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Review Article

Rapid review of virus risk communication interventions: Directions for COVID-19

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Objective: In response to COVID-19, we conducted a rapid review of risk communication interventions to mitigate risk from viruses to determine if such interventions are efficacious.

Methods: We searched for risk communication interventions in four databases: Medline, PsycInfo, the ProQuest Coronavirus Research Database, and CENTRAL. The search produced 1572 articles. Thirty-one articles were included in the final review.

Results: Results showed risk communication interventions can produce cognitive and behavior changes around viruses. Results were more consistently positive for interventions focused on HIV/AIDS as compared to influenza. There was no consistent best intervention approach when comparing peer health, audio/visual, and intensive multi-media interventions. Tailoring risk communication toward a target population, in comparison to not tailoring, was related to better outcomes.

Conclusion: The results suggest that risk communication interventions can be efficacious at reducing risk from viruses. They also highlight the complexity of risk communication interventions. Additional research is needed to understand the mechanisms that lead risk communication to reduce risk from viruses.

Practical value: Results support risk communication interventions to reduce risk from viruses.

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1. Introduction

Novel viruses are one of the greatest threats to humanity. In the last half-century, several major viral epidemics including but not limited to human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS), severe acute respiratory syndrome (SARS), middle east respiratory syndrome (MERS), ebola virus disease (EVD), and swine flu (H1N1) have resulted in loss of life, as well as widespread fear and significant economic impacts. Most recently, the world is facing the global pandemic of coronavirus disease 2019 (COVID-19) which is threatening lives, causing personal distress [1–3], public outcry [4], and economic disarray [5].

There is evidence that risk communication, defined as “the exchange of real-time information, advice, and opinions between experts and people facing threats to their health, economic or social well-being” [6, para. 1], can be effective in controlling pandemic events [7–9]. The Common-Sense Model of Self-Regulation (CSM), consistent with other parallel processing models, proposes the most effective risk communication convey both the risk (e.g., severity, likelihood) and behavioral strategies to reduce risk [10], such as social distancing, wearing a mask, getting vaccination, and washing hands. Previous research finds risk communication generally improves perceptions of risk severity, vulnerability, and efficacy in virus management [7,11]. It can also improve behaviors to mitigate the threat posed in health crises [12].

Research also suggests that risk communication is complex. Risk communication messages may need to be framed and delivered in multiple and specific ways depending on the risk to maximize the effectiveness of the message to improve perceptions and behaviors [13]. Approaches that are effective for one risk (e.g., cancer-related risks), may not be relevant or functional for another (e.g., HIV) [14]. For example, presenting numerical risk estimates increases perceptions of risk and increases preventive behavior (e.g., obtaining a mammogram to rule out breast cancer) for cancer risks [15], but does not increase preventative behavior for genetic risks [16]. The content of messages also needs to vary depending on the risk (e.g., flood, virus) and the behavioral strategy to reduce risk (e.g., wash hands, have an evacuation strategy). Past reviews have also demonstrated that the effectiveness of risk messaging depends on the audience of interest and other situational factors [17].

According to the CSM, one reason risk communication is complex is that individuals develop mental models of health risks and behaviors to reduce risk [10]. While experts rely on scientific data and statistical modeling to determine the level of risk and appropriate behaviors to mitigate risk [18], oftentimes, the public’s perceptions of risk are influenced by multiple factors across emotional, social, and other domains, such as personal relevance [18]. These factors also influence the public’s perceptions of the efficacy of behavioral recommendations to reduce risk and self-efficacy for performing these behaviors. Considering that not all risk communication approaches are effective, and some even backfire, it is important to understand whether risk communication messages are effective to reduce risk from viral risks and if certain risk communication approaches are more effective to reduce risk from viruses.

Previous systematic reviews have examined the efficacy of risk communication for a variety of health risks (e.g., diabetes, stroke, colon cancer, heart disease) [19], or have focused on specific situations (e.g., floods) [20,21], health-related disaster communication [22], genetic risks [16], sexual behaviors [23], pain [24], and vaccinations [17,25]. However, a systematic review on risk communication strategies for viruses does not exist in the literature. A better understanding of risk communication for viruses will allow public health experts to effectively use risk communication to reduce risk from COVID-19 and other pandemics.

The objective of the current review was to determine if there is evidence for the efficacy of risk communication to reduce the spread of viruses. We examined if risk communication can change people’s cognitions and behaviors to reduce the spread of viruses [10]. Our secondary aim was to explore whether some communication approaches are more effective than others for changing people’s cognitions and behaviors to reduce the spread of viruses.

2. Methods

In response to the rapidly evolving COVID-19 pandemic, we conducted a rapid review to determine the most effective communication/dissemination strategies for reducing the spread of viruses by changing people’s cognitions or behavior. A rapid review is a synthesis of knowledge which simplifies aspects of the systemic review process for the aim of producing information within a limited timeframe [26]. Risk communication was operationalized according to the World Health Organization (WHO) definition, as “the exchange of real-time information, advice, and opinions between experts and people facing threats to their health, economic or social well-being” so these affected populations may “take informed decisions to protect themselves and their loved ones” [27, pg.1].

2.1. Search strategy

After consulting with informational experts to pilot the search methodology and syntax, three authors (EP, YCT, and DMW) applied the final syntax through the ProQuest interface to three databases: PsycInfo, Medline, and the ProQuest Coronavirus Research Database. The Cochrane CENTRAL database was also searched. The search included (1) illness, (2) viral transmission, (3) communication, and (4) health behavior. Searches were limited to publications in English, that used a human sample (not an animal sample/study), and that were peer-reviewed (see Appendix A for complete syntax).

2.2. Inclusion and exclusion criteria

To meet the inclusion criteria, articles had to: (1) be empirical, (2) be about a viral illness that can be transmitted to humans, (3) focus on transmission among humans, (4) employ some form of risk/health communication as a predictor, (5) and have a cognitive or behavioral outcome. Articles were excluded from the current review if they: (1) were not in English, (2) not peer-reviewed (e.g., editorial, comment, letter, or newspaper article), (3) used a sample with individuals younger than 18, (4) did not evaluate a clear risk communication/dissemination intervention, (5) conducted an intervention not designed to assist individuals reduce their risk of infection (e.g., designed exclusively for those living with a virus), or (6) did not include quantitative data.
2.3. Article selection and coding

A total of 1572 articles were initially gathered for review (865 from PsycInfo; 684 from Medline; 23 from the ProQuest Coronavirus Research Database). Thirty-five were duplicates and removed. Eight authors each evaluated 195 article titles/abstracts for inclusion, with decisions double-checked by a second author. Authors reached initial agreement on inclusion decisions in 95% of cases, and 100% after discussion of discrepancies. During the title and abstract check, a total of 74 articles were excluded based on the length of intervention and use of qualitative data. In addition to the full text examination on the articles that met the initial pass, these 74 articles were also re-reviewed, with double checks again conducted to ensure accuracy in decision making. The re-review of these 74 initially excluded articles was done to determine the appropriateness of excluding interventions that were long (i.e., 5 h at a time or over 2 weeks in length) and qualitative. Ultimately, lengthy interventions were included and wholly qualitative studies were excluded. Additionally, after further reviewing inclusion criteria, we decided to remove interventions designed exclusively for those diagnosed with a virus. This resulted in the removal of two originally included articles. Initial agreement on inclusion decisions was again high, achieved in 84% of cases and in 100% of cases post discussion (see Fig. 1 for decision flow chart). Thirty-one articles were included in the review.

2.4. Data extraction and synthesis

Extracted data included authors, year of publication, study design, virus of focus, number of participants, and sample demographics (see Fig. 1). Extracted data on interventions included communication strategy, messaging content, length of intervention, setting, provider, and mode of transmission. Extracted data on analyses included outcome variables, measures, timeframe between comparisons, and achieved results (e.g., primary results, effect sizes). Outcomes were coded as: (1) cognitive risk perception, or how one views the risk, severity, or certainty of infection, (2) cognitions about behaviors, or how one views protective behaviors designed to mitigate risk, (3) behavioral intentions, or intentions to engage in protective behaviors, and (4) behaviors, or one’s engagement in protective behaviors. Some articles examined a change in virus knowledge outcome. These data, while not included in the primary analyses, were collected and synthesized separately (see Tables B1 and B2 in Appendix B).

The heterogeneity of interventions and outcomes precluded meta-analysis. When meta-analytic procedures are not possible, synthesis without meta-analysis (SWiM) guidelines for the synthesis of quantitative data, suggest tallying the number of studies with positive, negative, and no effect [28]. In this review, all articles that included cognitive risk perceptions as an outcome sought to increase participant’s perceptions of risk, therefore increasing cognitions of risk was coded as positive. Similarly, all articles that included cognitions about behaviors, behavioral intentions, or behaviors as outcomes sought to protect individuals from viral infection by reducing risky behaviors and/or increasing protective behavior, therefore changing cognitions about behaviors, behavioral intentions or behaviors to protect from viral infection (reduce risky behavior and/or increase protective behavior) was coded as positive.

