Health information seeking, processing, and sharing
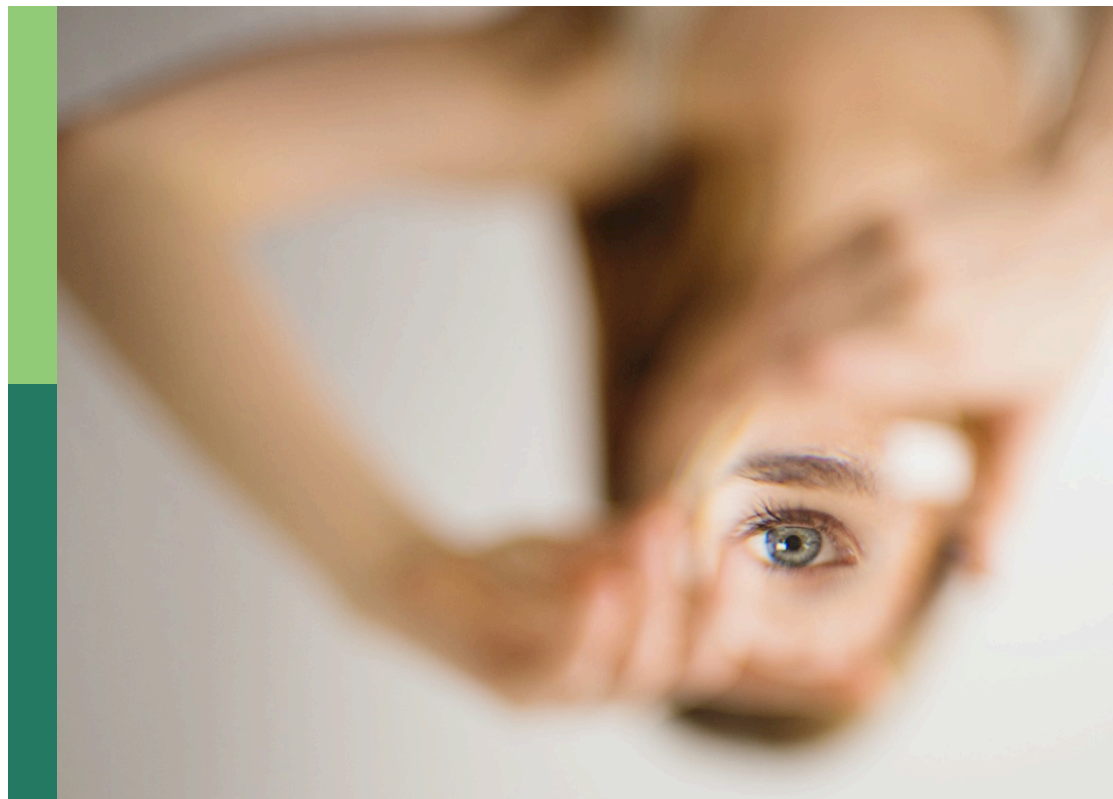
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Health information seeking, processing, and sharing

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Editorial: Health information seeking, processing, and sharing

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Editorial on the Research Topic
Health information seeking, processing, and sharing

Health is important to all aspects of a person's life. Thus, it comes as no surprise that people spend a great deal of time communicating about health. Over the past several decades, digital platforms and technology have made health information widely available, but unfortunately, the credibility of that information is far from consistent. Worse, individuals may have trouble finding and understanding the appropriate information and judging its value and relevance. When erroneous information is shared and spread through social networks, the difficulty of judging the credibility and accuracy of information is amplified.

During the global COVID-19 pandemic, individuals were receiving a great deal of information, not only facts about health but also governmental operations, politics, and the global economy, among many other topics. Along with this valid information surge came a great many rumors, falsehoods, and outright lies. The World Health Organization called this information overload laced with misinformation the "infodemic."

Fueled by this "infodemic," health communication research intensified, focusing on how and why people seek the health information they do, how they process it and what factors may influence that processing, what types of behaviors and behavioral intentions can be influenced, and how and why might individuals subsequently share information with others. This Research Topic sought to bring studies from each of these key areas together.

Some overall trends emerged in the submitted studies. Studies examining each of these critical subareas — health information seeking, processing, and sharing alike — are interested in the emotionality and social aspects of information and how those aspects interact with other message factors or individual differences to facilitate health information processes, subsequent attitudes, and behaviors.

In the area of information processes, several studies examine the role of social influences in messaging on behavioral intentions. For example, Wang et al. investigate social nudging information as it contributes to blood donation intentions. Other studies focus on social influences, but in the context of an emotional appeal. Liu et al. examine the combined influence of fear appeals with social norm information on vaccination

intentions. Bailey et al. also examine the combination of social information in fear-based messages, finding that social eating cues can helpfully buffer negative responses to fear appeals *via* their positive emotional and motivational aspects, but these aspects may backfire and fail to decrease unhealthy eating intentions.

Other information processing studies in this Research Topic are interested in other types of appeal techniques. Vandeberg et al. examine whether the type of text presentation (narrative vs. expository) influenced vaccination attitudes in individuals of varying vaccination hesitancy. Their findings indicate that motivated processing, rather than narrative persuasion, is a common health persuasion tactic. Myrick et al. also examine the role of different types of appeals in processing and responding to social imagery. They find that in the context of young women receiving sun-safety interventions in a social media context, the types of appeal utilized should consider the type of evoked emotions to create the most promising attentional and attitudinal outcomes.

Other studies are more interested in the individual differences of the information processor, especially individual differences in social and family structures.

For example, Zhang et al. investigate factors that persistently contribute to physical activity intentions, identifying social and family support as critical predictors. Mai et al. examine the role of personality traits in health literacy formation across different family structures. Marschalko et al., on the other hand, were interested in generational differences. They identify different information processing strategies for vaccine-related information across Gen X, Y, and Z Hungarian women, with Gen X and Z focusing more on benefits and Y focusing more on risks.

In the area of information sharing, investigations of affective impacts are again at the forefront. Huang et al. examine how individual experiences of pandemic anxiety influenced whether individuals were more willing to share unverified information that had been previously extensively shared, finding that sharing may be an anxiety coping mechanism in this type of scenario. Further, Li and Wang investigate the role of communication apprehension and health literacy in the willingness to share health information with physicians online and overall patient-physician relationships.

Lastly, in the area of information seeking, perhaps unsurprisingly, bias is a prominent topic. For example, Suzuki and Yamamoto examine the moderating effect of health literacy on confirmation bias in health search selection. Wedderhoff et al. also examine biases, investigating the role of risk feedback in

selective exposure to health-related information. Their findings highlight an impetus to select and consume information that would alleviate threats related to the risk raised by messaging.

Another information-seeking study examines information features and their influence on search processes. Wei and Hsu use topic modeling techniques to examine how certain features of online physician profiles expressing their different expertise affected individuals' search processes and responses.

The studies presented here highlight the complex nature of health in the digital age. The information landscape is dense and difficult to navigate given the rising levels of health mis- and disinformation. But the pressing need to advocate for and educate oneself about health and risk is communicated consistently. Thus, the attention given to emotional and social aspects of information, especially in the context of a host of individual differences, including bias, is promising given that misinformation, especially the sort with malicious intent (i.e., disinformation), often capitalizes on emotional appeals and social frames to gain attention and action. A key challenge for health communication research and practice moving forward will be determining how these and other important information characteristics function, especially in certain population subgroups.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The COVID-19 Pandemic Changes the Nudging Effect of Social Information on Individuals' Blood Donation Intention

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The positive effect of social information on nudging prosocial behavior is context dependent. Understanding how sensitive intervention outcomes are to changes in the choice context is essential for policy design, especially in times of great uncertainty, such as the current COVID-19 pandemic. The present paper explores the effectiveness of social information in changing voluntary blood donation intention in two contexts: before and after the peak of the COVID-19 pandemic in China. In addition to the dimension of context, information content and its source are also important. Using a survey administered to 1,116 participants, we conducted an intertemporal randomized-controlled experiment to systematically analyze how information can effectively nudge the intention to donate blood. Compared with content featuring blood donors' commendation information, blood users' demand information is found to have a stronger nudging effect. An official information source has a greater influence on participants' donation intention than an unofficial source. Furthermore, our analysis of two waves of experimental data (i.e., before and after the peak of the COVID-19 pandemic) shows that the COVID-19 pandemic has further enhanced the nudging effect of blood users' demand information and official information sources. These findings provide a theoretical basis and policy recommendations for relevant institutions to develop effective blood donation campaign strategies.

Keywords: COVID-19, blood donation, nudge, social information, information content, information source

INTRODUCTION

The COVID-19 pandemic poses a substantial challenge to global human well-being. Globally, it has been creating major disruptions at all levels of healthcare provision (Stanworth et al., 2020). Maintaining an adequate and consistent supply of blood to support ongoing needs is critical, as blood transfusion is essential for the operation of modern health services. Given safety and ethical concerns, non-government organizations, such as the World Health Organization, advocate donating blood, "the gift of life," in a voluntary and unremunerated manner (World Health Organization, 2015). However, the number of active and regular blood donors is rarely able to meet the clinical demands for blood. Therefore, there is a high demand for the identification of appropriate interventions to promote voluntary and unpaid blood donation intention and behavior.

Nudges have become a popular tool for fostering prosocial behavior, and the use of nudges not restricted to situations where they make choices easier or where they exploit inertia and procrastination (Bicchieri and Dimant, 2019). One particularly promising nudge is to provide decision makers with information about others, also referred to as social information. However, social information interventions in the context of blood donation have had mixed results, with some studies demonstrating success (Sun et al., 2016; Gemelli et al., 2018; Moussaoui et al., 2019), while others either fail to detect a significant effect (Sun et al., 2019) or indicate that interventions may backfire (Goette and Tripodi, 2020). For information nudging to be effective, we must advance our understanding of the mechanisms through which information affects behavior.

According to van Teunenbroek et al. (2020), the influence of social information depends on three Ws: "where" includes social information and donors, "what" is the content of social information, and "who" is the source of social information. In this study, we incorporate the three Ws into a holistic framework to systematically analyze the nudging effect of social information on blood donation intention. The first dimension we focus on, which is also relatively ignored in the existing literature, is "where," as the COVID-19 pandemic gives us a chance to investigate the association between changes in social context and the influence of social information. Furthermore, we construct four different kinds of social information based on the dimensions of "what" and "who" to analyze the main effects of information content and its source, as well as the interaction between the information-acting context and social information itself. Specifically, in the "what" dimension, information content is divided into blood donors' commendation information and blood users' demand information; in the "who" dimension, the information source is classified as an official source or an unofficial source.

In the context of blood donation, some studies have examined only one or two dimensions of the three Ws identified above. For example, different message content may prime different emotions among potential donors, which in turn may influence donors' perceived effectiveness of the message and their donation intentions (Song and Wen, 2019). Martín-Santana et al. (2018) emphasized the characteristics of the message source and demonstrated that spokesperson credibility is a direct antecedent of blood donation intention in radio advertising campaigns. In addition, Song and Wen (2019) just mentioned the role of contextual factors in their discussion, pointing out that differences in cultural and social norms embedded in different social contexts may lead to different perceptions of blood donation information and thus affect donation intention. It is, therefore, clear that these studies have relatively ignored the "where" and have only considered the "what" or the "who," thereby making general comprehension quite problematic.

Our results show that blood donation intention is higher among participants who had been exposed to the blood users' demand information treatment, as compared to those who had been exposed to the blood donors' commendation information treatment. The information given by an official source also increases the participants' donation intention more

than information given by an unofficial source. Furthermore, the analysis of the two waves of experimental data shows that the nudging effect of blood users' demand information is strengthened after the peak of the pandemic. Information released by official sources also exhibits a stronger nudging effect. Therefore, the COVID-19 pandemic has not only increased people's personal health- and mortality-related risk perceptions, but it may have also activated a slew of psychological mechanisms (Syropoulos and Markowitz, 2021) that changed people's perception of the same information. The findings of this study can assist researchers obtain a deeper understanding of social information and support policymakers or practitioners in choosing more effective marketing strategies for voluntary blood donation campaigns.

THEORETICAL BACKGROUND AND HYPOTHESES DEVELOPMENT

Motivational Determinants of Blood Donation

Previous studies have shown that individuals' blood donation behaviors are often driven by three main motivations: prosocial, reciprocity, and self-image. Prosocial motivation is considered to be one of the strongest motivators for voluntary blood donation. More specifically, prosocial motivation can be labeled altruism (a desire to help other people generally) or collectivism (a desire to help members of a target group, including the donor's community and friends/family) (Bednall and Bove, 2011; Martín-Santana et al., 2020). Reciprocity is also a frequently cited motivator of donation behavior. Some donors will donate blood out of gratitude after themselves or their families have received transfusions, or in the hope that blood is available when they have a future need (Bednall and Bove, 2011). The third motivator, concern over self-image (Engel and Kurschilgen, 2020), encourages individuals to behave in a more prosocial manner in order to avoid negative judgment from others and to protect their reputations (Sénémeaud et al., 2017).

Interventions to retain existing blood donors and recruit new ones have been proposed based on existing research into donor characteristics and motivations. In their review, Godin et al. (2012) classified non-incentive interventions into four types: social interventions that manipulate altruism and egoism, reminders, foot-in-the-door or door-in-the-face techniques, and intention activation. Most of these interventions are implemented through the provision of social information, including descriptions of social impact (Moussaoui et al., 2019; Goette and Tripodi, 2020); comparisons with social norms (Xie et al., 2019); modeling (Rushton and Campbell, 1977); descriptions of a current blood shortage (Sun et al., 2016, 2019); registry invitations (Heger et al., 2020); or questionnaires asking donors to specify their donation intention to activate cognitions about blood donation (Stutzer et al., 2011). However, evidence related to the efficacy of these information interventions is mixed.

Using the theoretical framework that includes "where," "what" and "who"(van Teunenbroek et al., 2020), the present study aims to provide a deeper understanding of how social information

nudges blood donation intention. We not only study the main effects of information content and its source, but also how the information-acting context may interact with social information to shape behavioral intention.

Influence of Information Content on Blood Donation Intention

The first independent variable manipulated between subjects is related to the dimension of "what," namely information content: in one condition, participants are presented with blood donors' commendation information; in the other condition, blood users' demand information is given. We do so based on the assumption that people who contemplate donating blood may consider the situation from either the perspective of a potential donor or from that of the people in need of help (Hung and Wyer, 2009). The two perspectives may be fundamentally different, as the arousing content or emotional intensity of these different cues may elicits different processing patterns (Liu and Bailey, 2019).

On the one hand, an extensive body of work has demonstrated that witnessing others' prosocial actions or being provided such information can drive people to engage in similar behaviors later on (see the reviews by Jung et al., 2020). A field experiment conducted by Rushton and Campbell (1977) showed that people who observed a positive role model were more likely to donate blood, not only immediately after the exposure, but also in different settings 6 weeks later. Bruhin et al. (2020) also found strong evidence for motivational spillovers in the context of voluntary blood donations, as 40 to 44 percent of the change in an individual's propensity to donate directly spills over to their fellow tenant's propensity to donate. These spillovers generate a substantial social multiplier for policy interventions, such as phone calls reminding about the time and location of the blood drive.

Furthermore, what happens after a model's behavior can affect the degree of imitative or matching behavior exhibited by an observer. People care about how important others approve or disapprove of their performing given behaviors before they actually have respective behavioral changes (Liu and Bailey, 2020). Compared with the situation in which a model's behavior is followed by punishment or no positive reinforcement, the prosocial modeling effect can be larger when the prosocial model is rewarded by a third party (e.g., confederate, experimenter, model target) *via* social approval, gratitude, or material compensation (Jung et al., 2020). This is because the rewards may have signaled the social acceptability and desirability of the specific behavior.

On the other hand, appeals with a detailed description of the victim's plight or a picture of the beneficiary has a greater impact on participants' willingness to donate than an abstract plea for help (Hung and Wyer, 2009). Emotional reactions, such as empathic concern, can be triggered through a vivid representation of victims and often increase with the severity of the situation (Cialdini et al., 1997). This enhanced emotional involvement is fundamental for prosocial attitudes (Haidt, 2001), judgments and decisions (Slovic et al., 2002), particularly decision making in helping situations (Batson, 2011),

where feeling more is assumed to be related to helping more. Laboratory experiments have shown that an identifiable victim is more likely to evoke empathy and incentivize people to donate (Kogut and Ritov, 2005). By randomizing advertising content in their field experiments, Sudhir et al. (2016) also found a significant impact that is consistent with the identified victim effect on the number of donors and amounts donated. These studies imply that narratives about the suffering of specified others may foster a desire to help.

Based on a dual deliberative (cognitive) and affective (emotional) process model of cognition (Kahneman, 2011), we propose that blood donors' commendation information nudges donation intention by activating the deliberative system (System 2), whereas blood users' demand information invokes the affective system (System 1). Specifically, the influence of blood donors' commendation information could be supported by the cultural learning account of prosocial behavior (Jung et al., 2020), which proposes that human prosociality is a direct product of social learning (Chudek and Henrich, 2011). The presence of others displaying prosocial behavior may increase norm salience or change individuals' norm perception (Goeschl et al., 2018). The universal tendency for people to rely on social norms when making prosocial decisions subsequently results in helping outcomes. Furthermore, communication that the prosocial model received a reward for helping also makes people aware that models' behaviors are encouraged by society, thereby providing an expectation of a similar social reward for mimicking their behavior (Morgenroth et al., 2015). It can be seen that blood donors' commendation information can stimulate potential donors to rethink (the relevant norms, ideals and duties in) the situation at hand (Engelen et al., 2018) and change their subjective goal expectations (Morgenroth et al., 2015). These updated thoughts, in combination with their own social experiences, promote subsequent willingness to voluntarily donate blood. This process demands cognitive investments and reflective reasoning, corresponding to the activation of System 2 (Lin et al., 2017).

In contrast, the emotional reactions associated with an urge to relieve the suffering of someone else, elicited by blood users' demand information, is fast and spontaneous (Bergh and Reinstein, 2020). The literature indicates that people are prosocial and cooperative when they make more spontaneous decisions (e.g., Rand et al., 2012; Rand, 2016). Such intuitive decision-making is distinctly associated with the operation of System 1. Systems 1 and 2 differ in the extent to which representations are accessible (Kahneman, 2003) and the effort with which particular mental contents explicitly come to mind (Brocas and Carrillo, 2014). Emotional decisions are made quicker and easier, as Kahneman (2003) argues in his theory that System 1 is the automatic system. Information processing can be facilitated by allowing affective reactions to be accessed more quickly (Johnson et al., 2012). System 2, in contrast, is commonly described as deliberate, analytical, controlled and effortful (Kahneman, 2011; Evans and Stanovich, 2013). Deliberative judgments emanating from System 2 require cognitive resources, such as working memory, attention, and self-control (Boureau et al., 2015), to play the part of monitor and intervener (Grayot,

2020). The involvement of these cognitive resources, especially self-control related resources, may suppress the potency of external information intervention (Janssen et al., 2010), thereby weakening information-based choices (Boureau et al., 2015). Therefore, we hypothesize the following:

Hypothesis 1. Relative to blood donors' commendation information, blood users' demand information has a stronger nudging effect on an individual's blood donation intention.

Influence of Information Source on Blood Donation Intention

When people receive information, it is important who provides it (van Teunenbroek et al., 2020). To examine the effect of information source, we added statements showing different subject attributes to the beginning of the donors' or users' material, including official, and unofficial sources.

Kim (2010) argues that a credible source of information is most frequently quoted by the respondents (general public in the age range of 20 to 30) as an important element for influencing them to perceive the information as useful. High credibility sources, compared with low credibility ones, are likely to change attitudes in the direction of the advocated position (Hovland and Weiss, 1951; Kumkale et al., 2010). Behavior can also be facilitated by perceptions of the source's credibility (Cheung et al., 2009). Public health messages have been shown to be more effective in changing behavior during pandemic when trusted voices are enlisted to deliver the message (Van Bavel et al., 2020).

In the context of blood donation appeals, the credibility of information also has a strong positive impact on receivers' intentions (Fonte et al., 2017; Martín-Santana et al., 2018). An authoritative image is a main contributor and predictor of the information being perceived as credible by young adults (Rieh, 2010). The "authority effect" is a powerful social influence principle frequently used in advertising to increase compliance (Jung and Kellaris, 2006). Thus, the following hypothesis is formulated:

Hypothesis 2. Compared with unofficial sources, when the information comes from an official source, social information has a stronger nudging effect on an individual's blood donation intention.

