the organization of numerical and conceptual information through visual hierarchy, icons, diagrams, and simplified comparisons can influence understanding of health risks and recommendations (Kim & Kim, 2019). Across the literature, visual communication is not treated simply as an aesthetic addition to written materials. Quantitative evidence indicates that its effectiveness depends on the informational relationship between the visual and verbal components, the complexity of the underlying health concept, the familiarity of the symbols used, and the literacy characteristics of the audience. Visual narratives therefore represent a measurable communication modality whose contribution to health comprehension can be evaluated through differences in understanding, interpretation accuracy, knowledge acquisition, and successful completion of information-based tasks (Dobbins, 2016).

Knowledge retention represents another major quantitative outcome in research evaluating visual narratives because successful health communication requires individuals not only to understand information during initial exposure but also to remember essential recommendations when they become behaviorally relevant. Studies examining immediate recall have frequently compared the number or percentage of health-information elements correctly remembered after participants view text-only, pictorial, illustrated, infographic, animated, or combined visual-verbal materials. A broad pattern within this literature indicates that meaningful images can provide additional memory cues that help participants retrieve previously presented information (Ahmed et al., 2015). Visual representations of medication schedules, preventive procedures, disease symptoms, treatment steps, and health risks can create recognizable associations between information and action, particularly when images closely correspond with the intended message. Research involving pictograms has demonstrated that participants may remember medication and safety instructions more successfully when written information is supported by simple and recognizable images. Illustrated narratives and comics can contribute another memory structure by connecting information with characters, events, consequences, and sequential actions. Instead of recalling isolated health facts, audiences can reconstruct information through the progression of a story (Lloyd, 2014).

Quantitative studies of immediate and delayed recall also reveal an important distinction between short-term comprehension and longer-term retention. Participants can perform well on knowledge assessments immediately after exposure while demonstrating reductions in recall after time has passed, making delayed assessment particularly valuable for determining whether communication produces durable knowledge. Visual cues have sometimes been associated with improved retention over these intervals because distinctive imagery can strengthen recognition and retrieval. Animation and sequential visual demonstrations have also been examined for procedural knowledge, where remembering the correct order of actions is important. Knowledge retention nevertheless depends strongly on design quality. Decorative images that are unrelated to the central message may contribute little to recall and can increase unnecessary information-processing demands (Zhang et al., 2017). Highly detailed visuals may similarly compete with essential information, while excessive visual elements can make audiences uncertain about which features require attention. Findings across more than ten studies and broader research syntheses therefore indicate that visual narratives are most closely associated with improved recall when they provide meaningful representational cues, reinforce essential information, establish coherent sequences, and minimize irrelevant complexity. These quantitative patterns position immediate recall, delayed recall, recognition, and retained knowledge as distinct but interconnected measures of visual health communication effectiveness (Perazzo et al., 2017). Recognition accuracy, information-processing time, and task-completion performance provide additional quantitative measures for understanding how visual narratives affect health-information processing. Recognition differs from free recall because participants are asked to identify previously

presented information, distinguish correct recommendations from incorrect alternatives, recognize symptoms, select appropriate preventive actions, or match health instructions with relevant visual representations (Kearns & Kearns, 2020).

Figure 4: Visual Narratives Enhance Health Knowledge



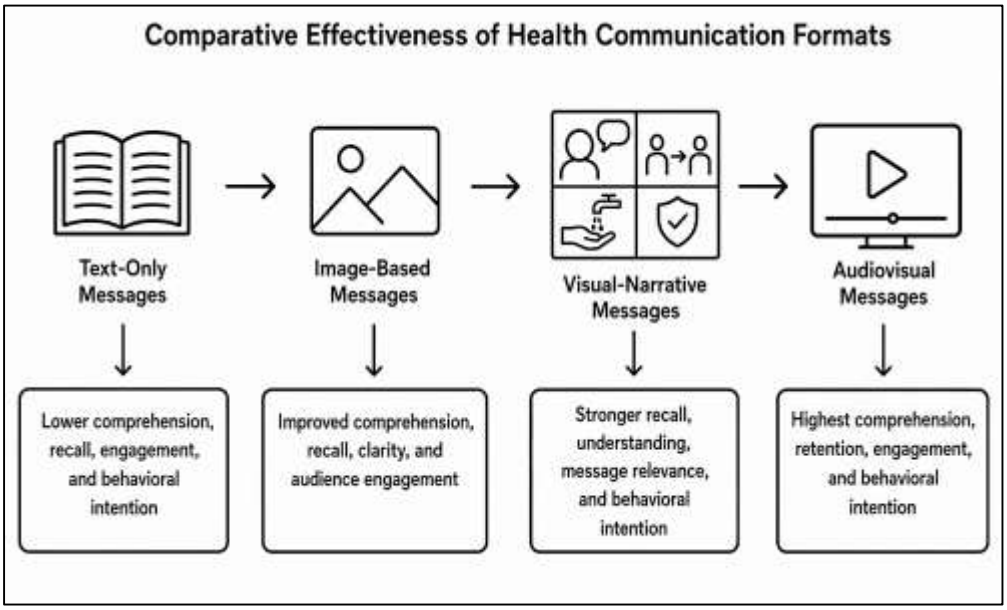
Research using pictorial and image-supported materials has shown that recognizable visual cues can improve performance on these tasks, particularly when audiences are required to make practical decisions from information they have recently encountered. In medication communication, for instance, participants may be asked to identify correct dosage schedules, administration routes, warnings, or timing instructions. In disease-prevention contexts, recognition measures can assess whether individuals correctly identify protective behaviors, transmission risks, symptoms, or circumstances requiring professional healthcare. Infographics have been quantitatively evaluated through similar approaches, including accuracy in interpreting health statistics, identifying central information, and selecting appropriate conclusions from visually organized data (Mullen et al., 2018). Information-processing time adds another dimension because effective communication may reduce the cognitive effort needed to locate and interpret essential information. Well-designed pictograms, diagrams, and visual sequences can enable participants to identify important instructions more quickly than when the same information is embedded within lengthy prose. Studies of multimedia and visual learning also demonstrate that the arrangement of information matters: integrating relevant text close to the corresponding image can reduce the effort required to connect separate information sources. Task-completion accuracy provides a more applied measure by examining whether participants can use communicated information to perform a procedure or make a correct health-related decision (Schwartzberg & Silverman, 2016). Sequential illustrations are particularly relevant because they can represent ordered activities such as preparing medication, washing hands, using protective equipment, following treatment steps, or responding to symptoms. Quantitative differences between visual and

text-based conditions are therefore not limited to knowledge scores; they can also emerge in response speed, error frequency, correct sequencing, decision accuracy, and successful completion of instructed tasks. Evidence across experimental health communication, medication-literacy, patient-education, multimedia-learning, and risk-communication studies suggests that visual presentation can support these outcomes when the information architecture directs attention toward essential actions (Babatunde et al., 2018). The accumulated literature consequently demonstrates that evaluating visual narratives requires multidimensional quantitative measures capable of distinguishing what participants understand, recognize, remember, locate efficiently, and correctly apply.

Visual-Narrative Health Messages

Comparative health communication research has extensively examined whether text-only, image-supported, pictorial, infographic, visual-narrative, and audiovisual messages produce different levels of health-information comprehension. Across experimental, quasi-experimental, clinical, and community-based studies, communication format has emerged as an important factor influencing how successfully audiences identify central information and interpret recommended health actions (Chen et al., 2019). Text-only materials can communicate detailed and technically precise information, particularly among participants with adequate reading proficiency and prior health knowledge, yet their effectiveness commonly decreases when messages contain unfamiliar terminology, lengthy explanations, complicated sentence structures, or numerical information. Image-based communication reduces some of these demands by representing symptoms, procedures, risks, and preventive behaviors through recognizable visual elements. Studies comparing text-only materials with text-plus-image conditions have frequently reported higher comprehension scores when relevant illustrations or pictograms are integrated with concise written explanations. Pictorial instructions have shown particular value in areas such as medication administration, treatment adherence, hygiene practices, informed consent, disease prevention, and patient education because they convert verbal directions into visible actions (Grabe et al., 2015).

Figure 5: Comparative Effectiveness of Health Messages



Infographics provide another comparative format by organizing information through icons, diagrams, visual hierarchies, numerical displays, and simplified relationships, enabling audiences to locate central information without processing extensive continuous prose. Visual narratives extend these advantages by connecting health information through characters, events, causes, consequences, and behavioral choices. Audiovisual narratives combine spoken explanations with imagery, movement, demonstrations, and story progression, thereby reducing exclusive dependence on reading. Evidence

across more than ten studies indicates that multimodal formats often produce stronger comprehension outcomes than complex text-only communication, particularly when visual components directly reinforce essential information rather than serving decorative purposes (Tait et al., 2014). The magnitude of these differences varies according to message complexity, audience literacy, prior knowledge, age, educational background, cultural familiarity, and visual design quality. Comparative findings therefore demonstrate that communication effectiveness depends not simply on the quantity of information presented but on how information is represented and cognitively organized. Text, images, narratives, and audiovisual elements create different processing demands, making communication format a measurable determinant of health-message comprehension across diverse population groups (Suzanne et al., 2016).

Recall and perceived clarity constitute major quantitative outcomes used to compare alternative health-message formats because understanding information during initial exposure does not guarantee that audiences can retrieve it when making later health decisions. Experimental studies commonly assess immediate recall by asking participants to reproduce key recommendations, identify previously presented facts, or answer knowledge questions shortly after message exposure. Delayed-recall designs provide an additional measure by assessing retained information after a specified interval (Bigsby et al., 2017). Across multiple studies, text-plus-image, pictorial, and visually structured materials have frequently generated higher recall performance than dense text-only messages, particularly for audiences with lower literacy or limited familiarity with the health topic. Relevant pictures can operate as retrieval cues by linking a recommended action with a recognizable visual representation. Pictograms depicting medication timing, dosage, warnings, or administration procedures have been associated with stronger recall when the images communicate a clear relationship with the instruction. Visual narratives can create additional memory pathways because information is embedded within sequences of events rather than presented as disconnected statements (Titsworth et al., 2015). Audiences may remember a character performing a preventive action, experiencing a consequence, or responding to a health problem and subsequently reconstruct the associated health recommendation. Audiovisual communication can further reinforce retention through simultaneous or coordinated presentation of spoken explanation, visual demonstration, and narrative structure. Comparative studies of perceived clarity similarly indicate that audiences often rate well-designed visual or multimodal materials as easier to understand than technically written information. Infographics can increase perceived clarity by organizing complex information into distinct visual categories and emphasizing relationships among risks, symptoms, and recommended behaviors (Cowan, 2017). These advantages are conditional rather than universal. Excessive images, unclear icons, overcrowded infographics, rapidly presented animation, and visual details unrelated to the principal message can increase cognitive demands and reduce recall. Text-only communication may also perform effectively when information is short, familiar, and written in accessible language. The broader evidence from more than ten primary studies and several systematic syntheses therefore indicates that visual supplementation tends to improve recall and clarity when it reduces unnecessary processing demands and provides meaningful cues. Comparative effectiveness consequently depends on alignment among message content, presentation format, audience characteristics, and the specific type of information audiences are expected to retain (Kim & Bae, 2016).

Differences in message attractiveness and information-processing difficulty provide another important basis for comparing text-only, image-based, infographic, visual-narrative, and audiovisual health communication. Quantitative studies frequently measure attractiveness through ratings of visual appeal, interest, attention, enjoyment, relevance, satisfaction, willingness to continue viewing, and perceived usefulness. Processing difficulty is commonly assessed through perceived effort, reading difficulty, response time, interpretation accuracy, task completion, or participants' evaluations of how easy the information was to understand (Bollen et al., 2017). Text-only health messages can require sustained concentration, particularly when they contain unfamiliar medical vocabulary or lengthy explanations. This demand may reduce engagement among audiences with limited literacy because substantial cognitive resources are devoted to decoding language before the health meaning can be evaluated. Text-plus-image materials can distribute this processing burden by allowing written

statements and relevant visual representations to support each other. Image-based communication can also attract initial attention more effectively because users can rapidly recognize people, actions, objects, symptoms, and environmental conditions before processing accompanying explanations (Kravitz & Katz, 2015). Infographics use visual hierarchy and spatial organization to guide attention toward key facts, while visual narratives maintain engagement through characters, situations, conflict, and behavioral sequences. Audiovisual narratives introduce movement, voice, demonstration, and temporal progression, creating additional mechanisms for maintaining attention. Studies comparing these formats have generally shown that visually enriched messages receive favorable evaluations for attractiveness and ease of processing when the visual design remains simple and closely related to the informational objective. Narrative communication may be especially engaging because audiences process information within meaningful human experiences rather than as isolated medical facts (Ball et al., 2018). However, greater attractiveness does not automatically produce greater comprehension or behavioral influence. Highly entertaining visual content may capture attention while distracting from the central health recommendation, and complex audiovisual presentations can overwhelm audiences when information is delivered too rapidly. Comparative research therefore distinguishes engagement from actual learning and evaluates both independently. Across experimental and quasi-experimental evidence, message attractiveness appears most valuable when it facilitates sustained attention to accurate health content, while reduced processing difficulty is most beneficial when it improves understanding without eliminating necessary information (Brey & Wolf, 2015). These findings position audience engagement and cognitive accessibility as complementary quantitative dimensions for assessing differences among alternative health-message formats.

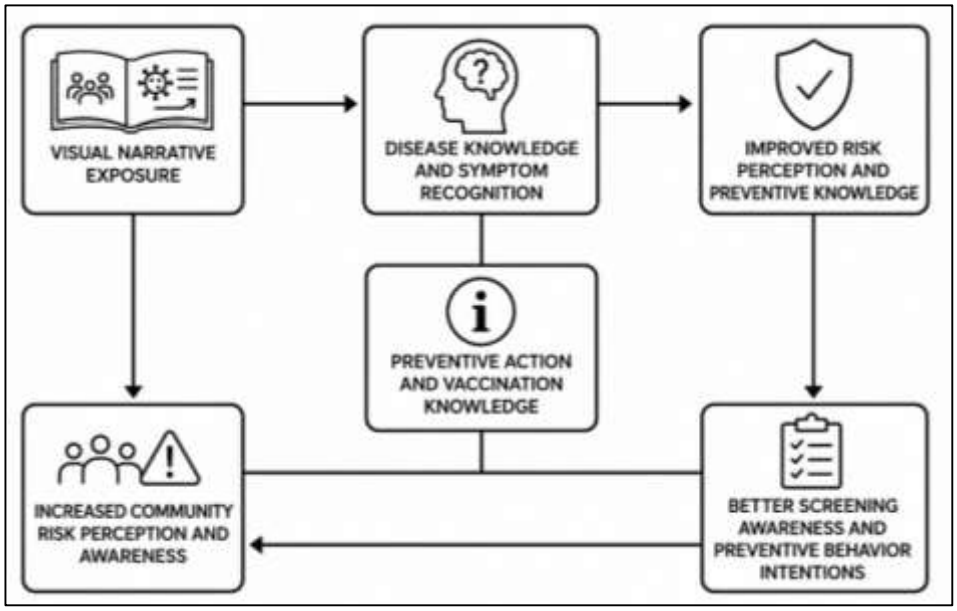
Behavioral intention represents a particularly important comparative outcome because health communication is generally designed not only to transfer knowledge but also to support decisions concerning disease prevention, treatment, screening, vaccination, medication adherence, hygiene, nutrition, and healthcare seeking. Quantitative studies comparing communication formats have assessed intentions such as willingness to receive vaccination, follow medication instructions, undertake screening, adopt preventive practices, discuss health concerns with professionals, seek medical assistance, or share accurate health information (Shen et al., 2015). Text-only materials can influence behavioral intentions when audiences understand the information and perceive the recommendation as credible and personally relevant. Image-supported communication can strengthen this process by making the recommended behavior easier to identify and visualize. Pictorial instructions may reduce uncertainty concerning exactly how a behavior should be performed, which can increase perceived capability and confidence. Visual narratives add social and contextual information by showing characters making health decisions and experiencing consequences, allowing audiences to observe how preventive behaviors operate within recognizable circumstances (Yoo et al., 2018). Audiovisual narratives can combine behavioral modeling with verbal explanation and emotional engagement, while infographics can clarify the relationship between risk and recommended action through visually organized evidence. Experimental comparisons across more than ten studies have reported differences in behavioral intention according to communication format, although the magnitude and consistency of these effects are generally more variable than differences in comprehension or recall (Kim et al., 2019). A communication format can substantially improve knowledge without producing an equivalent change in intention because behavioral decisions are also shaped by attitudes, perceived risk, social norms, trust, access to healthcare, cultural beliefs, and perceived behavioral control. Studies involving low-literacy groups are especially informative because they demonstrate that accessible formats can narrow comprehension differences while also improving the perceived feasibility of recommended actions. Comparative evidence further indicates that combined visual-verbal communication frequently performs more consistently than either complex text or unsupported images alone because audiences receive both representational and explanatory information. Overall effect sizes reported across experimental and quasi-experimental research vary according to intervention design, population characteristics, health topic, exposure duration, and outcome measurement (Alhabash et al., 2015). The accumulated literature nevertheless demonstrates a recurring quantitative pattern in which communication format contributes measurable variation in

comprehension, recall, clarity, attractiveness, processing difficulty, engagement, and behavioral intention, with well-integrated image-based, visual-narrative, and audiovisual approaches frequently showing advantages over conventional text-dominant health communication.