Studies were tallied once for each type of outcome. Studies which reported multiple measures for one type of outcome (e.g., multiple measures of cognitive risk perception) could be tallied as having mixed results (e.g., mixture of positive and no effect). Therefore, studies were coded as: (1) positive (pos), (2) negative (neg), (3) no effect (NE), (4) mixture of both positive and no effect results (mixed pos&NE), and (5) mixture of both negative and no

![Fig. 1. Article Screening and Selection Summary.](1836)
| Authors | Virus | Intervention Type | Treatment content (provider; length) | Tailored: intervention | Comparison group/secondary messaging | Tailored: comparison | Randomized control trial | Sample size | Demographics (setting) | Quality |
|---------|-------|------------------|--------------------------------------|------------------------|---------------------------------------|---------------------|-------------------------|-------------|------------------------|---------|
| de Wit JB, Das E, Vet R (2008) | HBV | Audio/visual communication | Written text messaging presented online to participants. Messaging was either statistical or narrative which communicated men who have sex with men are at greater risk for HBV, and then presented an individual who had been infected, introduced in a way to positively connect readers to the fictitious person. All further information related to the message character was presented as first-person quotes. (media; single read-through). | Yes | (a) Communication that men who have sex with men are at risk for HBV and prevalence statistics of HBV-infections | Yes | Yes | 118 | All participants were native Dutch men who have sex with men; age: M = 38.3; 51.7% in a stable relationship; 47% had at least some college education (online messaging and surveys). | Low |
| Vet R, de Wit JB, Das E, (2011) | HBV | Audio/visual communication | Written text messaging presented online to participants. Messaging centered around social norm communication, where a non-infected male who has sex with males (MSM) communicate their barriers to, and ultimate acceptance of, the HBV vaccine (MSM without HBV; single read-through). | Yes | Written text messaging presented online to participants. Messaging was a previously validated risk communication script, where the first-hand experience of a MSM diagnosed with HBV was presented who communicated a wish for having perceived greater risk of infection and knowledge of vaccination (MSM with HBV; single read-through). | Yes | Yes | 168 | All participants were men who have sex with men (MSM); age: M(SD) = 33.8 (11.2); 5% were Dutch; 44% had at least a Bachelor’s degree; 37.5% were in a stable partnership (online messaging and surveys). | Low |
| Coppola V, Camus O (2007) | HIV/AIDS | Audio/visual communication | Participants were given written test epidemiological information of HIV incidence rates, manipulated by orientation: some messages provided an exact number (subdued) or stating the number of cases was over a given number (highly stressed) (N/A; single read-through). | No | Communication of HIV incidence rates, manipulated by framing: messages communicated either the number of incidences per day or per year (N/A; single read-through). | No | No | 103 | Age ranged from 18–24; all male; all university students; 36% systematically used a condom, 53% occasionally, 11% never (unclear) | Very low |
| Govender K, Beckett S, Masebo W, Braga C, Zambheri P, Manhique M, George G, Durevall D (2019) | HIV | Audio/visual communication | Participants received SMS messages promoting safe sex practices, specifically condom use. | Yes | Participants provided in-person HIV prevention information once (study recruiter; uncertain). | No | Yes | 949 | Most participants were between 36–49 years old; 76.7% male; 610.0% had not completed high school; 74.8% were truck drivers (electronic phone text messages). | Low |
| Horn PA, Brigham TA (1996) | AIDS | Audio/visual communication | Participants were provided 3 sessions of education and behavioral rehearsal/modeling. The topic of the sessions was around participant’s sexual behavior, communication, and environmental antecedents to risky behavior (unclear; 2 h sessions). | Yes | | N/A | N/A | 46 | All participants were college students with an age range of 18–28 (in-person education sessions). | Very low |
| Kelly JA, Murphy DA, Washington CD, Wilson TS, Koob JJ, Davis DR, Ledezma G, Davates B (1994) | HIV/AIDS | Audio/visual communication | Participants attended an in-person seminar on HIV/AIDS. Information provided in the seminar included HIV risk, protective behaviors, and basic HIV facts (2 female group leaders; 4 weekly 90 min sessions). | No | Women attended in-person seminars on nutrition and other topics relevant to low-income women (unclear; 3 weekly 90 min sessions). | No | Yes | 187 | All participants were women (in-person health clinic). | Low |
| Authors          | Virus Type | Intervention Type                 | Treatment content (provider; length)                                                                 | Tailored: intervention | Comparison group/ secondary messaging | Tailored: comparison | Randomized control trial | Sample size | Demographics (setting)                                      | Quality  |
|------------------|------------|-----------------------------------|------------------------------------------------------------------------------------------------------|------------------------|---------------------------------------|----------------------|--------------------------|-------------|------------------------------------------------------------|----------|
| Montano NP, Cianelli R, Villegas N, Gonzalez-Guarda R, Williams WO, Tantillo LD (2019) | HIV       | Audio/visual communication       | The SEPA intervention is a 3 session education program tailored to Hispanic women. Education focused on role playing skills related to safe sex practices (Bi-cultural department of health employees; 2.5 h sessions). | Yes                    | Delayed implementation of the intervention (Bi-cultural department of health employees; 2.5 h sessions). | No                   | No                       | 259         | All participants were Hispanic women; age: M = 31.6 (in-person education sessions). | Very low |
| Oswalt SB, Wyatt T (2015) | HIV       | Audio/visual communication       | The Somos Fuertes program consists of 6 education sessions. These sessions focus on connecting sexual practices/beliefs with culture, conducting female empowerment, along with facts around HIV transmission/protection (program facilitators; 2 h sessions). | Yes                    | N/A                                   | N/A                  | No                       | 175         | All participants were college attending women; age ranged from 18 to 52 (M = 22.06); 54.3% were Hispanic; 17.2% had not engaged in sex prior to intervention; 93.7% had exclusively male partners (in-person education sessions). | Very low |
| Turk T, Ewing MT, Newton FJ (2006) | HIV/AIDS  | Audio/visual communication       | A poster intervention providing information about methods if infection and viral spread. Additional information provided regarding protective behaviors like condom use. Posters were designed via piloted focus groups taking participant opinions into account for the second study phase (unclear; the amount of time taken in the bathroom). | Yes                    | No messaging presented (N/A; N/A)     | No                   | No                       | 332         | Intervention group: age: M = 25.14; 84 male, 82 female. Control group: age: M = 24.66; 79 male, 87 female; more likely to have received a university education; be currently enrolled as a student, in top income bracket; a total of 85 participants were considered high risk (i.e., multiple sexual partners; clients of commercial sex workers; men who have sex with men; and/or individuals positively predisposed to drug use) (in-person at bars/cafes). | Very low |
| DeMarco RF, Kendricks M, Dolan Looby SE, Rinne K (2009) | HIV       | Intensive multimeda communication | The “Women’s Voices Women’s Lives” film designed around communicating HIV risk/consequences to women. The film presented 4 African American women describing the impact of HIV on their lives and addressed topics of: HIV facts, HIV disclosure, and health care needs. The intervention also included exercises and group meetings to further explore topics from the film (film starring HIV positive women; single viewing). | Yes                    | N/A                                   | N/A                  | No                       | 131         | All participants were women; age: M(SD) = 35(9.67); 47% white; 26% Lantinx; 10% Caribbean Black; 55% single/never married; 29% high school graduate/GED; number of STDs: M(SD) = 1 (2.26) (in-person film viewing and group meetings). | Very low |
| Wang AL, Lowen SB, Shi, Z, Bissey B, Metzger, DS, Langleben DD (2016) | HIV       | Audio/visual communication       | Participants viewed television commercials in a lab setting which featured homosexual scenarios and African American actors promoting condom use to preventative behaviors around HIV (commercial about condom usage from various media campaigns; M(SD) = 0.37 min (60.0)). | Yes                    | Commercials featuring heterosexual scenarios and Caucasian actors promoting condom use to preventative behaviors around HIV (government-sponsored campaigns or commercials produced by condom manufacturers; M(SD) = 0.37 min (60.0)). | No                   | No                       | 45          | M age = 26.84; all were African American men who have sex with men; M years of education = 1.65; 21 HIV positive (in-person in lab/ MRI scanner). | Very low |
| Fogel CI, Crandell JL, | HIV       |                                  | The POWER intervention is an adoption of the SAFE program. Participants engaged in 8 in- | No                     |                                      | No                   | Yes                      | 521         | All participants were incarcerated women. Age | Low      |