Changes in Social Context Brought by the COVID-19 Pandemic

As for the "where" dimension, the current literature shows that cultural characteristics, societal differences and some other social context-related factors may influence individuals' donation intention (Li et al., 2021). Depending on the distribution of context, the aggregate effect of a given piece of information might be markedly different, especially in times of great uncertainty, such as the current COVID-19 pandemic.

Firstly, the widespread collective action and cooperation that occurred during the peak of the COVID-19 pandemic (Syropoulos and Markowitz, 2021) may make society as a whole more collectivistic. It has been suggested that collectivism, as an important cultural value, can affect a person's sensitivity to

prosocial norms (Jung et al., 2020). Secondly, plenty of news reporting appearing during the pandemic about ordinary people as role models has made individuals realize that "ordinary people can be true heroes," thereby decreasing the psychological distance between people and these role models (Wessler and Hansen, 2017) and raising the desirability of obtaining social rewards for imitating their behavior. Thus, the effectiveness of blood donors' commendation information may have increased after the peak of the pandemic.

Secondly, the increasing severity of the pandemic has forced people to focus on the suffering and misfortune of others. People are increasingly capable of feeling and understanding other people's situations and emotions (Jin et al., 2020). Researchers have found that people with a stronger sense of empathy are more likely to be motivated to engage in prosocial behaviors, such as donating to charitable projects (Telle and Pfister, 2012; Murillo et al., 2016). Therefore, the effectiveness of information about blood users' demand may have also increased.

However, when people feel threatened by a range of emergencies and disasters, they may pay more attention to negative information, such as the suffering of others, than positive or neutral information (Van Bavel et al., 2020) and are more likely to be emotionally driven to make decisions. Therefore, we hypothesize the following:

Hypothesis 3a. Compared with information about blood donors' commendation, the context of the COVID-19 pandemic has enhanced the nudging effect of information about blood users' demand.

On the other hand, the COVID-19 pandemic has already seen a rise in fake news and misinformation. In this context, it is difficult for the public to distinguish scientific evidence and facts from less reliable sources of information (Van Bavel et al., 2020). It has also been suggested that the perceived threat triggered by the pandemic may lead people to display increased trust toward authorities such as governments (Yam et al., 2020) because doing so reduces uncertainty. Therefore, the following hypothesis is proposed:

Hypothesis 3b. Compared with unofficial information sources, the context of the COVID-19 pandemic has enhanced the nudging effect of the information released by official sources.

MATERIALS AND METHODS

Experiment Design and Measures

The experiment used a 2 (information content: blood donors' commendation information vs. blood users' demand information) × 2 (information source: official sources vs. unofficial sources) × 2 (context: before vs. after the outbreak of the COVID-19 pandemic) between-subject design to explore how the three dimensions influence the effectiveness of social information on nudging blood donation intention. Content and source are reflected in the presentation of the information itself. In the condition of blood donors' commendation information, the experimental materials were adapted from the document

No. 42 (2018) issued by the National Health Commission of China, while information about the blood users' demand was based on the real events of the Jiuzhaigou Earthquake in August 2017. For source manipulation, we added statements showing different subject attributes to the beginning of the donors' or users' material. The impact of information context was studied by conducting the same experiment twice: once in January 2019 and once February 2021, with the utilization of the COVID-19 pandemic. In China, the COVID-19 pandemic had been significantly abated by February 2021. Additional details of the experimental materials are provided in **Table 1**.

The dependent variable was the voluntary blood donation intention. It has been specified that an individual's intention to perform a behavior is the most proximal determinant of that behavior (Ajzen, 1991). Participants reported their intentions on a 5-point, 1-item Likert scale (i.e., "Would you like to donate blood after seeing this information"), ranging from 1 ("very strongly unwilling") to 5 ("very strongly willing"). Other control variables used include participants' demographic information, gender, age, major, political affiliation, household per capita monthly income, and past experience of blood donation.

Participants

Young adults represent the largest proportion of new and current blood donors; this group is essential for the maintenance of a sufficient and sustainable future donor base (Russell-Bennett et al., 2015). We selected undergraduate and graduate students as the target sample. The survey experiment was conducted on a digital online platform called "Wenjuanxing" in Mainland China, which provides functions equivalent to Amazon Mechanical Turk. A total of 1,185 participants[1] were recruited through WeChat to participate in the online experiment. Among these participants, 886 participated in January 2019, and 299 participated in February 2021. Surveys at both timepoints lasted ~10 min, and participants received $0.30–0.40 as remuneration for their participation.

Out of all participants, 79 were excluded from the analysis due to incomplete information or obvious errors in their responses. In sum, 94.18% of the respondents (1,116 out of 1,185) were considered for the statistical analyses. In the experiment conducted in January 2019, 212 participants engaged in the *blood donors' commendation information, official source condition*, 209 engaged in the *blood donors' commendation information, unofficial source condition*, 201 engaged in the *blood users' demand information, official source condition*, and 209 engaged in the *blood users' demand information, unofficial source condition*. In contrast, in the experiment conducted in February 2021, there were 72, 68, 73 and 72 participants engaged in the above four conditions, respectively.

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[1]We conducted a power analysis in G*Power 3.1 (Faul et al., 2007) for a repeated-measures ANOVA with the following parameters: 8 groups (2 × 2 × 2 between-subject design), a type-I error level of α = 0.05, a moderate effect size of f = 0.25, a power of 0.9 and a correlation among rep measures of r = 0.5. This power analysis revealed that the minimum sample size in the present study is n = 208.

Statistical Analyses

Descriptive analyses were conducted to describe the demographic characteristics. χ^2-tests were used to test the null hypothesis of perfect randomization in case of binary variables, and Kruskal-Wallis tests in case of interval variables.

A 2 × 2 × 2 ANOVA was conducted to preliminarily test the hypothesis. Then, taking control variables into account, we performed moderating effect test by using PROCESS Macro (extension in SPSS) by Hayes (2013) to further check whether the blood donation intention elicited by different information was moderated by the COVID-19 pandemic. All data were analyzed by SPSS version 22.0.

RESULTS AND DISCUSSION

Demographic Characteristics

We initially verified the comparability of the different conditions and periods. The results showed no significant differences in the sociodemographic characteristics of participants among the different conditions before and after the peak of the pandemic. **Table 2** provides detailed summary statistics of the characteristics of the overall sample and the non-parametric test results of the eight sub-samples.

Hypothesis Testing

The mean and standard deviation data for blood donation intentions under different conditions are shown in **Table 3**.

First, a 2 × 2 × 2 ANOVA was conducted to test the hypotheses 1 and 2. The results indicate that participants who were presented with information about blood users' demand were more willing to donate blood ($M = 3.763$) than those who were presented with the information about blood donors' commendation ($M = 2.770$)[2], $F_{[1,1108]} = 163.738$, $p < 0.0005$, $\eta^2 = 0.129$. Participants who read the information from official sources expressed a greater willingness to donate blood ($M = 3.398$) than those in the unofficial sources condition ($M = 3.129$)[3], $F_{[1,1108]} = 20.332$, $p < 0.0005$, $\eta^2 = 0.018$. While the main effect of context did not approach significance ($F_{[1,1108]} = 1.551$, $p = 0.213$, $\eta^2 = 0.001$; $M = 3.361$ after the outbreak of the pandemic and $M = 3.229$ before the outbreak of the pandemic), the interaction between the information content and context ($F_{[1,1108]} = 7.025$, $p = 0.008$, $\eta^2 = 0.006$), as well as the interaction between the information source and context ($F_{[1,1108]} = 6.688$, $p = 0.010$, $\eta^2 = 0.006$) were significant. Besides, the two-way interaction between the information content and source ($F_{[1,1108]} = 0.070$, $p = 0.791$, $\eta^2 < 0.0005$) and the three-way interaction ($F_{[1,1108]} = 0.204$, $p = 0.651$, $\eta^2 = < 0.0005$) are both non-significant. The results are shown in **Table 4**.

Thus, the following conclusions can be made: (1) relative to blood donors' commendation information, blood users' demand information has a stronger nudging effect on an individual's blood donation intention; (2) compared with unofficial sources, when the information source is an official source, social

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[2]The M reported here is a composite of the data from both periods before and after the pandemic.
[3]The same as above.

TABLE 1 | The detailed experimental materials.

Content	Source	Details
Blood donors' commendation information	Official subjects	**Official documents issued by National Health Commission "The decision on honoring the winners of the 2016–2017 Gold Award for Voluntary and other award winners' decisions" (China National Health Medical Institute (2018) No. 42) announced:** The National Health Commission, the Red Cross Society of China and the Health Bureau of the Logistical Support Department of the Central Military Commission have decided: 71,123 comrades, including Wang Liyou, who made outstanding achievements in blood donation work during 2016–2017, were awarded the "Gold Award for Voluntary Blood Donation;" 84,991 comrades, including Jia Chengzhen were awarded the "Silver Award for Voluntary Blood Donation;" 235,855 comrades, including Wanghui were awarded the "Bronze award for Voluntary Blood Donation;" 202 comrades, including Ji Hongwen were awarded the "Catalyst Award for Voluntary Blood Donation;" 9,390 comrades, including Liu Lirong were awarded the "Service Award for Voluntary Blood Donation."
	Unofficial subjects	**A WeChat group administrator posted the following in his group:** 71,123 comrades, including Wang Liyou, who made outstanding achievements in blood donation work during 2016–2017, were awarded the "Gold Award for Voluntary Blood Donation;" 84,991 comrades, including Jia Chengzhen were awarded the "Silver Award for Voluntary Blood Donation;" 235,855 comrades, including Wanghui were awarded the "Bronze award for Voluntary Blood Donation;" 202 comrades, including Ji Hongwen were awarded the "Catalyst Award for Voluntary Blood Donation;" 9,390 comrades, including Liu Lirong were awarded the "Service Award for Voluntary Blood Donation.""
Blood users' demand information	Official subjects	**Jiuzhaigou Tourism Management Department issued the following news:** An earthquake struck Jiuzhaigou on August 8. A 37-year-old man surnamed Lv, his wife surnamed Ye and their daughter were hit by a rock. Blood gushed from the wounded, and a puddle of blood suddenly appeared on the ground. The face of the wounded turned from red to yellow, from yellow to white. The wounded was dying and their body temperature dropping. They were in urgent need of blood transfusion.
	Unofficial subjects	**A visitor posted a message in the WeChat group:** An earthquake struck Jiuzhaigou on August 8. A 37-year-old man surnamed Lv, his wife surnamed Ye and their daughter were hit by a rock. Blood gushed from the wounded, and a puddle of blood suddenly appeared on the ground. The face of the wounded turned from red to yellow, from yellow to white. The wounded was dying and their body temperature dropping. They were in urgent need of blood transfusion.

information has a stronger nudging effect on an individual's blood donation intention; (3) the context of the COVID-19 pandemic shows no significant influence on blood donation intention. Hypothesis 1 and 2 are supported.

Second, we conducted a moderated regression analysis to further verify the nudging effect of social information on the blood donation intention taking other control variables into account. Results are presented in **Table 5**. As can be seen from **Table 5**, Model 1 results show that the hypothesized Context × Content interaction is significant such that the changes in the social environment brought about by the COVID-19 pandemic strengthened the negative relationship between the information content and blood donation intention. Blood users' demand information could stimulate participants' willingness to donate blood more than blood donors' commendation information, especially after the peak of the COVID-19. Furthermore, the coefficient of the interaction term between the context and information source in Model 2 is significantly positive, which means that compared with unofficial information sources, the nudging effect of the information released by official sources are further enhanced after the peak of the COVID-19 pandemic.[4]

These findings illustrate that the efficacy of social information strategies can in fact depend upon the content and source, especially after the COVID-19 pandemic. Hypothesis 3a and 3b are accepted.

Figure 1 presents a graphical depiction of the interaction. The negative relationship between information content and blood donation intention is stronger after the peak of the COVID-19 pandemic. There is no significant difference in donation intention in response to donors' commendation information before and after the outbreak of the COVID-19 ($p = 0.382$, two-sided Mann Whitney tests, the same as below). But the nudging effect of blood users' demand information is significantly strengthened after the COVID-19, compared with pre-pandemic ($p = 0.040$). At the same time, people tend to exhibit higher donation intention in response to information released by official sources after the peak of COVID-19 than before ($p = 0.009$), while unofficial information shows no significant inter-temporal effect ($p = 0.452$).

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[4]As the individual characteristics is not the focus of this paper, we briefly report some findings for reference. Those who are members of the Communist Party are significantly more likely to donate blood. Those with siblings have a higher

willingness to donate blood than only children, which is consistent with the findings of Cameron et al. (2013), who found that only children in China have a relatively lower sense of responsibility. Previous blood donations strongly predict one's propensity to donate, which is consistent with the findings of many other studies (Beerli-Palacio and Martín-Santana, 2009; Bednall and Bove, 2011).

TABLE 2 | Demographic characteristics of the sample and non-parametric test results.

Variables	Category	Number	Percentage	χ^2	*Asymp. Sig.*
Gender	Female	654	58.60%	4.414	0.731
	Male	462	41.40%		
Age	17–25	970	86.92%	4.774	0.687
	26–35	138	12.37%		
	36–52	8	0.72%		
Major	Humanities and Social Sciences	679	60.84%	7.588	0.370
	Science and Engineering	437	39.16%		
Only child	Yes	578	51.79%	11.714	0.110
	No	538	48.21%		
Polity	Mass	765	68.55%	11.032	0.137
	Communist Party	351	31.45%		
Income	<2,000 RMB	155	13.89%	11.785	0.108
	2,001–4,000 RMB	309	27.69%		
	4,001–6,000 RMB	283	25.36%		
	6,001–8,000 RMB	143	12.81%		
	More than 8,000 RMB	226	20.25%		
Experience	0	772	69.18%	5.217	0.633
	1	216	19.35%		
	2 times or more	128	11.47%		

TABLE 3 | Results for the effects of social information on blood donation intention.

Results	Context	Content	Source	Observations	Mean (SD.)
1	Before the outbreak of pandemic	Blood donors' commendation information	Official	212	2.873 (1.276)
2			Unofficial	209	2.722 (1.217)
3		Blood users' demand information	Official	201	3.766 (1.312)
4			Unofficial	209	3.584 (1.409)
5	After the outbreak of pandemic	Blood donors' commendation information	Official	72	3.014 (1.284)
6			Unofficial	68	2.338 (1.045)
7		Blood users' demand information	Official	73	4.289 (0.889)
8			Unofficial	72	3.736 (1.199)

DISCUSSION

The main purpose of this study is to explore the nudging effect of social information on blood donation intention in two contexts: before and after the peak of the COVID-19 pandemic. Based on the theoretical framework developed by van Teunenbroek et al. (2020), we focus on the three dimensions on which the effectiveness of social information depends, namely, the information-acting context (where), the information content (what) and the information source (who). By exploiting a 2 × 2 × 2 between-subject design survey experiment, we study not only the main effects of information content and its source, but also how the information-acting context may interact with social information.

The results show a significant main effect of information content on blood donation intention, suggesting that relative to blood donors' commendation information, blood users' demand information is a more effective strategy for increasing intention toward blood donation. This is consistent with those of recent

studies, which indicated that people considered other-focused arguments to be more persuasive (Luttrell and Petty, 2021). Decisions to donate are informed by both rational and emotional processes (Dickert et al., 2011), including cognitive factors such as moral judgment and social learning, and rather affective factors such as empathy (Christner et al., 2020). As the blood donors' commendation information affects the intention by triggering deliberative judgments generated by System 2, which requires cognitive resources, its nudging effect is weaker than the description of the victim's urgent needs. This finding thus highlights the importance of the emotional appeals in promoting prosocial behavior, especially blood donation behavior.

In terms of "who" dimension, we demonstrate that social information released by official sources has a stronger nudging effect. Previous study has unearthed a number of important factors impacting on donation decisions, such as the perceived credibility of the charitable organization, organizational accountability, and organizational commitment (Zagefka and James, 2015). Martins et al. (2019) also pointed that credibility

TABLE 4 | Analysis of variance results for the effect of social information on blood donation intention.

Source	Type III SS	df	MS	F	p	η_p^2
Content	259.707	1	259.707	163.738	< 0.001	0.129
Source	32.249	1	32.249	20.332	< 0.001	0.018
Context	2.461	1	2.461	1.551	0.213	0.001
Content × Source	0.112	1	0.112	0.070	0.791	< 0.001
Content × Context	11.143	1	11.143	7.025	0.008	0.006
Source × Context	10.609	1	10.609	6.688	0.010	0.006
Content × Source× Context	0.324	1	0.324	0.204	0.651	< 0.001
Error	1,757.412	1108	1.586			
Total	13,964.000	1116				
Corrected total	2„078.548	1115				

TABLE 5 | Moderation analysis.

	Coefficient	SE	t	Significance(p)	LLCI	ULCI
Moderation Model 1 (*Dependent* blood donation intention)						
Content	−0.857	0.084	−9.985	< 0.0005	−1.024	−0.688
Context	0.341	0.120	2.855	0.004	0.107	0.576
Content × Context	−0.398	0.170	−2.345	0.019	−0.731	−0.065
Conditional Effects	−0.062	0.080	−0.769	0.442	−0.219	0.096
Before the peak of pandemic	−0.856	0.086	−9.985	< 0.0005	−1.025	−0.688
After the peak of pandemic	−1.255	0.147	−8.559	< 0.0005	−1.542	−0.967
Demographic controls	Yes					
Moderation Model 2 (*Dependent* blood donation intention)						
Source	0.176	0.092	1.917	0.055	−0.004	0.355
Context	−0.051	0.129	−0.396	0.692	−0.305	0.202
Source × Context	0.413	0.181	2.282	0.022	0.059	0.768
Conditional Effects						
Before the peak of pandemic	0.176	0.092	1.917	0.056	−0.0041	0.3554
After the peak of pandemic	0.589	0.156	3.767	< 0.0005	0.282	0.896
Demographic controls	Yes					

is strongest predictor of the acceptance of messaging that can lead to behavior change. In China, social media suffer from the problems of information overload and prevalence of misinformation (Gao et al., 2020). Evidence shows that channels endorsed by officials were perceived to be highly credible among Chinese people (Zhang et al., 2014). Trust in official information sources is likely to increase acceptance of their proposition (Chen et al., 2018). Acceptance of information would further increase the tendency to adhere to these advocated behaviors.

Furthermore, the analysis of two waves of experimental data indicates that the nudging effect of blood users' demand information has been strengthened after the peak of the COVID-19 pandemic. An alternative explanation for such effects might be related to a slew of psychological mechanisms activated by the COVID-19 pandemic. The pandemic can be regarded as a threat to one's survival, which might activate the sense of a "common fate" and thereby increase empathy as a motivation of increasing other's welfare (Christner et al., 2020). The shared experience of a global threat could amplify people's need and thereby attune people to other's well-being. Such underlying

psychological changes are likely to change responsiveness to the blood users' demand information, as the decision on whether to donate is related to general psychological state (Dickert et al., 2011). By contrast, the prosocial modeling effect of blood donors' commendation information largely depends on cognitive factors, which involve deliberative reflection. It is suggested that people do not behave differently in response to contextual cues when investing enough cognitive resources to make a decision on whether to donate (Shi et al., 2020). Instead, they displayed a stable tendency for keeping their original decision. So, the pandemic has significantly strengthened the nudging effect of users' demand information, while has no significant effect on the responsiveness to donors' commendation information.