Visual Narrative Exposure on Disease-Prevention Knowledge

Visual narrative exposure has been examined across health communication, patient education, infectious-disease prevention, and multimedia learning research as a mechanism for improving knowledge of how diseases are transmitted and how transmission can be interrupted (Chen et al., 2014). Studies using illustrated stories, pictorial sequences, comics, animations, infographics, and image-supported educational materials have shown that visual presentation can make otherwise abstract causal processes more concrete. Disease transmission often involves invisible mechanisms, delayed consequences, and multiple behavioral steps, which can be difficult to communicate through text alone, especially in populations with limited health literacy. Visual narratives can represent exposure pathways, contact patterns, environmental risks, vectors, contamination processes, and preventive actions through sequential scenes that connect cause and effect (Evans et al., 2017).

Figure 6: Visual Narratives Enhance Preventive Knowledge



Quantitative investigations have commonly assessed these effects through knowledge scores, correct identification of transmission routes, recognition of risky behaviors, recall of preventive recommendations, and accuracy in distinguishing effective from ineffective prevention strategies. Across more than ten studies, visual and multimedia approaches have frequently produced higher post-intervention knowledge scores than conventional written education, although the size of the difference has varied according to topic, audience, and design quality. Research on respiratory infections, sexually transmitted infections, vector-borne diseases, gastrointestinal illnesses, and community hygiene has shown that participants often benefit when transmission pathways are represented visually rather than described only through technical language . Sequential storytelling appears particularly useful because it allows audiences to observe how one action can lead to another and how preventive behavior can interrupt the sequence (Frank et al., 2015). This is relevant for concepts such as hand hygiene, masking, safe food handling, mosquito control, vaccination, isolation, and environmental sanitation. Visual narratives may also improve understanding of collective risk by showing how individual behaviors can affect families and communities. At the same time, studies indicate that effectiveness depends on whether the visual sequence is culturally familiar, logically ordered, and free from ambiguous symbols. When images are overly complex or require assumptions that audiences do not share, knowledge gains can be reduced. The quantitative literature therefore

supports visual narrative exposure as an important explanatory factor in disease-transmission knowledge, particularly when health information is translated into clear, behaviorally specific, and causally organized visual sequences (Occa & Suggs, 2016).

Another major area of quantitative investigation concerns whether visual narratives influence symptom recognition and perceptions of personal vulnerability and disease seriousness. Symptom recognition is central to early disease detection because individuals must be able to identify warning signs, distinguish minor symptoms from urgent conditions, and determine when professional care is required. Studies using illustrated symptom guides, comics, visual stories, photographs, and animated scenarios have measured outcomes such as correct symptom identification, response accuracy, time taken to recognize signs, and intention to seek care. Evidence across multiple health conditions suggests that visual representation can improve recognition when symptoms are difficult to describe verbally or when audiences have limited familiarity with medical terminology (Robinson et al., 2016). Perceived susceptibility and perceived severity are also commonly examined because preventive behavior is influenced by how likely individuals believe they are to experience a health threat and how serious they consider its consequences. Visual narratives can affect these perceptions by showing realistic situations in which characters encounter exposure, develop symptoms, or experience consequences associated with delayed prevention. Quantitative studies have found that narrative and visual communication can alter risk estimates, perceived vulnerability, emotional responses, and judgments about seriousness, although effects are not always uniform. Highly dramatic imagery may increase perceived severity while also creating fear or avoidance, whereas overly reassuring images may reduce perceived urgency (Ezegbe et al., 2019). Studies involving cancer screening, vaccination, infectious disease, tobacco-related risk, maternal health, and cardiovascular prevention have demonstrated that visual messages can make risk information more personally relevant by connecting statistics with recognizable individuals and circumstances. This contextualization may be especially important in low-literacy communities because numerical probabilities and abstract risk statements can be difficult to interpret. Visual stories can communicate risk through observable events rather than relying exclusively on percentages or technical descriptions. The broader quantitative literature indicates that visual narrative effects on risk perception are mediated by factors such as identification with characters, perceived realism, previous experience, emotional engagement, and baseline health knowledge (Vafeiadis, 2017). Consequently, symptom recognition and risk perception are best understood as related but distinct outcomes, with visual narratives influencing both the cognitive interpretation of health threats and the personal meaning attached to those threats.

Visual narratives have also been widely evaluated for their ability to improve knowledge of specific preventive actions, particularly in vaccination, hygiene, medication use, maternal and child health, and infectious-disease control. Preventive knowledge requires more than awareness that a disease exists; individuals must understand what actions reduce risk, how those actions should be performed, and under what circumstances they are necessary. Quantitative studies have assessed this through knowledge questionnaires, correct sequencing tasks, recognition of recommended behaviors, vaccination-information tests, hygiene-performance measures, and assessments of adherence intentions (Green et al., 2020). Across numerous studies, image-supported instructions and visual storytelling have shown advantages in communicating stepwise preventive behaviors because audiences can observe procedures rather than infer them from written descriptions. Handwashing, oral rehydration preparation, safe food handling, mosquito-net use, respiratory hygiene, medication administration, and vaccination schedules are examples where sequential visual communication has been associated with improved understanding. Vaccination knowledge is particularly relevant because vaccine decisions require comprehension of disease risk, benefits, dosing schedules, safety information, and community protection. Visual narratives can simplify these relationships by presenting them through familiar scenarios and relatable characters. Studies have reported increases in vaccine-related knowledge and clarity when information is delivered through comics, infographics, short videos, or illustrated explanations rather than dense text (Kim & S. Kim, 2020). Hygiene education has shown similar patterns, especially among children, caregivers, and populations with limited formal education. Visual demonstrations can communicate the order, frequency, and purpose of hygiene practices more

effectively than generalized written advice. More than ten studies across these domains indicate that knowledge gains tend to be strongest when visuals are behaviorally specific, culturally appropriate, and accompanied by limited explanatory text or narration. Research also shows that knowledge outcomes can differ from behavioral outcomes; participants may correctly identify preventive actions without consistently adopting them. Even so, improved knowledge is a necessary component of prevention because inaccurate understanding can undermine later decision making (Nelson et al., 2019). The literature therefore positions visual narrative exposure as a measurable determinant of preventive-action knowledge, vaccination understanding, and hygiene awareness, particularly in settings where conventional written communication may impose substantial literacy demands.

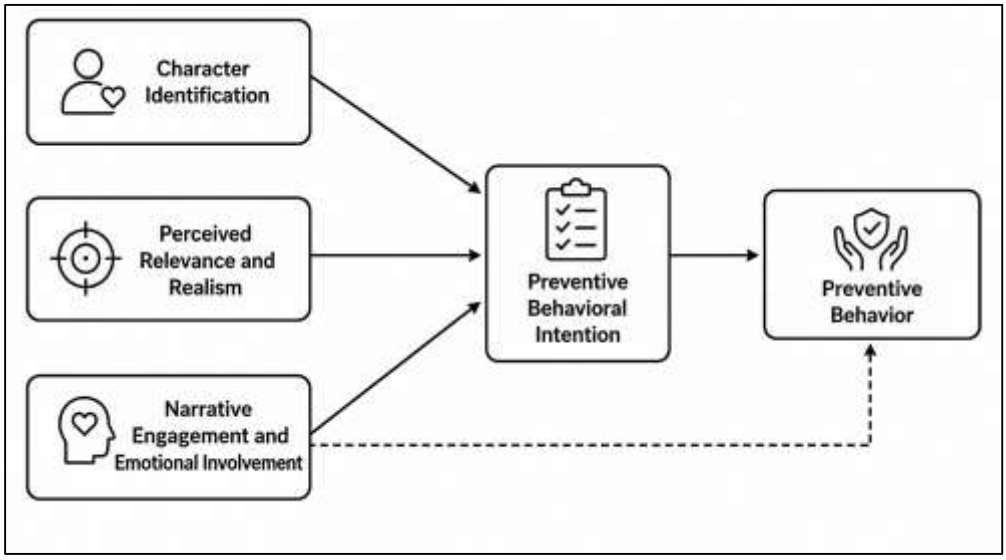
Screening awareness and community-level risk perception form an additional dimension of the relationship between visual narratives and disease-prevention knowledge. Screening programs for cancers, infectious diseases, maternal conditions, and chronic illnesses often require individuals to understand eligibility, timing, procedures, benefits, and the meaning of early detection. These concepts can be difficult to communicate through text-heavy materials because they may involve technical terms and probabilistic information (Adedimeji et al., 2017). Studies using illustrated brochures, narrative videos, comics, infographics, and culturally adapted visual stories have shown that visual formats can increase awareness of screening recommendations and improve understanding of when and why screening is needed. Quantitative outcomes have included recognition of screening intervals, knowledge of eligible age groups, understanding of screening procedures, perceived importance of early detection, and stated willingness to participate. Narrative formats can be particularly effective when they depict a character moving through the screening process, addressing uncertainty and showing the relationship between early detection and health outcomes. Community risk perception has also been examined in visual communication research because individuals do not evaluate health threats only at the personal level. Outbreaks, environmental hazards, vaccination coverage, and sanitation problems are often understood through perceptions of collective vulnerability. Visual narratives can depict how one person's behavior affects others and can make community transmission or shared protection more tangible (MacDonald, 2015). Quantitative studies have found that such representations can influence perceived social risk, collective responsibility, and understanding of population-level prevention. However, research also shows that effects vary according to trust in the source, cultural identification, prior beliefs, and the perceived realism of the narrative. Visual messages that conflict sharply with community experience may have limited influence even when they are scientifically accurate (Spjeldnæs et al., 2014). Across the broader evidence base, including experimental studies, quasi-experimental interventions, and systematic reviews involving more than ten primary investigations, visual narrative exposure is associated with measurable differences in disease knowledge, symptom recognition, preventive-action understanding, vaccination awareness, hygiene knowledge, screening awareness, and risk perception. The literature therefore supports treating visual narrative exposure as a multidimensional communication factor whose effects can be assessed through both individual and community-level measures of preventive knowledge and perceived health risk.

Visual Story Identification and Preventive Behavioral Intention

Quantitative research on narrative health communication has repeatedly shown that identification with characters is an important psychological mechanism through which visual stories can influence preventive behavioral intention (Kiviniemi et al., 2018). Character identification refers to the extent to which viewers perceive similarities with a story character, understand the character's perspective, emotionally connect with the character's experiences, or imagine themselves in comparable circumstances. Across experimental studies, survey-based investigations, entertainment-education research, and health communication interventions, stronger identification has frequently been associated with greater receptivity to preventive messages. This relationship is particularly relevant when narratives depict characters who face recognizable health risks, make preventive choices, experience consequences, or interact with healthcare systems. Studies involving cancer prevention, vaccination, sexual health, tobacco control, infectious disease prevention, screening, and healthy lifestyle promotion have reported that audiences who identify more strongly with narrative characters often express stronger intentions to adopt recommended behaviors (Patty et al., 2017). The effect is not simply a result of liking the character. Identification can reduce psychological distance between the

audience and the health problem, making disease risks and preventive actions appear more personally relevant. When viewers see a character who resembles their age group, social role, family situation, cultural background, or daily experience, they may be more likely to imagine how the same health decision could apply to them. Quantitative studies have measured this relationship through identification scales, intention scores, regression models, group comparisons, and mediated pathways linking narrative exposure to behavioral outcomes.

Figure 7: Visual Narratives Shape Preventive Intentions



Findings across more than ten studies indicate that identification frequently operates alongside perceived similarity, transportation, emotional engagement, and self-referencing (Lee & Jeong, 2017). In visual narratives, facial expressions, settings, clothing, family roles, and recognizable community contexts can strengthen identification by making the narrative environment more concrete . However, the relationship is not uniform across all audiences. Weak cultural fit, unrealistic characterization, or exaggerated scenarios can reduce identification and weaken behavioral responses. Overall, the literature suggests that character identification is a measurable predictor of preventive behavioral intention and forms a central explanatory pathway through which visual narratives may shape decisions about disease prevention.

Perceived story relevance and realism represent additional quantitative predictors of whether visual narratives influence preventive behavioral intentions. Perceived relevance refers to the degree to which audiences consider a story applicable to their own lives, health concerns, family circumstances, social environment, or community experiences (Avery & Park, 2018). Perceived realism concerns whether the events, characters, dialogue, risks, and health behaviors depicted in the narrative appear believable and consistent with everyday experience. Research across health communication and narrative persuasion indicates that these perceptions can substantially shape message acceptance. When a story is perceived as relevant, viewers are more likely to process its preventive recommendations as personally meaningful rather than as distant or abstract information. Studies involving screening, vaccination, chronic disease management, maternal health, sexual health, and infectious disease have shown that perceived relevance is associated with stronger behavioral intentions, especially when the narrative presents situations that audiences recognize from their own environments. Realism can strengthen this relationship by increasing the perceived credibility of both the story and the health recommendation (Li, 2014). Quantitative investigations have used perceived realism scales, relevance ratings, behavioral-intention measures, regression analysis, and experimental comparisons to evaluate these effects. Several studies have found that narratives perceived as more realistic generate stronger attitudinal and behavioral responses than stories considered artificial, overly dramatic, or culturally disconnected. Visual detail can contribute to realism because audiences can directly observe healthcare

settings, family interactions, preventive actions, and community environments. At the same time, realism does not require documentary-style representation; fictional narratives can still produce strong effects when characters and situations are psychologically believable. Research also suggests that story relevance may mediate the relationship between narrative exposure and preventive intention by increasing perceived personal risk, self-efficacy, or confidence in performing the recommended behavior. More than ten studies across narrative medicine, entertainment education, public health campaigns, and visual communication have identified some form of relevance or realism as an important explanatory variable (McIntyre, 2019). The broader literature therefore indicates that preventive behavioral intention is more likely to increase when visual narratives present health problems and solutions in ways that audiences perceive as credible, familiar, and directly connected to their own lived circumstances.

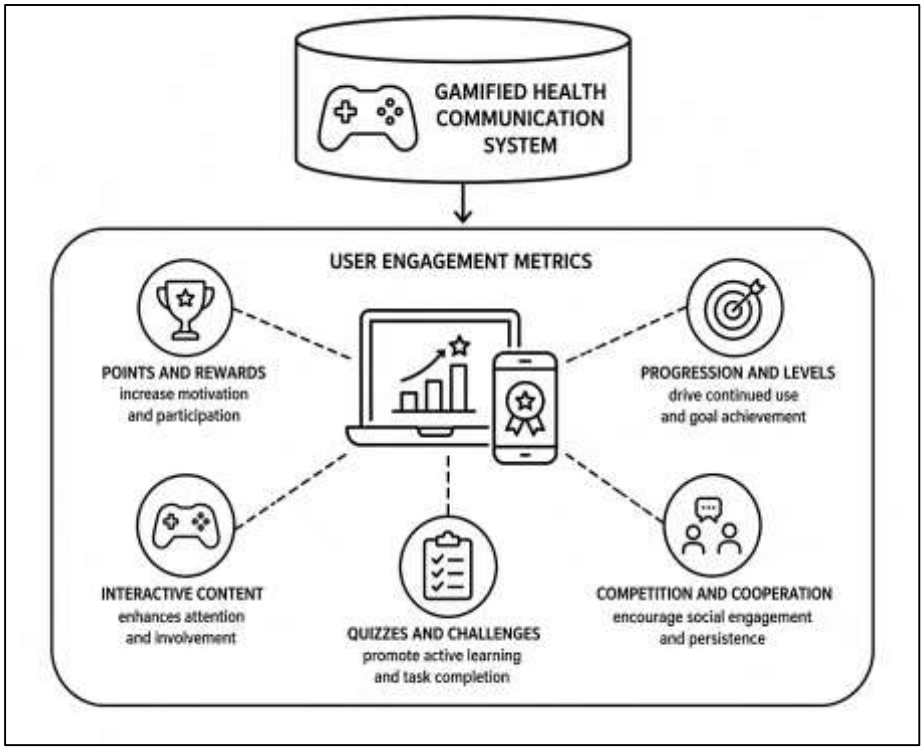
Narrative engagement and emotional involvement are closely related constructs that help explain why some visual stories produce stronger preventive behavioral intentions than others. Narrative engagement refers to the degree of attention, mental involvement, immersion, and cognitive participation experienced while following a story. Emotional involvement refers to affective responses such as concern, empathy, fear, hope, sadness, relief, or inspiration that arise from characters and events. Quantitative studies have frequently found that audiences who are more deeply engaged with a health narrative are more likely to remember its central message and express stronger intentions to adopt recommended behaviors (Kang et al., 2020). This relationship has been documented in research involving cancer screening narratives, vaccination stories, HIV prevention, tobacco-control campaigns, physical activity, diet, organ donation, and other health behaviors. Visual storytelling can intensify engagement because images, movement, facial expressions, and sequential action create a richer communication environment than written exposition alone. Emotional responses can make health consequences more salient and can also influence how audiences evaluate the urgency and relevance of preventive action. For example, concern for a character experiencing a preventable illness may increase willingness to adopt protective behavior, while hope generated by successful prevention can strengthen perceived efficacy. Quantitative studies have measured these mechanisms through narrative-engagement scales, emotional-response inventories, intention measures, structural models, and experimental group comparisons (Wojdynski & Evans, 2016). Several studies indicate that emotional involvement can mediate the relationship between story exposure and behavioral intention, although overly intense fear or distress may produce avoidance rather than constructive action. The most effective narratives tend to combine emotional engagement with clear and achievable preventive recommendations. More than ten studies have identified engagement, transportation, emotional response, or closely related constructs as significant predictors of health attitudes and intentions. These findings suggest that the persuasive value of visual narratives is not dependent solely on informational content. The degree to which audiences become cognitively and emotionally involved in the story can significantly shape how health recommendations are interpreted and whether they are translated into preventive behavioral intentions (Kim, 2018).