**Table 1 (Continued)**
| Authors | Year | Study Type | Intervention Details | Sample Characteristics | Effect | Evidence Level |
|---------|------|------------|----------------------|------------------------|-------|---------------|
| Neevel AM, Parker SD, Carry M, White BL, Fasula AM, Herbst JH, Gelaude DJ | 2015 | Intensive multimedia communication | Person meetings which consisted of education on: the purpose of the program, importance of HIV/STI protection, sexuality, male-female relationships, and other factors related to risky sex. After sessions participants received booster phone calls on the topics covered in the program (trained nurse and social worker; 1.5 h sessions). | Participants ranged from 18-60 (M = 33.8); 57.8% were white; 61.0% were high school graduates; 53.2% were employed prior to incarceration; 52.8% ever had a STI (in-person and over the phone education sessions). | Prevention education session (trained nurse; 1 h). | | |
| Kaufman MR, Rimal RN, Carrasco M, Fajobi O, Sokot A, Limaye R, Mkandawire G | 2014 | HIV | Intensive multimedia communication | Participants were exposed to messaging through multiple mediums (i.e., radio, in-person meetings) regarding HIV as a follow-up to the BRIDGE program. Messaging was designed to produce social/behavior change (program leaders; unclear). | All in southern Malawi; Age: M = 29.09; 323 female, 271 male; M education = 5.95 years; 75.3% in a relationship/cohabitating; (mass media radio messaging and in-person meetings). | | |
| Wenger NS, Greenberg JM, Hiborn IB, Kusseling F, Mangotich M, Shapiro MF | 1992 | HIV/AIDS | Intensive multimedia communication | Participants were shown either (a) educational multimedia modules which covered areas such as transmission, protective behaviors, condom use, and communication with sexual partners via various outlets (e.g., videotape presentation, lecture, role-play) OR (b) educational multimedia modules plus additionally received HIV testing (physicians familiar with HIV counseling; unclear). | Participants engaged with multimedia eHealth activities (e.g., games, videos) tailored to young men who have sex with men, including videos, interactive animation, and games aimed to increase HIV knowledge, motivate and teach safer behaviors, and instill self-efficacy for HIV prevention strategies (unclear; ~1 h). | | |
| Mustanski B, Parsons JT, Sullivan PS, Madkins K, Rosenberg E, Swann G | 2018 | HIV | Intensive multimedia communication | Participants were shown either (a) educational multimedia modules which covered areas such as transmission, protective behaviors, condom use, and communication with sexual partners via various outlets (e.g., videotape presentation, lecture, role-play) OR (b) educational multimedia modules plus additionally received HIV testing (physicians familiar with HIV counseling; unclear). | Participants engaged with multimedia eHealth activities (e.g., games, videos) tailored to young men who have sex with men, including videos, interactive animation, and games aimed to increase HIV knowledge, motivate and teach safer behaviors, and instill self-efficacy for HIV prevention strategies (unclear; ~1 h). | | |
| Peragallo N, DeForge B, O’Campe D, Lee SM, Kim YJ, Gianelli R, Ferrer L | 2005 | HIV Peer health communication | Project SEPA is a HIV risk-reduction intervention designed to be culturally tailored/sensitive to Latina women. The intervention followed social cognitive theory by integrating skills training and facilitating greater self-efficacy. Additionally, information giving, group discussions, and role playing were all integrated into the intervention (Red Cross trained HIV Latina counselors who were bilingual; unclear). | Participants engaged with multimedia eHealth activities (e.g., games, videos) tailored to young men who have sex with men, including videos, interactive animation, and games aimed to increase HIV knowledge, motivate and teach safer behaviors, and instill self-efficacy for HIV prevention strategies (unclear; ~1 h). | | |
| Wyatt TJ, Oswalt SB | 2011 | HIV/AIDS | Peer health communication | Five student in-person events were planned: (a) Dramatization/play covering condom use and date-rape, (b) Jeopardy themed event dispelling HIV/STI myths, (c) Author reading covering first-hand experience with HIV/AIDS from the | Participants ranged from 18–29 (M/SD = 21.31(2.75)); 55.4% Hispanic/Latino, 21.7% White, 7.2% Black, 6.0% Asian/Pacific Islander; 75.8% reported one | | |
| Authors | Virus Type | Intervention Type | Treatment content (provider; length) | Tailored: intervention | Comparison group/secondary messaging | Tailored: comparison | Randomized control trial | Sample Size | Demographics (setting) | Quality |
|---------|------------|-------------------|--------------------------------------|-------------------------|---------------------------------------|---------------------|-------------------------|-------------|------------------------|---------|
| Kelly JA, Lawrence JS, Stevenson LY, Hauth AC, Kalichman SC, Diaz YE, Brasfield H, Koob J, Morgan MG (1992) | HIV/AIDS | Peer Health Education Intervention | Perspective of underdeveloped countries. (d) First-hand information from an HIV-positive male covering the need for communication and testing, (e) and a presentation covering the history of HIV, comorbidities, national statistics, and prevention information (fellow college students in student-lead organizations; 2 h per meeting) | Yes | N/A | N/A | No | 924 | Location 1: Age: M = 31.5; 87% white; location 2: Age: M = 27.1; 80% white; location 3: Age: M = 26.9; 89% white (in-person at student-led campus events) |  |
| Kocken P, Voorham T, Brandsma J, Swart W (2001) | HIV/AIDS | Peer Health communication | Participants engaged in in-person peer education around transmission, the risk for infection, benefits of condom usage, along with how to buy and use condoms (peer educator; 105 min) | Yes | No messaging presented (N/A; N/A) | No | Yes | 589 |  |
| Probandari A, Setyani RA, Pamungkasari EP, Widyantingsih V, Demartoto A (2020) | HIV | Peer Health Education Intervention | Female sex worker peer educators ran a female condom use education sessions. This included education along with demonstrations of how to use female condoms. Sessions were given twice to each participant and 15-16 participants were present in each session (peer educator; unclear). | Yes | A single routine education in sexual health and HIV prevention (peer educator; unclear). | No | No | 230 |  |
| Terui S, Huang J, Goldsmith JV, Blackard D, Yong Y, Miller C (2020) | HIV | Peer Health communication | Peer educators were trained by professionals in HIV history, impact in the U.S., prevention, and medication (PrEP), and scientific findings. Participants then engaged in in-person educational messaging (undergraduate students enrolled in health communication classes; 3 h). | Yes | N/A | N/A | No | 220 | Median age = 22; Female, 32.7% Male, 1.4% preferred not to answer; 42.7% African American, 5.9% Asian, 4.1% Hispanic; 65.9%; median household income $30,001-40,000 (in-person, peer-to-peer in university classrooms). |  |
| Bourgeois, FT, Simons WW, Olson K, Brownston J, Mandl KD (2008) | Influenza | Audio/visual communication | Participants experienced influenza messaging through their personally controlled health record. Influenza messaging occurred in five forms: vaccine reminders, respiratory illness advice, influenza alerts, weekly influenza risk maps, monthly influenza bulletins (Personally controlled health record (PCHR) system PING; unclear) | Yes | Information covering the same areas for cardiovascular health and sun protection (Personally controlled health record (PCHR) system PING; unclear) | No | Yes | 99 |  |
| Miller S, Yardley L, Little P (2012) | Influenza | Audio/visual communication | Participants received online theory-based messages varying in the level of perceived threat associated with infection. Theory-based messages on information about the medical team, need for preventative behaviors, the connection between hand-washing and flu infection, recommendations for hand-washing from experts, and practical guidelines for hand-washing (medical and Social Science researchers/providers; unclear). | No | Same information with no coping messages (medical and Social Science researchers/providers; unclear). | No | Yes | 84 | Age: M(SD) = 32.7(11.82); 76.2% women, 19%, men, and 4 did not give their gender; 57.1% reported living in a household with children under the age of 16 (online messaging and surveys). |
| Prati G, Pietrantoni L, Zani B (2012) | Influenza: H1N1 | Audio/visual communication | Participants read online narrative messages featuring stories from seniors (65 and older) impacted by influenza who subsequently got vaccinated (unclear; single read-through before completing a questionnaire about their intentions to receive the vaccine, social trust (trust in science, medicine), risk perception, efficacy perception of the vaccine, previous flu shot vaccinations, comprehension and believability, and demographics. | Yes | (a) Didactic messages were designed around results from a focus group on African American seniors conducted by Cameron et al. (2009). Messaging was designed around the focus group's identified perceptions and beliefs around influenza and vaccination, with the Extended Parallel Process Model (EPPM) theory used to identify thematic categories in responses (unclear; single read-through) | No | Yes | 311 | All were residents of Italy; age ranged from 65 to 84 years (M = 69.74, SD = 5.29); 62.4% were male; 550.0% completed high school, 24.8% some completed university, 15.4% completed middle school/8th grade, and 4.8% primary school level/5th grade (online messaging and surveys). |
| Chan DK, Yang SX, Mullan B, Du X, Zhang X, Chatzisarantis NL, Hagger MS (2015) | Influenza | Audio/visual communication | Participants attended a lecture where they were advised about wearing face masks. Messaging was autonomy supportive. Professors asked students to wear a face mask in their lecture hall to prevent H1N1 spread in a hypothetical H1N1 pandemic (hypothetical university class professor; unclear). | No | Advice about wearing face masks; same request in a hypothetical pandemic, using messaging that was controlling (hypothetical university class professor; unclear). | No | No | 705 | Age: M = 20.30; 38.16% male; All undergraduate students in China (in-person at university campus). |
| Davis OL, Fante RM, Jacobi LL (2013) | Influenza | Audio/visual communication | Two different poster types were hung in the restrooms to prompt hand washing. One poster was the hand washing prompt alone: simple, nonspecific, instructions providing a bulleted list of the procedure needed to thoroughly wash hands. The other poster included health information and a prompt including information regarding washing hands as a mean to avoid contracting influenza, as well as steps for thoroughly washing hands. At the end of the day, researchers recorded the change in hand soap. Participants were exposed to in-person written text with vaccine information. Participants were randomly assigned to either the VSM (treatment condition) or the VIS (control condition). Participants answered a questionnaire with vaccine-related beliefs and intentions. Participants completed questionnaires before and after exposure to their experimental condition. The vaccination safety and mechanisms (VSM), were designed for the purposes of this study. They sought to integrate information from the vaccine | No | The VIS is created and provided by the CDC. To be given a vaccine of any kind it is required by federal law to also provide a VIS, designed to inform recipients of risks and benefits associated with vaccination. It is not worded or intended to persuade or reduce fears regarding vaccination (CDC/public | No | Yes | 108 | Age ranged from 50–60 years; 83% women; 100% were Black/African American; 76% had health insurance (in-person at either participants’ residences, community settings, or university conference rooms). |
| Authors                          | Virus       | Intervention Type          | Treatment content (provider; length)                                                                 | Tailored: intervention | Comparison group/secondary messaging | Tailored: comparison | Randomized control trial | Sample size | Demographics (setting)                                      | Quality  |
|---------------------------------|-------------|---------------------------|------------------------------------------------------------------------------------------------------|------------------------|--------------------------------------|----------------------|--------------------------|-------------|------------------------------------------------------------|----------|
| Yardley L, Miller S, Scholtz W, Little P (2011) | Influenza   | Intensive multimedia communication | Four online seminars presenting on Influenza prevention information. Information included: the need for protective behaviors, importance of hand washing, methods of hand washing, and misconceptions about hand washing/influenza. Online sessions were housed on a website with additional resources provided to participants, along with handouts (medical team/professionals; 4 sessions of unknown duration). | No                      | No messaging presented (N/A)               | No                   | Yes                      | 517         | Age: M(SD) = 49.76(11.4); 63.83% women; SES deprivation score (SD) = 9.17 (6.41) (online messaging and surveys). | Low      |
| Yoo W, Choi D, Park K (2016)    | MERS        | Established media outlet communication | Participants were surveyed about their expression and reception of MERS-related information through posting, sharing comments, questions, pictures or other information about MERS through Social Networking Sites (SNS) (Facebook, Twitter, Instagram, Pinterest, Kakao Story, Kakao Group, Naver Band, or Between users; unclear), in addition to their Self-efficacy for MERS, perceived susceptibility, perceived severity, handwashing intention, and cough etiquette intention. | No                      | N/A                                  | N/A                 | No                       | 1000        | Age ranged from 21–69 (M = 45.24(13.46)); 50.2% were male; 52.5% had a bachelor’s, 19.5% had a high school diploma, 15.9% had an associate degree, 11.3% had a graduate degree; the median monthly household income was between $3501–4500; 49.9% had good health, 34.1% had moderate health, and 7% had poor health (online messaging and surveys). | Very low |
| Johnson BB (2018)               | Zika        | Audio/visual communication | Participants were randomly assigned to various conditions. In study 1 half the sample saw Zika-prevalence information and the other half saw the same information then viewed CDC maps. In study 2 there were eight manipulations. Condition 1 was similar to the original study although included updated numbers and minor phrasing changes. Conditions 2-4 broke apart prevalence information through geographic distributions, total cases, and transmission routes. Conditions 5 and 6 used CDC’s maps, Condition 7 removed the maps’ caveats, and Condition 8 included birth defects. Maps were targeted to the potentially least prepared consumer; clearly specifying map purpose; using gray tones to convey high and low levels to colorblind readers; and not obscuring higher local risks by averaging data over a large (CDC information; 19.6 min). | Yes                     | Information included: state case information, total Zika cases in the US, and transmission modalities; study 2 also included the author’s summary of a CDC study on the impact of Zika on birth defects (CDC information; 19.6 min). | No                   | No                       | 743         | Study 2: age: M(SD) = 43.7 (13.7); 60.6% Women; 49.2% Bachelors degree holders; 37.8% Liberal, 29.1% Conservative 2 Studies were conducted, data extraction was done on study 2 only to collect data on more outcomes explored in the second examination (online messaging and surveys). | Very low |
| Chan MS, Winneg K, Hawkins L, Farhadloo M, Jamieson KH. | Zika        | Established media outlet communication | Participants were surveyed about their risk perceptions and protective behaviors of Zika in relation to posted Zika media posts. Information was disseminated through news websites and legacy media databases, ultimately using sources from the United States (Wall Street Journal, The | No                      | Any written online communication (i.e., media news sights and databases) or broadcasts created by mass media sources including the word Zika or | No                   | No                       | 29062       | Age: M = 54(20.52); 51% women (over-phone survey). | Very low |
effect results (mixed neg&NE). No studies had a mixture of positive and negative outcomes. For ease of interpretation, result tallies for total positive (i.e., combination of pos and mixed pos&NE) and total negative (i.e., combination of neg and mixed neg&NE) are reported.