In addition, information released by official sources also exhibits a stronger nudging effect after the peak of the COVID-19. With the impact of uncertainty brought by the pandemic, the perceived credibility of various sources of information also varies greatly in the eyes of the public. Compared with the long-standing, general trust in government which has been shaped by various social and cultural factors, the specific aspect of trust

FIGURE 1 | Interaction effects of information content and pandemic on blood donation intention **(A)**; Interaction effects of information source and pandemic on blood donation intention **(B)**.
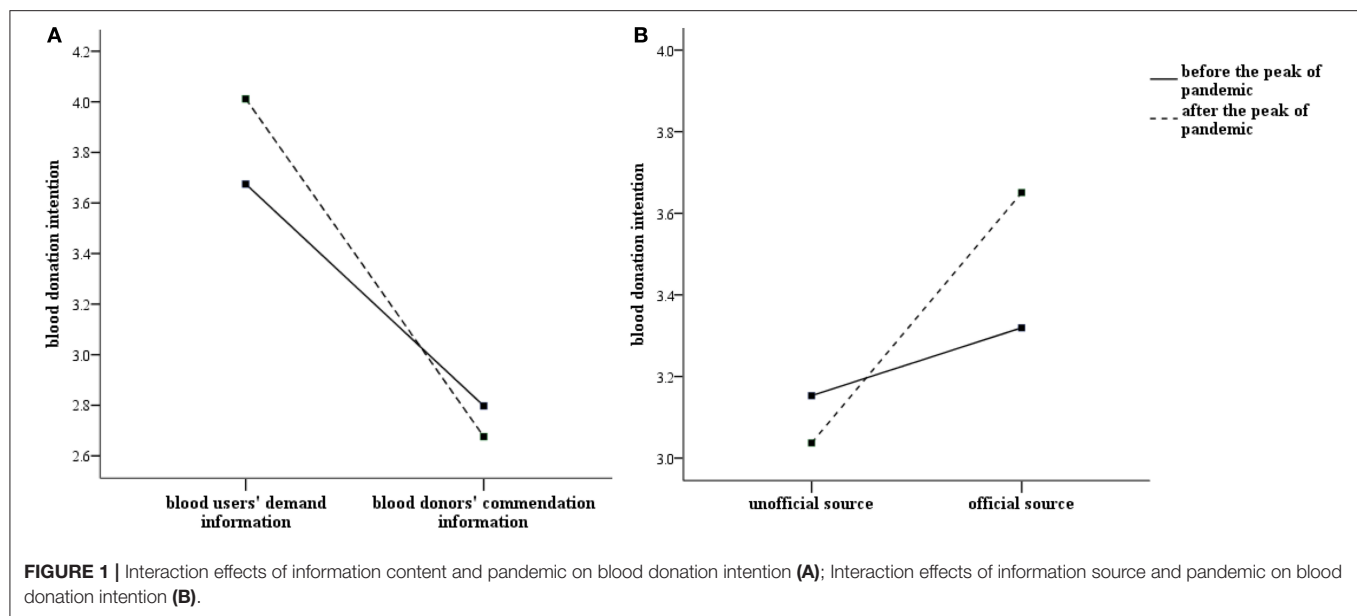
in authorities during crises, such as the COVID-19 pandemic, could be more dynamic. It has been found that the pandemic itself both relies on and may change the extent to which the public trust in government or other organizations (Van Bavel et al., 2020). Consistent with existing research results, sudden crisis situations often result in an increase in support and trust in government caused by a "rally-round-the-flag" effect (Yam et al., 2020). Research from China during the COVID-19 pandemic also revealed that public showed a higher level of perceived credibility in governments than the usual levels documented in general social surveys (Wu et al., 2021), perhaps due to effective implementation of anti-COVID policies official media propaganda, and public's expectation (Su et al., 2021). As information is thought to be more credible when they are issued by trustworthy organizations (Rifon et al., 2004), such enhanced trust in official organizations could amplify public's compliance with social policies that rely on their behavioral responses (San Lau et al., 2020).

Theoretical Contributions

This study contributes to the relevant research on how to nudge blood donation behavior from the perspective of social information. Previous studies have focused on the nudging effects of information methods, such as sending reminders, providing feedback, and strengthening social norms (Sun et al., 2019; Goette and Tripodi, 2020; e.g., Fosgaard et al., 2020). As for social information itself, existing literature recommends developing differentiated strategies only on the basis of subdividing blood donor types (Zhou et al., 2012), without establishing a holistic framework to systematically analyze how information can effectively nudge the intention to donate blood. This study uses a survey experiment to quantitatively study the influence of the three Ws of social information on individuals' blood donation

intention, which complements the current research on the nudging mechanism of blood donation intention and behavior.

Our study also adds to the nascent but exploding literature on the COVID-19 pandemic. To cope with the large-scale challenges and alleviate the negative consequences of the pandemic, it is of great significance to understand how people might react to different information interventions. The importance of finding efficient information is clear, as such information represents an easy and potentially scalable intervention; it can be texted by phone or spread on social media in a low-cost way. Our results suggest that information with a detailed description of the victim's plight and with identification of the official source can be most effective in nudging individuals' blood donation intention, especially in times of great uncertainty like the current COVID-19 pandemic.

Managerial Implications

From the present study, a series of practical conclusions can be drawn that are particularly relevant for blood transfusion centers when managing their communication strategies. To encourage people to donate blood, the appeal for voluntary blood donation should clarify the critical situation of blood users. Detailed narratives of the urgent needs of victims can immediately make the public have a strong empathic response. Some narrative techniques need to be skillfully used to stimulate individual empathy to the greatest extent. For example, the display form of social information should not be limited to paper materials. Videos and other forms of publicity can also be used so that the public can truly experience the crisis situation in which blood users find themselves. We also suggest that more emotive words be used to elicit a high level of empathy from the public, so as to nudge their intention to donate blood.

Second, the results of this study show that individuals are more willing to donate blood when the information is released

by official sources, whether it is information about blood donors' commendation or blood users' demand. Therefore, in their blood donation campaigns, official organizations should take full advantage of their brand's image and perceived authority to promote blood donation more efficiently. For example, markers that indicate the official attributes of an information source should be highlighted.

Limitations and Future Research

Firstly, the main limitation of this study refers to the population under study (undergraduate and graduate students). Considering the intergenerational differences between individuals of different ages, their attitudes toward things may differ. It would be valuable to investigate our question in a more diverse sample. Exploring the heterogeneous impact of nudges on people, such as some of the most vulnerable groups in the pandemic, rather than the average effect collapsing across general public (e.g., Mrkva et al., 2021) would also be worthy of attention. Secondly, the measurement of blood donation intention in the present study is measured by the one-item Likert scale, "Would you like to donate blood after seeing this information." Although individuals' blood donation intention is positively correlated with actual behavior (Ferguson and Bibby, 2002), it is still necessary to use field experiments to validate our findings. Furthermore, the question how nudging effect of such information may change at different time points or under different conditions is highly interesting, as the COVID-19 pandemic is a worldwide phenomenon and countries react differently. It is worthy to cross-country validate our findings and to explore how long the enhanced nudging effect the specific information would last in later stages of the pandemic.

CONCLUSION

How to nudge voluntary and unpaid blood donation intention by exploiting social information is of great significance, especially in the midst of a global pandemic. Our results suggest that relative to blood donors' commendation information, blood users' demand information has a stronger nudging effect, social information released by official sources has a stronger nudging effect than unofficial information. And the nudging effect of blood users' demand information and information released by official sources both have been strengthened after the peak of the COVID-19 pandemic.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of Nankai University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

WW, JL, and SL conceived and designed the experiments. WW, JL, and YW performed the experiments. WW analyzed the data. WW, SL, and JL contributed to the writing and revision of the manuscript. All authors contributed to the article and approved the submitted version.

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Characterizing the Influence of Confirmation Bias on Web Search Behavior

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In this study, we analyzed the relationship between confirmation bias, which causes people to preferentially view information that supports their opinions and beliefs, and web search behavior. In an online user study, we controlled confirmation bias by presenting prior information to participants that manipulated their impressions of health search topics and analyzed their behavioral logs during web search tasks. We found that web search users with poor health literacy and negative prior beliefs about the health search topic did not spend time examining the list of web search results, and these users demonstrated bias in webpage selection. In contrast, web search users with high health literacy and negative prior beliefs about the search topic spent more time examining the list of web search results. In addition, these users attempted to browse webpages that present different opinions. No significant difference in web search behavior was observed between users with positive prior beliefs about the search topic and those with neutral belief.

Keywords: web search, confirmation bias, information behavior analysis, human factor, health information seeking

1. INTRODUCTION

The credibility of web information has become a serious social issue. For example, Sillence et al. reported that more than half of the health information available on the web has not been verified by experts (Sillence et al., 2004). Therefore, if web search users may believe misinformation, they cannot distinguish correct and incorrect web information.

In addition, problems with web information credibility are amplified due to the personalization of information delivery, e.g., web search engines and recommendation systems. The "filter bubble," which is phenomenon where users only access information they are interested in due to the optimization of information access, is becoming a social problem because it deprives users of the opportunity to examine information from broader perspectives to facilitate careful and effective decision making (Le et al., 2019; Yamamoto and Yamamoto, 2020).

People can believe incorrect or low-quality information due to "confirmation bias," which is a concept defined in cognitive psychology. In cognitive psychology, confirmation bias, i.e., the tendency to preferentially view information that is consistent with one's opinions or hypotheses, has a significant impact on decision making (Nickerson, 1998; Kahneman, 2011). Confirmation bias occurs frequently in web searches. For example, assume that user X, who is health conscious, learns on TV that food Y, which uses genetic modification, is harmful to health and distrusts food Y. When user X performs a web search to obtain information about food Y's safety, they unconsciously seek to support the idea that food Y is harmful to their health; therefore, user X will preferentially browse negative information about food Y, even if that information is incorrect or low-quality.

Thus, confirmation bias can be a significant problem in web search behavior because confirmation bias that occurs when users search the web for information about food, clothing, housing, and politics can significantly impact society.

There are several studies on the relationship between confirmation bias and web search behaviors (White, 2013; Schweiger et al., 2014; Pothirattanachaikul et al., 2019). For instance, White investigated the impact of prior beliefs on web search behaviors and demonstrated that the prior beliefs of web search users are likely to be strengthened by web search when their prior beliefs about the search topics are not strong (White, 2013). White also found that web search users are more susceptible to positive search results. Pothirattanachaikul et al. studied how opinion polarity and document credibility affect the search behavior and prior belief of web search users (Pothirattanachaikul et al., 2019). They found that web search users spent more time on search tasks when they viewed webpages with opinions that are inconsistent with their existing beliefs. Schweiger et. al. focused on treatment for manic depression and studied the relationship between confirmation bias toward psychotherapy and searchers' belief change on the treatment after reading web pages (Schweiger et al., 2014). Their study suggested that showing experts' evaluation on treatment could reduce confirmation bias and change the prior belief. Like the above studies, many have focused on investigating how confirmation bias influences searcher belief on topics via web searches. However, few studies have characterized the influence of confirmation bias on *behaviors on search engine results pages (SERPs) and webpages* as well as belief change via web searches, based on log-based analysis (e.g., number of clicks, dwell time on webpages, and click depth). Moreover, few studies have examined the relationship between confirmation bias, web search behaviors, and critical information-seeking skills, i.e., information literacy.

In the fields of information retrieval and human-computer interaction, several studies have investigated how to present information to enhance critical information seeking on the web (Liao and Fu, 2014a; Liao et al., 2015; Yamamoto and Yamamoto, 2018, 2020). For instance, Liao et al. revealed that indication of the opinion stance and expertise of the information sender can mitigate the confirmation bias (Liao and Fu, 2014a). Yamamoto et al. proposed the QUERY PRIMING system, which facilitates careful information retrieval by showing keywords that evoke critical thinking on web search systems (Yamamoto and Yamamoto, 2018). QUERY PRIMING employs keyword auto-completion and keyword suggestion to present search terms that stimulate critical thinking and encourages careful information seeking and decision making. In addition, Yamamoto et al. proposed the PERSONALIZATION FINDER, web browser extension to reveal the effects of web search personalization and promote careful web search practices (Yamamoto and Yamamoto, 2020). The PERSONALIZATION FINDER exposes search results personalized/hidden by web search engines so that searchers can get aware that web search engines provide them with a biased list of web pages according to the searchers' preference. However, these methods were designed for situations where useful meta-information can be obtained to mitigate confirmation bias,

e.g., information provider's expertise/perspective, typical search queries used by careful web searchers, and user preference models. If the typical behaviors of web search users with confirmation bias can be identified and compared to those of users with critical information search skills, we believe it will be possible to design web search systems that consider and reduce confirmation bias.

Previously, we conducted a pilot-study to investigate the relationship between confirmation bias and web search behaviors (Suzuki and Yamamoto, 2020). Although the results of that study suggested that people with confirmation bias can perform web search differently to people without the bias, the study design was not sufficiently rigorous to validate the findings because it was difficult to clearly distinguish participants with confirmation bias from those without the bias. Thus, in this study, we quantitatively analyzed the relationship between confirmation bias, information literacy, and web search behavior on health topics by generating pseudo-confirmation bias in participants. We had participants conduct online search tasks by manipulating prior information about health topics to control confirmation. We then analyzed the differences in the web search behaviors of users with and without confirmation bias. We believe it is essential to design information access systems such as web search engines ans web browsers that considers confirmation bias to encourage users to avoid incorrect information for critical health information seeking on the web.

Ennis defined critical thinking as logical and reflective thinking to determine what to believe or do (Ennis, 1987). Ennis also claimed that ideal critical thinkers are disposed to: seek reasons, consider the total situation, look for alternatives, and use logical thinking, e.g., deductive reasoning. Kusumi et al. stated that accurate evaluations of information require searchers to possess critical thinking attitudes and critical thinking skills, e.g., language and reasoning skills (Kusumi et al., 2017). In addition, using the elaboration likelihood model (ELM), Petty et al. indicated that possessing motivation to scrutinize information is a prerequisite for people to utilize critical thinking skills (Petty and Cacioppo, 1986). Confirmation bias can influence people's attitudes about evaluating information. We expect that, if search users have no confirmation bias and do web searches as critical thinkers, to obtain correct and information from the web during web search processes, they will behave in the same manner which the information literacy researchers or librarians think is important. According to Meola (2004) and Yamamoto et al. (2018), the following actions are necessary to obtain correct information on the web: (1) spending more time searching, (2) browsing more webpages for comparison, (3) browse web pages in lower-ranked web search results as well as higher-ranked ones, and (4) checking evidence to support webpage content, such as the expertise of webpage authors, existence of valid references, and the freshness of webpages. Therefore, we set the following hypotheses **H1** and **H2** for our online user study.

H1 Web searchers with confirmation bias preferentially browse information that is consistent with their beliefs and do not carefully examine which information they should view. Thus, they spend less time browsing the search

results list and preferentially browse higher-ranked pages in the results.

H2 Web searchers with confirmation bias only view information that is consistent with their beliefs and do not browse information carefully. Thus, they spend less time browsing webpages and view fewer webpages.

As mentioned above, the ELM theory indicates that if people are more willing to understand information about a topic, they often make more efforts to scrutinize its quality and modify their prior belief if necessary (Petty and Cacioppo, 1986). On the other hand, White found that web search users often strengthen their own beliefs through search (White, 2013). Based on these two studies, we also set the following hypothesis **H3** for the user study.

H3 Web searchers with confirmation bias do not change their beliefs significantly when they search the web, compared to users without confirmation bias.

Lopes et al. analyzed the relationship between health literacy and web search behavior using eye-tracking analysis (Teixeira Lopes and Ramos, 2020). They found that web search users with higher health literacy visited more webpages and spent more time reading webpages. Furthermore, Yamamoto et al. revealed that the higher health information literacy web searchers have, the more tolerant they are for cognitive biases in web searches (Yamamoto et al., 2018). Therefore, we set the following hypothesis **H4**.

H4 The degrees of **H1**, **H2**, and **H3** are influenced by the web search user's degree of information literacy.

2. MATERIALS AND METHODS

This section describes the methodology employed to analyze the impact of confirmation bias and information literacy on web search behavior. The details of the experiment are described in the following. Note that we refer to the group with negative beliefs about the search topic as the BIASED(−) group, we refer to the group with positive beliefs as the BIASED(+) group, and we refer to the group with no bias as the NEUTRAL group.

2.1. Procedures

We conducted an online user study in Japanese according to the following procedure: (1) user registration; (2) prior belief questionnaire; (3) presentation of prior information about the search topic; (4) search task; and (5) post-task questionnaire.

First, the participants visited the experimental site prepared by our laboratory after they registered as users at Lancers.jp, which is a Japanese crowdsourcing service[1]. Then, the participants answered a questionnaire on their prior beliefs about a given search topic. In the prior belief questionnaire, we asked the participants to answer the following question on a five-point Likert scale: "How do you feel about the safety of eating GM (genetically modified) foods?" ("1. Danger;" "2. Somewhat

danger;", "3. Neither danger nor safe;" "4. Somewhat safe;" to "5. Safe").

We then assigned participants to specific experimental conditions based on their answers regarding their prior beliefs about the search topic.

- BIASED(−) group: Participants who answered "Dangerous" or "Somewhat dangerous."
- BIASED(+) group: Participants who answered "Safe" or "Somewhat safe."
- NEUTRAL group: Participants who answered "Neither danger nor safe."

Next, we presented prior information to strengthen the participants' prior beliefs to introduce confirmation bias during the search task. Here, the presented information comprised a section 1 that described the search task and a section about GM foods. Note that we used the same description for all participants; however, we presented different descriptions about GM foods depending on the participants' prior beliefs.

The introduction for the search task is as follows.

You pick up a bottle of rapeseed oil that was on sale, and you notice a label that states that "it may contain GM rapeseed." You have always been a little curious about GM foods. Then, you asked your friend to give you some advice about GM foods.

In addition, we presented different information to strengthen the participants' prior beliefs depending on the experimental group. The information presented to each group is described as follows.

- BIASED(−) group: This group was shown a 200-word negative description of GM foods (e.g., "Europe has strict regulations against GM foods.") and a 2-min video[2] against GM foods.
- BIASED(+) group: This group was shown a 200-word positive description of GM foods (e.g., "Japan's Ministry of Health, Labor and Welfare (MHLW) carries out strict screening, and many Japanese people eat GM foods.") and a 2-min video[3] supporting GM foods.
- NEUTRAL group: This group was shown the negative and positive information presented to the BIASED(−) and (+) groups so that the participants in this group could understand there is controversy about whether or not GM foods are safe to eat.

To ensure all participants viewed the preliminary information, we asked them to summarize the content in approximately 100 words after viewing the video.

The participants performed the search task after viewing the preliminary information. The following instructions were presented to the participants when they began the search task.

Follow the steps below to complete the task of investigating whether or not it is safe to eat GM foods. Click on the "Start the search" button below and browse a list of search results and their links.

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[1]https://www.lancers.jp/.

[2]https://www.youtube.com/watch?v=umXN64zIH-8 (in Japanese).
[3]https://www.youtube.com/watch?v=zMnX3qS6Dj4 (in Japanese).

FIGURE 1 | SERP presented to participants in the user experiment.

When you have reached a satisfactory conclusion about "whether it is safe to eat GM foods," please stop searching the web and report your final opinion and the reasons for it in the form.

After participants clicked the "Start the search" button, they browsed a search engine results page (SERP) and the documents linked from the SERP to collect information about the safety of eating GM foods.

When the participants were satisfied with the obtained information, they completed the search and reported their responses to the search task (posterior beliefs). Here, the participants were asked to answer a questionnaire about whether it is safe to eat GM foods using the same five-point Likert scale used in the prior belief questionnaire. Note that we did not set a time limit in this search task because the goal was to analyze how participants searched and browsed at their discretion.

After completing the search task, the participants answered the post-task questionnaire about health literacy and demographic characteristics. We used the eHealth Literacy Scale (eHEALS) to survey information literacy on health topics, i.e., the ability to search for reliable health information on the web (health literacy) (Norman and Skinner, 2006). The participants answered the eight questions on a five-point Likert scale ("1: I never agree" to "5: Completely agree"). Here, we used the total eHEALS score as an indicator of the degree of each participant's health literacy. In addition, in the demographic characteristics questionnaire, we investigated the participants' gender, age, and educational background.

2.2. Search Task and Search Results List

We set a search task for a search topic that increases the polarity's variance and degree of prior beliefs. In this experiment, we selected "GM foods," which is a controversial topic in Japan, as the search topic.

In the search task, we presented the participants with a list of search results that imitated those returned by common web search engines, e.g., Google[4] and Yahoo![5] The search result list included 30 search results prepared in advance for the given search topic. **Figure 1** shows the search result list used in the search task.

Before starting the task, we performed a Google search using the queries "GM foods safe" and "GM foods dangerous" to obtain 15 search results containing the words "safe" and "dangerous" in the title or summary (referred to as a snippet). We defined the search results collected by the former query as *search results containing positive information about prior beliefs* and search results collected by the latter query as *search results containing negative information about prior beliefs*. We then created a list of search results by alternately displaying the results of the two queries from the top (**Figure 2**). We displayed the positive and negative results alternately to present both types of information as equally as possible to the participants. Although the search results imitate the results screen of a general web search, the system was configured such that participants could not modify the search queries.