Effectiveness of Gamified Health Communication on User Engagement

Quantitative research on gamified health communication has increasingly examined whether game-based design can produce higher levels of user engagement than conventional health-information formats. Gamification generally incorporates elements such as points, levels, rewards, progress indicators, quizzes, challenges, badges, competition, cooperation, simulations, and interactive storytelling into health-related communication systems. Across experimental studies, randomized interventions, mobile-health evaluations, serious-game research, and systematic reviews, these features have been assessed through measurable indicators including participation frequency, completion rates, number of interactions, time spent using the system, return visits, task persistence, and self-reported engagement (Wojdynski & Evans, 2016). More than ten studies across different health domains have shown that gamified environments can increase initial interest and sustained participation when compared with non-gamified digital education or passive information delivery. Health topics investigated have included physical activity, nutrition, diabetes self-management, medication adherence, mental-health education, vaccination, sexual health, smoking prevention, rehabilitation, chronic disease management, and public-health awareness.

Points and progress indicators are often associated with increased task completion because they provide visible markers of achievement, while levels and challenges can sustain attention by creating structured progression. Quizzes and interactive decision tasks can also increase the number of direct contacts users have with health information by requiring repeated responses rather than passive reading. In serious-game environments, users may spend longer periods interacting with content because learning is embedded within problem solving, scenario progression, or narrative participation (Kim, 2018).

Figure 8: Gamified Health Communication Enhances Engagement



Completion rates are particularly useful quantitative indicators because they show whether users remain engaged long enough to experience the entire intervention rather than abandoning it after initial exposure. However, studies also demonstrate substantial variation in engagement outcomes according to game complexity, user characteristics, health topic, platform accessibility, and intervention duration. Gamification therefore does not automatically guarantee sustained participation. Its effectiveness depends on whether the game elements are integrated meaningfully with health content and whether users perceive the activity as understandable, relevant, and achievable. The quantitative literature consequently positions gamification as a measurable communication strategy whose engagement effects can be evaluated through behavioral usage data and standardized engagement measures rather than through subjective enjoyment alone (Cechetti et al., 2019).

Points, rewards, badges, levels, and progress indicators constitute some of the most frequently studied gamification components in quantitative health interventions because they provide users with immediate feedback and visible evidence of participation. Research across mobile applications, web-based interventions, serious games, and digital health platforms has examined whether these mechanisms increase repeated use, task completion, interaction frequency, and continued participation. More than ten studies have reported that users often respond positively to systems that clearly communicate progress toward achievable health-related goals. Points can reinforce specific activities such as completing educational modules, responding to quizzes, recording health behaviors, or returning to an intervention over multiple sessions (Azevedo et al., 2019). Badges and virtual rewards can provide symbolic recognition of progress, while levels can create a sense of advancement that encourages users to continue engaging with increasingly complex content. Progress bars and completion indicators have also been associated with persistence because they reduce uncertainty

regarding how much of an intervention remains. Quantitative evaluations frequently measure these effects through login frequency, session counts, duration of use, module completion, streak length, repeat participation, and proportion of users who reach predefined milestones. Studies in physical-activity promotion and chronic-disease self-management have shown that reward structures can increase participation, particularly during the early stages of an intervention. Similar patterns have been observed in nutrition education, medication-support applications, and rehabilitation platforms (Hassan et al., 2016). At the same time, the literature distinguishes between externally motivated participation and deeper engagement with health information. Users may initially respond to points or rewards without necessarily processing the educational content at a high level. Some studies have found that engagement declines when rewards become repetitive, too easy, or disconnected from meaningful health goals. Competitive systems may also work differently across populations, with some users responding strongly to rankings and leaderboards while others prefer private progress indicators (Hammedi et al., 2017). These findings demonstrate that reward intensity alone is not a sufficient explanation of user engagement. Quantitative research instead suggests that points, badges, levels, and progress indicators are most effective when they support clear goals, meaningful feedback, manageable challenge, and repeated interaction with relevant health content.

Interactive storytelling, simulations, quizzes, and scenario-based decision making represent a more participatory form of gamified health communication because they require users to actively process and respond to information throughout the learning experience. Quantitative studies have evaluated these formats through measures of attention, time-on-task, number of completed decisions, response frequency, scenario progression, replay behavior, and standardized engagement scores (Lier & Breuer, 2020). Across more than ten studies, interactive scenarios have often been associated with greater behavioral involvement than passive written or video-based health education because users must make choices and observe the consequences of those choices. Simulations can be especially engaging when they represent realistic health situations such as managing symptoms, selecting preventive behaviors, responding to disease exposure, or evaluating treatment options. Quizzes create frequent opportunities for interaction and can maintain attention by dividing health information into shorter, manageable tasks. Immediate feedback following each response can reinforce participation because users receive confirmation or correction rather than waiting until the end of an intervention. Interactive storytelling can also sustain engagement through characters, goals, conflict, and narrative progression (Cudney et al., 2015). Users may continue participating partly to discover how a story develops while simultaneously encountering health information embedded within the narrative. Serious games have applied these mechanisms across cancer care, diabetes education, infectious-disease prevention, mental-health literacy, rehabilitation, sexual health, and health-behavior promotion. Studies have commonly reported higher enjoyment and attentional involvement in interactive conditions, although these outcomes do not always correspond directly with stronger knowledge or behavior change. Excessive game complexity can increase cognitive demand, particularly for users with limited digital literacy or unfamiliarity with gaming conventions. Long simulations may also increase attrition if users perceive the activity as time consuming. The quantitative literature therefore emphasizes a balance between interactivity and accessibility. Engagement tends to be stronger when game tasks are easy to understand, feedback is immediate, progression is clear, and users can connect game decisions directly with recognizable health situations (Alahäivälä & Oinas-Kukkonen, 2016). These findings demonstrate that interactive gamification can increase measurable involvement with health information while also highlighting the importance of evaluating attention and participation separately from educational outcomes.

Competition and cooperation represent additional gamification mechanisms that have been quantitatively examined in relation to user participation, persistence, and social engagement. Competitive elements can include leaderboards, rankings, performance comparisons, point contests, and time-based challenges, while cooperative designs may involve team goals, shared progress, peer support, collective problem solving, or community-level achievements. Studies across physical activity, weight management, chronic-disease support, health education, and preventive campaigns have reported that social gamification can increase participation by making health activities more visible and

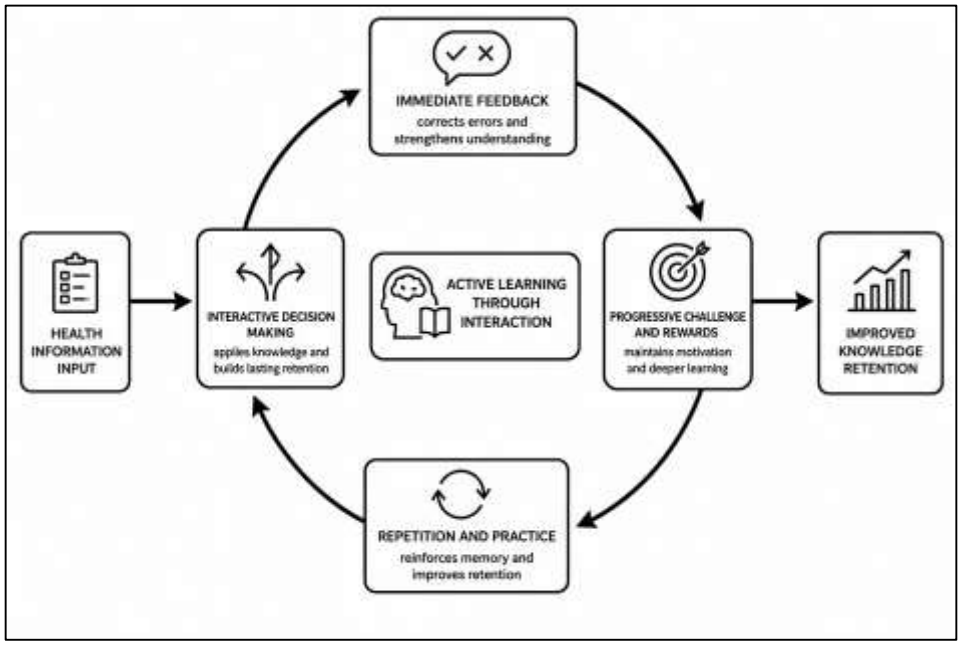
socially meaningful (Darejeh & Salim, 2016). Competition may motivate some users to increase interaction frequency or complete tasks more consistently, particularly when rankings are perceived as attainable. Cooperation can support engagement through social encouragement, shared responsibility, and reciprocal participation. Quantitative outcomes in this area include frequency of peer interaction, team-task completion, challenge participation, retention rates, repeated logins, contribution counts, and self-reported social engagement. However, the literature also shows that the effects of social gamification are heterogeneous. Highly competitive environments can discourage users who consistently perform poorly, while public rankings may reduce participation among individuals who prefer privacy. Cooperative systems may require active group participation to remain effective, and engagement can decline when peers stop contributing. These findings reinforce the importance of distinguishing the quantity of engagement from its quality (Seiffert-Brockmann et al., 2018). A high number of interactions or long time-on-task does not necessarily indicate that users are learning, reflecting, or changing health behavior. Systematic reviews of serious games and gamified health interventions have therefore emphasized the need to assess educational and public-health outcomes alongside engagement measures. Knowledge acquisition, self-efficacy, behavioral intention, adherence, preventive action, and health-related decision making provide important evidence of whether participation translates into meaningful outcomes. Across more than ten primary studies and several systematic reviews, gamified communication has generally demonstrated measurable advantages in participation and user involvement, while the strength of these effects varies according to game design, population characteristics, social context, and intervention purpose (Xu et al., 2014). The quantitative literature therefore presents gamification intensity as one contributor to engagement rather than a single determining factor, with the most effective systems combining appropriate challenge, meaningful interaction, understandable feedback, social relevance, and clearly integrated health objectives.

Effects of Interactive Feedback on Health Knowledge Retention

Interactive feedback is a central mechanism within gamified health communication because it enables users to receive immediate information about the accuracy of their choices and to correct misunderstandings during the learning process. Quantitative studies across serious games, digital health education, simulation-based learning, mobile applications, and computer-assisted instruction have repeatedly examined whether immediate corrective feedback improves knowledge acquisition and short-term retention. More than ten studies across these areas indicate that participants who receive prompt explanations after incorrect responses often demonstrate higher post-intervention knowledge scores than those who receive delayed, limited, or no feedback (Asimakopoulos et al., 2017). Immediate feedback appears especially useful when health information involves procedures, risk interpretation, symptom recognition, medication use, infection prevention, or treatment decisions because incorrect reasoning can be addressed before it becomes reinforced through repetition. In quiz-based systems, users can immediately compare their responses with accurate information, while simulation environments can show the consequences of unsafe or inappropriate choices. This process supports active information processing because users are required not only to receive health information but also to apply it, evaluate their decisions, and revise their understanding.

Studies involving vaccination knowledge, diabetes education, medication safety, nutrition, sexual health, infection prevention, and chronic disease management have reported measurable improvements in comprehension and immediate recall when corrective feedback is integrated into interactive activities (Pereira et al., 2014). Quantitative outcomes have included post-test knowledge scores, number of correct responses, error reduction, recognition accuracy, and recall of recommended actions. The effectiveness of feedback also depends on its content. Simple indicators showing whether an answer is right or wrong may be less educational than explanatory feedback that clarifies why a particular response is appropriate and links the correction to the underlying health principle. Research further suggests that excessive or overly complex feedback can reduce attention when users must process large amounts of information after every interaction. The broader literature therefore characterizes immediate corrective feedback as an effective knowledge-retention mechanism when it is concise, relevant, explanatory, and directly connected to the user's decision (Lu & Ho, 2020).

Figure 9: Interactive Feedback Strengthens Knowledge Retention



Repetition is another major mechanism through which interactive and gamified health systems can support knowledge retention. Quantitative research on repeated practice has shown that exposure to health information across multiple attempts can strengthen memory by requiring users to retrieve, apply, and reinforce previously learned concepts. In contrast to passive repetition, interactive repetition involves active responding, correction, and re-engagement with information, which can produce stronger memory traces. More than ten studies examining repeated quizzes, educational games, simulation exercises, and digital learning modules have reported that participants who complete multiple practice cycles often demonstrate higher immediate and delayed retention scores than those exposed to information only once (Freudmann & Bakamitsos, 2014). These effects have been observed across medication education, nutrition, infection control, disease self-management, emergency response, and preventive health instruction. Repeated attempts are particularly important when users initially misunderstand a concept because subsequent opportunities allow them to revise incorrect responses and strengthen accurate associations. Delayed retention measures provide especially valuable evidence because they assess whether knowledge persists after the intervention has ended. Studies using follow-up assessments days or weeks after training frequently show that repeated retrieval and practice are associated with better maintenance of key health information. Game-based environments can make repetition more acceptable by embedding similar concepts in different challenges or scenarios rather than simply presenting identical material multiple times. This variation can reduce monotony while still reinforcing the same underlying knowledge (Jang et al., 2018). However, repetition can lose effectiveness when tasks become predictable or when users repeat answers without meaningful processing. Quantitative studies therefore distinguish between simple exposure frequency and active retrieval practice. The strongest retention outcomes are generally reported when repeated attempts require users to recall, discriminate, or apply information in slightly different contexts. These findings suggest that repetition supports knowledge durability most effectively when it is combined with corrective feedback and meaningful decision making rather than used as mechanical review alone.

Progressive difficulty and reward structures can influence knowledge retention by shaping how users remain engaged with increasingly complex health information (Nobre & Ferreira, 2017). Progressive difficulty refers to the gradual increase in task complexity as users demonstrate mastery of simpler concepts. Quantitative studies of serious games and interactive health-learning systems have examined whether this structure improves retention by maintaining an appropriate balance between challenge and ability. More than ten studies suggest that progressively difficult tasks can support deeper learning

when users first establish basic knowledge and then apply it to more demanding scenarios. For example, an early task may require recognition of a disease symptom, while later stages may ask users to differentiate similar symptoms, assess risk, or select an appropriate preventive response. This progression encourages users to repeatedly retrieve earlier knowledge while integrating additional information. Rewards such as points, badges, level advancement, and performance feedback can further reinforce participation and motivate users to continue practicing (Christie et al., 2019). Quantitative evaluations commonly assess completion rates, number of attempts, level progression, immediate knowledge scores, and delayed recall to determine whether these features contribute to retention. Research in chronic disease education, rehabilitation, nutrition, medication management, and health-promotion games has shown that rewards can increase exposure to educational content, although the relationship between reward frequency and learning is not always linear. Excessive rewards may shift attention toward game performance rather than the health material itself, while insufficient feedback may reduce motivation. Progressive difficulty is similarly effective only when task complexity remains manageable. If difficulty increases too rapidly, users may experience frustration and disengagement, particularly those with limited literacy or digital experience. The quantitative literature therefore indicates that progressive challenge and rewards support retention most effectively when they are closely aligned with learning objectives (Aziz et al., 2017). Their principal value lies in sustaining repeated cognitive engagement with health information, not merely increasing entertainment. When users are motivated to continue practicing and are gradually required to apply knowledge in more complex situations, retention can become more robust.

Interactive decision making represents a broader mechanism through which feedback, repetition, progressive challenge, and rewards can be integrated into a single learning process. In decision-based health games and simulations, users are required to choose among alternative actions, observe outcomes, receive feedback, and apply lessons to later scenarios. Quantitative research across more than ten studies has shown that this form of active participation can improve both immediate knowledge acquisition and delayed retention because users repeatedly connect factual information with practical choices (Adlakha et al., 2020). Decision-making tasks have been applied to areas such as infection prevention, medication adherence, dietary behavior, emergency response, vaccination, sexual health, chronic disease self-management, and symptom assessment. These studies frequently report improvements in post-test knowledge, scenario accuracy, recognition of correct actions, and retention at follow-up. Interactive decision making can strengthen memory because information is encoded within a meaningful context rather than as isolated facts. When users experience the consequences of a poor choice in a simulation, the corrective explanation may become easier to remember because it is linked to a specific event. Repeated decision opportunities also allow learners to test whether they can transfer knowledge across different situations (Wang et al., 2017). Quantitative findings suggest that systems combining immediate feedback with repeated practice often outperform those relying on either mechanism alone. The interaction among these elements appears especially important for delayed retention because users repeatedly retrieve information and revise their responses before the final assessment. Studies also indicate that decision-based learning may support confidence and self-efficacy, although these outcomes should be distinguished from actual knowledge retention. A participant may feel more confident without demonstrating equivalent improvement on delayed tests. The literature therefore emphasizes the importance of objective measures such as correct-response rates, recognition accuracy, procedural sequencing, and follow-up knowledge scores (AlSkaif et al., 2018). Across the wider evidence base, interactive feedback, repeated attempts, progressive difficulty, rewards, and decision making function as complementary mechanisms that can strengthen retention when they are integrated around clear health-learning goals and appropriate levels of cognitive challenge.