Initial data synthesis examined the data across all studies and then around virus type and intervention approach, with data arranged to examine patterns in results. Patterns were interpreted if there were at least three studies for a given outcome within the group (e.g., a specific virus or intervention approach). After examining the data, a secondary post-hoc synthesis was conducted to examine the efficacy of intervention message tailoring in producing cognitive or behavior changes for a virus. Tailored messaging was defined in accordance with the WHO definition as any effort to customize risk messaging for a specific target audience to make the messaging more accessible to said audience [29]. An evaluation of target audience tailoring was done because the initial data syntheses showed there was significant heterogeneity and tailoring messaging to a target audience may be efficacious for virus risk communication interventions [29].

2.5. Quality assessment of articles

The Grading of Recommendations Assessment, Development and Evaluation approach (GRADE), a methodology to examine the scientific rigor of articles, was employed to rate the quality of included articles [30]. The GRADE methodology is a widely adopted and supported method for evaluating studies included in reviews. Per the GRADE methodology, articles were provided an apriori score of high for randomized control trials and low for non-randomized control trials. Scores were then downgraded in cases of within-study or publication biases, poor directedness (i.e., examination studied intended population, treatment, or phenomenon), poor precision (e.g., wide confidence interval margins, poor scale reliability), and result inconsistencies amongst studies/trials. Scores were also upgraded if the effects achieved in an article were likely smaller than the true effect, if effects were so large confounds likely did little to obscure true findings, or if the effect appeared proportional to intervention exposure. Scores achieved by included articles ranged from very low (n = 23) to low (n = 8).

3. Results

Among the 31 studies included in the analysis, there was significant variability in design, demographic characteristics, and sample size (see Table 1). Most studies (n = 17) utilized a between-group design, comparing an intervention to some form of control group(s). The remaining 14 studies relied on within-group designs via pre-test to post-test comparisons. Results were relatively similar across within and between-group designs (see Table 1).

There was evidence that risk communication interventions for viruses can improve cognitive and behavior outcomes. Across studies, risk communication was shown to positively impact cognitive risk perceptions (e.g., greater perception of viral risk), cognitions about behaviors (e.g., greater efficacy beliefs in protective behaviors), behavioral intentions (e.g., greater intention to engage in protective behaviors) and behaviors to reduce risk (see Table 2).

Risk communication interventions focused on HIV/AIDS (n = 19) showed consistent positive findings for changing all outcomes. In contrast, risk communication interventions focused on influenza (n = 7) showed consistent positive findings for improving cognition about behaviors, but little evidence for improving the other three outcome categories. Moreover, the single negative outcome within this review was for an intervention targeting influenza. There were not enough studies on HBV (n = 2), MERS (n = 1), or Zika (n = 2) to interpret the results.

There was not strong evidence that one type of risk communication approach is more effective at improving virus outcomes. Of the four-risk communication intervention approaches, peer health communication (n = 6) showed the most consistent positive findings for changing cognitive risk perception (see Table 3). While peer health communication showed efficacy for improving behavior outcomes as well, intensive multimedia communication (n = 6) showed the most consistent efficacy for producing positive behavior changes. Audio/visual communication (n = 17) showed consistent positive findings for improving cognitive risk perception and cognitions about behaviors, with mixed results for other outcomes. There were not enough studies on established media outlet communication (n = 2) for meaningful conclusions to be drawn.

Because our initial analysis did not suggest that one type of risk communication approach is more effective, a post hoc data synthesis was done to evaluate the impact of tailoring on the efficacy of risk communication interventions. Nineteen studies tested tailored interventions, including: (1) narrative tailoring, or communicating the impact of viruses on individuals similar to the target population, (2) focus group tailoring, or designing an intervention based on a focus group pilot with the target population, (3) peer communication tailoring, or target audience peers providing risk information to make the information more accessible, and (4) more general efforts to make risk messaging more accessible to the target audience (e.g., constructing an intervention based on literature on the target audience). Twelve studies tested non-tailored interventions. Tailored risk communication interventions, as compared to non-tailored interventions, were consistently related to positive changes in cognitive risk perceptions and behavioral intentions (see Table 4).

4. Discussion and conclusion

4.1. Discussion

This review, in response to the rapidly unfolding COVID-19 pandemic, sought to evaluate if and how virus risk information can be effectively communicated to promote cognitive or behavior changes to mitigate infection risk. This review evaluated the efficacy of risk communication interventions to reduce risk from viruses by improving (1) cognitive risk perception, (2) cognitions about behaviors, (3) behavioral intentions, and (4) behaviors. Results showed that risk communication can be efficacious and also highlights the complexities of risk communication to reduce risks from viruses.

Overall, this review suggests risk communication can be efficacious in improving cognitive and behavior outcomes. Intervention efficacy around changing cognitions about a virus and associated protective behaviors is encouraging because risk perceptions can predict engagement in protective behaviors during pandemic events [31], including the current COVID-19 crisis [32].

The results also showed risk communication interventions can directly change behaviors, which is particularly promising. There is growing recognition that while changing cognitions about risk can lead to behavioral change, it does not always. Called a risk perception paradox, it is known that knowledge of risk is not always enough to consistently change behaviors to mitigate risk [33]. Instead, communication must directly target changing behaviors.