When the participants clicked each search result, an archived version of the corresponding webpage was displayed. Here, we embedded JavaScript code in the archived webpages to measure the browsing time on each webpage. In addition, we disabled hyperlinks in the documents; thus, the participants could not view documents other than those displayed in the search results list. As a result, we measured the page browsing time for only the webpages in the search result list.

2.3. Participants

We recruited 300 Japanese participants using Lancers.jp. We excluded data for participants who failed to complete the task or worked on the task multiple times for some reasons. After

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[4]https://www.google.co.jp/.
[5]https://www.yahoo.co.jp/.

FIGURE 2 | Allocation of search results on SERP. Red and blue search results contain the terms "safe" and "dangerous" in their title or summary, respectively.
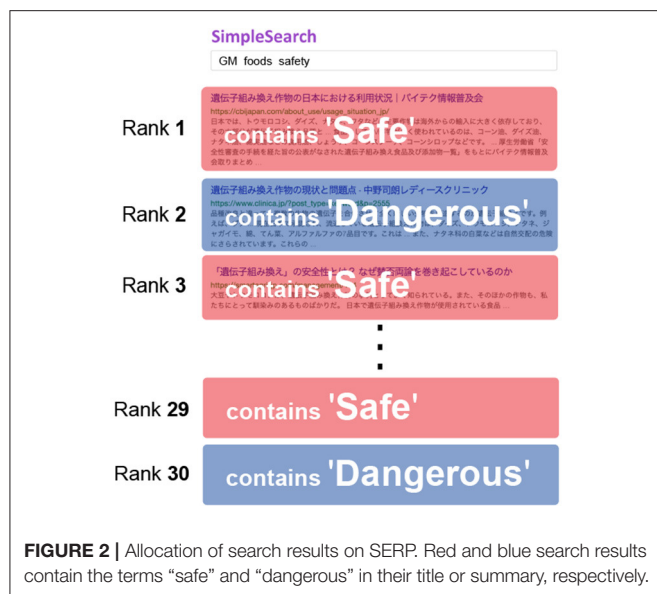
selecting the data to exclude, we used the data from a total of 275 participants in our analysis.

We then assigned the participants to specific groups according to their prior beliefs. In the BIASED(−) group, 148 participants completed the task, and 96 and 31 participants completed the task in the NEUTRAL group and BIASED(+) group, respectively. Note that we paid 100 Japanese yen to each participant who completed the task.

2.4. Monitored Data

We collected data on the following items during the search task to analyze the relationship between confirmation bias and web search behavior.

- Dwell time on search engine results page (SERP)
- Dwell time on webpages
- Search session time
- Clickthrough of search results.

The dwell time on SERP is the total time the participants browsed the SERP, and the dwell time on webpages is the time the participants spent browsing the webpages linked from the SERP. The search session time is the total time the participants browsed the webpages and SERP, and the clickthrough of search results is the information in the search results the participants clicked on the SERP. The clickthrough information includes the title, summary text, URL, search result rank, and belief polarity (i.e., whether the search result contains "safe" or "dangerous" in the title or summary text). We set up these indicators in reference to the paper by White et al., which analyzed web search behavior logs (White and Morris, 2007).

2.5. Analyses

We employed the generalized linear mixed model (GLMM) (Barr et al., 2013) to analyze the users' behavioral logs. The GLMM can separate the main effect of the intervention from the

random effect, which is the effect of individual differences among the participants and tasks. Note that the GLMM can analyze small-scale data more accurately than methods that employ frequentist statistics (Kay et al., 2016). The GLMM is becoming an increasingly established method to model user behavior in the information retrieval and human-computer interaction fields (Kim et al., 2017). In this study, we modeled the behavioral data using the GLMM extended by the Bayesian statistical model.

Here, we assumed that search session time and dwell time on SERP follow a Weibull distribution (Liu et al., 2010). We also assumed that the number of page views and maximum click depth follow a Poisson distribution, and that the amount of belief change follows a normal distribution.

In the GLMM, we set the two factors, i.e., confirmation bias (condition) and health literacy score (eHEALS), as the main effects and the participant as a random effect. Following the literature (Barr et al., 2013), we modeled the behavioral indicator measured in the user experiment as follows[6]:

$$Y \sim \mathrm{Cond} + \mathrm{eHEALS} + \mathrm{Cond}:\mathrm{eHEALS}$$
$$+ \left(1 + \mathrm{Cond} + \mathrm{eHEALS} + \mathrm{Cond}:\mathrm{eHEALS}|\mathrm{Participant}\right),$$

where Y is the target variable, Cond is a binary value indicating the presence or absence of confirmation bias for each participant, and eHEALS is the health literacy score. Here, (x|y) means that y is a random effect of x.

We used the highest density interval (HDI) as a measure to investigate the effect of the condition and eHEALS factors. The HDI represents the possible range of the parameter, where the parameter is considered effective if the HDI does not contain zero. Note that this is equivalent to rejecting the null hypothesis in frequentist statistics. Following Kruschke's point, we set the HDI for the parameter to be effective at 90% (Kruschke, 2014).

We used a non-parametric test to analyze the results of the post-task questionnaire.

3. RESULTS

From the user experiment, we collected behavioral and questionnaire data from the 275 participants. Here, we describe the results of the analyses of the behavioral data, the pre-task questionnaire, and post-task questionnaires.

We analyzed the effects of two factors, i.e., the presence of condition and eHEALS, on search/browsing behavior and information scrutiny perspectives. Here, we set three levels for the condition: (1) with negative confirmation bias (BIASED(−) group), (2) without confirmation bias (NEUTRAL group), and (3) with positive confirmation bias (BIASED(+) group). We then analyzed the differences between the BIASED(−) and BIASED(+) groups compared to the NEUTRAL group.

Table 1 shows the mean values and standard deviations of the various behavioral indices for each condition.

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[6]The `brms` package in R was used for modeling.

3.1. Search Session Time

To analyze how carefully participants performed their search and browsing behavior, we compared the search session time for each group of participants. **Table 2** shows that the 90% HDI of the coefficient of the condition did not contain zero in the analysis comparing the BIASED(−) and NEUTRAL groups. Note that this is equivalent to rejecting the null hypothesis in frequentist statistics.

These results demonstrate that the BIASED(−) group tended to have shorter search session time than that of the NEUTRAL group. However, the 90% HDI of the coefficients of the eHEALS and interaction contained zeros, which is equivalent to not rejecting the null hypothesis in frequentist statistics. In addition,

we observed that eHEALS and interaction had no effect on the search session time.

The 90% HDI for condition, eHEALS, and interaction coefficients contained zero in the analysis comparing the BIASED(+) and NEUTRAL groups. Therefore, the presence or absence of positive confirmation bias had no effect on the search session time.

3.2. Dwell Time on SERP

We compared the SERP browsing time to analyze how carefully the participants browsed the list of search results while collecting information. We found that the 90% HDI of the coefficient of the condition and interaction did not contain zero in the analysis comparing the BIASED(−) and NEUTRAL groups.

The interaction was confirmed; thus, we conducted a simple main effect analysis, and the results are shown in **Figure 3**. As can be seen, when the participant's eHEALS was low, the BIASED(−) group tended to spend less time browsing SERP compared to the NEUTRAL group. However, when the eHEALS was high, the BIASED(−) group tended to spend more time browsing the SERP compared to the NEUTRAL group.

As shown in **Table 2**, the 90% HDI of the coefficients of condition and interaction contained zero in the analysis comparing the BIASED(−) and NEUTRAL groups. Therefore, the presence or absence of positive confirmation bias had no effect on SERP dwell time.

3.3. Maximum Dwell Time on Webpage

To analyze how carefully the participants browsed the webpages in the SERP, we compared the participants' maximum webpage browsing time during the search task. Compared to the NEUTRAL

TABLE 1 | Mean and standard deviation of condition in each behavioral index.

Behavioral index	Condition		
	BIASED(−)	NEUTRAL	BIASED(+)
Search session time (second)	446.6 (446.8)	437.0 (379.3)	269.7 (314.0)
Dwell time on SERP (second)	73.0 (86.6)	75.7 (63.4)	58.4 (82.9)
Maximum dwell time on webpage (second)	146.4 (118.5)	155.5 (144.9)	93.6 (58.5)
Maximum click depth	11.2 (9.2)	12.5 (9.9)	8.9 (9.4)
Number of page views	5.0 (4.7)	5.3 (5.2)	5.1 (7.5)
Number of page views(−)	2.8 (2.6)	2.9 (2.8)	4.2 (5.0)
Number of page views(+)	3.0 (2.4)	3.2 (2.6)	3.1 (3.6)
Belief change	0.39 (1.15)	0.26 (0.99)	−0.35 (1.02)

TABLE 2 | GLMM results compared to neutral group.

Behavioral Index	BIASED(−)			BIASED(+)		
	Condition	eHEALS	Interaction	Condition	eHEALS	Interaction
Search session time	**-1.01**	-0.02	0.01	0.28	-0.02	-0.04
	[-1.96, -0.14]	[-0.05, 0.01]	[-0.01, 0.04]	[-1.36, 1.91]	[-0.05, 0.01]	[-0.10, 0.03]
Dwell time on SERP	**-1.00**	$4.58e^{-3}$	**0.05**	0.89	$4.58e^{-3}$	-0.06
	[-1.82, -0.11]	[-0.02, 0.03]	**[0.01, 0.08]**	[-0.57, 2.35]	[-0.02, 0.03]	[-0.12, 0.02]
Maximum dwell time on page	-0.54	-0.02	0.02	0.40	-0.02	-0.04
	[-1.37, 0.32]	[-0.04, 0.01]	[-0.01, 0.05]	[-0.92, 1.78]	[-0.04, 0.01]	[-0.09, 0.02]
Maximum click depth	**-1.02**	$1.75e^{-3}$	**0.04**	-0.20	$1.75e^{-3}$	-0.01
	[-1.97, -0.15]	[-0.03, 0.03]	**[0.00, 0.07]**	[-1.76, 1.34]	[-0.03, 0.03]	[-0.07, 0.05]
Number of page views	-0.45	$9.92e^{-4}$	0.01	0.24	$9.92e^{-4}$	-0.02
	[-1.29, 0.37]	[-0.02, 0.03]	[-0.09, 0.04]	[-1.43, 1.79]	[-0.02, 0.03]	[-0.09, 0.04]
Number of page views(−)	-0.14	$8.52e^{-3}$	$5.33e^{-3}$	-0.23	$8.52e^{-3}$	0.01
	[-1.15, 0.82]	[-0.02, 0.04]	[-0.03, 0.05]	[-3.12, 2.94]	[-0.02, 0.04]	[-0.12, 0.14]
Number of page views(+)	**-0.84**	$-9.99e^{-3}$	**0.03**	-0.12	$-9.99e^{-3}$	$4.58e^{-3}$
	[-1.60, -0.09]	[-0.03, 0.01]	**[0.00, 0.06]**	[-1.55, 1.25]	[-0.03, 0.01]	[-0.06, 0.05]
Belief change	0.50	$9.03e^{-3}$	-0.34	0.39	$9.03e^{-3}$	-0.01
	[-0.55, 1.44]	[-0.02, 0.04]	[-1.80, 1.20]	[-2.12, 2.65]	[-0.02, 0.04]	[-0.07, 0.05]

Numbers represent the median and interval of 90% HDI. Bold numbers do not contain zero in the 90% HDI.

group, the 90% HDI of the condition, eHEALS, and interaction coefficients contained zero for the BIASED(−) and BIASED(+) groups (**Table 2**), which indicates that the presence or absence of confirmation bias had no effect on maximum dwell time.

3.4. Number of Page Views

We also evaluated the number of webpages viewed by the participants during the search task to analyze how intensively the participants attempted to collect evidence when they assessed the truth of the given search topic. Compared to the NEUTRAL group, the 90% HDI of the condition, eHEALS, and interaction coefficients contained zero for both the BIASED(−) and BIASED(+) groups (**Table 2**), which indicates that the presence or absence of confirmation bias had no effect on the number of page views.

We also analyzed the extent to which participants viewed webpages containing information that was consistent with their prior beliefs. Here, the number of clicks on a webpage that included the word "dangerous" in the title or summary of the search result was defined as the number of PAGEVIEWS(−). In addition, we defined the number of clicks on a webpage that included the word "safe" as the number of PAGEVIEWS(+).

For the number of PAGEVIEWS(−), the 90% HDI of the condition, eHEALS, and interaction coefficients contained zero for both the BIASED(−) and BIASED(+) groups (**Table 2**), which indicates that the number of PAGEVIEWS(−) was not affected by the presence or absence of confirmation bias.

For the number of PAGEVIEWS(+), the 90% HDI of the condition and interaction coefficients did not contain zero in the analysis comparing the BIASED(−) and NEUTRAL groups (**Table 2**). Here, as we observed the interaction, we conducted a simple main effect analysis, and the results are shown in **Figure 4**. As can be seen, when the participant's eHEALS was low, the BIASED(−) group tended to have fewer PAGEVIEWS(+) than the NEUTRAL group. However, when the participant's eHEALS was high, the BIASED(−) group tended to have more PAGEVIEWS(+) than the NEUTRAL group.

For the number of PAGEVIEWS(+), the 90% HDI of the condition and interaction coefficients did not contain zero in the analysis comparing the BIASED(+) and NEUTRAL groups (**Table 2**). This indicates that the presence or absence of positive confirmation bias had no effect on the number of PAGEVIEWS(+).

3.5. Maximum Click Depth

To analyze how deeply the participants scanned the search result list, we investigated the order of the search results the participants clicked on to analyze the maximum search result rank, i.e., the maximum click depth. **Table 2** shows that the 90% HDI of the condition and interaction coefficients did not contain zero in the analysis comparing the BIASED(−) and NEUTRAL groups. Here, we conducted a simple main effect analysis because we observed the interaction, and the results are shown in **Figure 5**. As can be seen, when the participant's eHEALS was low, the BIASED(−) group tended to click on higher search results than the NEUTRAL group. However, when the participant's eHEALS was high, the BIASED(−) group tended to click on lower search results than the NEUTRAL group.

FIGURE 4 | Estimated effect of condition and eHEALS on number of page views(+). The red line represents the NEUTRAL group and the blue line represents the BIASED(−) group. The background color indicates the confidence interval.

FIGURE 3 | Estimated effect of condition and eHEALS on SERP dwell time. The red line represents the NEUTRAL group, and the blue line represents the BIASED(−) group. The background color indicates the confidence interval.

FIGURE 5 | Estimated effect of condition and eHEALS on maximum click depth. The red line represents the NEUTRAL group, and the blue line represents the BIASED(−) group. The background color indicates the confidence interval.

As shown in **Table 2**, the 90% HDI of the condition, eHEALS, and interaction coefficients contained zero in the analysis comparing the BIASED(+) and NEUTRAL groups, which indicates that the presence or absence of positive confirmation bias had no effect on the maximum click depth.

3.6. Belief Change

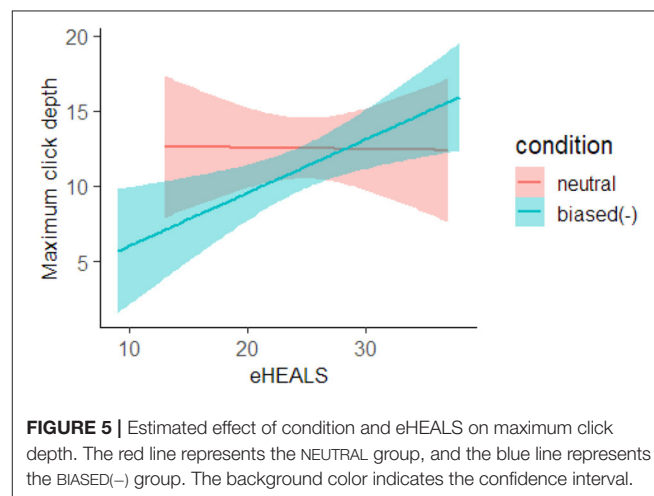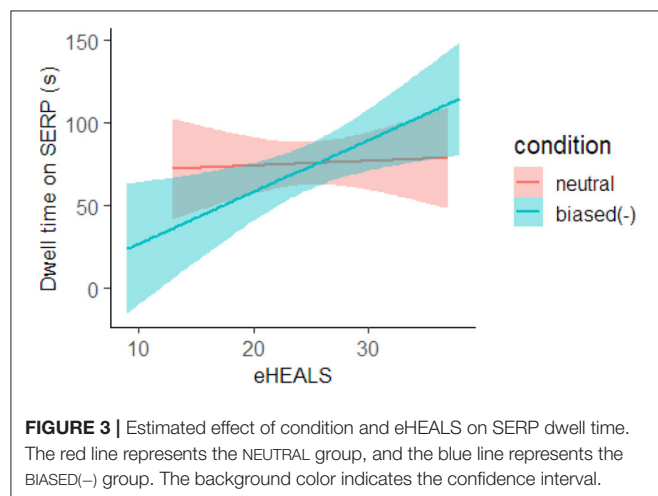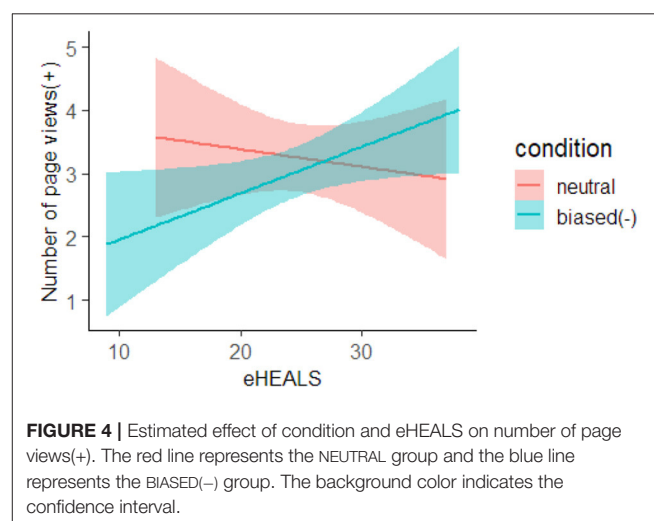We evaluated the difference between the posterior and prior beliefs to analyze the extent to which the participants' prior beliefs changed as a result of the search task. **Table 2** shows that the 90% HDI of the condition, eHEALS, and interaction coefficients included zero for both the BIASED(−) and BIASED(−) groups compared to the NEUTRAL group. These results indicate that participants did not change their prior beliefs much over the course of the search task regardless of the presence of positive or negative confirmation bias.

4. DISCUSSION

4.1. Hypothesis Verification

In this study, we analyzed the SERP browsing time and maximum click depth to verify **H1** regarding the webpage selection behavior. The results demonstrated that when the participant's eHEALS score was low, the BIASED(−) group spent less time browsing the SERPs than the NEUTRAL group, tended to click on the higher (shallower)-ranked search results, and viewed pages that were inconsistent with their prior belief less frequently. When the participants' eHEALS score was high, the BIASED(−) group spent more time browsing the SERPs than the NEUTRAL group, tended to click on lower (deeper)-rank search results, and viewed pages that were inconsistent with their prior belief more often. In contrast, no difference was observed in SERP browsing time and maximum click depth for the BIASED(+) and NEUTRAL groups.

The eHEALS score is a scale that reflects the information literacy required to obtain and view health information on the web carefully (health literacy). Therefore, even if participants with high health literacy had negative confirmation bias for the search topic, they could reduce the negative confirmation bias and carefully select webpages to view. In contrast, when participants with low health literacy had negative confirmation bias about the search topic, they could not reduce the negative confirmation bias and spent much attention and time selecting the webpages to view from the search result list. Thus, we believe that hypotheses H1 and H4 regarding webpage selection are supported only when web search users have negative confirmation bias for the given search topic.

We also analyzed the maximum page browsing time and number of page views to verify **H2** regarding webpage browsing behavior. Here, we did not find that maximum page browsing time was affected by confirmation bias. For the number of page views, the BIASED(−) group with low eHEALS score tended to view fewer webpages containing the word "safe" in the title or summary text compared to the NEUTRAL group. In contrast, the BIASED(−) group with a high eHEALS score tended to view more webpages with the word "safe" in the title or summary text compared to the NEUTRAL group. Similar to the results of

the analyses of dwell time on SERP and maximum click depth, these results suggest that the participants with low health literacy could not control the effects of confirmation bias when they had negative confirmation bias for the given search topic. In addition, the results indicate that the participants did not actively browse webpages that were inconsistent with their belief (i.e., webpages that refers to GM foods as safe). In contrast, participants with high health literacy were able to reduce the impact of negative confirmation bias and actively browsed webpages that were inconsistent with their prior belief in the search results. Therefore, we believe that H2 and H4 were supported only when the participants had a negative confirmation bias about the given search topic.