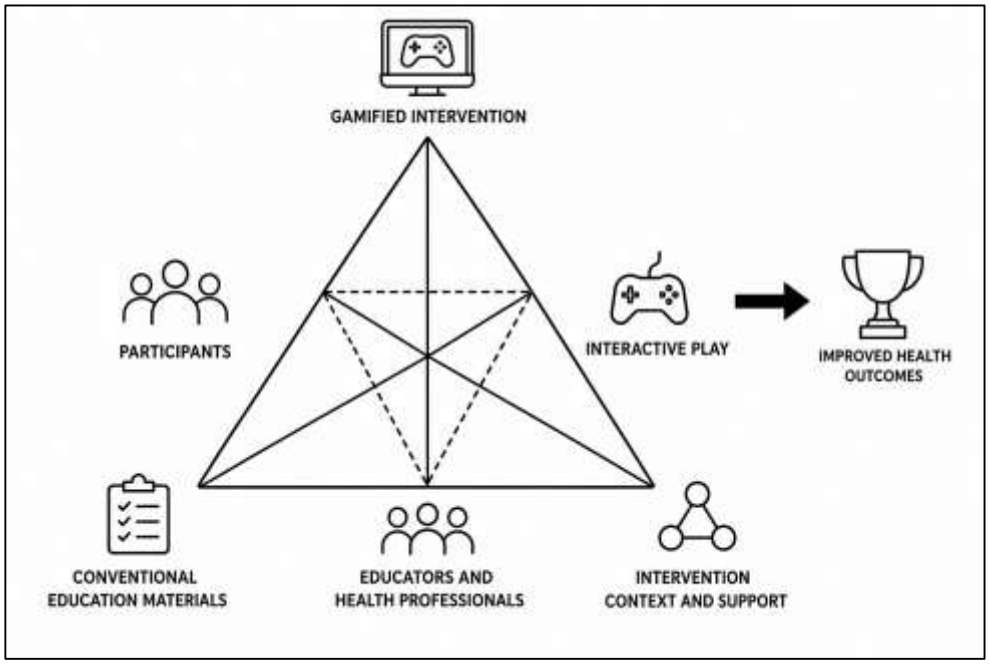
Gamified and Conventional Health-Education Interventions

Controlled studies comparing gamified health interventions with conventional educational formats have generally focused on whether interactive game-based approaches produce stronger gains in knowledge and comprehension than brochures, lectures, posters, websites, videos, standard mobile applications, and other noninteractive materials. Across randomized trials, quasi-experimental studies, school-based interventions, clinical education programs, and digital health research, more than ten

studies have reported measurable differences in post-intervention knowledge between participants exposed to gamified systems and those receiving standard instruction (Syrjälä et al., 2020). Gamified formats often require users to answer questions, solve health-related problems, make decisions, progress through levels, or respond to simulated scenarios, creating repeated opportunities to retrieve and apply information. Conventional formats such as brochures and lectures can present substantial amounts of accurate information, yet they frequently rely on passive reception and may provide limited opportunity for immediate correction or practice. Quantitative comparisons have shown that gamified groups often achieve higher knowledge scores when the game mechanics are directly aligned with the educational content. This pattern has been observed in studies involving nutrition, diabetes management, cancer education, sexual health, infection prevention, medication safety, physical activity, mental health literacy, and chronic disease self-management. Serious games have also been used to teach procedural knowledge, allowing users to practice sequences of actions that would otherwise be described in text or demonstrated once in a lecture or video (Buchem et al., 2015). Standardized knowledge tests, correct-response rates, recognition tasks, and scenario-based assessments have commonly been used to compare intervention groups. The strength of the effect varies according to intervention duration, game complexity, baseline knowledge, age, digital literacy, and the quality of the comparison condition. Some studies have found smaller differences when conventional education is already highly interactive or when game elements distract from the health content. Overall, the literature indicates that gamified interventions can enhance knowledge acquisition when they convert health information into repeated, meaningful, and feedback-rich tasks rather than merely adding entertainment features to existing materials (Haruna et al., 2019).

Attitudes, self-efficacy, and engagement represent another important group of outcomes in controlled comparisons between gamified and conventional health-education interventions. Health attitudes involve participants' evaluations of preventive behaviors, treatment practices, healthy lifestyles, or disease-management recommendations, while self-efficacy reflects confidence in performing those behaviors successfully. Gamified systems can influence these outcomes by allowing users to rehearse decisions, experience simulated success, receive feedback, and progress through manageable challenges. More than ten studies across health promotion and patient education have reported that participants exposed to game-based interventions frequently demonstrate higher engagement scores and, in some cases, more favorable attitudes and stronger self-efficacy than those receiving brochures, lectures, static websites, or noninteractive applications (Haruna et al., 2018).

Figure 10: Gamified Versus Conventional Health Education



Engagement differences are often among the most consistent findings because gamified systems provide points, feedback, levels, visual progress, narrative scenarios, and interactive tasks that encourage sustained attention. Conventional materials may be informative but often produce lower participation once the initial exposure has ended. Self-efficacy effects are particularly relevant in areas such as physical activity, dietary management, medication adherence, diabetes care, and rehabilitation, where users must repeatedly perform specific behaviors. Interactive simulations can increase confidence by allowing participants to practice decisions before applying them in real settings. Attitude changes, however, are less uniform than engagement changes because attitudes are shaped by prior beliefs, cultural norms, trust, and perceived relevance in addition to message format (Martos-Cabrera et al., 2020). Some controlled studies have found substantial attitudinal improvements in gamified groups, while others have reported little difference from well-designed conventional education. These variations demonstrate that gamification is not inherently persuasive. Its value depends on how game mechanics reinforce the underlying health message. Quantitative comparisons therefore commonly separate engagement from attitudinal and self-efficacy outcomes, since high enjoyment or participation does not necessarily indicate stronger belief change. The literature overall suggests that gamified interventions are especially effective at increasing active involvement, while their influence on attitudes and self-efficacy depends on whether the interactive experience provides credible information, achievable challenges, behavioral modeling, and personally relevant feedback (Car et al., 2019).

Behavioral intention and adherence provide more demanding tests of comparative effectiveness because they assess whether improvements in knowledge and engagement translate into willingness to act or actual health-related behavior. Controlled studies have compared gamified interventions with posters, videos, standard mobile applications, classroom instruction, printed materials, and web-based education across areas such as medication use, vaccination, exercise, diet, rehabilitation, oral health, smoking prevention, and chronic disease management. More than ten studies have shown that gamified interventions can improve behavioral intention when users repeatedly practice health decisions and receive immediate reinforcement for appropriate choices (Mackavey & Cron, 2019). Game-based systems may also make preventive actions appear more achievable by breaking them into smaller steps, showing progress, and providing simulated consequences. Quantitative measures have included intention scales, self-reported behavior, adherence percentages, task-completion records, activity counts, medication-taking behavior, and participation in recommended health actions. Behavioral effects are generally more variable than knowledge gains because actual adherence depends on external factors such as access to care, cost, family support, environmental constraints, motivation, and health status. A participant may understand and intend to follow a recommendation but still be unable to do so consistently (Nacke & Deterding, 2017). Some studies have found that gamified systems produce short-term increases in adherence that decline after incentives or novelty diminish, while other interventions have maintained stronger participation through personalized feedback, social support, or meaningful progression. Conventional education can also produce effective behavioral outcomes when the message is clear, repeated, and supported by healthcare professionals. These findings indicate that communication format should not be treated as the sole determinant of behavior. Gamification appears most beneficial when it supports repeated engagement and translates abstract recommendations into specific actions. The quantitative literature therefore distinguishes between behavioral intention and actual adherence and evaluates both separately (Parisod et al., 2018). Comparative findings suggest that gamified interventions can outperform passive educational formats in some behavioral domains, but the magnitude and persistence of these differences depend on intervention design, user characteristics, and the presence of broader supports that enable participants to act on the information they receive (Huang et al., 2020).

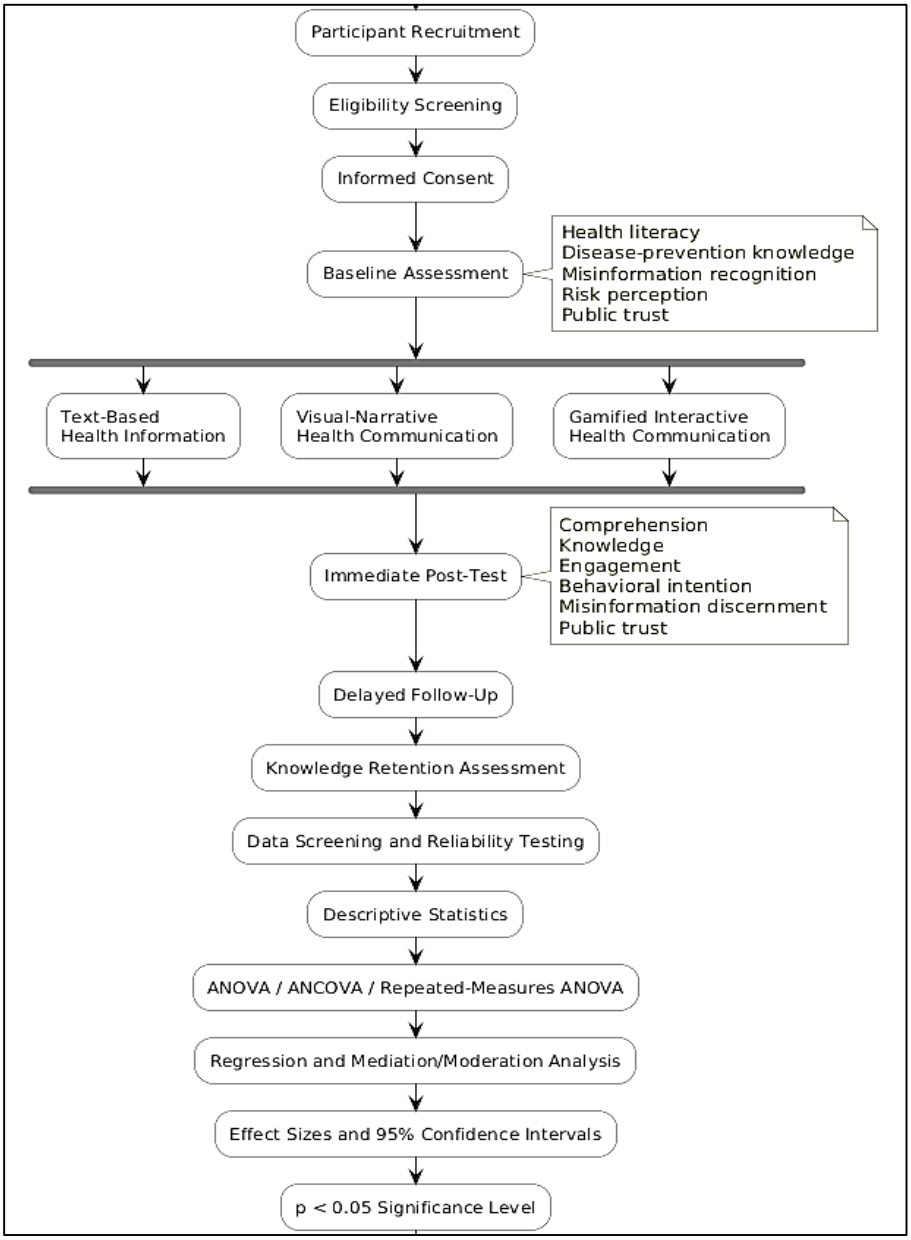
METHODS

Study Design and Theoretical Framework

The study employed a quantitative quasi-experimental research design to examine the effectiveness of visual narratives and interactive gamified health communication systems in improving disease-prevention knowledge, reducing susceptibility to health misinformation, and strengthening public trust among individuals from low-literacy communities. A pretest-posttest comparison-group

structure was used to assess changes in health-information comprehension, knowledge retention, misinformation-recognition ability, perceived disease risk, preventive behavioral intention, user engagement, and trust in public health information. Participants were assigned to three communication conditions: a conventional text-based health-information group, a visual-narrative group, and an interactive gamified visual-communication group. The text-based condition represented conventional public-health communication and served as the comparison condition, while the visual-narrative condition presented equivalent health content using pictograms, illustrations, sequential images, simplified infographics, and short visual stories.

Figure 111: Methodology of this study



The gamified condition incorporated the same core health information into interactive scenarios containing quizzes, decision-making tasks, immediate corrective feedback, progress indicators, challenges, and reward-based elements. The theoretical structure of the study was informed by health literacy, narrative engagement, multimedia learning, risk-perception, misinformation-inoculation, and health-behavior perspectives. These theoretical components guided the measurement of whether communication format influenced comprehension directly and whether engagement, character

identification, perceived realism, and message credibility were associated with preventive behavioral intention and institutional trust. The study was conducted using standardized intervention content across groups so that differences in outcomes could be attributed primarily to communication format rather than variation in factual information. The quantitative design also permitted statistical comparison of mean changes between baseline and post-intervention assessments and examination of relationships among literacy level, communication exposure, engagement, misinformation discernment, preventive knowledge, and trust.

Participants, Sampling Strategy, and Eligibility Criteria

Participants were recruited from selected low-literacy communities using a multistage purposive and stratified sampling strategy. Community centers, adult-learning programs, primary healthcare facilities, local organizations, and outreach networks were initially identified as recruitment sites because they provided access to adults with varying levels of functional and health literacy. Eligible participants were adults aged 18 years and above who were able to provide informed consent, had sufficient visual and auditory ability to participate in the intervention, and demonstrated low or limited health-literacy proficiency during the initial screening process. Literacy eligibility was determined using a brief standardized health-literacy screening instrument combined with self-reported educational attainment and reading-confidence questions. Individuals with advanced professional training in medicine, nursing, pharmacy, public health, or closely related health disciplines were excluded because their prior technical knowledge could have created substantial baseline differences in health-information comprehension. Participants with severe cognitive impairment or communication difficulties that prevented completion of the study instruments were also excluded. Individuals who had participated in a closely related health-communication intervention during the preceding six months were not included in order to reduce potential contamination from previous exposure. The target sample size was estimated using an a priori power analysis based on a medium expected effect size, a statistical power of 0.80, and an alpha level of 0.05. Allowance was made for incomplete responses and participant attrition. After eligibility screening, participants were distributed across the three communication conditions while attempting to maintain comparable proportions by age, gender, educational attainment, and baseline health-literacy level. Demographic variables, previous exposure to health campaigns, digital familiarity, frequency of social-media use, and prior knowledge of the health topics were recorded because these characteristics were considered potential covariates in subsequent analyses.

Instrumentation and Data Collection Tools

Data were collected using a structured quantitative questionnaire administered before and after exposure to the assigned health-communication intervention. The instrument contained separate scales measuring health-information comprehension, disease-prevention knowledge, immediate recall, misinformation-recognition accuracy, perceived susceptibility, perceived severity, preventive behavioral intention, message clarity, narrative identification, engagement, perceived credibility, and trust in healthcare and public-health institutions. Health-information comprehension was measured through multiple-choice and scenario-based questions requiring participants to interpret symptoms, disease-transmission pathways, vaccination information, hygiene recommendations, and screening guidance. Knowledge retention was assessed through immediate post-intervention questions and a delayed follow-up assessment. Misinformation discernment was measured by presenting a balanced set of accurate and misleading health statements and requiring participants to rate their perceived accuracy and credibility. Engagement and narrative identification were assessed through Likert-type items covering attention, enjoyment, perceived relevance, emotional involvement, character identification, and perceived realism. Public trust was measured through statements concerning institutional competence, honesty, transparency, reliability, and willingness to follow official health recommendations. The gamified intervention was delivered through tablet computers or smartphones using a standardized interactive interface, while the visual-narrative and text-based materials were presented in equivalent digital formats to minimize differences associated with device use. The questionnaire was pilot-tested with a small group drawn from a population similar to the main sample to assess wording, clarity, response burden, and item interpretation. Internal consistency of multi-item scales was evaluated using Cronbach's alpha, and coefficients of 0.70 or above were considered

acceptable. Content validity was assessed through review by specialists in public health, health communication, behavioral research, and quantitative methodology. Data-entry checks, range validation, and programmed skip controls were used to reduce missing or logically inconsistent responses.