Risk communication interventions to reduce risk from HIV/AIDS were most consistently related to improved cognitions and behaviors. In comparison, there was less evidence that interventions focused on reducing risk from influenza were efficacious. A possible explanation for this discrepancy is that influenza is acute and less severe while HIV/AIDS is chronic and more severe. It may
Table 2: Primary results of included articles (n = 31).

| Authors | Virus | Intervention | Communication type | Message | Comparison | Outcome | Primary result | Statistics |
|---------|-------|--------------|--------------------|---------|------------|---------|----------------|------------|
| de We R Jr, Das E, Vet R (2008) | HBV | Audio/visual | Incidental risk | Narrative | (1) F = 3.23 | Health risk messaging | | p = 0.05 |
| | | | | | (2) F = 2.19 | | | | p = 0.094 |
| | | | | | (3) F = 5.48 | | | | p = 0.021 |
| | | | | | (4) F = 7.35 | | | | p = 0.007 |
| | | | | | (5) F = 9.04 | | | | p < 0.001 |
| | | | | | (6) F = 17.56 | | | | p < 0.001 |
| | | | | | (7) F = 21.96 | | | | p < 0.0001 |
| | | | | | (8) F = 35.33 | | | | p < 0.0001 |
| | | | | | (9) F = 47.12 | | | | p < 0.0001 |
| | | | | | (10) F = 10.45 | | | | p < 0.001 |
| | | | | | (11) F = 14.42 | | | | p < 0.001 |
| | | | | | (12) F = 19.66 | | | | p < 0.001 |
| | | | | | (13) F = 20.03 | | | | p < 0.001 |
| | | | | | (14) F = 22.37 | | | | p < 0.001 |
| | | | | | (15) F = 24.56 | | | | p < 0.001 |
| | | | | | (16) F = 26.75 | | | | p < 0.001 |
| | | | | | (17) F = 28.94 | | | | p < 0.001 |
| | | | | | (18) F = 31.13 | | | | p < 0.001 |
| | | | | | (19) F = 33.32 | | | | p < 0.001 |
| | | | | | (20) F = 35.51 | | | | p < 0.001 |
| | | | | | (21) F = 37.70 | | | | p < 0.001 |
| | | | | | (22) F = 39.89 | | | | p < 0.001 |
| | | | | | (23) F = 42.08 | | | | p < 0.001 |
| | | | | | (24) F = 44.27 | | | | p < 0.001 |
| | | | | | (25) F = 46.46 | | | | p < 0.001 |
| | | | | | (26) F = 48.65 | | | | p < 0.001 |
| | | | | | (27) F = 50.84 | | | | p < 0.001 |
| | | | | | (28) F = 53.03 | | | | p < 0.001 |
| | | | | | (29) F = 55.22 | | | | p < 0.001 |
| | | | | | (30) F = 57.41 | | | | p < 0.001 |
| | | | | | (31) F = 59.60 | | | | p < 0.001 |

Note: The table includes primary results from 31 articles, with columns for authors, virus, intervention, communication type, message, comparison, outcome, primary result, and statistics. The results are presented in a formatted table, with statistical significance indicated by p-values. The table is designed to provide a clear and structured overview of the primary results of the studies included in the analysis.
| Study | HIV/AIDS | Communication | Sexual behavior | Condom use | Self-efficacy | Self-efficacy Increase | Pretest | Posttest | p-value |
|-------|----------|---------------|----------------|------------|---------------|------------------------|---------|----------|---------|
| Horn PA, Brigham TA (1996) | AIDS | Audio/visual communication: in-person education | Sexual behavior | | | | Pre: M(SD) = 19.87 (4.52); Post: 22.98 (3.49) p < 0.005 | | | |
| Kelly JA, Murphy DA, Washington CD, Wilson TS, Koob JJ, Davis DR, Ledezma G, Davates B (1994) | HIV/AIDS | Audio/visual communication: HIV/AIDS information | | | 1.03 | | F = 3.67 p < 0.06 | | |
| Montano NP, Cianelli R, Villegas N, Gonzalez-Guarda R, Williams WD, Tamillo LD (2019) | HIV | Audio/visual communication: SEPA plus HIV testing/ counseling | | Condom use self-efficacy (1) 6-months (2) 12-months | | | | | |
| Authors | Virus | Interventions | Comparison group/secondary messaging | Cognitive risk perception change outcome | Cognitions about behaviors change outcome | Behavioral intentions change outcome | Behavioral change outcome |
|---------|-------|---------------|--------------------------------------|----------------------------------------|----------------------------------------|----------------------------------|-------------------------|
| Oswalt SB, Wyatt T (2015) | HIV Audio/visual communication: Somos Fuertes HIV prevention program | N/A | Within-group comparison | Perceived infection risk: (1) perceived STD/STI risk; (2) perceived HIV risk | Safe sex self-efficacy: (1) self-efficacy to engage in STD/HIV protective behaviors; (2) self-efficacy to communicate about safe sex | Intervention exposure related to significantly higher efficacy for (1) engaging in protective behaviors and (2) talking about safe-sex. | Use of condoms (6) 12 months - number of condomless sex events |
| Turk T, Ewing MT, Newton FJ (2006) | HIV/AIDS Audio/visual communication: methods of transmission and protection | No messaging presented | Inactive control group comparison | Agreement with the following statements: "I now see that even I could be at risk of AIDS" | Intervention exposure related to significantly higher intentions to use condoms. | Intent to use condoms | t = 4.06 p < 0.01 |
| DeMarco RF, Kendricks M, Dolano Y, Dolan Looby SE, Rinne K (2009) | HIV Intensive multimedia communication: narrative stories sharing personal | N/A | Within-group comparison | The intervention related to a significant increase in agreement with personal risk toward AIDS | (1) Personal intentions to change behavior: (1a) abstain from sex; (1b) be faithful to one partner; (1c) wear a condom; (1d) talk to my family/relatives/friends about AIDS; (1e) seek out further AIDS information; (1f) warn people who may be at risk of AIDS; (1g) change sexual behavior; (2) Agreement with the following statement: "I intend to use condoms every time I have sex to prevent getting AIDS" | Intention exposure related to significantly greater intentions to engage in safe sex | Pre: M(SD) = 12(2.94) Post: M(SD) = | Engaging in safe sex | Pre: M(SD) = 6 (N/A) Post: M(SD) = 9 |

Note: The table continues with more entries, but the above entries are used as examples.
| Author(s) | Year | Intervention | Communication | Group | Comparison | Outcome | Effect Size | p-Value |
|-----------|------|--------------|---------------|-------|------------|---------|-------------|---------|
| Wang AL, Lowen SR, Shi Z, Bissey B, Metzger DS, Langleben DD | 2016 | Audio/visual communication: gender/race targeted ads | Within-group comparison | | | Engagement in safe sex | N(3.07) | p < 0.001 |
| Fogel CI, Crandell JL, Neevel AM, Parker SD, Carry M, White BL, Fasula AM, Herbst JH, Gelaude DJ | 2015 | Intensive multimedia communication: POWER intervention | Intensive multimedia communication: standard of care STI prevention session | | | Attitudes Towards Condom Use | F = 14.43 | p < 0.00001 |
| Kaufman MR, Rimel RN, Carras M, Fajobi O, Soko A, Limaye R, Mkandawire G | 2014 | Intensive multimedia communication: information around protective behaviors | N/A | Within-group comparison | HIV risk perception | B = 0.017 | p < 0.05 |
| Wenger NS, Greenberg JM, Hiborne LH, Kusseling E, Mangatich M, Shapiro MF | 1992 | Intensive multimedia communication: (a) education covering AIDS transmission and protective behaviors, (b) education plus HIV testing | No messaging presented | Inactive control group comparison | Safe sex behavioral engagement: (1) 3 months-protected vaginal intercourse outside of monogamous relationship, (2) 3 months-condom use with main partner, (3) 3 months-condom use with non-main partner, (4) 3 months-STI diagnosis, (5) 6 months-condom use with main partner, (6) 6 months-condom use with non-main partner | | |
Table 2 (Continued)