We analyzed the difference in belief before and after performing the web search task to verify **H3** regarding belief change after web searches. The results demonstrate that no significant difference was observed in terms of the amount of belief change in the BIASED(−) and BIASED(+) groups compared to the NEUTRAL group. Thus, we consider that **H3** was not supported. The results for **H1** and **H2** indicate that even if web search users with high health literacy had negative confirmation bias for the given search topic, they viewed pages with different positions actively. Thus, the results for **H3** suggest that it is difficult for users with high health literacy to change their beliefs in a significant way, even if they are able to reduce the negative effects of confirmation bias and perform careful search browsing behavior.

Finally, we discuss the differences in the various behavioral indexes only for the BIASED(−) group. Rozin et al. found that humans are more influenced by negative information than positive information (Rozin and Royzman, 2001); therefore, we expected that the negative confirmation bias for search topics would impact search browsing behavior more than positive confirmation bias. We found that the BIASED(−) group was more affected by confirmation bias than the BIASED(+) group, and the values of the various behavioral indexes decreased significantly compared to those of the NEUTRAL group.

In summary, our study revealed that when web searchers with poor health literacy have negative prior beliefs about health topics, they could not examine web search results and preferentially view web pages supporting their beliefs. On the other hand, if web searchers with high health literacy have negative prior beliefs about health topics, they could spend more time examining web search results and browsing web pages that present different opinions. However, the study results indicate that their prior belief could not change so much even if they browse various opinions. In the case where web searchers have positive prior beliefs about health search topics, we did not observe the relationship between health literacy and web search behaviors.

The study results imply several points to design classes and information access systems for critical information seeking on the web. Firstly, we might need to develop educational classes related to information literacy so that people can reflect and improve their web search behaviors toward critical information seeking. It might be good to collaborate with computer scientists to develop a function on web search/browsing systems that

general web searchers can use to reflect their search behaviors. As our study revealed, web searchers with poor health literacy did not often examine web search results and compare them with various web pages. Consequently, they lost opportunities to check if their prior belief could be wrong or disputed. Bateman et al. proposed a search user interface that summarizes web search histories of users and revealed that the interface could help users modify their search behavior to improve search performance (Bateman et al., 2012). For supporting web searchers with low health literacy, one possible application is a web browser extension to visualize user behavior tendencies in order to encourage people to improve deficiencies relative to behaviors of web searchers with high health literacy.

The second point is prediction of the extent of health literacy. Our study revealed that if web searchers with poor health literacy have negative prior beliefs about health search topics, they often make less effort to examine web search results than those with high health literacy. For supporting web searchers with poor health literacy efficiently, we need a method to find such searchers. We observed specific web search behaviors to distinguish web searchers with poor health literacy and those with high literacy (e.g., dwell time on SERP, number of page views, and maximum click depth) through the online study. In the field of computer science, machine learning is a popular technique to make predictions with data. We plan to apply machine learning techniques to web search behavior data to build a predictor for the health literacy of web searchers.

The third point is mitigation of confirmation bias in web searches. Although our study suggests that it is difficult for web searchers to change their prior beliefs, we need to support web searchers mitigating their confirmation bias or doing web searches objectively. One possible application is interactive chat-bot systems that ask web searchers which evidence supports the belief and show contradictory opinions while searching for web information. If computer scientists collaborate with experts from the field of health psychology, we believe that they can develop such systems and contribute to reducing confirmation bias.

4.2. Limitations

To realize more accurate analyses, at least two issues must be considered and improved in this user experiment. The first is the generalizability of the results of the online study. In this study, we considered "GM foods" as a search topic in the health field. To confirm whether this study's findings can be generalized to other topics, we must conduct search task experiments in other fields and examine the effects of confirmation bias in each field.

The second issue is the quality of the webpages in the list of search results in the given search task. In our user experiment, we used the results of a Google search with a query pair of the words "safe" or "dangerous" and "GM foods" to create the list of search results. However, when we investigated the domains of the collected webpages, we found that many of the webpages containing the word "safe" were authorized by public organizations, which are generally considered reliable. The "GM foods" chosen as the search topic in this user experiment represents foods that have been confirmed as safe by the Ministry of Health, Labor, and Welfare in Japan (MHLW). Therefore, the

list of results including the word "safe" collected by the Google search also contained a significant amount of information from national public organizations, e.g., the MHLW. According to Liao et al., even if information is inconsistent with one's beliefs, users are more likely to view the information if the information provider is identified as having a high level of expertise (Liao and Fu, 2014b). In other words, users with negative confirmation bias may be more likely to click on positive information if it contains reliable information regardless of the polarity of their beliefs. Therefore, it is difficult to precisely analyze why participants with negative confirmation bias viewed the search results containing the word "safe" actively in the current experimental design. Thus, we must conduct user experiments by creating search results for both negative and positive information with the same level of reliability.

5. CONCLUSION

In this paper, we have described an online experiment using crowdsourcing that was conducted to identify web search behaviors in consideration of confirmation bias. To divide users into groups with and without confirmation bias, we provided the participants with prior information to manipulate their impressions of the given search topic. We then analyzed the logs of their search and browsing.

We found that participants with negative beliefs about the given search topic often spent less time browsing the search result list page, clicked on higher-ranked search results, and did not browse search results about positive opinions when they had low health literacy. In contrast, participants with high health literacy, even if they had negative beliefs about the given search topic, often spent more time browsing the search results page, scanned lower ranked search results, and browsed more actively for search results containing positive opinions. However, the results also suggest that it was difficult for participants with high health literacy to remove the negative effects of confirmation bias and change their beliefs, even if they were able to perform careful search browsing behavior. We conclude from these results that web searchers with confirmation bias are unlikely to change their prior beliefs even if they spend a lot of effort searching for information. Therefore, we consider that the most important issue is to design a function on web access systems that supports web searchers to mitigate confirmation bias. Moreover, we need to develop a function of the systems to detect web searchers with poor health literacy and improve their health literacy and web search behaviors toward critical information seeking on the web.

In the future, we plan to challenge the following several issues based on our study results. First, we must conduct additional user experiments with different search topics and search result lists to obtain a deeper understanding of user web search behaviors in consideration of confirmation bias and generalize our findings to other fields. Secondly, we need to develop a function on web search/browsing systems that general web searchers can use to reflect their search behaviors toward critical information seeking. Furthermore, we need to build a system that predicts the health literacy of web searchers and

encourages the searchers with poor health literacy to make more efforts for critical web searches. Finally, we need to support web searchers mitigating their confirmation bias by showing contradictory opinions in web searches.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for

participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

MS and YY contributed to conception and design of the study. MS developed an experimental system and wrote the first draft of the manuscript. YY performed the statistical analysis. Both authors contributed to manuscript revision, read, and approved the submitted version.

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Perceived Information Overload and Unverified Information Sharing on WeChat Amid the COVID-19 Pandemic: A Moderated Mediation Model of Anxiety and Perceived Herd

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Individuals' unverified information sharing on social media, namely, sharing information without verification, is a major cause of the widespread misinformation amid the COVID-19 pandemic. The association between perceived information overload and unverified information sharing has been well documented in the cognitive overload approach. However, little is known about the underlying mechanism of this process. This study aims to explore the mediating role of anxiety and the moderating role of perceived herd between perceived information overload and unverified information sharing on WeChat. Anxiety demonstrates people's emotional response to the pandemic, whereas perceived herd describes a willingness to share certain information if it has been shared by many. The results of an online survey in China ($N = 525$) showed that perceived information overload was positively associated with unverified information sharing. In addition, this relationship was partially mediated by anxiety. Moreover, perceived herd positively moderated the link between anxiety and unverified information sharing, such that the indirect effect of perceived information overload on unverified information sharing *via* anxiety was significant in conditions where the level of perceived herd was high, whereas the indirect effect was not significant in conditions where the level of perceived herd was low. The moderated mediation model extends the cognitive overload approach and indicates that unverified information sharing is not only an individual strategy to cope with information overload but also a herding behavior to manage anxiety. Practical implications for curbing people's tendencies toward unverified information sharing on social media are discussed.

Keywords: unverified information sharing, perceived information overload, anxiety, perceived herd, moderated mediation, COVID-19

INTRODUCTION

The COVID-19 pandemic has not only posed a severe threat to public health but has also brought about an infodemic. An infodemic occurs when an excessive amount of information, including false or misleading information, circulates in digital and physical environments during a disease outbreak, which leads to public confusion, risk-taking behaviors, mistrust in health

authorities, and other negative social impacts (WHO, 2020a). The prevalence of social media amplifies this phenomenon because information travels much faster and further compared with the times when web-based technologies are not prevalent (Zarocostas, 2020). Moreover, social media afford users the great convenience of sharing information with just a click, usually without careful scrutiny of the information content (Apuke and Omar, 2021). The individual-level behavior of sharing information without verification is a major cause of the wide spread of misinformation. Thus, understanding individuals' unverified information sharing on social media is of great importance in fighting the infodemic.

In relation to the term *unverified information sharing*, several other terms, such as *misinformation sharing* and *fake news sharing*, have been used interchangeably in extant research (Islam et al., 2020; Laato et al., 2020; Apuke and Omar, 2021). However, we suggest important differences between them. Unverified information sharing emphasizes people's sharing without authenticating the information (Laato et al., 2020), and the shared information could be either true or false. By contrast, misinformation sharing refers to people's sharing of incorrect information that is created without the intention of causing harm (Madraki et al., 2021), whereas fake news sharing describes individuals' sharing of false information that is intentionally created to mislead readers (Di Domenico et al., 2021). The rapidly evolving situation of the COVID-19 pandemic and the information overload have made it increasingly difficult for ordinary people to differentiate between misinformation, fake news, and facts (Eysenbach, 2020; Huynh, 2020). In most cases, individuals do not intentionally share misinformation or fake news when they realize the information is incorrect (Mena, 2020). Nevertheless, not knowing the veracity of information and sharing it without verification is quite common (Islam et al., 2020; Laato et al., 2020). Thus, we consider unverified information sharing an appropriate term.

A majority of prior research has used a psychological perspective to explicate unverified information sharing. The first research line has adopted the uses and gratifications theory and viewed unverified information sharing as a behavior motivated by fulfilling certain needs, such as socialization, self-promotion, pass time, entertainment, and altruism (Islam et al., 2020; Apuke and Omar, 2021; Balakrishnan et al., 2021). The second line has employed the cognitive overload approach and assumed that human brains overloaded by information have limited processing capability; to cope with cognitive overload, people tend to share information without authentication (Fox et al., 2007; Talwar et al., 2019; Laato et al., 2020). In relation to unverified information sharing, the third line has identified that negative emotions, especially anxiety, are a significant predictor of people's information-sharing behaviors (Rosnow, 1991; He et al., 2019; Lim et al., 2021).

Although the uses and gratifications theory has illuminated the motives of people's information sharing on social media, such as socialization, self-promotion, entertainment, pass time, and altruism (Islam et al., 2020; Apuke and Omar, 2021; Balakrishnan et al., 2021), these motives do not capture the uniqueness of sharing without verification. In other words, people share information without verifying its content, mainly because they have limited processing capability when faced with the uncertainty of the pandemic and the excessive amount of rapidly updating information (Fox et al., 2007; Sweller, 2011). Thus, we propose that the cognitive overload approach is more appropriate than the uses and gratifications theory to explain unverified information sharing in this study. Furthermore, a plethora of research has shown that repeated and excessive exposure to COVID-19 information can potentially induce anxiety and other related negative emotions (Bao et al., 2020; Nekliudov et al., 2020; Zou et al., 2021), which suggests that the cognitive overload approach and the emotional predictors should be integrated to understand unverified information sharing. Moreover, unverified information sharing is not only an individual behavior to cope with information overload and the associated anxiety (He et al., 2019; Talwar et al., 2019; Laato et al., 2020; Lim et al., 2021) but is also susceptible to others' influence, especially on social media (Apuke and Omar, 2020). Thus, social influence should be considered when examining unverified information sharing on social media.

Based on the cognitive overload approach (Fox et al., 2007; Samson and Kostyszyn, 2015; Laato et al., 2020; Whelan et al., 2020), this study introduces perceived information overload as a predictor of unverified information sharing. Furthermore, given that cognitive overload is often associated with negative emotions, especially anxiety (Bao et al., 2020; Nekliudov et al., 2020; Zou et al., 2021), we treat anxiety as a mediator between perceived information overload and unverified information sharing. According to the social impact theory (Latané, 1981; Handarkho, 2020), social media create situations in which individuals can observe others' behaviors, which generates pressure for individual users to follow the crowd. Thus, we include perceived herd, a willingness to share a piece of information when shared by many on social media (Apuke and Omar, 2020), as a moderator in the mediating relationship. In particular, WeChat is the most widely used smartphone application for people to acquire information or news about COVID-19 in China (Liu, 2020). A considerable amount of misinformation related to the COVID-19 pandemic has been circulating on WeChat (Naeem and Bhatti, 2020). Thus, we test the moderated mediation model of unverified information sharing on WeChat. The results would provide us with a comprehensive understanding of the socio-psychological mechanism of unverified information sharing on social media and offer new directions for curbing the widespread misinformation.

THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

Perceived Information Overload and Unverified Information Sharing

During the COVID-19 pandemic, a vast number of messages created by multiple sources, such as scientists, government and health agencies, news media, key opinion leaders, and

ordinary social media users, have been widely circulating on various social media platforms worldwide (WHO, 2020b). This is also the case for WeChat in China (Ma et al., 2020). In the face of a huge amount of information, individuals tend to feel overwhelmed, which is termed perceived information overload in prior research (Hong and Kim, 2020). Scholars have defined information overload in relation to the quantity and quality of the information and the cognitive responses toward the information (Eppler and Mengis, 2004; Ji et al., 2014). Accordingly, information overload consists of the following key components: (1) an overflow of information, (2) information characterized by ambiguity, and (3) ineffective management of information due to limited capacity (Kim et al., 2007). Based on these studies, we define perceived information overload as a state of feeling overwhelmed due to exposure to an excessive amount of complex, ambiguous, and uncertain COVID-19 information on WeChat and a limited capacity to process this information.

We employ the cognitive overload approach to illustrate the relationship between perceived information overload and unverified information sharing. The cognitive overload approach assumes that the human working memory has a limited capacity and that only a small amount of new information can be processed at a time (Sweller, 2011). When overloaded by complex and excessive messages, individuals tend to make careless decisions, such as accepting incoming messages without verification, as they experience less self-control and are unable to process these messages (Fox et al., 2007; Samson and Kostyszyn, 2015). Because perceived information overload is a major indicator of the cognitive overload approach (Whelan et al., 2020), we regard unverified information sharing as an outcome of perceived information overload.

Within the cognitive overload approach, the coping theory helps us further understand why people share information without verification when they experience information overload. The coping theory argues that individuals tend to make behavioral changes to manage psychological stress (Lazarus and Folkman, 1984; Tennen et al., 2000). Specifically, individuals employ the problem-focused coping strategy to solve the perceived problem by doing something to alter the source of stress (Lazarus and Folkman, 1984). Perceived information overload is a major source of psychological stress during the pandemic (Bermes, 2021). To alter this stressful encounter, individuals adjust their behaviors (Livneh and Martz, 2007). As a result, unverified information sharing, which requires little cognitive effort, represents a behavioral adaptation to manage the stressful state of information overload. Moreover, the positive association between perceived information overload and unverified information sharing has been empirically supported in previous studies (Talwar et al., 2019; Islam et al., 2020; Laato et al., 2020). Accordingly, we put forward the following hypothesis to examine unverified information sharing on WeChat:

> *Hypothesis 1 (H1)*: Perceived information overload is positively associated with unverified information sharing.

The Mediating Role of Anxiety

The COVID-19 pandemic has severely threatened people's mental wellbeing and caused major emotional distress (Sheek-Hussein et al., 2021). Across the globe, high rates of anxiety have been reported in the general population during the pandemic (Xiong et al., 2020; Santabárbara et al., 2021). Anxiety is a future-oriented mood state that arises when individuals experience the risk of upcoming negative events (Freiling et al., 2021; Sampaio et al., 2021). The mutation of the coronavirus and the uncertainty about pandemic control globally denote a great risk to public wellbeing (Gomez et al., 2021). In the face of the risk, individuals tend to have a feeling of anxiety, a feeling of tension and worriedness, together with physical changes, such as increased blood pressure, sweating, trembling, dizziness, and a rapid heartbeat (Kazdin, 2000).

On the one hand, an individual's anxiety about the pandemic can be exacerbated by his or her perceived information overload (Khaleel et al., 2020). The constant information influx on COVID-19 makes it difficult for people to differentiate between facts and rumors, which increases their stress in managing uncertainty (Mohammed et al., 2021). In such a circumstance, people's perceived control over information seeking and processing decreases (Swar et al., 2017). An individual's inability to access, understand, and make use of pertinent information might make this person anxious (Bawden and Robinson, 2009). Moreover, an abundance of studies have demonstrated that the overconsumption of COVID-19 information and the associated perceived information overload are positively correlated with anxiety (Holmes et al., 2020; Siebenhaar et al., 2020; Bendau et al., 2021; Song et al., 2021). Thus, we posit the following hypothesis:

> *Hypothesis 2 (H2)*: Perceived information overload is positively associated with anxiety.

On the other hand, to cope with anxiety, people tend to engage in unverified information sharing. According to the coping theory, emotion-focused coping is aimed at managing or reducing the emotional distress caused by a given situation (Lazarus and Folkman, 1984). The severe and uncertain threat of the COVID-19 pandemic to public health has triggered anxiety among the general population (Xiong et al., 2020; Santabárbara et al., 2021). To manage anxiety and reduce emotional distress, people share information with their family, friends, co-workers, and community members to feel connected to close others (Chen et al., 2021; Lim et al., 2021). The positive association between anxiety and information sharing on social media has been empirically supported in previous research (Thelwall and Thelwall, 2020; Yin et al., 2020; Sharma and Kapoor, 2021). Because individuals in an anxious state are likely to make careless decisions during public health emergencies (Moghanibashi-Mansourieh, 2020), their information-sharing behaviors are often characterized by a lack of verification. Consequently, we expect that the more anxious an individual is about the pandemic, the more likely that he or she is

to share information without authentication. More formally, we posit the following hypothesis:

Hypothesis 3 (H3): Anxiety is positively associated with unverified information sharing.

The above postulated hypotheses suggest that anxiety may mediate the association between perceived information overload and unverified information sharing. Based on the stimulus-organism-response paradigm, a recent study demonstrated that external stimuli (e.g., perceived information overload) affected individuals' internal states (e.g., anxiety) and their subsequent information behaviors amid the COVID-19 pandemic (Song et al., 2021). Because unverified information sharing is a specific type of information behavior, Song's et al. (2021) findings provide a rationale for us to examine the following mediation effect:

Hypothesis 4 (H4): Anxiety mediates the association between perceived information overload and unverified information sharing.

The Moderating Role of Perceived Herd

Based on the social impact theory, individual behaviors are usually influenced by the presence of others' actions (Latané, 1981; Handarkho, 2020). When individuals observe a large number of others performing a certain behavior, this person is also highly likely to perform the same behavior (Apuke and Omar, 2020). Thus, whether or not an individual shares a piece of information without authentication is susceptible to the number of others' information-sharing behaviors observed on WeChat. We introduce perceived herd to illustrate this social impact on people's unverified information sharing. Perceived herd refers to one's willingness to follow a behavior performed by a substantial number of others (Handarkho, 2020). In this study, we define perceived herd as people's willingness to share a piece of information when it is shared by a large number of others on WeChat. Specifically, we test whether perceived herd moderates the direct link between perceived information overload and unverified information sharing and the indirect link between them *via* anxiety.