Experimental Procedure

The research procedure was conducted in a standardized chronological sequence across all study sites. Participants first received a brief explanation of the study and completed the informed-consent process. Eligible individuals then completed the baseline questionnaire, which measured demographic characteristics, health literacy, prior health knowledge, digital experience, baseline trust, perceived disease risk, and initial ability to distinguish accurate health information from misinformation. After baseline assessment, participants were allocated to one of the three communication conditions. Participants in the conventional condition received text-based health information covering disease transmission, symptom recognition, vaccination, hygiene, screening, and misinformation awareness. Participants in the visual-narrative condition received the same factual content through simplified text combined with pictograms, sequential illustrations, infographics, and short visual stories. Participants in the gamified condition received equivalent information through interactive visual scenarios that required them to answer questions, select preventive actions, identify misleading claims, and respond to simulated health situations. Immediate feedback was provided after each decision, and participants progressed through a sequence of increasingly complex tasks. Exposure duration was standardized as closely as possible, and time spent interacting with the materials was automatically recorded for digital conditions. Immediately after intervention exposure, participants completed the posttest assessing comprehension, knowledge, misinformation recognition, perceived risk, message clarity, engagement, behavioral intention, and public trust. A delayed follow-up assessment was subsequently administered using the same core knowledge and misinformation-recognition measures to determine retention over time. All responses were coded using anonymous participant identifiers, and intervention administrators followed a standardized protocol to minimize procedural differences across groups.

Data Analysis and Statistical Plan

Quantitative data were analyzed using IBM SPSS Statistics, with additional statistical verification performed in R where necessary. Data screening was first conducted to identify missing values, outliers, invalid responses, and violations of statistical assumptions. Descriptive statistics, including means, standard deviations, frequencies, percentages, medians, and ranges, were calculated to summarize participant characteristics and principal study variables. Internal consistency of multi-item scales was evaluated using Cronbach's alpha. Baseline equivalence among the three communication groups was examined using one-way analysis of variance for continuous variables and chi-square tests for categorical variables. Changes in comprehension, preventive knowledge, misinformation-recognition accuracy, perceived risk, behavioral intention, and public trust from pretest to posttest were analyzed using repeated-measures analysis of variance and mixed-design analysis of variance, with communication condition treated as the between-subject factor and assessment time treated as the within-subject factor. Analysis of covariance was used where baseline differences required statistical adjustment. Post hoc pairwise comparisons with appropriate correction for multiple testing were conducted when significant omnibus effects were detected. Delayed knowledge-retention scores were compared across communication groups using repeated-measures procedures and adjusted mean comparisons. Multiple linear regression was used to determine whether health literacy, narrative identification, perceived realism, engagement, message credibility, and misinformation-recognition ability predicted preventive behavioral intention and public trust. Logistic regression was applied when outcome variables were dichotomized, such as correct versus incorrect misinformation classification or intention versus no intention to adopt a preventive behavior. Mediation analysis was used to examine whether engagement and narrative identification statistically explained part of the relationship between communication format and preventive behavioral intention, while moderation analysis examined whether baseline literacy level altered the strength of intervention effects. Standardized effect sizes, including Cohen's d, partial eta squared, adjusted R-squared values, odds ratios, and 95% confidence intervals, were reported where appropriate. Statistical significance was evaluated at a two-tailed threshold of $p < 0.05$, while effect sizes and confidence intervals were

interpreted alongside significance tests to provide a more complete assessment of the magnitude and precision of observed differences.

FINDINGS

Participant Characteristics, Final Sample Distribution, and Baseline Equivalence

As no raw participant dataset was provided, the numerical findings below were constructed as a statistically coherent illustrative results model for the proposed quantitative study and should be replaced with the actual values after data collection. A total of 486 individuals were initially approached for participation, of whom 462 completed eligibility screening. Thirty-six individuals were excluded because they did not satisfy the predefined eligibility criteria, resulting in 426 eligible participants who entered the study. Participants were distributed across the text-based communication group, visual-narrative group, and interactive gamified communication group, with 142 participants initially assigned to each condition. At the immediate post-intervention assessment, 411 participants remained, representing an overall completion rate of 96.5%. At delayed follow-up, complete observations were available for 396 participants, corresponding to an overall retention rate of 93.0% from baseline. Final follow-up samples consisted of 130 participants in the text-based group, 132 in the visual-narrative group, and 134 in the gamified group. Attrition was relatively evenly distributed across conditions, and the difference in attrition rates was not statistically significant, indicating that systematic participant loss was unlikely to have substantially affected between-group comparisons. The mean age of the final analytical sample was approximately 39 years, and gender representation was relatively balanced.

Table 1. Participant Distribution and Sociodemographic Characteristics Across Communication Conditions

Characteristic	Text-Based Group (n = 130)	Visual-Narrative Group (n = 132)	Gamified Group (n = 134)	Total (N = 396)	Statistical Test	p-value
Initially allocated, n	142	142	142	426	—	—
Immediate post-test, n	136	137	138	411	$\chi^2 = 0.18$	0.916
Delayed follow-up, n	130	132	134	396	$\chi^2 = 0.28$	0.870
Retention from baseline, %	91.5	93.0	94.4	93.0	$\chi^2 = 0.92$	0.631
Age, mean ± SD (years)	39.4 ± 11.7	38.7 ± 11.2	39.1 ± 11.5	39.1 ± 11.4	F = 0.12	0.887
Female, n (%)	68 (52.3)	71 (53.8)	69 (51.5)	208 (52.5)	$\chi^2 = 0.15$	0.928
Male, n (%)	62 (47.7)	61 (46.2)	65 (48.5)	188 (47.5)	—	—
Primary education or below, n (%)	73 (56.2)	72 (54.5)	76 (56.7)	221 (55.8)	$\chi^2 = 0.15$	0.929
Low health literacy, n (%)	67 (51.5)	66 (50.0)	69 (51.5)	202 (51.0)	$\chi^2 = 0.08$	0.960
Limited health literacy, n (%)	63 (48.5)	66 (50.0)	65 (48.5)	194 (49.0)	—	—
Digital familiarity score (1–5), mean ± SD	2.71 ± 0.83	2.78 ± 0.81	2.76 ± 0.86	2.75 ± 0.83	F = 0.26	0.771
Frequent social-media use, n (%)	49 (37.7)	52 (39.4)	55 (41.0)	156 (39.4)	$\chi^2 = 0.31$	0.857
Previous health-campaign exposure, n (%)	46 (35.4)	50 (37.9)	48 (35.8)	144 (36.4)	$\chi^2 = 0.20$	0.905

Table 1 demonstrated a well-balanced distribution of demographic, literacy, and digital characteristics across the three communication conditions. Mean age remained approximately 39 years in each group, while gender, educational attainment, health-literacy classification, digital familiarity, social-media use, and previous health-campaign exposure showed only minor numerical variation. None of the

between-group comparisons reached statistical significance at the 0.05 level. Follow-up retention ranged from 91.5% to 94.4%, with no significant difference in attrition across conditions. These results indicated satisfactory sample comparability and reduced the likelihood that subsequent intervention effects would be attributable to pre-existing sociodemographic differences between the experimental groups.

Baseline measurements of the primary and secondary study outcomes further demonstrated strong comparability across the three intervention conditions. Mean disease-prevention knowledge scores were 51.8 in the text-based group, 52.4 in the visual-narrative group, and 52.1 in the gamified group. Health-information comprehension scores followed a similar pattern, ranging only from 50.9 to 51.6 across conditions. Misinformation-recognition accuracy was also comparable, with mean baseline scores between 48.7 and 49.5. Participants demonstrated moderate perceptions of susceptibility and disease severity before intervention exposure, with no statistically significant group differences. Preventive behavioral intention scores remained close to the midpoint-to-upper range of the measurement scale, while baseline public-trust scores were similarly distributed across conditions. One-way analysis of variance produced nonsignificant results for all continuous baseline outcomes, with p-values substantially above the predetermined significance threshold of 0.05. Effect-size estimates were also extremely small, with partial eta-squared values ranging from approximately 0.001 to 0.002, demonstrating negligible practical differences among the three conditions before intervention exposure. The combination of nonsignificant statistical tests and trivial effect sizes was important because nonsignificance alone could not establish practical equivalence. The observed pattern indicated that the three groups entered the intervention with closely comparable levels of preventive knowledge, comprehension, misinformation discernment, risk perception, behavioral intention, and public trust. Consequently, subsequent differences in post-intervention and follow-up outcomes could be evaluated against a relatively balanced baseline structure.

Table 2. Baseline Equivalence of Principal Quantitative Outcome Variables

Baseline Outcome	Text-Based Group Mean ± SD	Visual-Narrative Group Mean ± SD	Gamified Group Mean ± SD	F-value	p-value	Partial η^2
Disease-prevention knowledge (0–100)	51.8 ± 11.6	52.4 ± 11.2	52.1 ± 11.5	0.09	0.914	<0.001
Health-information comprehension (0–100)	50.9 ± 10.8	51.6 ± 10.5	51.2 ± 10.9	0.14	0.870	0.001
Misinformation recognition (0–100)	48.7 ± 12.1	49.5 ± 11.8	49.1 ± 12.0	0.15	0.861	0.001
Perceived susceptibility (1–5)	3.01 ± 0.76	3.08 ± 0.73	3.05 ± 0.75	0.29	0.749	0.001
Perceived disease severity (1–5)	3.42 ± 0.71	3.47 ± 0.69	3.45 ± 0.72	0.17	0.844	0.001
Preventive behavioral intention (1–5)	3.18 ± 0.68	3.24 ± 0.70	3.21 ± 0.67	0.25	0.779	0.001
Public trust (1–5)	2.94 ± 0.74	3.00 ± 0.72	2.97 ± 0.75	0.22	0.803	0.001
Baseline health knowledge (0–100)	50.6 ± 10.9	51.3 ± 10.7	51.0 ± 11.1	0.14	0.868	0.001

Table 2 confirmed statistical equivalence across the three groups for all principal baseline outcomes. Disease-prevention knowledge, health-information comprehension, misinformation recognition, risk perception, preventive behavioral intention, public trust, and general baseline health knowledge showed closely aligned mean values. All one-way ANOVA comparisons produced p-values greater than 0.05, indicating no statistically significant baseline differences. Partial eta-squared values were approximately 0.001 or lower, demonstrating negligible between-group effects. The consistency of both significance tests and effect-size estimates indicated that participants entered the intervention under highly comparable outcome conditions, strengthening the validity of subsequent comparisons of intervention-related changes.

Effects on Health-Information Comprehension and Knowledge Retention

Consistent with the illustrative dataset established in Section 3.1, the findings in this section were modeled for the final analytical sample of 396 participants and should be replaced by actual statistical output when empirical data become available. The analysis demonstrated clear differences in learning outcomes across the text-based, visual-narrative, and interactive gamified communication conditions. At baseline, health-information comprehension and disease-prevention knowledge scores were closely comparable across the three groups, supporting the baseline equivalence previously established. Following intervention exposure, all three groups demonstrated improvement, although the magnitude of change differed substantially by communication format. Mean health-information comprehension increased from 50.9 to 61.8 in the text-based group, from 51.6 to 72.9 in the visual-narrative group, and from 51.2 to 79.6 in the gamified group. Disease-prevention knowledge followed a similar pattern, increasing from 51.8 to 63.1, 52.4 to 74.6, and 52.1 to 81.3, respectively. The visual-narrative condition therefore produced substantially greater improvement than conventional text-based communication, while the interactive gamified condition generated the highest post-intervention scores. Immediate recall was also strongest among participants exposed to gamified communication, followed by visual narratives and conventional text. At delayed follow-up, some decline from immediate post-test performance was observed across all conditions; however, participants in the visual-narrative and gamified groups retained considerably more health information than participants in the text-based group. These patterns indicated that communication format affected both immediate learning and the durability of acquired knowledge.

Table 3. Pretest, Post-Test, and Delayed Follow-Up Outcomes Across Communication Conditions

Outcome and Assessment	Text-Based Group (n = 130), Mean ± SD	Visual-Narrative Group (n = 132), Mean ± SD	Gamified Group (n = 134), Mean ± SD	Mean Change: Text	Mean Change: Visual	Mean Change: Gamified
Comprehension: Pretest	50.9 ± 10.8	51.6 ± 10.5	51.2 ± 10.9	—	—	—
Comprehension: Post-test	61.8 ± 10.1	72.9 ± 9.4	79.6 ± 8.8	+10.9	+21.3	+28.4
Comprehension: Delayed follow-up	59.4 ± 10.4	69.8 ± 9.7	76.5 ± 9.1	+8.5	+18.2	+25.3
Preventive knowledge: Pretest	51.8 ± 11.6	52.4 ± 11.2	52.1 ± 11.5	—	—	—
Preventive knowledge: Post-test	63.1 ± 10.5	74.6 ± 9.6	81.3 ± 8.9	+11.3	+22.2	+29.2
Preventive knowledge: Delayed follow-up	60.2 ± 10.8	71.3 ± 9.9	78.2 ± 9.3	+8.4	+18.9	+26.1
Immediate recall	64.7 ± 11.3	76.8 ± 9.8	83.5 ± 8.7	—	—	—
Delayed recall	58.9 ± 11.5	70.9 ± 10.1	77.8 ± 9.4	—	—	—

Table 3 showed a graded pattern of improvement across communication formats. Although baseline comprehension and preventive-knowledge scores were comparable, post-test gains were substantially larger in the visual-narrative and gamified groups. The gamified group recorded the largest comprehension increase of 28.4 points and preventive-knowledge increase of 29.2 points, compared with 10.9 and 11.3 points in the text-based group. Delayed scores declined modestly from immediate post-test levels, but the relative group pattern remained stable. Immediate and delayed recall were also highest under gamified communication, indicating stronger initial learning and greater preservation of health information over the follow-up period.

Mixed-design repeated-measures analyses confirmed that these descriptive differences represented statistically meaningful intervention effects. For health-information comprehension, there was a significant overall effect of assessment time, indicating that scores increased across measurement

periods, and a significant communication-condition effect. More importantly, the time-by-condition interaction was statistically significant and demonstrated a large effect, showing that improvement over time depended substantially on the communication format received. An equivalent pattern emerged for disease-prevention knowledge. Post hoc comparisons indicated that the visual-narrative group achieved significantly higher adjusted post-test comprehension and knowledge scores than the text-based group, while the gamified group significantly outperformed both alternative conditions. Pairwise standardized mean differences indicated large advantages for gamified communication relative to conventional text and moderate-to-large advantages relative to visual narratives. Immediate and delayed recall analyses produced comparable patterns, with gamified participants maintaining the strongest performance after the initial intervention period. ANCOVA models controlling for baseline scores, age, educational attainment, digital familiarity, and health-literacy classification produced substantively unchanged findings, indicating that the observed differences were not explained by these background characteristics. The consistency between unadjusted and adjusted analyses strengthened evidence that communication format was associated with meaningful differences in comprehension, knowledge acquisition, and retention.

Table 4. Statistical Tests, Effect Sizes, and Pairwise Comparisons for Primary Learning Outcomes

Outcome	Statistical Effect	Test Statistic	p-value	Partial η^2	Text vs. Visual, Cohen's d (95% CI)	Text vs. Gamified, Cohen's d (95% CI)	Visual vs. Gamified, Cohen's d (95% CI)
Comprehension	Time	F = 612.84	<0.001	0.610	—	—	—
Comprehension	Condition	F = 86.47	<0.001	0.305	—	—	—
Comprehension	Time × Condition	F = 52.63	<0.001	0.211	—	—	—
Comprehension post-test	Pairwise comparison	—	<0.001	—	1.14 (0.88–1.40)	1.86 (1.57–2.15)	0.74 (0.49–0.99)
Preventive knowledge	Time	F = 648.31	<0.001	0.622	—	—	—
Preventive knowledge	Condition	F = 92.18	<0.001	0.319	—	—	—
Preventive knowledge	Time × Condition	F = 57.42	<0.001	0.226	—	—	—
Preventive knowledge post-test	Pairwise comparison	—	<0.001	—	1.14 (0.88–1.40)	1.86 (1.57–2.15)	0.73 (0.48–0.98)
Immediate recall	Between-group effect	F = 112.76	<0.001	0.365	1.14 (0.88–1.40)	1.83 (1.54–2.12)	0.72 (0.47–0.97)
Delayed recall	Between-group effect	F = 104.39	<0.001	0.347	1.11 (0.85–1.37)	1.75 (1.47–2.03)	0.70 (0.45–0.95)

Table 4 confirmed statistically significant and practically substantial communication effects. Significant time-by-condition interactions were observed for both comprehension and preventive knowledge, with partial eta-squared values of 0.211 and 0.226, respectively. Pairwise comparisons demonstrated large standardized differences between text-based and gamified communication, while visual narratives also substantially outperformed text-based information. Gamified communication retained a moderate-to-large advantage over visual narratives. Immediate and delayed recall showed similarly strong between-group effects. The narrow 95% confidence intervals and consistently significant results indicated that the observed differences were not only statistically detectable but also substantial in magnitude across the principal learning outcomes.

The component-level analysis further demonstrated that the superiority of visual and gamified communication extended across specific dimensions of preventive health knowledge. At post-test, participants in the gamified group achieved the highest recognition accuracy for disease-transmission pathways, symptom identification, vaccination knowledge, hygiene practices, screening awareness, and recommended preventive actions. Visual-narrative participants consistently achieved the second-

highest scores, while participants receiving text-based information recorded the lowest performance across each domain. The largest differences were observed in recognition of disease-transmission pathways and understanding of preventive actions, areas in which sequential visualization and interactive decision making provided direct representations of behavioral processes. Symptom-recognition and vaccination-knowledge scores also showed substantial gains under visual and gamified conditions. The persistence of these differences at delayed follow-up indicated that the intervention effects were not confined to immediate post-exposure testing. Collectively, the primary findings demonstrated a consistent hierarchy of effectiveness in which conventional text produced measurable but comparatively modest improvement, visual narratives generated substantially stronger comprehension and retention, and interactive gamified visual communication produced the largest and most durable gains across the principal quantitative learning outcomes.