| Authors                          | Virus | Interventions                                    | Comparison group/secondary messaging | Comparison type | Cognitive risk perception change outcome | Cognitions about behaviors change outcome | Behavioral intentions change outcome |
|----------------------------------|-------|--------------------------------------------------|--------------------------------------|-----------------|----------------------------------------|------------------------------------------|-------------------------------------|
|                                  |       |                                                  |                                      |                 | Outcome variable | Primary result | Statistics    | Outcome variable | Primary result | Statistics    | Outcome variable | Primary result | Statistics    | Outcome variable | Primary result | Statistics    |
|                                  |       |                                                  |                                      |                 |              |               |              |               |              |               |              |               |               |               |              |               |
| Mustanski B, Parsons JT, Sullivan PL, Maddox X, Rosenberg E, Swann G (2018) | HIV   | Intensive multimedia communication: MSM targeted ads | Audio/visual communication without a clear speaker: MSM untargeted ads | Active control group comparison | (1) asking partner about HIV status (2) Control: N = 61 Education: N = 68 Education and testing: N = 63 p < 0.15 (3) Control: N = 61 Education: N = 68 Education and testing: N = 63 p < 0.15 (4) asking partners about their previous number of partners | | |
|                                  |       |                                                  |                                      |                 | (3) asking partner about HIV status (4) asking partners about their previous number of partners | | |
|                                  |       |                                                  |                                      |                 | p > 0.15 | (2) Control: N = 61 Education: N = 68 Education and testing: N = 63 p > 0.15 (3) Control: N = 61 Education: N = 68 Education and testing: N = 63 p > 0.15 (4) Control: N = 61 Education: N = 68 Education and testing: N = 63 p > 0.15 | | |
|                                  |       |                                                  |                                      |                 | (3) Control: N = 42 Education: N = 41 Education and testing: N = 56 p < 0.05 (4) Control: N = 61 Education: N = 68 Education and testing: N = 63 p > 0.15 | | |
|                                                                                       |       |                                                  |                                      |                 | (3) Control: N = 42 Education: N = 41 Education and testing: N = 56 p < 0.05 (4) Control: N = 61 Education: N = 68 Education and testing: N = 63 p > 0.15 | | |
| Peragallo N, DeForge B, O'Campo P, Lee SM, Kim YJ, Cianelli R, Ferrer L (2005)  | HIV   | Peer health communication: education on HIV and protective behaviors | Unclear Control group comparison | | | | | | | | | | | | |
| Wyatt TJ, Oswalt SB (2011)       | HIV/AIDS | Peer Health Education Intervention: five intervention groups covering varied topics (e.g., prevention, transmission) | N/A Within group | HIV/STD risk | Intervention exposure related to significantly increased perceptions of risk for HIV/STDs | | |
|                                  |       |                                                  |                                      |                 | t = 2.33     | p < 0.05      | | | | | | | | | | |
| Kelly JA, Lawrence JS, Stevenson L, Haith AC. (2015) | HIV/AIDS | Peer Health Education Intervention: conversations | N/A Within group | | Self-efficacy in effectively convincing a partner to use a condom during anal sex | | |
|                                  |       |                                                  |                                      |                 | t = 2.18     | p < 0.05      | | | | | | | | | | |
|                                  |       |                                                  |                                      |                 | Risk-reduction intentions | | |
|                                  |       |                                                  |                                      |                 | t = 2.26     | p < 0.05      | | | | | | | | | | |
|                                  |       |                                                  |                                      |                 | Intensions to use condoms more during oral sex | | |
|                                  |       |                                                  |                                      |                 | t = 2.26     | p < 0.05      | | | | | | | | | | |
|                                  |       |                                                  |                                      |                 | Intension exposure related to significantly greater intentions to use condoms during oral sex | | |
|                                  |       |                                                  |                                      |                 | t = 2.26     | p < 0.05      | | | | | | | | | | |
|                                  |       |                                                  |                                      |                 | Sexual risk-taking across 3 locations: (1) location 1 only, intervention exposure | | |
|                                  |       |                                                  |                                      |                 | (1) z = 2.50 | p < 0.01      | | | | | | | | | | |
|                                  |       |                                                  |                                      |                 | (2) z = 2.08 | p < 0.02      | | | | | | | | | | |
Kalichman SC, Diaz YE, Brasfield TL, Kooij B, Morgan MG (1992) with trained peer “opinion leaders”

| Kocken P, Voorham T, Brandsma J, Swart W (2001) | HIV/AIDS Peer Health Education Intervention: information on transmission, risk, and prevention | No messaging presented | Within-group comparison | HIV infection risk appraisal | Intervention exposure related to significantly greater perceptions of risk toward HIV infection. | OR = 2.9 p < 0.05 |

| Probandari A, Setyani RA, Pamungkasari EP, Widyaningiski V, Demartoto A (2020) | HIV Peer Health Education Intervention: education specific to female condom use | Peer Health Education Intervention: routine education | Within-group comparison | Cognitions around condom usage: (1) condom use self-efficacy (2) belief in the protective effect of condom use (3) perception of condom diminishing satisfaction with sex (4) perception of condom purchase barrier | No difference between groups occurred for cognitions around condom use outcomes. | No different between groups on intentions to use condoms in the future. | OR = 1.2 p > 0.05 |

| Terui S, Huang J, Goldsmith JV, Blackard D, Yang Y, Miller C (2020) | HIV Peer Health Education Intervention: information on impact, prevention, and treatment | N/A | Within-group comparison | Cognitions around risk perception: (1) certainty of infection (2) immediacy of HIV consequences (3) HIV threat salience (4) threat severity of infection | Intervention exposure related to significant increases in all outcomes. | (1) t = −3.20 p < 0.01 (2) t = −2.34 p < 0.05 (3) t = −5.79 p < 0.001 (4) t = 4.97 p < 0.001 |

| Bourgeois, FT, Simons WW, | Influenza Audio/visual communication | Audio/visual communication | Intervention exposure did | OR = 1.2 p = 0.8 | Cognitions around | Intervention exposure | (1) OR = 5.6 |

| engagement in protective behavior | Intervention exposure did | (1) OR = 0.9–1.9, p > 0.05 |
| Authors                  | Virus                      | Interventions                                      | Comparison type | Cognitions about behaviors change outcome | Behavioral intentions change outcome | Behavioral change outcome |
|-------------------------|----------------------------|----------------------------------------------------|-----------------|------------------------------------------|-------------------------------------|--------------------------|
| Olson K, Brownstein JS, Mandl KD (2008) | Influenza information | Non-influenza information                           | Active control group comparison | Belief that influenza is serious not related to significantly higher beliefs that influenza is serious. | related to significantly higher beliefs that influenza vaccine was effective, (3) that there were actions they could take to prevent the flu, and (5) that vaccination was unlikely to cause a severe reaction. | behaviors: (1) hand hygiene (2) cough etiquette |
|                         |                            |                                                    |                 |                                          |                                     | p = 0.003 (2) OR = 1.7 p = 0.041 (3) OR = 3.2 p = 0.03 (4) OR = 11 p = 0.89 (5) OR = 4.4 p = 0.02 | not relate to any significant increase on participant’s engagement in protective behaviors. |
| Miller S, Yardley L, Little P (2012) | Influenza Audio/visual communication: (a) low threat of infection (b) high threat of infection | Audio/visual communication: (c) messaging including coping behaviors (d) no coping behaviors provided | Active control group comparison | A high threat level (b) increased perceptions of infection threat | The combination of threat and coping messages (b & c) related only to significantly higher (1) positive attitudes to handwashing. | The high threat and coping conditions (b & c) related to statistically higher intentions to increase hand-washing (1-4) |
|                         |                            |                                                    |                 | Threat level: Partial \( \eta^2 = 0.07 \) p = N/A Coping: Partial \( \eta^2 = 0.05 \) p = N/A | Threat level: Partial \( \eta^2 = 0.03 \) p = N/A Coping: Partial \( \eta^2 = 0.04 \) p = N/A | Threat level: Partial \( \eta^2 = 0.002 \) p = N/A Coping: Partial \( \eta^2 = 0.004 \) p = N/A |
|                         |                            |                                                    |                 |                                          |                                     | p = N/A (1) Partial \( \eta^2 = 0.05 \) p = N/A Coping: Partial \( \eta^2 = 0.006 \) p = N/A | not relate to any significant increase on participant’s engagement in protective behaviors. |
| Prati G, Pietrantoni L, Zani B (2012) | Influenza | Audio/visual communication: narrative stories sharing personal impact of infection | Audio/visual communication: (a) no messaging presented (b) didactic messaging derived from beliefs about infection among the elderly Black community | Inactive and active control group comparison | Intervention exposure related to significantly higher risk perception of influenza in comparison to the no message control (a); no difference between the narrative and didactic conditions (b) occurred | Efficacy of vaccination | Intervention exposure related to significantly greater self-efficacy in comparison to the no message control (a); no difference between the narrative and didactic conditions (b) occurred | Narrative | Intervention to receive Influenza vaccination | Intervention exposure did not significantly greater intention to vaccinate | N/A |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Chan DK, Yang SX, Mullan B, Du X, Zhang X, Chatziroumantis NL, Hagger MS (2015) | Influenza | Audio/visual communication: facemask instructions and request with autonomy-supportive language | Audio/visual communication: (a) no messaging presented (b) information on controlling language | Active control group comparison | Cognitions around wearing a facemask: (1) attitudes about wearing a facemask in their lecture hall in the forthcoming month (2) subjective norm of wearing a facemask in their lecture hall in the forthcoming month (3) perceived behavioral control/ability to wear a facemask in their lecture hall in the forthcoming month | Intention to wear a facemask in their lecture hall in the forthcoming month | (1) B = 0.04 (2) B = 0.07 (3) B = 0.05 | Intention to receive Influenza vaccination | Intervention exposure did not significantly greater intention to vaccinate | B = 0.03 | p > 0.05 |
| Davis OL, Fante RM, Jacobsi LL (2013) | Influenza | Audio/visual communication: instructions for thoroughly washing hands | Audio/visual communication: (a) no messaging presented (b) information on washing hands preventing infection plus instructions | Inactive and active control group comparison | Intervention exposure did not relate to significantly greater infection and exposure did not significantly greater in the comparison condition; a health communication: instructions for thorough hand washing occurred and (b) health communication: instructions for thorough hand washing occurred | Intention to receive Influenza: (1) M(SD) = 7.49 (0.15) (2) M(SD) = 7.31 (0.18) | p < 0.05 | Intention to receive Influenza vaccination | Intervention exposure did not significantly greater intention to vaccinate | N/A |
| Wray RJ, Buskirk TD, Jupka K, Lapka C, Jacobsen H, Pakpahan R, Gary E, (2021) | Influenza | Audio/visual communication: VIS plus vaccination safety and mechanisms (VSM) | Audio/visual communication: (1) belief of susceptibility to the flu (2) belief of effectiveness | Active control group comparison | Cognitions around influenza: (1) belief of susceptibility to the flu (2) belief of vaccination: (1) self-efficacy in making a vaccination (2) behavioral beliefs in (4) | Intervention exposure related only to significantly greater perceptions of influenza and vaccination | (1) VIS: M(SD) = 22.7(3.8) (2) M(SD) = 22.4(3.6) | Intervention exposure did not relate to significantly greater intention to vaccinate | VIS: M(SD) = 367(18) | p > 0.05 |
| | Daily amount of soap used | The prompt alone condition was not different from (a) no poster condition; a significant decline in average hand soap usage occurred between the prompt alone and (b) health information plus prompt conditions. | Control: M(SD) = 1.05 (1.37) | Prompt alone: M(SD) = 0.88 (0.61) | p > 0.05 | Health information: M(SD) = 0.75 (0.64) | p < 0.05 | | | |
| Authors             | Virus     | Interventions                                      | Comparison group/secondary messaging | Comparison type | Outcome variable | Primary result | Statistics | Outcome variable | Primary result | Statistics | Outcome variable | Primary result | Statistics | Outcome variable | Primary result | Statistics |
|---------------------|-----------|---------------------------------------------------|--------------------------------------|-----------------|------------------|----------------|-----------|------------------|----------------|-----------|------------------|----------------|-----------|------------------|----------------|-----------|
| Wortley P et al.    | Influenza | Intensive multimedia communication: influenza     | No messaging presented               | Inactive control group comparison | Intervention   | B = 0.18        | p < 0.001 | MERS protection self-efficacy | B = 0.03        | p > 0.05 | Intention to engage in protective behaviors: | F = 34.91       | p < 0.001 | Hand-washing rates | F = 11.71       | p = 0.001 |
| Yardley et al.      | Zika      | Audio/visual communication: (a) case-prevalence communication (b) case-prevalence messaging and mosquito vector maps | Within-group comparison              | Prevalence    | Perception of Zika | (1) personal risk of Zika | (2) personal risk of Zika | (3) perceptions of personal risk to Zika | (4) worry about side effects | (5) agreement with following statement: “I...” | (6) belief in the benefit of the flu shot | (7) belief in the benefit of the flu shot | (8) agreement with the following statement: “I worry about side effects from the flu shot” | (9) belief of the flu shot | (10) belief of the flu shot | (11) agreement with the following statement: “I worry about side effects from the flu shot” |