The mechanism of herding behaviors helps explain the moderating role of perceived herd in the relationships between perceived information overload, anxiety, and unverified information sharing. Herding behaviors can be seen as imitating others and discounting one's own decision (Sun, 2013). Herding behaviors usually occur under two conditions: uncertainty about the decision and observation of others' actions (Sun, 2013). In other words, when an individual feels uncertain about whether or not to perform a certain behavior, that person is likely to imitate others. Notably, the likelihood of imitating others increases if an individual observes that a considerable number of others are performing the behavior. For instance, during the early COVID-19 outbreak, many people were uncertain about whether to stock up; nevertheless, when they noticed that a majority of others were engaging in panic buying,

they followed such a behavior (Loxton et al., 2020). Likewise, when individual users are uncertain about whether to share a social media post or endorse an online review, they tend to imitate others; if they observe many "likes" of the post and many favorable online reviews, they will follow the crowd and perform the same behavior (Mattke et al., 2020; Xue et al., 2020). These studies demonstrate that perceived herd may largely increase an individual's likelihood of performing a behavior about which he or she is previously uncertain.

People's perceived information overload and the associated anxiety are often accompanied by their uncertainty about the veracity of information related to COVID-19 (Mohammed et al., 2021). Thus, people may hesitate to share this uncertain information. However, their hesitation may decrease when they observe a considerable number of close others and influential users have shared uncertain information on social media. In such circumstances, people are more likely to herd and share the same information, usually without verification (Rao et al., 2001; Apuke and Omar, 2020). Thus, we propose that perceived herd may moderate the link between perceived information overload and unverified information sharing and the link between anxiety and unverified information sharing. For individuals with high levels of perceived herd, the association between perceived information overload and unverified information sharing will be stronger compared with those with low levels of perceived herd. Similarly, the association between anxiety and unverified information sharing will be stronger for individuals with high levels of perceived herd than for those with low levels of perceived herd. We put forward the following hypotheses to test the moderating role of perceived herd:

Hypothesis 5 (H5): Perceived herd positively moderates the direct link between perceived information overload and unverified information sharing. The direct link between perceived information overload and unverified information sharing is stronger in conditions where the level of perceived herd is high than in conditions where the level of perceived herd is low.

Hypothesis 6 (H6): Perceived herd positively moderates the link between anxiety and unverified information sharing. The link between anxiety and unverified information sharing is stronger in conditions where the level of perceived herd is high than in conditions where the level of perceived herd is low.

Moreover, considering that perceived herd moderates the association between anxiety and unverified information sharing, perceived herd is also likely to moderate the indirect effect. Thus, we posit another hypothesis:

Hypothesis 7 (H7): Perceived herd positively moderates the indirect effect of perceived information overload on unverified information sharing *via* anxiety. The indirect effect of perceived information overload on unverified information sharing *via* anxiety is stronger in conditions
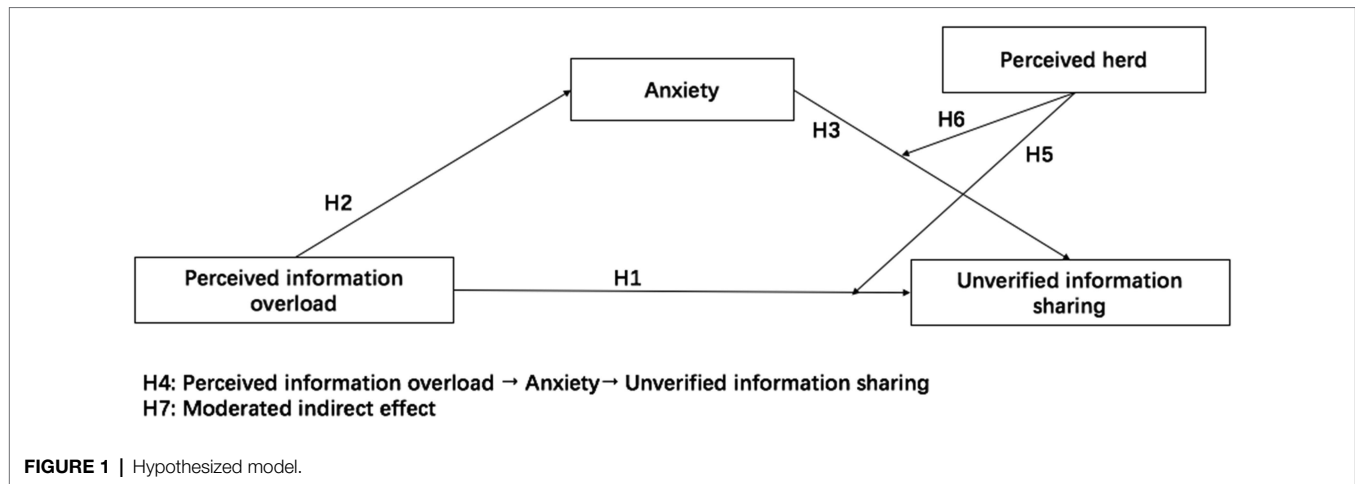
FIGURE 1 | Hypothesized model.

where the level of perceived herd is high than in conditions where the level of perceived herd is low.

Figure 1 presents the hypothesized model in this study.

MATERIALS AND METHODS

Participants

A cross-sectional online survey was conducted to collect the data. We recruited participants by using Sojump's sampling service,[1] a professional online survey website in China. The sampling pool provided by Sojump consists of 2.6 million registered respondents with diverse demographic characteristics in mainland China. A number of previous studies have used this sampling strategy to examine various social issues in China, such as air pollution, renewable energy use, and the development of e-commerce (Zhou et al., 2013; Chen et al., 2016; Huang, 2020). Our survey began on December 6, 2021, and ended on December 8, 2021. By December 8, 2021, the COVID-19 pandemic was generally under control in China, but small-scale outbreaks were occurring in local areas: eight high-risk areas and 44 medium-risk areas were noted across the country (The State Council of the People's Republic of China, 2021). A plethora of information related to COVID-19 circulated on WeChat during this time period. Through exposure to this information, individuals may experience information overload and anxiety. Furthermore, they could observe others' information-sharing behaviors on WeChat. Thus, during this time period, respondents might feel information overload, experience anxiety and perceived herd, and engage in unverified information sharing on WeChat, although the degree of these variables might differ between respondents. The institutional review board of the authors' university approved the data collection protocol. Voluntary informed consent was obtained from the participants before the online survey.

To be eligible for this study, participants had to have experience using WeChat to acquire the COVID-19 information. A total of 556 participants in Sojump's survey pool completed the online survey. We considered questionnaires invalid if they met one of the two criteria: (1) made multiple submissions using the same IP address or (2) did not pass any of the five attention checks (e.g., "please select 'strongly agree'"). Finally, 525 valid cases were used for the data analysis. **Table 1** displays the demographic features of the participants.

Measures
Perceived Information Overload

Referring to prior research (Laato et al., 2020), perceived information overload was measured with three items on a 5-point Likert scale (1 = "strongly disagree," 5 = "strongly agree"): (1) "I am often distracted by the excessive amount of the COVID-19 information on WeChat," (2) "I find that I am overwhelmed by the amount of the COVID-19 information on WeChat that I process on a daily basis," and (3) "I receive too much information regarding the COVID-19 pandemic to form a coherent picture of what's happening." The three items were averaged, with higher scores suggesting higher levels of perceived information overload ($M = 2.89$, $SD = 0.92$, Cronbach's $\alpha = 0.76$).

Anxiety

The measurement of anxiety was developed through adapting two previous scales (Lovibond and Lovibond, 1995; He et al., 2019). Participants were asked to indicate the extent to which they experienced the following feelings about the COVID-19 pandemic: (1) anxious, (2) panicky, (3) terrified, (4) scared, and (5) dizzy. The items were measured on a 7-point scale (1 = "not at all," 7 = "very strongly"). The five items were averaged to create a composite index, with higher values indicating higher levels of anxiety ($M = 3.45$, $SD = 1.23$, Cronbach's $\alpha = 0.88$).

Perceived Herd

In accordance with a previous instrument (Apuke and Omar, 2020), we measured perceived herd with three items on a

TABLE 1 | Demographic characteristics of the participants.

Measure	Item	Frequency	Percentage (%)
Gender	Male	217	41.3
	Female	308	58.7
Age	18–24	39	7.4
	25–34	279	53.1
	35–44	98	18.7
	45–65	106	20.2
	Over 65	3	0.6
Education level	Never attend to school	0	0
	Primary school	0	0
	Middle school	5	1.0
	High school	17	3.2
	Vocational high school	13	2.5
	Higher vocational school	64	12.2
	Bachelor	383	73.0
	Master	41	7.8
	PhD	2	0.4
Monthly income	Less than 1,500 RMB	7	1.3
	1,501–2,000 RMB	6	1.1
	2,001–3,000 RMB	13	2.5
	3,001–5,000 RMB	74	14.1
	5,001–8,000 RMB	161	30.7
	8,001–12,000 RMB	140	26.7
	12,001–20,000 RMB	96	18.3
	More than 20,000 RMB	28	5.3

5-point Likert scale (1 = "strongly disagree," 5 = "strongly agree"): (1) "My choice to share the COVID-19 information on WeChat is influenced by the number of people who like and share it," (2) "If I realized that many of my friends share certain COVID-19 information on WeChat, then I would be more willing to share this information," and (3) "The more people like and share the COVID-19 information on WeChat, the more likely it is for me to reshare it." A composite index was created by calculating the mean score of the three items, with a higher value indicating a higher degree of perceived herd ($M = 3.22$, $SD = 0.96$, Cronbach's $\alpha = 0.84$).

Unverified Information Sharing

Following a previous instrument (Laato et al., 2020), we used four items to measure the frequency of unverified information sharing on WeChat: (1) "How often do you share information or news related to COVID-19 on WeChat without checking its authenticity?," (2) "How often do you share information or news about COVID-19 on WeChat without checking facts through trusted sources?," (3) "How often do you share information or news related to COVID-19 on WeChat without verifying it?," and (4) "How often do you share information or news related to COVID-19 on WeChat even if sometimes you feel the information may not be correct?" Participants answered the questions on a 5-point Likert scale (1 = "never," 5 = "always"). The four items were averaged to create an additive index of unverified information sharing ($M = 1.61$, $SD = 0.76$, Cronbach's $\alpha = 0.87$).

Control Variables

Age was measured as a continuous variable ($M = 35.14$, $SD = 9.83$) and gender as a dichotomous variable (41.3% males). Monthly income (Median = 6.00, or 8,001–12,000 RMB/month, $SD = 1.33$) and education level (Median = 7.00, or Bachelor's degree, $SD = 0.84$) were both measured as ordinal variables. In addition, considering that exposure frequency was associated with information sharing (He et al., 2019), we included it as a control variable. A single item was used to measure exposure frequency on a 5-point scale (1 = "never," 5 = "always"): "How often do you encounter information or news related to COVID-19 in the past month?" ($M = 3.50$, $SD = 0.82$).

Statistical Analyses

We first used SPSS version 26.0 to calculate the means and standard deviations of the examined variables and the bivariate correlations between them. Then, we employed PROCESS version 3.5 to test the research hypotheses. Age, gender, monthly income, education level, and WeChat exposure frequency were entered as covariates in the analysis. The mediating role of anxiety between perceived information overload and unverified information sharing was tested using Model 4 of the PROCESS macro (Hayes, 2013). The moderating role of perceived herd in the mediation model was tested using Model 15 of the PROCESS macro (Hayes, 2013). We tested the mediation effect and moderated mediation effect with 5,000 bootstrap samples at 95% bias-corrected confidence intervals (Preacher and Hayes, 2008). A bootstrap confidence interval that did not include zero indicated a significant effect. Unstandardized coefficients were reported.

RESULT

Preliminary Analyses

Table 2 presents a correlation matrix of the variables. Perceived information overload was positively correlated with unverified information sharing ($r = 0.28$, $p < 0.001$) and anxiety ($r = 0.41$, $p < 0.001$). Both anxiety ($r = 0.29$, $p < 0.001$) and perceived herd ($r = 0.42$, $p < 0.001$) were positively associated with unverified information sharing. Among the control variables, exposure frequency was positively correlated with unverified information sharing ($r = 0.18$, $p < 0.001$), while age was negatively correlated with unverified information sharing ($r = -0.14$, $p < 0.01$).

The Mediating Role of Anxiety

To test the mediating role of anxiety in the relationship between perceived information overload and unverified information sharing, a mediation analysis was performed. Exposure frequency, gender, age, education level, and monthly income were entered as covariates. Perceived information overload was entered as the independent variable, unverified information sharing as the outcome variable, and anxiety as the mediator variable. The statistical results are shown in **Table 3**.

Supporting H1, a positive association was found between perceived information overload and unverified information

TABLE 2 | Correlations between the variables.

	UIS	PIO	Anxiety	PH	Exposure	Gender	Age	Education	Income
UIS	1								
PIO	0.28***	1							
Anxiety	0.29***	0.41***	1						
PH	0.42***	0.25***	0.21***	1					
Exposure	0.18***	0.17***	0.13**	0.22***	1				
Gender	− 0.05	− 0.002	0.06	− 0.02	− 0.04	1			
Age	− 0.14**	− 0.11*	− 0.18***	− 0.07	− 0.04	− 0.28***	1		
Education	0.06	0.01	0.04	− 0.03	0.08	0.07	− 0.35***	1	
Income	− 0.02	− 0.08	0.02	0.01	0.07	− 0.07	0.01	0.33***	1

***p < 0.001; **p < 0.01; and *p < 0.05. N = 525. UIS, unverified information sharing; PIO, perceived information overload; and PH, perceived herd.

TABLE 3 | Testing the mediating role of anxiety.

Predictors	Model 1	Model 2	Model 3
	UIS	Anxiety	UIS
	B (SE) t	B (SE) t	B (SE) t
PIO	0.20 (0.04) 5.70***	0.52 (0.05) 9.56***	0.14 (0.04) 3.69***
Anxiety			0.12 (0.03) 4.28***
R^2	0.11	0.19	0.14
F	10.70***	20.62***	12.09***

***p < 0.001. N = 525. Each column is a regression model which predicts the criterion at the top of the column. Unstandardized coefficients were reported. UIS, unverified information sharing; PIO, perceived information overload.

sharing ($B = 0.14$, $SE = 0.04$, $p < 0.001$). Consistent with H2 and H3, perceived information overload was positively associated with anxiety ($B = 0.52$, $SE = 0.05$, $p < 0.001$), and anxiety was positively correlated with unverified information sharing ($B = 0.12$, $SE = 0.03$, $p < 0.001$). In addition, the bootstrap analysis demonstrated that the indirect effect of perceived information overload on unverified information sharing *via* anxiety was significant (effect size = 0.06, $SE = 0.02$, CI [0.03, 0.10]). Thus, H4 was supported.

Moderated Mediation Effect

To test H5–H7, we examined the moderated mediation effect. Exposure frequency, gender, age, education level, and monthly income were treated as covariates. Perceived information overload was entered as the independent variable, unverified information sharing as the outcome variable, anxiety as the mediator variable, and perceived herd as the moderator variable. Three conditions were created based on the value of the moderator variable (Hayes, 2013): one standard deviation below the mean (2.00), the mean (3.33), and one standard deviation above the mean (4.33).

Inconsistent with H5, the results showed that the interaction effect of perceived information overload and perceived herd on unverified information sharing was not significant ($B = 0.04$, $SE = 0.04$, $p = 0.23$). Supporting H6, we found that the interaction effect of anxiety and perceived herd on unverified

information sharing was significant ($B = 0.06$, $SE = 0.03$, $p < 0.05$). The significant interaction effect was further examined using simple slope analysis. We plotted the interaction effect of anxiety and perceived herd on unverified information sharing in **Figure 2**. Notably, the association between anxiety and unverified information sharing was stronger for people with high levels of perceived herd (simple slope = 0.16, $t = 4.11$, $p < 0.001$) than for those with low levels of perceived herd (simple slope = 0.10, $t = 3.83$, $p < 0.001$). Moreover, perceived herd moderated the indirect effect of perceived information overload on unverified information sharing *via* anxiety: the indirect effect was significant in conditions where the level of perceived herd was high (effect size = 0.08, $SE = 0.03$, CI [0.03, 0.14]), whereas the indirect effect was not significant in conditions where the level of perceived herd was low (effect size = 0.01, $SE = 0.01$, CI [−0.0, 0.04]). Hence, H7 was supported. **Table 4** presents the results of the moderated mediation analysis. **Figure 3** depicts the final model based on the statistical results.

DISCUSSION

Although a number of studies have demonstrated the association between perceived information overload and unverified information sharing (Talwar et al., 2019; Islam et al., 2020; Laato et al., 2020), the potential mechanisms underlying the process remain underexplored. To this end, the present study proposes a moderated mediation model to test the mediating role of anxiety and the moderating role of perceived herd. The results showed a direct and positive association between perceived information overload and unverified information sharing. Furthermore, the mediating role of anxiety demonstrated that as perceived information overload increased, anxiety intensified, which then facilitated the behavior of unverified information sharing. Moreover, perceived herd moderated this mediating effect: the indirect effect of perceived information overload on unverified information sharing *via* anxiety was significant in conditions where the level of perceived herd was high, whereas the indirect effect was not significant in conditions where the level of perceived herd was low.

FIGURE 2 | Interaction effect of anxiety and perceived herd on unverified information sharing.
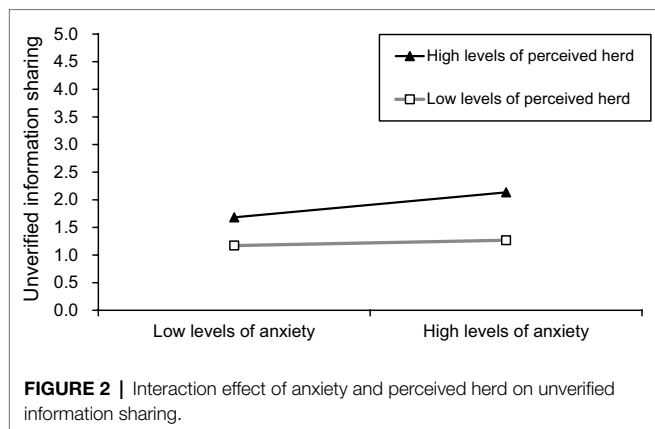
TABLE 4 | Testing the moderated mediation effect.

Predictors	Model 1	Model 2
	Anxiety	UIS
	B (*SE*) *t*	*B* (*SE*) *t*
PIO	0.52 (0.05) 9.56***	−0.06 (0.12) −0.52
PIO × PH		0.04 (0.04) 1.21
Anxiety		−0.10 (0.08) −1.22
Anxiety × PH		0.06 (0.03) 2.44*
R^2	0.19	0.26
F	20.62***	18.45***

*$p < 0.05$ and ***$p < 0.001$. N = 525. Unstandardized coefficients were reported. UIS, unverified information sharing; PIO, perceived information overload.*

Theoretical Implications

First, consistent with our hypothesis, this study showed that perceived information overload facilitated unverified information sharing on WeChat. The finding supported that individuals overloaded by large packets of complex information had limited processing capability and tended to make quick decisions without a second thought (Sweller, 2011; Samson and Kostyszyn, 2015). Meanwhile, this quickly made decision—unverified information sharing in the current study—served as a coping strategy for individuals to resolve the problem of perceived information overload (Lazarus and Folkman, 1984). Thus, our findings corroborated the cognitive overload approach (Fox et al., 2007; Talwar et al., 2019; Laato et al., 2020) in explicating people's unverified information sharing on social media, especially in circumstances characterized by an imminent threat and high levels of uncertainty, such as the COVID-19 pandemic.

Second, our results showed that anxiety partially mediated the association between perceived information overload and unverified information sharing. On the one hand, the mediation effect exhibited that perceived information overload induced anxiety. This finding may help researchers better understand the antecedents of anxiety in information-sharing research, which has rarely been examined. On the other hand, the mediation effect showed that anxiety triggered unverified information sharing. Compared with previous research that

identified anxiety as a predictor of information sharing (Thelwall and Thelwall, 2020; Yin et al., 2020; Sharma and Kapoor, 2021), our findings demonstrated that anxiety also predicted unverified information sharing. Moreover, the findings also supported that unverified information sharing functioned as a coping strategy for individuals to deal with emotional distress (Lazarus and Folkman, 1984) during the pandemic. Taken together, this mediation effect extended the cognitive overload approach by including anxiety as an emotional outcome of information overload and an emotional predictor of unverified information sharing.