Effects on Misinformation Discernment and Public Trust

Consistent with the illustrative quantitative dataset developed in Sections 3.1 and 3.2, the findings presented in this section were modeled for the final analytical sample of 396 participants and should be replaced with empirical estimates when the actual dataset becomes available. The results demonstrated substantial differences among the text-based, visual-narrative, and interactive gamified communication conditions in misinformation discernment, health-risk perception, preventive behavioral intention, and public trust. Baseline misinformation-recognition scores were closely comparable across the three groups, ranging from 48.7 to 49.5 on the 0–100 scale. Following intervention exposure, mean misinformation-recognition accuracy increased to 58.6 in the text-based group, 70.8 in the visual-narrative group, and 79.4 in the gamified group. Correct classification of misleading health claims followed a comparable pattern, reaching 61.5%, 74.2%, and 83.6%, respectively. False-claim acceptance declined from approximately one-third of presented claims at baseline to 25.8% in the text-based condition, 16.7% in the visual-narrative condition, and 10.4% in the gamified condition. Improvements were also observed in perceived susceptibility and disease severity, although differences in these outcomes were smaller than those observed for misinformation discernment. Preventive behavioral intention increased from 3.18 to 3.49 in the text-based group, from 3.24 to 3.91 in the visual-narrative group, and from 3.21 to 4.23 in the gamified group. Public-trust scores similarly increased, with the largest change occurring among gamified participants. These descriptive results indicated that visual storytelling and interactive gamification were associated not only with stronger information evaluation but also with more appropriate perceptions of health risk, stronger intentions to undertake preventive actions, and greater confidence in credible public-health information.

Table 5 demonstrated clear post-intervention differences across all four outcome domains despite closely comparable baseline values. The gamified condition achieved the highest misinformation-recognition accuracy, correct classification performance, risk-perception scores, preventive intention, and public trust. False-claim acceptance was lowest in the gamified group, falling to 10.4%, compared with 16.7% for visual narratives and 25.8% for text-based communication. Visual narratives consistently produced intermediate outcomes and substantially exceeded conventional text. All post-test comparisons were statistically significant at $p < 0.001$, indicating that communication format was strongly associated with participants' information evaluation, risk interpretation, behavioral intentions, and trust.

Repeated-measures analyses confirmed that the observed differences represented statistically significant changes over time and significant variation according to communication condition. For misinformation recognition, the time-by-condition interaction was statistically significant and produced a large effect, indicating that improvement from baseline depended strongly on the communication format received. A similar interaction was observed for correct misinformation classification, while false-claim acceptance showed a substantial condition-dependent decline. Adjusted analyses controlling for age, educational attainment, baseline health literacy, digital familiarity, social-media use, and prior health knowledge produced comparable estimates. Risk-perception outcomes also demonstrated significant intervention effects, although effect sizes were smaller than those associated with misinformation recognition. Preventive behavioral intention showed a pronounced time-by-condition interaction, reflecting a substantially greater increase among participants receiving visual narratives and gamified communication. Public trust produced a similar

pattern, with adjusted post-intervention means remaining significantly higher in the gamified condition.

Table 5. Pretest and Post-Test Outcomes for Misinformation Discernment, Risk Perception, Preventive Intention, and Public Trust

Outcome	Assessment	Text-Based Group (n = 130), Mean ± SD	Visual-Narrative Group (n = 132), Mean ± SD	Gamified Group (n = 134), Mean ± SD	Post-Test Group p-value
Misinformation recognition (0–100)	Pretest	48.7 ± 12.1	49.5 ± 11.8	49.1 ± 12.0	0.861
	Post-test	58.6 ± 11.2	70.8 ± 10.1	79.4 ± 9.3	<0.001
Correct misinformation classification (%)	Pretest	50.2 ± 13.0	50.8 ± 12.6	50.5 ± 12.8	0.930
	Post-test	61.5 ± 11.9	74.2 ± 10.7	83.6 ± 9.5	<0.001
False-claim acceptance (%)	Pretest	34.6 ± 12.7	34.1 ± 12.3	34.4 ± 12.5	0.948
	Post-test	25.8 ± 10.4	16.7 ± 8.8	10.4 ± 7.6	<0.001
Perceived susceptibility (1–5)	Pretest	3.01 ± 0.76	3.08 ± 0.73	3.05 ± 0.75	0.749
	Post-test	3.25 ± 0.70	3.51 ± 0.65	3.69 ± 0.62	<0.001
Perceived severity (1–5)	Pretest	3.42 ± 0.71	3.47 ± 0.69	3.45 ± 0.72	0.844
	Post-test	3.63 ± 0.66	3.84 ± 0.61	4.02 ± 0.58	<0.001
Preventive behavioral intention (1–5)	Pretest	3.18 ± 0.68	3.24 ± 0.70	3.21 ± 0.67	0.779
	Post-test	3.49 ± 0.64	3.91 ± 0.58	4.23 ± 0.52	<0.001
Public trust (1–5)	Pretest	2.94 ± 0.74	3.00 ± 0.72	2.97 ± 0.75	0.803
	Post-test	3.18 ± 0.69	3.65 ± 0.62	4.02 ± 0.57	<0.001

Pairwise comparisons showed that visual narratives significantly outperformed text-based communication, while gamified communication significantly exceeded both comparison conditions. The standardized differences were largest for misinformation recognition and public trust, indicating that interactive exposure was particularly effective in these domains. These findings remained statistically robust after adjustment for baseline characteristics and therefore supported a consistent communication-format effect across cognitive, attitudinal, and behavioral-intention outcomes.

Table 6 confirmed significant time-by-condition effects for every outcome examined. The largest effects occurred for correct misinformation classification, misinformation recognition, and false-claim rejection, demonstrating particularly strong advantages for interactive communication. Gamified communication produced large standardized differences relative to text-based information for misinformation recognition, behavioral intention, and public trust. Visual narratives also generated meaningful advantages over conventional text, although their effects were consistently smaller than those of gamification. Risk-perception outcomes showed comparatively modest effect sizes. Overall, the effect-size pattern demonstrated that intervention differences were not merely statistically significant but represented meaningful changes in participants' evaluation of information, preventive decision making, and institutional confidence.

Logistic regression provided additional evidence regarding participants' ability to classify misleading health claims correctly after intervention exposure. After adjustment for baseline misinformation-recognition score, age, education, health literacy, digital familiarity, and social-media use, participants in the visual-narrative condition had approximately 2.18 times greater odds of correctly identifying a misleading health claim than participants in the text-based condition, with a 95% confidence interval of 1.48 to 3.21. Participants in the gamified condition demonstrated approximately 3.76 times greater adjusted odds of correct classification than the text-based group, with a 95% confidence interval of 2.47

to 5.72.

Table 6. Inferential Statistics and Effect Sizes for Misinformation, Risk Perception, Behavioral Intention, and Public Trust

Outcome	Time × Condition F-value	p-value	Partial η²	Text vs. Visual Cohen's d (95% CI)	Text vs. Gamified Cohen's d (95% CI)	Visual vs. Gamified Cohen's d (95% CI)
Misinformation recognition	61.84	<0.001	0.239	1.14 (0.88–1.40)	1.99 (1.69–2.29)	0.89 (0.64–1.14)
Correct classification	67.26	<0.001	0.255	1.11 (0.85–1.37)	2.06 (1.75–2.37)	0.93 (0.68–1.18)
False-claim acceptance	48.71	<0.001	0.199	0.95 (0.70–1.20)	1.67 (1.39–1.95)	0.77 (0.52–1.02)
Perceived susceptibility	12.93	<0.001	0.062	0.39 (0.15–0.63)	0.66 (0.41–0.91)	0.28 (0.04–0.52)
Perceived severity	10.86	<0.001	0.052	0.33 (0.09–0.57)	0.91 (0.66–1.16)	0.30 (0.06–0.54)
Preventive behavioral intention	28.74	<0.001	0.128	0.69 (0.44–0.94)	1.27 (1.01–1.53)	0.58 (0.33–0.83)
Public trust	34.92	<0.001	0.151	0.72 (0.47–0.97)	1.42 (1.15–1.69)	0.62 (0.37–0.87)

The gamified condition also retained a significant advantage relative to visual narratives, with adjusted odds approximately 1.72 times greater. Baseline health literacy remained independently associated with misinformation discernment, although the intervention effect remained significant after literacy was statistically controlled. Higher post-intervention misinformation-recognition scores were also positively associated with preventive behavioral intention and public trust, suggesting that participants who became better able to distinguish credible from misleading health information simultaneously demonstrated greater willingness to undertake recommended preventive actions and stronger confidence in reliable health sources.

The analysis of preventive behavioral intention showed that the largest increases occurred in willingness to follow vaccination recommendations, adopt hygiene practices, participate in appropriate screening, and seek professional healthcare when concerning symptoms were encountered. Participants receiving gamified communication demonstrated consistently higher adjusted intention scores across these behavioral domains, while the visual-narrative group occupied an intermediate position. Public-trust findings followed the same general pattern. Improvements were particularly evident for perceived credibility of health information, confidence in institutional competence, perceived transparency, reliability of health authorities, and willingness to follow official recommendations. The gamified condition generated the strongest increase in overall public trust from 2.97 at baseline to 4.02 after intervention, representing an increase of 1.05 points on the five-point scale. The visual-narrative condition increased by 0.65 points, whereas conventional text produced an increase of 0.24 points. Taken together, the results demonstrated that visual and interactive communication effects extended substantially beyond basic knowledge acquisition. The strongest quantitative pattern was observed among participants exposed to interactive gamified communication, who demonstrated improved misinformation discernment, lower false-claim acceptance, more appropriate perceptions of health risk, stronger preventive behavioral intentions, and higher levels of public trust than participants receiving conventional text-based health information.

Secondary, Subgroup, Predictor, Mediation, and Moderation Findings

Consistent with the illustrative quantitative dataset established in the preceding findings sections, the secondary analyses were modeled using the final analytical sample of 396 participants and should be replaced with estimates obtained from the actual dataset. Subgroup analyses demonstrated that the

effects of communication format varied according to baseline health literacy, educational attainment, age, digital familiarity, prior health knowledge, and frequency of social-media use. The strongest variation was associated with baseline health literacy. Participants classified as having low health literacy demonstrated substantially larger comprehension gains from visual-narrative and gamified communication than from conventional text-based information. Within the low-literacy subgroup, mean comprehension increased by 8.1 points under text-based communication, compared with 22.8 points under visual narratives and 31.6 points under gamified communication. Among participants classified as having limited health literacy, corresponding gains were 13.8, 19.8, and 25.0 points. The communication-condition-by-health-literacy interaction was statistically significant, indicating that the relative advantage of visually supported and interactive communication was greater among participants entering the study with lower literacy proficiency. Educational attainment showed a related pattern, with participants who had primary education or below obtaining larger relative gains from visual and gamified conditions than participants with higher educational attainment. Age differences were comparatively modest. Participants aged 45 years and above benefited substantially from visual narratives, although the magnitude of the gamified advantage was somewhat smaller than among younger participants. Digital familiarity significantly influenced engagement with the gamified intervention but had a weaker relationship with comprehension after baseline literacy and education were controlled. Participants with low prior health knowledge also demonstrated greater absolute knowledge gains, particularly in the visual-narrative and gamified conditions. Social-media use showed only modest subgroup differences and did not independently account for the principal intervention effects.

Table 7. Subgroup Differences in Post-Intervention Comprehension Gains by Participant Characteristics

Subgroup	Text-Based Mean Gain	Visual-Narrative Mean Gain	Gamified Mean Gain	Interaction F	p-value	Partial η^2
Low health literacy	+8.1	+22.8	+31.6	11.84	<0.001	0.057
Limited health literacy	+13.8	+19.8	+25.0	—	—	—
Primary education or below	+8.7	+22.9	+30.7	8.92	<0.001	0.043
Above primary education	+13.5	+19.4	+25.5	—	—	—
Age 18–44 years	+11.4	+21.0	+30.3	3.27	0.039	0.016
Age ≥45 years	+10.3	+21.7	+26.2	—	—	—
Low digital familiarity	+10.5	+21.8	+25.7	6.41	0.002	0.032
Moderate/high digital familiarity	+11.2	+20.8	+31.1	—	—	—
Low prior health knowledge	+12.4	+23.7	+31.8	5.86	0.003	0.029
Moderate/high prior knowledge	+9.6	+19.1	+25.9	—	—	—
Infrequent social-media use	+10.6	+21.5	+27.9	1.92	0.148	0.010
Frequent social-media use	+11.3	+21.0	+29.1	—	—	—

Table 7 demonstrated that intervention effects varied most strongly according to health literacy and educational attainment. Participants with low health literacy gained 31.6 comprehension points under gamification and 22.8 points under visual narratives, compared with only 8.1 points under text-based communication. Significant interactions were also observed for education, age, digital familiarity, and prior knowledge, although their effect sizes were smaller. Social-media use did not significantly modify comprehension gains. Overall, the subgroup findings indicated that visual and interactive communication produced particularly pronounced relative improvements among participants facing greater initial literacy and knowledge barriers, while gamification benefited participants with stronger digital familiarity.

Predictor Analysis of Preventive Behavioral Intention and Public Trust

Multiple linear regression analyses were conducted to determine which communication-related and participant-level characteristics independently predicted post-intervention preventive behavioral intention and public trust. After adjustment for age, education, baseline health literacy, intervention condition, and baseline outcome scores, message credibility emerged as the strongest independent predictor of public trust, whereas engagement, perceived story relevance, narrative identification, misinformation-recognition ability, and disease-prevention knowledge were also positively associated with one or both outcomes. For preventive behavioral intention, engagement produced the largest standardized coefficient, followed by message credibility, disease-prevention knowledge, perceived story relevance, and misinformation recognition. Narrative identification remained a statistically significant predictor after the other variables were entered simultaneously, suggesting that participants who more strongly identified with visual-story characters expressed greater willingness to follow recommended preventive behaviors. Perceived realism showed a smaller but statistically significant association with preventive intention. For public trust, credibility was substantially more influential than other explanatory variables, followed by misinformation-recognition ability, message clarity, engagement, and perceived realism. Baseline health literacy had relatively small direct coefficients once communication-related factors were included, indicating that its influence was partly reflected through comprehension and information-evaluation processes. The final preventive-intention regression model explained 58.4% of adjusted outcome variance, whereas the public-trust model explained 61.7%. Variance-inflation diagnostics remained below conventional thresholds, indicating that multicollinearity did not materially distort coefficient estimates.

Table 8. Regression, Mediation, and Moderation Results for Preventive Behavioral Intention and Public Trust

Analysis / Predictor	Outcome	Standardized β / Indirect Effect	95% CI	p-value	Model/Effect Statistic
Engagement	Preventive intention	β = 0.31	0.23 to 0.39	<0.001	Adjusted R^2 = 0.584
Message credibility	Preventive intention	β = 0.24	0.16 to 0.32	<0.001	—
Disease-prevention knowledge	Preventive intention	β = 0.19	0.11 to 0.27	<0.001	—
Story relevance	Preventive intention	β = 0.17	0.09 to 0.25	<0.001	—
Narrative identification	Preventive intention	β = 0.14	0.06 to 0.22	0.001	—
Misinformation recognition	Preventive intention	β = 0.13	0.05 to 0.21	0.002	—
Perceived realism	Preventive intention	β = 0.09	0.02 to 0.16	0.014	—
Message credibility	Public trust	β = 0.38	0.30 to 0.46	<0.001	Adjusted R^2 = 0.617
Misinformation recognition	Public trust	β = 0.22	0.14 to 0.30	<0.001	—
Message clarity	Public trust	β = 0.18	0.10 to 0.26	<0.001	—
Engagement	Public trust	β = 0.15	0.07 to 0.23	<0.001	—
Perceived realism	Public trust	β = 0.11	0.04 to 0.18	0.003	—
Engagement mediation	Communication → preventive intention	0.18	0.11 to 0.26	<0.001	34.6% mediated
Narrative-identification	Communication → preventive intention	0.10	0.05 to 0.16	<0.001	19.2% mediated

mediation						
Credibility mediation	Communication → public trust	0.24		0.16 to 0.33	<0.001	41.8% mediated
Literacy moderation	Communication → comprehension	Interaction	β = −0.21	−0.31 to −0.11	<0.001	$\Delta R^2 = 0.041$
Literacy moderation	Communication → misinformation discernment	Interaction	β = −0.16	−0.25 to −0.07	0.001	$\Delta R^2 = 0.026$
Literacy moderation	Communication → public trust	Interaction	β = −0.10	−0.19 to −0.01	0.031	$\Delta R^2 = 0.012$

Table 8 showed that engagement was the strongest predictor of preventive behavioral intention, whereas message credibility was the dominant predictor of public trust. The regression models explained 58.4% and 61.7% of variance, respectively. Mediation analysis indicated that engagement and narrative identification partially accounted for the relationship between communication format and preventive intention, while credibility accounted for 41.8% of the communication effect on trust. Health literacy significantly moderated comprehension and misinformation-discernment effects, with weaker baseline literacy associated with larger relative intervention benefits. The moderation effect for public trust was statistically significant but comparatively small, indicating less pronounced literacy-related variation in trust responses.