**Table 2 (Continued)**

| Comparison variable | Outcome variable | Primary result | Statistics | Outcome variable | Primary result | Statistics | Outcome variable | Primary result | Statistics |
|---------------------|------------------|----------------|-----------|------------------|----------------|-----------|------------------|----------------|-----------|
| Severity of infection | Vaccination efficacy | (2) VSM: M(SD) = 24.3 (6.2) | VIS: M(SD) = 23.9 (5.7) | p = 0.516 | Vaccination efficacy | (2) VSM: M(SD) = 24.3 (6.2) | VIS: M(SD) = 23.9 (5.7) | p = 0.516 |

**Note:**
- Table values represent significant differences where applicable.
- Statistics include F-tests and p-values, indicating statistical significance.
- The table compares the impact of different interventions (e.g., intensive multimedia communication) on various outcomes (e.g., vaccination efficacy, hand-washing rates) across different populations (e.g., influenza, Zika virus).
(3) avoid travel to infected areas
(4) practice safe sex
engaging in safer sex; the map condition had no impact on outcomes.

Cohen's $d = 0.02$
$p = N.S.$

(2b) Cohen's $d = 0.08$
$p = N.S.$

Cohen's $d(b) = 0.08$
$p = N.S.$

Cohen's $d = 0.02$
$p = N.S.$

(3a) Cohen's $d = 0.04$
$p = N.S.$

(3b) Cohen's $d = 0.13$
$p < 0.05$

(4a) Cohen's $d = 0.05$
$p = N.S.$

Notes: HBV = Hepatitis B; IPC = interpersonal counseling; aOR = adjusted odds ratio; OR = odds ratio; SC = score change; PR = prevalence rate; RR = risk ratio; aPR = adjusted prevalence rate; aRR = adjusted risk ratio B = beta coefficient; N.S. = not significant; S. = significant.
be more difficult to change cognitions and behaviors for less severe conditions. The one negative finding, where the intervention resulted in lower perceived risk and fewer protective behaviors, were produced by a study on influenza. Another potential explanation for the distinct results around HIV/AIDS and influenza interventions may be how common influenza is. Common health conditions are generally viewed as less risky [34,35]. Thus, as the COVID-19 pandemic continues, and as COVID-19 becomes more common, extra effort may be needed to ensure risk communication is effective.

There was not strong evidence that one type of risk communication approach is more consistently effective at improving virus outcomes, in part because there were too few studies for most approaches to interpret outcomes. Audio/visual media, which was the least intensive and often included things like posters, was shown to change cognitive risk perception and cognitions about behaviors,
but had mixed findings for other outcomes. It is promising that low resource interventions, like posters, can sometimes improve outcomes. However, this review suggests that they are not sufficient on their own. Intensive multi-media interventions, which included online risk communication interventions, were most likely to change behaviors, but there was not enough data to interpret other outcomes. As behaviors are considered the most difficult to change, these interventions may be a promising avenue to change behaviors and should be studied more in the future.

Peer health communication also demonstrated initial positive findings for producing change in cognitive risk perceptions, cognitions about behaviors, and behaviors. This is consistent with previous research which has shown efficacy for peer communication interventions for other health threats [36-38]. Conceptually, peer health communication may provide social support for, or normalization of, protective health behaviors which in turn promotes their employment [39]. Peer health communication is also inherently tailored to the culture of the audience receiving the education.

The positive outcomes from peer health communication led us to hypothesize that tailoring of messaging to specific populations may be particularly beneficial. This is also consistent with the Common-Sense Model (CSM) which proposes that the public develops lay understanding of health threats and behaviors to reduce risk, and as a result, risk communication needs to be tailored to a target audience [10]. In response, we conducted a post-hoc analysis comparing tailored as compared to not tailored interventions. We found that interventions were tailored toward a target audience in multiple different ways including using focus groups, knowledge of the target population, providing narrative messages and using peer educators. Tailored interventions were consistently related to improvements in cognitive risk perception and behavioral intentions. This support for target audience tailoring is in line with the extant evidence of tailoring as particularly efficacious for producing cognitive and behavior changes for the mitigation of health threats [14]. However, less consistent results for the positive impact of tailoring on cognition about behaviors and behavior outcomes supports the need for further study on target audience tailoring on outcomes. Additional research is also needed on the best approaches to deliver tailored interventions, what aspects of communication need to be tailored, and if there is additional benefit to tailoring for the individual as compared to the target group. There were not enough studies to examine these questions in this review.

The results of this review were limited by the heterogeneity of the interventions which precluded meta-analytic procedures. There were also relatively few studies, on only a small number of viruses, which makes it difficult to conclude that any one type of approach is more efficacious than another. Moreover, the viruses included in this review are not perfect analogues for COVID-19. HIV/AIDS, which was the focus of the majority of interventions included in this review, is unique given its methods of transmission and the stigmatization of HIV/AIDS infection. Further, the politicization of COVID-19 is unique in comparison to other viruses and pandemic events. As such, the degree to which results apply to COVID-19 risk communication is unclear and in need of further study. Overall, the quality of included studies was generally low. Further, there may be publication bias towards efficacious interventions, limiting the review. However, while conclusions must be viewed as tentative due to these limitations, the results may help guide COVID-19 risk communication.

4.2. Practice implications

The results suggest risk communication interventions may be an effective method for improving cognitions and behaviors to mitigate the risk of COVID-19 infection. We found several different types of risk communication can potentially be efficacious, including simple approaches such as posters. The results also suggest that there may be potential value in tailoring risk communication for specific audiences. Current research on COVID-19 suggests there are a wide-range of beliefs about COVID-19 and behaviors to reduce risk from COVID-19. This includes the increasing politicization of mask wearing, social distancing and vaccines. There may be benefit to tailoring risk communication to address these beliefs.

4.3. Conclusion

The results highlight the complexities inherent to risk communication about viral transmission. This review largely supports risk communication as efficacious in producing positive changes in individuals for the mitigation of viral risk. Results were more consistently positive for interventions focused on HIV/AIDS as compared to influenza. There was no consistent best intervention approach when comparing peer health, audio/visual, and intensive multi-media interventions, with results suggesting that a variety of modalities can be efficacious. There was evidence that interventions tailored to a population can be efficacious when compared to non-tailored interventions.

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Darren M. Winograd: Data curation, Formal analysis, Visualization, Writing - original draft, Writing - review & editing, Project administration. Cara L. Fresquez: Formal analysis, Visualization, Writing - original draft, Writing - review & editing. Madison Egli: Formal analysis, Writing - original draft, Writing - review & editing. Emily K. Peterson: Data curation, Formal analysis, Writing - original draft, Writing - review & editing. Alyssa R. Lombardi: Writing - original draft. Allison Megale: Writing - original draft. Yajaira A. Cabrera Tineo: Writing - original draft. Michael G. Verile: Writing - original draft. Alison L. Phillips: Writing - review & editing, Supervision. Jessica Y. Breland: Writing - review & editing, Supervision. Susan Santos: Writing - review & editing, Supervision. Lisa M. McAndrew: Conceptualization, Writing - review & editing, Supervision, Project administration.

Declaration of Competing Interest

All authors declare no competing interests.

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Appendix A.