Third, the moderated mediation effect demonstrated that the indirect effect of perceived information overload on unverified information sharing *via* anxiety was significant only in conditions where the level of perceived herd was high, whereas the indirect effect was not significant in conditions where the level of perceived herd was low. As previously discussed, the mediation effect suggested that unverified information sharing served as a strategy for individuals to cope with the anxiety induced by information overload. However, the moderated mediation effect indicated that this coping mechanism worked only when individuals had high levels of perceived herd. Consistent with the social impact theory (Latané, 1981; Apuke and Omar, 2020; Handarkho, 2020), these results suggested that people's unverified information sharing on social media was susceptible to the influence of others' information sharing behaviors. Moreover, whether individuals engaged in unverified information sharing to cope with anxiety largely depended on their levels of perceived herd. Compared with prior research that focused on the cognitive and emotional predictors of unverified information sharing (He et al., 2019; Talwar et al., 2019; Islam et al., 2020; Laato et al., 2020; Lim et al., 2021), the moderating role of perceived herd highlighted that social influence might precondition cognitive and emotional effects on one's unverified information sharing.

Fourth, inconsistent with our hypothesis, we found that perceived herd did not significantly moderate the direct association between perceived information overload and unverified information sharing. This is probably because behaviors driven by emotions are highly susceptible to perceived herd, whereas perceived herd makes little difference to the occurrence of behaviors based on cognitive judgment (Loxton et al., 2020). In the current study, the direct association between perceived information overload and unverified information sharing represented a process of how one's cognition of information overload triggered their behavior of unverified information sharing. Thus, this direct association was not easily affected by perceived herd.

Practical Implications

The moderated mediation model proposed in this study has some practical implications for managing people's unverified information sharing on WeChat and other social media platforms. First, the direct association between perceived information overload and unverified information sharing suggests that individuals' perceived information overload should be decreased to lower their tendency to engage in unverified
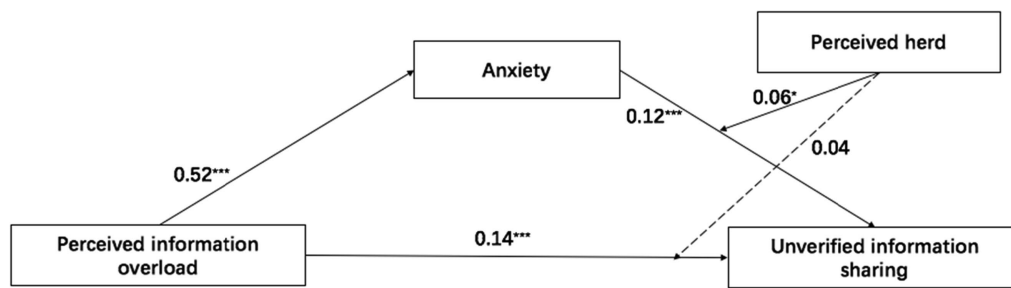
FIGURE 3 | Final model based on statistical results. *$p < 0.05$ and ***$p < 0.001$.

information sharing. This can be realized in several ways. Social media platforms should improve gatekeeping functions, such as setting up effective fact checkers to filter out a vast number of misinformation. Meanwhile, platforms can use algorithms to push information on other topics to divert users' attention to COVID-19 information. Furthermore, based on users' web browsing records, platform corporations can target heavy users who are likely to experience information overload and set a protective mode to prevent them from browsing posts related to the coronavirus for too long. Social media users are encouraged to enhance their digital literacy so that they are more capable of dealing with the information influx and thus reduce the feeling of perceived information overload.

Second, given that anxiety mediated the relationship between perceived information overload and unverified information sharing, anxiety should be regulated to properly manage unverified information sharing on social media. For instance, social media platforms are advised to insert a note in sections of COVID-19-related information, thereby reminding users to stay alert to the content that may trigger their anxiety and other negative feelings. Furthermore, AI-powered chatbots can be built in the browsing interface for users to initiate a conversation if necessary, thus easing users' anxiety caused by information overload. In addition to these online measures, users are advised to regulate their anxiety by themselves, such as seeking emotional support from close ones or reappraising the encounter of information overload.

Third, the indirect effect of perceived information overload on unverified information *via* anxiety was only significant in conditions where the level of perceived herd was high, which indicates that special attention should be paid to social media users with high levels of perceived herd. Through lawfully analyzing users' digital footprints on social media, platforms can target groups of users who often herd in terms of information sharing. To reduce the perceived herd of these targeted groups, platforms can use algorithms to recommend diverse topics and views to them.

Limitations and Future Research

The current study has several limitations. First, we collected data only from China. Because unverified information sharing related to the COVID-19 pandemic on social media has become a common problem in many countries across the globe (Islam et al., 2020; Laato et al., 2020; Apuke and Omar, 2021), the one country- and single platform-based design provides us with limited insights into understanding this problem. Thus, in the future, scholars can conduct comparative research to examine unverified information sharing on different social media platforms between different countries. Furthermore, we could not claim causality between the examined variables, as we used a cross-sectional design. Hence, experimental or longitudinal studies can be used to test causal relationships in the future. In addition, the mean value of unverified information sharing on WeChat was low. This is probably because our study was conducted during a time period when the COVID-19 pandemic was not very salient in China. Accordingly, future research can test the moderated mediation model in areas where the pandemic is salient. Lastly, the self-reported measures of unverified information sharing in this study, which were also widely used in prior research (Islam et al., 2020; Laato et al., 2020), were prone to social desirability and estimation biases. To overcome this limitation, we advise researchers to use an experimental design to observe subjects' unverified information sharing.

CONCLUSION

This study proposes a moderated mediation model to unveil the socio-psychological mechanism of people's unverified information sharing on WeChat during the COVID-19 pandemic. Perceived information overload predicts unverified information sharing. Furthermore, this relationship is partially mediated by anxiety. Moreover, the indirect path between perceived information overload and unverified information sharing through anxiety is significant only in conditions where the level of perceived herd is high. The findings indicate that unverified information sharing on social media not only serves as an individual strategy to cope with information overload but also represents a herding behavior to resolve anxiety. In relation to extant research on unverified information sharing, this moderated mediation model not only extends the cognitive overload approach by including anxiety as a mediator but also highlights that perceived herd may precondition the effects of cognitive and emotional

predictors on unverified information sharing. The model also provides social media platforms and social media users with some practical implications to lower the tendency toward unverified information sharing. Hopefully, our study could offer some insights into curbing the widespread misinformation and fighting the infodemic.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Institutional Review Board of the Faculty of Social Sciences, Zhejiang University. The patients/participants

provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

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Social Facilitation in Fear Appeals Creates Positive Affect but Inhibits Healthy Eating Intentions

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The social facilitation of eating plays a significant role in influencing individuals' eating decisions. However, how social eating cues are processed in health promotion messages is unclear. This study examined individuals' food craving in response to social cues in images (Experiment 1) and emotional experiences, perceived threat, perceived efficacy, behavioral intentions, and motivational coactivation elicited by social eating cues in obesity prevention fear appeals (Experiment 2). Results suggested that the presence of a group of people eating in an image facilitated food craving for the presented foods. Moreover, fear appeals that presented obesity and its consequences with more social eating cues, versus individual eating cues, generated greater positive emotional responses, perceived threat severity, response and self-efficacy, and motivational coactivation indicating more attention and threat vigilance. However, these cues also generated fewer self-reported intentions to change unhealthy eating behaviors. Implications and suggestions for future research are discussed.

Keywords: cue reactivity, fear appeals, social facilitation of eating, health communication, coactivation

INTRODUCTION

The use of fear appeals to limit unhealthy behaviors is contentious. Decades of research have revealed mixed findings regarding their efficacy, and meta-analyses and systematic reviews have come to mixed conclusions regarding their use as well (e.g., Witte and Allen, 2000; Ruiter et al., 2014; Tannenbaum et al., 2015). In general, empirical data support that behavioral change is more likely when threat information is accompanied by high efficacy messaging (Witte and Allen, 2000; Ruiter et al., 2014; Tannenbaum et al., 2015), but this combination may still prove ineffective. Why? Unfortunately, the context and cues in which threat and efficacy are embedded into messages are sometimes at cross-purposes with the goal of behavior change.

From a cue-reactivity perspective, message designers can expect certain cues to trigger certain types of cognitive and motivational processing and behavior automatically due to incentive-sensitization (Robinson and Berridge, 1993; Carter and Tiffany, 1999). The incentive-sensitization model posits that repeated exposure to addictive substances and their cues can create "incentive-sensitization" in which individuals exhibit attentional biases and compulsive cravings when re-exposed to these cues (Robinson and Berridge, 1993; Carter and Tiffany, 1999). The influences

of incentive-sensitization have been well documented in the substance addiction literature (Robinson and Berridge, 1993; Carter and Tiffany, 1999) as well as in work focusing on food cues, especially for the most palatable types of food (Sobik et al., 2005; Hou et al., 2011). With this previous research in mind, work in health communication has noted the appetitive and incentivizing effects of different types of substance cues (i.e., tobacco, vaping, alcohol, and food) in prevention messages, potentially creating unintended effects. These cues elicit approach tendencies indicated by increased craving, self-reported positivity, physiologically appetitive responses, and attention (Bailey, 2015, 2017; Clayton et al., 2017a,b, 2019a,b; Liu and Bailey, 2019; Sanders-Jackson et al., 2019) increased visual fixation (Sanders-Jackson et al., 2011); and greater memory for the cues (Clayton et al., 2017b; Bailey et al., 2018; Sanders-Jackson et al., 2019). The important take-away from this growing evidence is that message designers must understand how these cues function, particularly in fear appeal messaging, which use them to gain attention (Clayton et al., 2017a) and potentially inhibit message rejection (Bailey et al., 2018; Sarge and Gong, 2019). The studies presented here build on this previous work by considering social cue influences. Social facilitation of eating cues was examined across two experiments. Study 1 sought to determine whether social facilitation of eating cues induced more craving with simple visual still image stimuli. Study 2 then examined how the presence of these cues may influence effectiveness of more complex televised anti-obesity public service announcements (PSAs) containing fear appeals.

STUDY 1

Social Facilitation Cues

Social facilitation occurs when a behavior is increased due to the perceived presence of others (Zajonc, 1965; Cottrell et al., 1968; Bond and Titus, 1983; Baron, 1986). Some social facilitation studies find that mere presence of others is enough to trigger facilitation (Zajonc, 1965); others find individuals must recognize being watched for their behavior to be influenced (Cottrell et al., 1968). Suggested mechanisms include increased arousal (Zajonc, 1965), increased attention (Baron, 1986), self-presentational concerns (Bond and Titus, 1983), and evaluation apprehension (Cottrell et al., 1968). One behavior in which social facilitation research has been abundant is eating.

Previous research has indicated that social cues and settings influence how much food is consumed by individuals (De Castro, 1990; Clendenen et al., 1994; Herman, 2017). Human eating is generally social. Perceptions of "ideal" meals involve eating in other people's company (Sobal and Nelson, 2003). Further, people tend to eat more with others (without high evaluative contexts in place) especially in larger groups (De Castro, 1990) and when eating sessions are longer (Herman, 2017). When evaluative contexts are in place, self-presentational norms may encourage individuals to match behavior of others or eat less when restriction seems to be socially appropriate; women seem to be especially susceptible to the latter, depending on the context, social

companions, and types of norms displayed (Mori et al., 1987; Roth et al., 2001; Hermans et al., 2008; Young et al., 2009; Higgs and Thomas, 2016). Suggested mechanisms behind this phenomenon mirror that of social facilitation in general and range from increased positive affect and arousal, greater exposure to food cues, and social modeling (Herman, 2017). In other words, social eating contexts provide more and longer exposure to both food and eating cues, which both generally increase positive affect, arousal, and appetitive motivational activation, leading to greater food intake (unless normative expectations preclude that behavior).

These co-occurring appetitive cues (food and eating) create an interpretation problem for those intending to understand their individual influences. Because organisms need food to provide the energy and nutrients required to sustain their bodily functions, food stimuli are thought to be primary appetitive motivationally relevant stimuli (Bradley et al., 2001; Bailey, 2015). Empirical findings have demonstrated that exposure to food cues automatically elicit appetitive motivational responses (Sobik et al., 2005; Hou et al., 2011). Thus, disentangling responses to food cues and responses to social eating cues is quite difficult; viewing someone eating naturally includes food cues. But, does the social nature of more than one person eating further increase appetitive responses, as would be predicted if social facilitation effects occur?

Three recent studies (Liu and Bailey, 2020; Samson and Buijzen, 2020, 2021) have found that mediated eating cues can increase attention, positive emotion, and appetitive responses toward foods. Samson and Buijzen (2020) found that viewing individuals eating foods with hedonic expressions, compared to neutral expressions, increased positive responses toward healthy foods. Liu and Bailey (2020) found viewers paid more attention and reported more purchase intentions when viewing ads with multiple individuals present. Samson and Buijzen (2021) found increased attention and positive responses toward healthier foods in particular.

Thus, empirical data suggest that the *mediated* mere presence of others has the ability to facilitate behaviors leading to eating. However, these studies do not directly disentangle food cues from social eating cues. Thus, the first experiment reported here tested whether mediated social eating cues increased appetitive responses more than food cues alone.

Methods

Participants ($N = 61$) were predominantly female (59%), young ($M_{age} = 20.38$, $SD_{age} = 2.38$), and predominantly Caucasian (49.2%) undergraduate students at a large public university in the United States. They completed a 2 (social eating cue: individual eating vs. social eating) x 3 (repetition of cue exemplar) within-subject experiment utilizing still images of food and eating cues as stimuli. *A priori* power analysis using the G*power program (Faul et al., 2009) indicated for an 0.80 power estimate, specifying a standard small effect (0.20), a 0.05 alpha level, and 0.5 correlation among repeated measures, a 2×3 *F*-test required a sample size of 42.

These participants completed the 60-min, Institutional Review Board-approved protocol individually. After informed

consent was obtained in a lab setting, participants were seated approximately 7 feet from a high definition 42 Inch LCD screen with access to a computer keyboard. Participants viewed a series of images, one at a time, which varied in cue type in one of two orders. They reported their craving level for the food depicted in each image *via MediaLab* software (Jarvis, 2014). Social eating cues were manipulated in images by varying the number of individuals present: only one individual eating versus a group of people eating. In all images, individuals' faces and facial expressions (in particular their eyes and mouths) were visible and expressions were emotionally neutral to positive (smiling, laughing, engaged in eating). Individuals in the images were all relatively young to match the sample of participants. A mix of gender and race/ethnicity cues were present. The foods being eaten were all highly energy dense items (e.g., potato chips and ice cream) likely to induce craving (Drewnowski, 1997) to increase variability in responses. Three images were used in each cue level to increase generalizability of craving results to a type of cue rather than a particular food, for a total of six images. **Table 1** describes the exemplar images used in each type of image.

Craving was measured using the 8-item Alcohol Urge Questionnaire (Bohn et al., 1995) often used in cue-reactivity research altered to refer to food: for example, "Eating __ would make things seem perfect right now." Each item used a 5-point scale from 1 = *do not at all agree* to 5 = *strongly agree*. A craving index was created for each food image by averaging the responses to the eight items, $\alpha = 0.96$. These data were collected as part of a larger study examining individual and polysubstance cue-induced craving. Other non-overlapping data from this series are published here [blinded].

Results

The hypothesis predicted that the presence of more than one individual eating would evoke greater craving than one individual eating. In order to test this hypothesis, craving index data were submitted to a 2 (social eating cue: individual eating vs. social eating) × 3 (repetition of image) repeated measures ANOVA. The predicted social cue main effect was found, $F(1,60) = 4.997$, $p = 0.029$, $\eta_p^2 = 0.077$, such that when more than one individual was present ($M = 3.28$, $SE = 0.159$), craving was higher than when only one individual was present ($M = 3.12$, $SE = 0.159$).

TABLE 1 | Study 1 still image descriptions.

	Individual Eating Cue Images	Social Eating Cue Images
Exemplar 1	Medium shot of a young man eating a potato chip	Medium shot of a group of young women eating ice cream cones
Exemplar 2	Medium shot of a young man eating pizza	Medium shot of mixed gender group eating cookies
Exemplar 3	Medium shot of a young woman eating a cookie	Medium shot of mixed gender group eating pizza

Discussion

These results indicated that the mediated mere presence of multiple people eating does create a small but significant increase in craving. This supports that the social nature of social eating cues increases appetitive activation over and above food cues alone. Further, this expected outcome is important in understanding influences of multiple mediated contexts, not least of which is anti-obesity messages. Substance cues are used in these types of prevention messages in order to gain and keep attention (Clayton et al., 2017a) and potentially inhibit message rejection when a fear appeal is present (Bailey et al., 2018; Sarge and Gong, 2019). The following study examines social facilitation of eating cues in anti-obesity fear appeals to determine whether they also create the problematic, unintended outcomes that other incentivized substance cues do (e.g., craving for and intended use of the problematic substance).

STUDY 2

Given that more than one-third of US adults are now obese (Hales et al., 2020), obesity prevention messaging must evolve. These messages often include imagery of individuals eating junk food, likely because the imagery immediately captures attention and directly communicates behaviors to limit (Clayton et al., 2017b). Further, this imagery likely creates more positive evaluations of the messages overall because it is positively valent and appetitively motivating (Bailey, 2015; Bailey et al., 2018). This second reason may be even more likely when message designers are creating fear appeals, which are messages that communicate "the harmful physical or social consequences of failing to comply with message recommendations" (Hale and Dillard, 1995, p. 65).

Fear appeals are so-named because they rely on an audience associating experienced fear with certain behaviors. In this case, associating fear of health consequences such as heart disease and diabetes with eating junk food. However, the effectiveness of fear appeals is often questioned. In some cases, fear appeal messages can create stimulus rejection responses (e.g., Leshner et al., 2018) and in others, psychological reactance responses including anger and counterarguments (e.g., Nabi et al., 2008; Clayton et al., 2019a,b, 2020). One potential solution to this problem is for message designers to include enough positive information that the messages do not create rejection or reactance. This positive information often comes in the form of efficacy information (Witte and Allen, 2000; Nabi et al., 2008), based on theoretical assumptions and empirical data that support efficacy may trigger danger rather than a fear protection, creating message-aligned responses (Witte, 1994). This efficacy information may elicit specific discrete positive emotions (e.g., hope; Nabi and Myrick, 2019) that counter deleterious effects of fear. The positive information needed to inhibit stimulus rejection responses may also come in the form of positive emotional content (Bailey et al., 2018; Liu and Bailey, 2019; Sarge and Gong, 2019; Liu and Bailey, 2020); however, as discussed above, this may mean message

designers inadvertently provide cues encouraging unintended responses (e.g., craving) if they select substance cues to fill this role.

As Bailey et al. (2018) noted, by including food items in anti-obesity fear appeals, the messages present cues that automatically elicit appetitive responses (Boysen et al., 1996; Bailey, 2015), which, in the broader context of a fear appeal message, creates messaging that is coactive, or containing both appetitive (positive) and aversive (negative) motivationally relevant content. Their findings indicated that fear appeals including food cues, especially in messages that were highly arousing, created memory decrements likely due to cognitive overload (Bailey et al., 2018), though these types of messages were rated as more engaging and likable. Similar work by Clayton et al. (2019b) demonstrated that these messages generate "motivational dissonance" in viewers as they rate the messages as both positive and negative. Thus, message designers may be seeing benefits of positive affect which, all else being equal, yield higher ratings of engagement and likability, and potentially greater perceived efficacy.

The Extended Parallel Process model (Witte, 1994) proposes that if a threat is perceived as severe, individuals will then assess their susceptibility to and efficacy in dealing with the threat. If individuals do not believe they are susceptible, they will not perceive the threat as relevant and may not move on to make efficacy assessments. Two types of efficacy are thought to be assessed: self-efficacy and response efficacy. Self-efficacy is the ability of the individual to deal with the threat, and response efficacy is the evaluation of whether the recommended action will actually lessen the threat (Witte, 1994). When both self and response efficacy are high, individuals are more likely to adopt recommended actions, but if either or both are not sufficiently high, message rejection or reactance may occur.

Fear appeals often use peers to tailor messages to indicate susceptibility to targeted groups. Further, fear appeals often contain highly threatening information to ensure that a threat is perceived as severe; but, in order to keep individuals from rejecting the information and recommendations, positive contents are used to ensure individuals experience greater self and response efficacy. Positive affect, induced by different positive emotional contents, has been shown not only to increase self and response efficacy (Guan and Monahan, 2017), but also create better attitudes toward the health behaviors being promoted in the messaging (Dillard and Peck, 2000). Previous research has also indicated that positive affect may increase intent to engage in a message's recommended health behaviors (Previte et al., 2015). Therefore, positive content in health messages may increase recommended behaviors, all else being equal. However, some positive content may also elicit other responses.