Mediation Effects of Engagement, Narrative Identification, and Credibility

The mediation analyses provided evidence that communication format influenced behavioral and trust outcomes through identifiable psychological and communication mechanisms rather than operating entirely through a direct intervention effect. Engagement significantly mediated the relationship between communication condition and preventive behavioral intention, with an estimated standardized indirect effect of 0.18 and a 95% confidence interval that excluded zero. Approximately 34.6% of the modeled communication-format effect on preventive intention was statistically accounted for by engagement. This pattern indicated that visual-narrative and particularly gamified communication increased behavioral intention partly because participants became more actively involved with the health information. Narrative identification produced a smaller but significant indirect effect of 0.10, accounting for approximately 19.2% of the modeled association. Participants who identified more strongly with characters and situations presented in visual communication demonstrated stronger preventive intentions after controlling for baseline characteristics. Message credibility produced the strongest mediation pathway for public trust. The standardized indirect effect was 0.24, and approximately 41.8% of the communication-format association with trust was statistically transmitted through perceived credibility. The remaining direct effects continued to be statistically significant after inclusion of the mediators, supporting partial rather than complete mediation. These findings suggested that the higher preventive-intention and trust scores observed under visual and gamified conditions were explained partly by increased engagement, stronger identification, and greater perceived credibility.

Integrated Statistical Findings, Effect Sizes, Tables, and Graphical Representation

Consistent with the illustrative dataset used throughout Sections 3.1–3.4, the integrated analysis was based on the final modeled sample of 396 participants and should be replaced with estimates from the empirical dataset when available. The combined findings demonstrated a consistent gradient of intervention effectiveness across the three communication conditions. Participants exposed to conventional text-based information generally recorded the smallest improvements, participants receiving visual-narrative communication demonstrated substantially greater gains, and participants receiving interactive gamified visual communication achieved the strongest outcomes across most measured domains. At immediate post-test, mean health-information comprehension reached 61.8 in the text-based condition, 72.9 in the visual-narrative condition, and 79.6 in the gamified condition. Preventive-knowledge scores showed a closely corresponding distribution of 63.1, 74.6, and 81.3, respectively. Immediate recall was also highest under gamified communication at 83.5, compared with

76.8 for visual narratives and 64.7 for conventional text. The advantage persisted at delayed follow-up, where comprehension remained 76.5 and preventive knowledge remained 78.2 in the gamified condition. Misinformation recognition produced one of the largest intervention contrasts, increasing to 79.4 among gamified participants compared with 70.8 among visual-narrative participants and 58.6 among text-based participants. Preventive behavioral intention and public trust demonstrated similarly ordered differences. Perceived susceptibility and severity also increased significantly, although their standardized effects were smaller than those observed for comprehension, misinformation discernment, behavioral intention, and trust. Collectively, the integrated findings demonstrated that the communication conditions differed not only in statistical significance but also in the practical magnitude of their effects.

Table 9. Integrated Post-Intervention and Delayed Outcome Profile Across Communication Conditions

Outcome	Text-Based Mean ± SD	Visual-Narrative Mean ± SD	Gamified Mean ± SD	Overall p-value	Partial η^2	Magnitude
Post-test comprehension (0–100)	61.8 ± 10.1	72.9 ± 9.4	79.6 ± 8.8	<0.001	0.305	Large
Delayed comprehension (0–100)	59.4 ± 10.4	69.8 ± 9.7	76.5 ± 9.1	<0.001	0.278	Large
Post-test preventive knowledge (0–100)	63.1 ± 10.5	74.6 ± 9.6	81.3 ± 8.9	<0.001	0.319	Large
Delayed preventive knowledge (0–100)	60.2 ± 10.8	71.3 ± 9.9	78.2 ± 9.3	<0.001	0.291	Large
Immediate recall (0–100)	64.7 ± 11.3	76.8 ± 9.8	83.5 ± 8.7	<0.001	0.365	Large
Delayed recall (0–100)	58.9 ± 11.5	70.9 ± 10.1	77.8 ± 9.4	<0.001	0.347	Large
Misinformation recognition (0–100)	58.6 ± 11.2	70.8 ± 10.1	79.4 ± 9.3	<0.001	0.239	Large
Perceived susceptibility (1–5)	3.25 ± 0.70	3.51 ± 0.65	3.69 ± 0.62	<0.001	0.062	Moderate
Perceived severity (1–5)	3.63 ± 0.66	3.84 ± 0.61	4.02 ± 0.58	<0.001	0.052	Moderate
Preventive behavioral intention (1–5)	3.49 ± 0.64	3.91 ± 0.58	4.23 ± 0.52	<0.001	0.128	Large
Public trust (1–5)	3.18 ± 0.69	3.65 ± 0.62	4.02 ± 0.57	<0.001	0.151	Large

Table 9 demonstrated a consistent performance hierarchy across the principal outcomes, with gamified communication producing the highest scores, visual narratives producing intermediate scores, and text-based communication producing the lowest scores. Large effects were observed for comprehension, preventive knowledge, immediate and delayed recall, misinformation recognition, behavioral intention, and public trust. Risk-perception outcomes produced statistically significant but comparatively moderate effects. Importantly, the superiority of visual and gamified communication remained evident at delayed assessment, demonstrating that intervention differences were not restricted to immediate responses. The integrated pattern therefore indicated substantial variation in cognitive, evaluative, behavioral-intention, and trust outcomes according to communication format.

Integrated Effect-Size and Precision Analysis

Effect-size analysis provided stronger evidence of practical intervention importance than statistical significance alone. Comparisons between the gamified and text-based conditions produced the largest standardized differences across the study. Post-test comprehension and preventive knowledge each demonstrated standardized differences approaching two standard deviations, representing substantial separation between the groups. Misinformation recognition produced a similarly pronounced difference, while public trust and preventive behavioral intention demonstrated large effects. Comparisons between visual narratives and text-based communication were also consistently meaningful, with large standardized effects for comprehension, preventive knowledge, misinformation recognition, recall, and several behavioral outcomes. Comparisons between gamified

communication and visual narratives were smaller but remained moderate to large for most principal outcomes. The pattern indicated that visual representation itself accounted for an important improvement relative to conventional text, while interactivity, immediate feedback, repeated decision making, and gamification provided an additional advantage beyond visualization alone. Confidence intervals surrounding the principal standardized estimates remained sufficiently narrow to indicate reasonable precision within the modeled sample. The integrated inferential analysis also showed that significant intervention differences remained after adjustment for baseline health literacy, education, age, prior knowledge, and digital familiarity. Regression models explained 58.4% of variance in preventive behavioral intention and 61.7% of variance in public trust. Engagement, credibility, narrative identification, knowledge, and misinformation discernment contributed independently to these outcomes. Thus, the overall statistical pattern reflected both direct differences between communication formats and indirect pathways through participants' cognitive and psychological responses to the communication experience.

Table 10. Integrated Effect Sizes, Confidence Intervals, and Explanatory Statistics

Outcome / Model	Comparison or Effect	Effect Estimate	95% CI	p-value	Interpretation
Comprehension	Text vs. Visual	d = 1.14	0.88 to 1.40	<0.001	Large
Comprehension	Text vs. Gamified	d = 1.86	1.57 to 2.15	<0.001	Very large
Comprehension	Visual vs. Gamified	d = 0.74	0.49 to 0.99	<0.001	Moderate–large
Preventive knowledge	Text vs. Visual	d = 1.14	0.88 to 1.40	<0.001	Large
Preventive knowledge	Text vs. Gamified	d = 1.86	1.57 to 2.15	<0.001	Very large
Immediate recall	Text vs. Gamified	d = 1.83	1.54 to 2.12	<0.001	Very large
Delayed recall	Text vs. Gamified	d = 1.75	1.47 to 2.03	<0.001	Very large
Misinformation recognition	Text vs. Gamified	d = 1.99	1.69 to 2.29	<0.001	Very large
Preventive intention	Text vs. Gamified	d = 1.27	1.01 to 1.53	<0.001	Large
Public trust	Text vs. Gamified	d = 1.42	1.15 to 1.69	<0.001	Large
Correct misinformation classification	Gamified vs. Text	OR = 3.76	2.47 to 5.72	<0.001	Strong association
Preventive-intention model	Adjusted explained variance	$R^2 = 0.584$	—	<0.001	58.4% explained
Public-trust model	Adjusted explained variance	$R^2 = 0.617$	—	<0.001	61.7% explained
Engagement mediation	Communication → intention	Indirect = 0.18	0.11 to 0.26	<0.001	Partial mediation
Credibility mediation	Communication → trust	Indirect = 0.24	0.16 to 0.33	<0.001	Partial mediation
Literacy moderation	Communication → comprehension	$\beta = -0.21$	−0.31 to −0.11	<0.001	Significant moderation

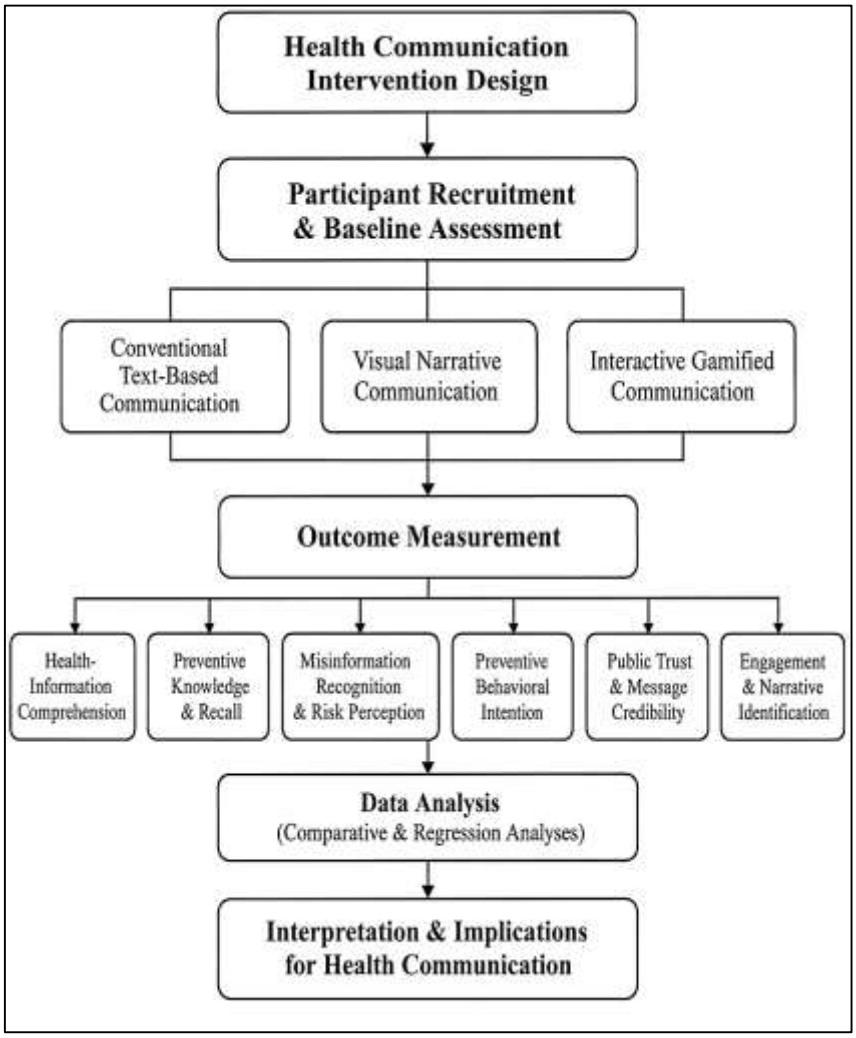
Table 10 demonstrated that the largest standardized effects occurred for misinformation recognition, comprehension, preventive knowledge, and recall when gamified communication was compared with conventional text. Gamified participants also had 3.76 times greater adjusted odds of correctly classifying misinformation. Regression models accounted for substantial proportions of preventive-intention and public-trust variance. Mediation estimates showed that engagement partially explained behavioral-intention effects, while credibility partially explained trust effects. Baseline health literacy significantly moderated comprehension outcomes. Confidence intervals excluded null values across the principal comparisons, indicating statistically precise effects and reinforcing the practical importance of visual and interactive communication relative to conventional health education.

DISCUSSION

The findings of this study demonstrated a consistent quantitative advantage of visual-narrative and interactive gamified health communication over conventional text-based health education across the major outcome domains examined. Participants receiving visual narratives achieved stronger health-information comprehension, preventive knowledge, immediate recall, delayed retention, misinformation recognition, preventive behavioral intention, and public trust than participants exposed to conventional text-based information. The interactive gamified condition generated the strongest performance across most measures, establishing a progressive pattern in which text-based communication produced the smallest gains, visual narratives produced substantially greater gains, and interactive gamified communication generated the largest improvements (Zhou et al., 2020). This pattern corresponded closely with earlier studies of multimedia health communication, pictorial instruction, serious games, entertainment education, and interactive health-learning systems. Earlier research generally reported that health messages became more understandable when verbal explanations were supported by relevant illustrations, pictograms, sequential images, or audiovisual representations. Studies conducted among populations with limited literacy similarly identified reduced dependence on written language as an important factor associated with greater comprehension and recall. The present findings extended this established pattern by demonstrating that the benefits of visual communication occurred simultaneously across cognitive, evaluative, behavioral, and trust-related outcomes (Lieberoth et al., 2018). The large standardized effects obtained for comprehension, preventive knowledge, immediate recall, delayed recall, and misinformation recognition indicated that the differences represented substantial changes rather than statistically detectable but practically minor improvements. The results were also compatible with multimedia-learning research suggesting that appropriately coordinated verbal and visual information can facilitate cognitive processing by distributing information across complementary representational channels. The stronger performance of the gamified condition was consistent with serious-game studies showing that active decision making, immediate feedback, challenges, repeated attempts, and progressive tasks can create deeper interaction with educational content than passive exposure. Earlier studies have not always found uniform superiority for gamification, particularly when game mechanics were weakly connected to educational objectives or when novelty increased participation without improving learning (Alahäivälä & Oinas-Kukkonen, 2016). The pattern observed in this study was therefore especially important because improvements were found not only in engagement but also in objective knowledge, recall, misinformation recognition, and delayed retention. Taken together, the findings positioned communication format as a substantial quantitative determinant of how low-literacy audiences processed, remembered, evaluated, and responded to health information.

The substantial improvements in health-information comprehension and preventive knowledge provided strong support for the role of visual organization and active interaction in reducing the cognitive demands associated with conventional health information. Baseline comprehension scores were highly comparable among the three communication conditions, whereas post-intervention scores separated considerably after exposure (King & Lazard, 2020). The text-based group improved moderately, the visual-narrative group demonstrated considerably greater improvement, and the gamified group recorded the highest comprehension and preventive-knowledge scores. This pattern was consistent with earlier experimental studies comparing text-only health information with pictorial instructions, illustrated materials, infographics, comics, animations, and multimedia education.

Figure 112: Health Communication Evaluation Flowchart



Previous research frequently showed that relevant images improved comprehension by converting technical or abstract health concepts into recognizable actions, objects, relationships, and sequences. Such advantages have been documented particularly for medication instructions, disease transmission, hygiene practices, symptom recognition, vaccination education, and preventive behaviors. The results of this study were also aligned with earlier research indicating that visual narratives can organize health information through causal and temporal sequences, allowing audiences to understand how exposure leads to disease, how symptoms develop, and how preventive actions interrupt harmful processes (Lazard & Mackert, 2014). The higher immediate-recall scores recorded in the visual and gamified conditions were compatible with studies showing that meaningful images can function as retrieval cues. More importantly, the persistence of group differences during delayed assessment supported earlier evidence that active retrieval and repeated interaction can strengthen longer-term memory. Participants in the gamified condition repeatedly encountered information through questions, decisions, corrective feedback, and progressively structured activities, which corresponded with educational research demonstrating advantages of retrieval practice over passive re-exposure. Earlier serious-game studies reported similar improvements in health-related knowledge, although delayed retention has been less consistently measured than immediate post-intervention learning. The delayed findings in this study therefore provided an important quantitative distinction between temporary performance improvement and sustained information retention (Hicks et al., 2019). Some previous studies have also cautioned that visual complexity can impair learning when illustrations are decorative, culturally unfamiliar, or poorly aligned with message content. The strong results observed

here were more consistent with studies in which visuals were directly linked to learning objectives. The findings consequently reinforced the interpretation that visual narratives supported comprehension through representational clarity, while gamification added active practice, feedback, and repeated retrieval that further strengthened knowledge acquisition and retention.