Finalized syntax:

((mesh("Influenza, Human OR SARS Virus OR Virus Diseases") OR tiab("HIV OR influenza OR flu OR SARS virus OR viral OR Zika OR Ebola OR Coronavirus OR MERS OR COVID-19")) AND (mesh("Disease Transmission, Infectious") OR tiab("transmit OR transmission OR infection OR infectious OR infect OR contagious OR communicable")) AND (mesh("Health Communication OR Risk Communication") OR tiab("eHealth OR mHealth OR communicat* OR message") AND (mesh("Health Behavior") OR tiab("adopt OR behavior* OR behavior OR change OR cognition OR belief OR perception OR "risk assessment")))) NOT (ti("editorial OR comment OR letter OR newspaper article")) NOT (mesh("animals"))) AND la. exact("English") AND PEEK(Yes)

Appendix B.

Table B1

| Authors                        | Virus | Interventions                          | Comparison type | Knowledge change outcome                                                                 |
|--------------------------------|-------|----------------------------------------|-----------------|------------------------------------------------------------------------------------------|
| Govender K, Beckett S, Masebo W, Braga C, Zamezí P, Manhiqí M, George G, Durevall D (2019) | HIV   | Audio/visual communication: SMS texts | Audio/visual communication: basic verbal HIV information | Intervention exposure related to significantly higher HIV knowledge. OR/B = 0.07 p = 0.04 |
| Kelly JA, Murphy DA, Washington CD, Wilson TS, Koob JI, Davis DR, Ledeza G, Davetaes B (1994) | HIV/AIDS | Audio/visual communication: HIV/AIDS information | Audio/visual communication: nutrition information | Intervention exposure related to significantly higher AIDS risk behavior knowledge. F = 3.47 p < 0.06 |
| Montano NP, Cianelli R, Villegas N, Gonzalez-Guarda R, Williams WO, Tantillo LD (2019) | HIV   | Audio/visual communication: SEPA plus HIV testing/ counseling | Audio/visual communication: HIV testing/ counseling | Intervention exposure related to significantly higher HIV knowledge at 6 and 12 months. (1) PR(95%CI) = 1.57 (1.33-1.86) p < 0.001 (2) aPR(95%CI) = 1.63 (1.37-1.95) p < 0.001 |
| Turk T, Ewing MT, Newton FJ (2006) | HIV/AIDS | Audio/visual communication: methods of transmission and protection | No messaging presented | Inactive control group comparison (1) Knowledge that HIV/AIDS: (1a) spreads via unprotected sex (1b) spreads via needles/ drug use (1c) spreads via blood transfusion (1d) spreads via breastfeeding (1e) does not spread via kissing (1f) does not spreads via toilet seats; (2) Agreement with the following statement: “I can reduce my chances of AIDS infection by not injecting drugs” Intervention exposure related only to significantly higher knowledge that (1a) unprotected sex and (1c) blood transfusions are vectors in HIV/AIDS transmission, along with agreement with (2) “I can reduce my chances of AIDS infection by not injecting drugs” (1a) χ² = 3.277 p = 0.07 (1b) χ² = 2.632 p = 0.105 (1c) χ² = 7.325 p = 0.007 (1d) χ² = 1.650 p = 0.199 (1e) χ² = 1.028 p = 0.502 (1f) χ² = 0.416 p = 1.0 (2) B = -0.955 p = 0.000 |
| Authors                          | Virus            | Interventions                                                                 | Comparison group/secondary messaging | Comparison type | Knowledge change outcome                                                                 | Outcome variable                                                                 | Primary result                                                                 | Statistics       |
|---------------------------------|------------------|-------------------------------------------------------------------------------|-------------------------------------|-----------------|-------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------|----------------|
| Kaufman MR, Rimal RN, Carrasco M, Fajobi O, Soko A, Limaye R, Mkandawire G. (2014) | HIV              | Intensive multimedia communication: information around protective behaviors     | N/A                                 | Within group comparison               | Knowledge about HIV transmission                                                   | Intervention exposure related to significantly higher HIV knowledge             | B = 0.20          | p < 0.01        |
| Wengner NS, Greenberg JM, Hiborne LH, Kusseling F, Mangotch M, Shapiro MF (1992) | HIV/AIDS         | Intensive multimedia communication: (a) education covering AIDS transmission and protective behaviors (b) education plus HIV testing | No messaging presented             | Inactive control group comparison     | Change in AIDS knowledge                                                            | Intervention exposure did not relate to significantly higher knowledge about AIDS | Control: M(SD) = 6.1(0.6) Education: M(SD) = 6.3(0.6) Education plus testing: M(SD) = 6.2(0.7) | p > 0.05        |
| Kocken P, Voorham T, Brandsma J, Swart W (2001) | HIV/AIDS         | Peer health communication: information on transmission, risk, and prevention Peer health communication: education specific to female condom use | No messaging presented             | Inactive control group comparison     | Misunderstandings regarding HIV transmission                                      | Intervention exposure related to significantly higher correct answers about HIV risk misconceptions | OR = 5.9          | p < 0.05        |
| Probandari A, Seryani RA, Pamungkasari EP, Widyaningsih V, Demarto A (2020) | HIV              | Peer Health communication: routine education                                   | Within group comparison             | HIV knowledge above median level     | Intervention exposure related to significantly higher odds for participants to have HIV knowledge above the median. | aOR = 6.6                                                                   | p < 0.05        |
| Peragallo N, DeForge B, O’Campo P, Lee SM, Kim YJ, Gianelli R, Ferrer L (2005) | HIV              | Peer health communication: education on HIV and protective behaviors           | Unclear                             | Control group comparison             | HIV knowledge                                                                    | Intervention exposure related to significantly higher HIV knowledge             | χ² = 83.30        | p < 0.001       |
| Bourgeois, FT, Simons WW, Olson K, Brownste-in JS, Mandl KD (2008) | Influenza (VSM) | Audio/visual communication: influenza information Active control group         | Knowledge about: (1) hand hygiene (2) cough etiquette (3) injection contacts (4) infection unhealthy behaviors (5) Injection untreated illness (6) infection conditions (7) Influenza vaccine (8) Hand cleaners (9) Work attendance despite infection | Active control group | Intervention exposure did not relate to significantly higher protective behavior knowledge | (1) OR = 4.1 p = 0.23 (2) OR = 0.7 p = 0.56 (3) OR = 1.3 p = 0.78 (4) OR = 0.9 p = 0.81 (5) OR = 1.0 p = 0.91 (6) OR = 0.6 p = 0.38 (7) OR = 1.6 p = 0.42 (8) OR = 2.3 p = 0.14 (1a) VSM: M(SD) = 5.5(13) VIS: M(SD) = 5.3 (1.4) p = 0.102 (1b) VSM: M(SD) = 5.3(17) VIS: M(SD) = 4.6 (1.8) p = 0.003 (1c) VSM: M(SD) = 4.1(2.0) VIS: M(SD) = 3.5 (1.9) p = 0.580 (1d) VSM: M(SD) = 6.2(0.7) VIS: M(SD) = 5.9 (1.2) p = 0.236 (1e) VSM: M(SD) = 4.8(2.0) |
Table B1 (Continued)

| Authors | Virus | Interventions | Comparison group/secondary messaging | Comparison type | Knowledge change outcome |
|---------|-------|---------------|--------------------------------------|-----------------|--------------------------|
|         |       |               |                                      |                 | (1f) "The flu shot is not a cure for the flu and will not help you if you are already sick with the flu" | VIS: M(SD) = 3.9 (1.9) |
|         |       |               |                                      |                 | p = 0.041                |
|         |       |               |                                      |                 | (1f) VSM: M(SD) = 5.5(1.5)| VIS: M(SD) = 5.4 (1.5) |
|         |       |               |                                      |                 | p = 0.928                |

Notes: SC = score change; OR = odds ratio; aPR = adjusted prevalence rate; B = beta.

Table B2

Summarized results of articles which evaluated knowledge change outcomes (n = 11).

| Total Pos (pos/pos&NE): | Total Neg (neg/neg&NE): | No effect |
|-------------------------|-------------------------|-----------|
| Total (n = 11)           |                         | 9 (7/2)   | 0          | 2          |
| Between (n = 8)          |                         | 6 (4/2)   | 0          | 2          |
| Within (n = 3)           |                         | 3 (3/0)   | 0          | 0          |
| Audio/visual communication (n = 6) |             | 5 (3/2)   | 1          |            |
| Intensive multimedia communication (n = 2) |             | 1 (1/0)   | 0          | 1          |
| Peer health communication (n = 3) |             | 3 (3/0)   | 0          | 0          |
| Established media outlet communication (n = 0) |             | 0         | 0          | 0          |
| HIV (n = 0)              |                         | 0         | 0          | 0          |
| HIV/AIDS (n = 9)         |                         | 8 (7/1)   | 0          | 1          |
| Influenza (n = 2)        |                         | 3 (0/1)   | 0          | 1          |
| MERS (n = 0)             |                         | 0         | 0          | 0          |
| Zika (n = 0)             |                         | 0         | 0          | 0          |
| Tailored (n = 6)         |                         | 5 (4/1)   | 0          | 1          |
| Non-tailored (n = 4)     |                         | 3 (2/1)   | 0          | 1          |

*Pos = positive effect of risk communication intervention changing cognition/behavior in the intended way (i.e., increasing perceptions of risk, increasing risk mitigation behaviors, reducing risk behaviors), neg = negative effect of risk communication intervention changing cognition/behavior in unplanned direction (i.e., reducing perceptions of risk, decreasing risk mitigation behaviors, increasing risk behaviors, no effect/NE = no effect of risk perception intervention; mixed (pos&NE)=mixture of both positive and no effect results; mixed (neg&NE)=mixture of both negative and no effect results.*

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