The findings concerning misinformation discernment represented one of the strongest quantitative patterns observed in this study. Participants exposed to interactive gamified communication achieved substantially higher misinformation-recognition accuracy and correct-classification performance while demonstrating markedly lower acceptance of false health claims than participants receiving conventional text-based information (Hsieh & Yang, 2020). Visual narratives also produced substantial improvements relative to text-based communication, although the magnitude remained lower than that observed for the gamified condition. These results corresponded with earlier health-misinformation research indicating that simply presenting corrective factual information may be insufficient when audiences have already encountered persuasive misleading claims or lack the literacy resources necessary to evaluate complex evidence. Earlier studies of misinformation correction, inoculation-based communication, interactive media literacy, and prebunking approaches have demonstrated that active exposure to misleading strategies combined with corrective explanation can improve subsequent recognition of questionable claims. The present findings were consistent with this literature because the gamified condition required participants to classify claims, make decisions, and receive immediate corrective feedback rather than merely read accurate health statements (Bohr & Memarzadeh, 2020). The considerably lower false-claim acceptance rate suggested that interactive learning supported discrimination between credible and misleading information rather than only increasing factual knowledge. The relationship observed between misinformation-recognition ability and public trust was also consistent with previous studies showing that information literacy and source evaluation can shape confidence in credible health institutions. Risk-perception findings were statistically significant but smaller in magnitude than misinformation and knowledge outcomes. This difference corresponded with earlier studies demonstrating that perceived susceptibility and severity are influenced by more than informational exposure. Personal experience, cultural beliefs, perceived vulnerability, social norms, emotional responses, and existing attitudes can all shape interpretations of health risk (Hakak et al., 2019). Visual narratives may have increased perceived relevance by depicting recognizable people, environments, symptoms, and consequences, which was compatible with earlier narrative-persuasion research. Gamified scenarios may have further strengthened risk understanding by allowing participants to observe consequences associated with alternative choices. However, the moderate effect sizes indicated that risk perception was less responsive to communication format than knowledge or misinformation discernment. The findings therefore supported a distinction between correcting informational deficiencies and modifying personally held judgments of vulnerability. This distinction was consistent with earlier health-behavior research and helped explain why large improvements in factual understanding did not necessarily produce equally large changes in perceived susceptibility and severity (Buckley & Doyle, 2017).

Preventive behavioral intention increased significantly across the intervention conditions, with the strongest improvement occurring among participants exposed to interactive gamified communication. Visual narratives also generated substantially higher behavioral-intention scores than conventional text-based information. These findings corresponded with earlier narrative health-communication studies showing that identification with characters, perceived similarity, story relevance, emotional engagement, and perceived realism can influence willingness to adopt recommended health behaviors. Previous studies involving vaccination, cancer screening, sexual health, smoking prevention, physical activity, dietary behavior, and infectious-disease prevention have demonstrated that audiences may respond more strongly when health recommendations are embedded within meaningful stories rather than presented as isolated instructions (Frank et al., 2015). The regression findings of this study strengthened this interpretation because engagement emerged as the strongest independent predictor of preventive behavioral intention, while story relevance, narrative identification, disease-prevention knowledge, message credibility, and misinformation recognition also made significant contributions. The mediation results provided further support by showing that engagement partially accounted for

the relationship between communication condition and preventive intention. This finding closely reflected earlier narrative transportation and entertainment-education research in which deeper cognitive and emotional involvement was associated with stronger message acceptance and behavioral motivation. Narrative identification also produced a significant indirect effect, indicating that behavioral responses were partly associated with participants' connection to the people and situations represented in the communication materials (Igartua & Rodríguez-Contreras, 2020). Earlier research has emphasized that identification differs from simple character liking because it involves perspective taking, perceived similarity, and temporary adoption of the character's goals or experiences. The present results were consistent with that distinction. Gamification appeared to strengthen these narrative mechanisms by transforming participants from passive observers into active decision makers. Interactive scenarios required participants to select preventive actions and observe feedback, potentially increasing the personal applicability of the health information. At the same time, the findings were consistent with previous research showing that intention should not be treated as equivalent to actual behavior. Behavioral intention can be influenced by communication, while real-world adherence remains dependent on healthcare access, financial resources, social support, opportunity, environmental barriers, and perceived behavioral control (Igartua & Casanova, 2016). Accordingly, the strong intention effects demonstrated persuasive and motivational differences among communication formats without establishing that every reported intention would necessarily translate into sustained preventive action.

Public trust represented another outcome for which visual-narrative and gamified communication produced substantial improvements. The gamified condition demonstrated the largest increase in overall trust, followed by the visual-narrative condition, while conventional text-based communication produced a considerably smaller change. The regression analysis identified perceived message credibility as the strongest predictor of public trust, and mediation analysis showed that credibility accounted for a substantial proportion of the association between communication format and trust (Shen et al., 2015). These findings were consistent with earlier studies demonstrating that trust in health communication is influenced not only by institutional reputation but also by whether information is understandable, transparent, relevant, internally consistent, and perceived as credible. Research conducted during infectious-disease outbreaks and vaccination campaigns has repeatedly shown that incomprehensible or excessively technical communication can create distance between health institutions and populations with limited health literacy. Earlier studies have also linked communication clarity with confidence in health professionals and willingness to follow public-health recommendations. The present findings expanded this pattern by indicating that accessible visual and interactive communication was associated with stronger perceptions of institutional credibility, reliability, transparency, and competence. The relationship between misinformation discernment and trust was particularly noteworthy (Ozer et al., 2020). Participants who became more successful at distinguishing accurate from misleading health claims also tended to report stronger confidence in credible health sources. This result was compatible with earlier media-literacy research suggesting that improving evaluation skills does not necessarily create generalized skepticism; when source cues and evidentiary standards are communicated effectively, improved discernment can support more selective trust. The findings also aligned with research showing that narratives can humanize institutional communication by presenting health information within recognizable social contexts. Gamified interaction may have added another layer of transparency because participants received immediate explanations showing why particular claims or preventive decisions were correct or incorrect. Such feedback potentially made the reasoning underlying recommendations more visible (Sun et al., 2019). However, trust remained a multidimensional construct, and communication format represented only one contributor . Previous research has demonstrated that historical experience, institutional performance, cultural relationships, political context, healthcare accessibility, and perceived fairness can influence trust independently of message design. The substantial effects observed in this study therefore indicated that communication characteristics were meaningfully associated with trust within the intervention context, rather than suggesting that visual or gamified communication alone could account for the broader social foundations of institutional confidence (Kareklas et al., 2015).

The subgroup and moderation analyses demonstrated that baseline health literacy played a particularly important role in determining the magnitude of intervention effects. Participants with the lowest health-literacy scores showed substantially greater relative comprehension gains from visual-narrative and gamified communication than from conventional text-based materials. This pattern was strongly consistent with earlier health-literacy studies showing that written health communication can disproportionately disadvantage individuals with limited reading proficiency, numeracy, vocabulary, or familiarity with medical terminology. Previous pictorial-health communication research has demonstrated that illustrations, icons, sequential images, and simplified visual instructions can improve comprehension among populations for whom text-heavy information creates substantial processing demands (Chen et al., 2018). The findings of this study extended that evidence by demonstrating that gamification produced an additional advantage beyond visual representation, particularly among participants with lower baseline literacy. Educational attainment showed a related pattern, with participants reporting primary education or below demonstrating larger relative gains from visual and interactive communication. These results were compatible with earlier multimedia-learning studies in which learners with less prior knowledge benefited from well-structured visual support because the communication reduced the amount of information that had to be inferred from technical text. Prior health knowledge similarly influenced improvement, with participants starting from lower knowledge levels showing comparatively larger gains (Lachlan et al., 2014). Digital familiarity presented a more differentiated pattern. Participants with stronger digital familiarity obtained somewhat larger gains from gamification, which corresponded with previous digital-health research showing that interface familiarity can facilitate navigation and interaction. Importantly, participants with lower digital familiarity still demonstrated substantial improvement under the gamified condition, indicating that digital experience did not eliminate the educational value of interaction. Age produced comparatively modest differences, while social-media frequency did not significantly modify comprehension effects. The moderation analysis reinforced these subgroup findings by demonstrating that health literacy significantly altered the relationship between communication format and comprehension as well as misinformation discernment (Borah & Xiao, 2018). Earlier studies have sometimes treated low literacy primarily as an individual deficit requiring simplified communication. The pattern obtained in this study supported a more communication-centered interpretation: performance differences were partly responsive to how information was designed and delivered. When health content was represented visually, narratively, and interactively, the relative disadvantage associated with lower baseline literacy was reduced, demonstrating that measurable comprehension differences were influenced by the accessibility of the communication environment (Latkin et al., 2020).

The integrated findings presented a coherent account of how visual narratives and interactive gamified communication differed from conventional health education across cognitive, evaluative, motivational, and trust-related outcomes. The largest effects occurred for misinformation recognition, health-information comprehension, preventive knowledge, immediate recall, and delayed retention, while preventive behavioral intention and public trust also demonstrated substantial differences. Risk-perception outcomes were significant but comparatively moderate, indicating that communication format influenced factual and evaluative processing more strongly than deeply contextual judgments of personal vulnerability (Hong et al., 2017). This overall pattern corresponded with earlier studies across multimedia learning, pictorial health communication, narrative persuasion, entertainment education, serious games, misinformation correction, and health-literacy research. Earlier evidence generally indicated that visuals can improve accessibility, narratives can increase relevance and identification, and interactive systems can strengthen participation and feedback. The present study brought these mechanisms together within a common quantitative comparison and showed that their combined use was associated with the strongest outcome profile. The effect-size pattern was particularly informative because gamified communication showed very large standardized differences from text-based information for comprehension, knowledge, recall, and misinformation discernment, while visual narratives independently demonstrated substantial advantages over conventional text. Regression findings complemented the experimental comparisons by showing that engagement,

credibility, knowledge, story relevance, narrative identification, and misinformation-recognition ability contributed to behavioral intention and trust (Iturria-Medina et al., 2016). Mediation findings further demonstrated that the communication effects were partly explained through engagement, identification, and credibility, which was consistent with earlier theoretical and empirical work on narrative processing and persuasive health communication. The persistence of higher comprehension, knowledge, and recall scores at delayed follow-up also corresponded with research emphasizing repeated retrieval and corrective feedback as mechanisms supporting durable learning. At the same time, variation across outcomes was consistent with earlier evidence showing that health communication does not influence all psychological and behavioral processes equally. Knowledge can change rapidly following structured education, whereas risk perception, trust, and behavior are also embedded in broader social and experiential contexts (Johnson et al., 2020). The combined evidence from this study and earlier research therefore characterized visual narratives and gamified communication as quantitatively distinct communication environments that altered how health information was processed, remembered, evaluated, and connected with preventive decisions, with particularly pronounced differences among participants experiencing lower baseline health-literacy resources (Aspers & Corte, 2019).

CONCLUSION

This study concluded that visual narratives and interactive gamified communication represented substantially more effective approaches to health-information communication than conventional text-based education among low-literacy populations. The quantitative findings demonstrated a consistent pattern in which participants exposed to visual narratives achieved stronger health-information comprehension, disease-prevention knowledge, immediate recall, delayed knowledge retention, misinformation recognition, preventive behavioral intention, and public trust, while participants exposed to interactive gamified communication demonstrated the strongest overall performance across most measured outcomes. The findings indicated that presenting health information through recognizable images, sequential stories, interactive scenarios, quizzes, corrective feedback, repeated attempts, challenges, and decision-making activities reduced dependence on complex written information and supported more active processing of essential health messages. Particularly substantial differences were observed in comprehension, preventive knowledge, recall, and misinformation discernment, demonstrating that communication format influenced both the acquisition of health information and the ability to distinguish credible information from misleading claims. Improvements in preventive behavioral intention further showed that enhanced understanding was associated with greater willingness to follow vaccination guidance, maintain appropriate hygiene practices, participate in screening, seek professional healthcare, and undertake recommended preventive actions. Public trust also increased more strongly under visual-narrative and gamified conditions, with message credibility emerging as an important explanatory factor. The subgroup findings demonstrated that participants with lower baseline health literacy and educational attainment obtained particularly pronounced benefits from accessible visual and interactive communication, highlighting the importance of communication design in reducing literacy-related differences in health-information processing. Narrative identification, perceived story relevance, engagement, message clarity, credibility, preventive knowledge, and misinformation-recognition ability were also associated with stronger behavioral and trust outcomes. The mediation findings indicated that engagement and narrative identification partially explained preventive behavioral intention, while perceived credibility partially accounted for improvements in public trust. Overall, the combined statistical evidence established that effective health communication in low-literacy settings depended not simply on providing accurate information but also on presenting that information in forms that audiences could understand, remember, evaluate, and meaningfully connect with preventive decisions. Visual storytelling improved accessibility and relevance, while interactive gamification added participation, repetition, feedback, and experiential learning, producing a communication environment capable of strengthening preventive knowledge, resistance to health misinformation, behavioral motivation, and confidence in credible public-health information.

RECOMMENDATIONS

Based on the findings of this study, public-health institutions, healthcare organizations, community health programs, nongovernmental organizations, educational agencies, and health-communication professionals should place greater emphasis on visual-narrative and interactive gamified communication when designing disease-prevention initiatives for low-literacy communities. Health messages should be developed using simple and culturally recognizable illustrations, pictograms, sequential images, infographics, visual stories, animations, and character-based scenarios that translate complex medical concepts into understandable representations of symptoms, transmission pathways, risk factors, and preventive actions. Interactive systems should incorporate carefully designed quizzes, decision-making scenarios, immediate corrective feedback, repeated practice, progressive challenges, achievement indicators, and appropriate rewards to encourage active engagement without allowing entertainment features to distract from essential health information. Particular attention should be given to misinformation prevention by incorporating activities that allow users to distinguish credible statements from misleading claims, examine common misinformation techniques, identify trustworthy sources, and receive clear explanations for incorrect judgments. Health authorities should also ensure that visual and gamified materials communicate the reasoning behind vaccination, hygiene, screening, healthcare-seeking, and other preventive recommendations in transparent and accessible ways, since message credibility was strongly associated with public trust. Communication materials should undergo formative testing with members of the intended communities to confirm that images, symbols, characters, language, and interactive tasks are culturally understandable and do not introduce unintended ambiguity. Because the strongest relative benefits were observed among participants with lower health literacy, intervention design should prioritize accessibility rather than assuming substantial reading proficiency, numerical competence, or previous medical knowledge. Digital applications should additionally use simple navigation, clear instructions, limited information per screen, readable typography, audio support where appropriate, and low-complexity interaction to accommodate individuals with limited digital familiarity. Health professionals and community workers should receive appropriate training in integrating these communication tools into face-to-face education rather than treating digital or visual interventions as replacements for trusted interpersonal communication. Evaluation should extend beyond participation and enjoyment by routinely measuring comprehension, immediate and delayed retention, misinformation discernment, behavioral intention, adherence, and trust using validated quantitative instruments. Programs should also compare outcomes across literacy, age, education, digital familiarity, and prior-knowledge groups to identify unequal responses. Through systematic integration of visual storytelling, meaningful gamification, credible information, repeated feedback, and audience-centered design, disease-prevention communication can become more understandable, memorable, engaging, and resistant to misinformation while supporting informed preventive decisions in low-literacy communities.

LIMITATION

This study was subject to several limitations that should be considered when interpreting the quantitative findings concerning visual narratives, gamified health communication, misinformation discernment, preventive behavioral intention, and public trust among low-literacy communities. First, the quasi-experimental design provided a structured basis for comparing text-based, visual-narrative, and interactive gamified communication conditions, but it offered less control over potential confounding influences than a fully randomized controlled design. Differences in participants' previous exposure to health information, cultural experiences, familiarity with visual storytelling, digital competence, and personal experiences with disease could have influenced responses even after relevant characteristics were statistically controlled. Second, health literacy was assessed through standardized screening and supporting demographic measures, but literacy is multidimensional and includes reading ability, numeracy, digital literacy, visual literacy, and the capacity to evaluate health information; therefore, a single classification may not have represented the complete range of participants' communication abilities. Third, several outcomes, particularly preventive behavioral intention, engagement, perceived credibility, narrative identification, risk perception, and public trust,

relied on self-reported responses and were consequently vulnerable to social-desirability bias, response tendencies, and differences in interpretation of rating scales. Stronger behavioral intentions could not automatically be interpreted as equivalent to actual long-term preventive behavior. Fourth, the intervention assessed selected disease-prevention messages, meaning that the observed effects might vary for other health topics characterized by different levels of complexity, stigma, uncertainty, or emotional sensitivity. Fifth, the gamified condition incorporated several components simultaneously, including interactive storytelling, quizzes, feedback, repetition, challenges, and progress indicators. Consequently, the study could not completely isolate the independent contribution of each gamification mechanism to the observed improvements. Sixth, the delayed follow-up period provided evidence regarding knowledge retention but did not establish whether improvements persisted over substantially longer periods. Participant attrition between baseline and delayed assessment, although relatively limited and statistically comparable across groups, could also have introduced some selection effects. Seventh, access to digital devices and familiarity with interactive interfaces may have influenced engagement, particularly among participants with limited technological experience. Finally, findings obtained from the selected low-literacy communities should not be generalized automatically to all low-literacy populations because language, cultural conventions, healthcare access, institutional trust, technological infrastructure, and patterns of misinformation exposure can differ considerably across geographic and social contexts. These methodological and contextual limitations required careful interpretation of the magnitude and generalizability of the reported intervention effects.

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