Social Facilitation Cues: Implications for Fear Appeal Outcomes

As discussed above, food-related cues create positive affect but also may encourage unhealthy eating behaviors (Bailey et al., 2018). Social eating portrayals may further exacerbate this due to social facilitation effects (De Castro, 1990; Clendenen et al.,

1994; Drewett, 2007; Herman, 2017; Liu and Bailey, 2019; Samson and Buijzen, 2021), as replicated in Study 1.

Based on the large body of research indicating social facilitation of eating, predictions for emotion, attention, and behavioral outcomes are straightforward. However, the mere presence of others in fear appeals likely also has other influences *via* the assessment of social norms. Social norms are "rules and standards that are understood by members of a group, and that guide or constrain social behaviors" (Cialdini and Trost, 1998, p. 152). Descriptive social norms, in particular, deal with communicating prevalence of appropriate behaviors. Descriptive social norms may be interpreted as "if a lot of people are doing this, it's probably a wise thing to do," which serves to initiate norm-congruent behavior (Cialdini, 2007, p. 264). Thus, these norms are often communicated by observing others, implicitly functioning to influence behaviors, but also can be communicated explicitly (Hogg and Reid, 2006). Studies have suggested that social norms commonly influence eating, especially in contexts in which social comparisons and self-presentational concerns are important (Roth et al., 2001; Higgs and Thomas, 2016) In these cases, matching norms, in which one is expected to match the eating amounts and styles of others as well as the expectations of the situation can be prevalent, but a minimal eating norms can also be present, especially for women (Roth et al., 2001; Higgs and Thomas, 2016).

Social norm manipulations are often utilized in health campaigns to assess and correct misperceptions of how much peers engage in unhealthy (or do not engage in healthy) behaviors in order to encourage compliance with health recommendations (McAlaney et al., 2011; Dempsey et al., 2018). Some scholars have noted that social norms approaches may be particularly useful as a counterpoint to fear appeals due to their over-depiction of high-risk behaviors (McAlaney et al., 2011; Dempsey et al., 2018). For this reason, when fear appeals 1. contain highly threatening information to ensure that a threat is perceived as severe and 2. depict viewer peer groups demonstrating the risky behaviors in order to highlight viewer susceptibility, the descriptive norm implicitly communicated is that the behavior is risky but common.

These theoretical predictions and empirical findings suggest that when social eating cues are present in messages, they may have different behavioral influences than designers intend. Thus, these hypotheses are posed: portraying a group of people eating (versus one person eating) in obesity prevention PSAs will generate higher levels of (H1) positive affect, (H2) perceived threat severity and susceptibility, and (H3) self- and response efficacy, but (H4) create less intention to avoid the foods in question. Further, because these appetitive cues are embedded in aversive fear appeal messaging, their presence has implications for motivational activation and subsequent cognitive and emotional processing of the messages, including attention and arousal.

Social Facilitation Cues: Implications for Motivational Coactivation

The motivated cognition framework argues that cognitive processing is biased toward information related to our biological

imperative to survive and pass on genes (Bradley et al., 2001). Thus, information that is related to survival, threat avoidance, seeking of opportunities for food and mates, and other base-level drives is most automatically attention-grabbing and consequent for behavior. Theory predicts and empirical evidence has found that automatic behaviors are organized by activation in either or both of two motivational systems, the appetitive and the aversive (Cacioppo and Gardner, 1999; Bradley et al., 2001; Norris et al., 2010). The appetitive system activates automatically upon encountering positive stimuli, which functions to support approach behaviors. The aversive system automatically activates upon encountering negative stimuli, helping individuals respond quickly to potential threats.

Given that many health communication messages contain fear appeals layered with positive emotional contents, including substances cues and social norms reinforcement, several researchers have begun to explore the processing of so-called coactive messages, which are messages that elicit activations of both the appetitive and aversive systems, either simultaneously or sequentially (Wang et al., 2012; Lang et al., 2013; Keene and Lang, 2016; Clayton et al., 2017a; Bailey et al., 2018). Behavioral and neural evidence have revealed the pattern of processing, emotional experience, and behavior that occur when individuals are experiencing coactivity (see Norris et al., 2010), which indicates that some mutual inhibition between appetitive and aversive substrates may occur (Berntson and Cacioppo, 2008). This may account for the relatively consistent finding that during coactivation, individuals pay more attention but experience overall less physiological (Wang et al., 2012) and self-reported arousal (Lang et al., 2013).

Thus, we expect to see motivational coactivation in response to fear appeals that contain social facilitation of eating cues. In response to onset of social eating cues embedded in fear appeal anti-obesity messages, we expect (H5) viewers will exhibit an autonomic pattern consistent with greater motivational coactivation across time, greater deceleration in heart rate and lesser skin conductivity level, compared to responses elicited by individual eating cues.

These hypotheses were tested in a fully within-subject experiment in which participants viewed televised anti-obesity PSAs that varied in the number of people portrayed eating (one individual vs. a group). Dependent variables were self-reported affect, perceived susceptibility and severity, self-efficacy and response efficacy, behavioral intentions to avoid unhealthy foods, and psychophysiological indicators of cognitive resource allocation (heart rate) and arousal (skin conductance) during message exposure.

Methods

Participants ($N = 83$) were predominantly young ($M_{age} = 22.04$, $SD = 9.20$) and female (60.2%) undergraduate students at a large public university in the United States. They completed a 2 (social eating cue: individual eating vs. social eating) × 2 (repetition of exemplar message) repeated measures within-subject experiment utilizing televised fear appeal anti-obesity messages as stimuli. For the physiological investigation,

we wanted to examine the evoked autonomic responses to the eating cues. In order to do so, we selected six examples of eating cues within the messages: three that contained one person eating and three that contained multiple persons eating. Previous work examining the effects of emotionally social cues on self-reported affect including positivity, negativity, and arousal (Samson and Buijzen, 2020) indicated effect sizes ranging from 0.23–0.44. However, as Study 1 reported a lower effect size for craving self-reports, and psychophysiological studies also often report smaller effect sizes (as well as present higher correlations between repeated measurements), we specified a small effect size (0.15), an α of 0.05, and 0.6 correlation between repeated measurement in the G*Power program (Faul et al., 2009). The proposed 2×2 F-test of the self-reported data and 2×3 F-test of the physiological data require at least 72 and 60 participants, respectively, to achieve 0.80 power estimates.

These participants completed the IRB-approved protocol individually. After informed consent was obtained, participants were seated approximately 4 feet from a 42 Inch screen. The experimenter placed physiological data collection sensors while explaining the protocol. *MediaLab* software (Jarvis, 2014) was used to display each PSA. The same questionnaire was answered after each, randomized within-scale. When participants had viewed and rated all messages, they answered demographic questions and were debriefed, thanked, and dismissed. The entire procedure lasted approximately 60 min. These data were collected as part of a larger study examining emotional responses to fear appeals. Other data collected are published here (blinded).

Stimuli Selection
Messages
Four 30-s televised anti-obesity fear appeal PSAs were selected to meet objective criteria: the messages had to contain information that communicated "harmful physical or social consequences" of obesity (Hale and Dillard, 1995, p. 65) such as risk of disease or death, and all messages had to contain food cues for items the message indicated were unhealthy. And lastly, individuals in the PSAs had to be consuming these unhealthy foods. These PSAs were grouped into two types to satisfy the objective manipulation of how many individuals were eating in the PSA: 1 individual or more than 1. Two messages of each type were used in order to be better able to generalize the findings to a type of social cue rather than a singular message. The messages varied in terms of content in other ways (e.g., gender, age, race/ethnicity of those depicted, and contexts). Facial expressions were generally visible in all messages. Emotional expressions ranged from neutral to positive (smiling, engaged in eating) to more negative (frowning) during expression of health risks. **Table 2** lists brief descriptions of each exemplar message.

Eating Cues
Within the messages that were identified as containing individual and social eating cues, three exemplar onsets of eating cues were selected. The cues met these criteria: they contained eating

cues, they were changes from frames that did not contain eating cues to frames that contained eating cues, they were at least 6 sec from the other selected exemplar cues.

Dependent Variables
Self-Reported Emotional Experience
Self-reported emotional experience was measured using 3 items: 1. "Overall, how positive/pleasant/happy did the message make you feel?"; 2. "Overall, how negative/unpleasant/unhappy did the message make you feel?"; 3. "Overall, how aroused/excited/awake did the message make you feel?" Response options ranged from *Not at all* (1) to *Extremely* (7). Here, we followed Cacioppo and Berntson (1994), who suggest emotional responses should be assessed in underlying dimensions. Thus, each component was analyzed separately, not as an index.

Perceived Severity
Perceived severity of the threat was assessed with 3 items: "Based on this ad, I believe that obesity is serious" and "Based on this ad, I believe that obesity is severe" and "Based on this ad, I believe that obesity is significant." Response options ranged from *strongly disagree* (1) to *strongly agree* (7). The inter-item consistency was acceptable with a Cronbach alpha of 0.88.

Perceived Susceptibility
Perceived susceptibility to the threat was assessed with 3 items: "Based on this ad, it is possible that I would suffer from obesity" and "Based on this ad, I at a risk for becoming obese" and "Based on this ad, it is likely that I will be obese." Response options ranged from *strongly disagree* (1) to *strongly agree* (7). The inter-item consistency was acceptable with a Cronbach alpha of. 91.

TABLE 2 | Study 2 video PSA descriptions.

	Individual Eating Cue Messages	Social Eating Cue Messages
Exemplar 1	Televised PSA depicting an adult male eating unhealthy heavily processed and calorie-dense foods from a vending machine on a work break with a commentary about the health risks of doing so, including obesity and heart disease	Televised PSA depicting four family members (presumably a mother, father, son, and daughter) eating a fast food meal of burgers and chips/fries around a dinner table with a commentary indicating eating fast food may cause a fast death
Exemplar 2	Televised PSA depicting a mother giving her child a fast food burger with a comparison made of giving the child other addictive unhealthy substances.	Televised PSA depicting an adult male eating unhealthy heavily processed and calorie-dense foods with others across multiple meals juxtaposed with later portions of the message depicting health consequences of those eating choices including obesity

Perceived Self-Efficacy
Perceived self-efficacy was assessed using 3 statements based on Witte et al. (1996): "I am able to use the recommendation(s) provided in this video to prevent obesity" and "The recommendation(s) is/are easy to do to prevent obesity" and "The recommendation(s) to prevent obesity is/are convenient." Response options ranged from *strongly disagree* (1) to *strongly agree* (7). The inter-item consistency was acceptable with a Cronbach alpha of 0.81.

Perceived Response Efficacy
Perceived response efficacy was assessed with 3 statements based on Witte et al. (1996): "The recommendation(s) is/are effective in preventing obesity" and "If I follow the recommendation(s), I am less likely to become obese" and "The recommendations work for preventing obesity." Response options ranged from *strongly disagree* (1) to *strongly agree* (7). The inter-item consistency was acceptable with a Cronbach alpha of 0.77.

Behavioral Intention
Behavioral intention was assessed with 3 items adapted from Lee and Bichard (2006): "I would like to follow the recommendations made, such as eating healthy food" and "I am planning to change my unhealthy eating and drinking habits very soon" and "I do not plan to ever change my unhealthy eating and drinking behaviors unless I see my health suffering" (Reverse coded). Response options ranged from *strongly disagree* (1) to *strongly agree* (7). Inter-item consistency was reasonable with a Cronbach alpha of 0.61.

Heart Rate
Heart rate data were collected to index cognitive resource allocation across time. Heart rate deceleration is commonly used in media message research as an overtime, unobtrusive indicator of cognitive resource allocation to encoding stimuli. An assumption of psychophysiological measures is that the work of the body is more influential on physiological systems than the work of the brain, but both are continuously and simultaneously influential on outcomes like autonomic activity, and consequently, heart rate and other physiological metrics. A great many studies have found that heart rate deceleration is indicative of greater external stimulus processing, even when messages are arousing in nature, while acceleration is indicative of internal mental focus, external stimulus rejection, imagery creation, and preparation for action, depending on context (see Lang, 1994; Lang et al., 2009; Potter and Bolls, 2012 for reviews). A Biopac MP-150 wireless amplifier and two disposable 8 mm Ag-AgCI electrodes placed on the forearms with a ground on the non-dominant wrist were used to collect Raw electrocardiogram data. Raw data were sampled at 1000hz and cleaned off-line with Biopac Acqknowledge software. Recording artifacts were identified and corrected using interpolation. Average beats per minute (BPM) per second data were computed for each second of exposure for each participant.

FIGURE 1 | Self-reported emotional experience as a function of type of social eating cues present in the obesity PSA messages.

FIGURE 2 | Perceived severity of and susceptibility to threat ratings as a function of type of social eating cues present in the obesity PSA messages.

Skin Conductivity Level

Skin conductivity level (SCL) data were collected to index sympathetic arousal (Potter and Bolls, 2012). Tonic SCL was recorded using a Biopac MP150 wireless unit that passed a constant measurement voltage of 0.5v between two disposable 8 mm Ag/AgCl electrodes on the non-dominant hand. Raw data were sampled at 1000hz. Average SCL data were computed for each second of exposure for each participant.

Data Treatment and Analysis

Self-report data were submitted to a 2 (social eating cue: individual eating vs. social eating) × 2 (repetition) repeated measures ANOVA. Prior to analysis, the physiological data (heart rate and skin conductivity level) were transformed to assess change from onset of eating cues (see information regarding selection of eating cue exemplars above). The first second of each cue onset was identified, and the values for these onsets in the average BPM and average SCL data were located. The values of the 5 sec following each cue onset were also located. The value of the first second of onset was used as a reference point and subtracted from each of the following five values to construct a change

from onset of eating cue trajectory of BPM and average SCL data. This was done in order to better examine the evoked responses to the cues and better isolate the changes in these two metrics due to the cues themselves rather than the many factors that play a role in fluctuations of heart rate and skin conductivity (see Potter and Bolls, 2012 for a discussion of this data treatment method). These change-transformed data were submitted to a 2 (social eating cue: individual eating vs. social eating) × 3 (repetition of exemplar) × 6 (time in seconds from onset of the eating cues) repeated measures ANOVA. In order to deal with the autocorrelated nature of the physiological data, which violated sphericity assumptions, Hyun–Feldt corrections were utilized. Original and corrected degrees of freedom are reported.

Results
Emotional Responses

Hypothesis 1 predicted that a group of people portrayed eating would increase positive affect compared to an individual. The predicted social eating cue main effects on positive affect, $F(1,82) = 26.99$, $p < 0.001$, $\eta_p^2 = 0.25$, negative affect, $F(1,82) = 13.73$, $p < 0.001$, $\eta_p^2 = 0.14$, and emotional arousal ratings, $F(1,82) = 67.12$, $p < 0.001$, $\eta_p^2 = 0.45$, were found. As can be seen in **Figure 1**, when social eating cues were present, viewers rated messages as less negative, more positive, and more emotionally arousing. Hypothesis 1 was supported.

Perceived Severity and Susceptibility

Hypothesis 2 predicted that more people portrayed eating would increase perceived threat severity and susceptibility compared to individuals eating. This predicted main effect of social eating cue was found on perceived severity, $F(1,82) = 22.30$, $p < 0.001$, $\eta_p^2 = 0.22$, but not on perceived susceptibility, $F(1,82) = 2.03$, $p = 0.14$, $\eta_p^2 = 0.03$. As can be seen in **Figure 2**, when social eating cues were present, viewers reported more perceived severity and more perceived susceptibility (though, again, this latter difference was not statistically significant). Hypothesis 2 was partially supported.

Perceived Efficacy

Hypothesis 3 predicted that more people portrayed eating would increase response and self-efficacy compared to individuals eating. This predicted main effect of social eating cue was found on response efficacy, $F(1,82) = 7.54$, $p = 0.007$, $\eta_p^2 = 0.08$, and self-efficacy ratings, $F(1,82) = 11.53$, $p = 0.001$, $\eta_p^2 = 0.12$. As can be seen in **Figure 3**, when social eating cues were present in PSAs, viewers reported more response efficacy and self-efficacy. Hypothesis 3 was supported.

Behavioral Intentions

Hypothesis 4 predicted that a group of people portrayed eating would decrease healthy eating intentions compared to an individual portrayed eating. The main effect of social eating cue was found on eating intention ratings, $F(1,82) = 26.00$, $p = 0.001$, $\eta_p^2 = 0.24$. When social eating cues were present, viewers reported fewer intentions to change their unhealthy

FIGURE 3 | Efficacy ratings as a function of type of social eating cues present in the obesity PSA messages.

FIGURE 4 | Heart rate in beats per minute as a function of time of exposure and type of social eating cues present in the obesity PSA messages.

FIGURE 5 | Skin conductivity level as a function of time of exposure and type of social eating cues present in the obesity PSA messages.

eating behaviors ($M = 2.62$, $SE = 0.10$) compared to when individual eating cues were present ($M = 3.29$, $SE = 0.12$). Hypothesis 4 was supported.

Motivational Coactivation

Hypothesis 5 predicted that when social eating cues were presented in fear appeal messages, individuals would exhibit an autonomic pattern consistent with coactivation across time, more deceleration in heart rate and lesser skin conductivity level. The predicted interactions of social eating cue with time were found on the heart rate data, $F(5,320/1.9,122.5) = 6.87$, $p < 0.001$, $\eta_p^2 = 0.10$ and SCL data, $F(5,320/1.4,90.7) = 8.19$, $p = 0.002$, $\eta_p^2 = 0.11$, such that when a group of people were portrayed eating, viewers exhibited more deceleration in heart rate and less SCL overall. See **Figures 4, 5**. Hypothesis 5 was supported.

Discussion

This study examined the influence of social eating cues in anti-obesity fear appeals on individuals' reported emotional experiences, perceived severity and susceptibility, efficacy ratings, healthy eating intentions, and motivational coactivation indexed *via* autonomic patterns in heart rate and skin conductivity. Results indicated that the messages containing a group of individuals eating created not only more positive emotional responses, but also more response and self-efficacy. Further, the social facilitation components functioned to increase perceived threat. However, the social eating imagery elicited lower ratings of healthy eating intentions, as predicted.

Perceived susceptibility was not significantly affected by social eating cues. Group affiliations with the persons portrayed in the messages may not have been strong enough to induce this effect. Further, the mixture of social norms portrayals of unhealthy eating paired with severe threat information may have made the outcomes described in the message (obesity and obesity-related illness) seem unlikely, yielding lower perceptions of susceptibility (see McAlaney et al., 2011 for related discussion).

GENERAL DISCUSSION

The findings presented here are in line with previous health communication and cue-reactivity research, but may be counterintuitive for health communication message designers. Food and eating cues in real and mediated contexts automatically elicit appetitive motivational activation (De Castro, 1990; Clendenen et al., 1994; Bailey, 2015, 2017; Herman, 2017; Liu and Bailey, 2020), which creates more positive affect that yields greater response and self-efficacy (Previte et al., 2015; Guan and Monahan, 2017). However, this automatic appetitive motivation is concurrently activating approach and consumption behaviors, leading to fewer intentions to actually change unhealthy eating behaviors. Further, the psychophysiological data presented here support that social eating cues are experienced coactively when embedded in fear appeals. This confirms previous explanations regarding why message designers may turn intuitively to social eating cues. The motivational coactivation elicited by social eating cues in fear appeals facilitates attention to the

messages as well as overall positive affect and message evaluation. Thus, even though televised fear appeal PSAs with social eating imagery intend to persuade people not to consume unhealthy food, the increased appetitive motivational responses generated may create unintended and opposite behavioral consequences from those encouraged by the messaging.

Overall, these data tell an interesting story about the counterproductive effects of the presentation of food-related cues in anti-obesity PSAs that may be discouraging positive behavior changes. These results may seem paradoxical but align well with a social norms approach as well as a cue-reactivity point of view. Eating is an inherently social behavior in humans, and the indications of eating encourage eating in others (de Castro, 1990). Because these kinds of eating and food-related cues are primary biologically motivators, creating positive affect, which in turn makes individuals feel more positive and efficacious while simultaneously encouraging them to eat (Bailey, 2015). Taken together, these findings indicate that food-related cues, especially those that also engage social facilitation, play a role in appetitive motivation and reward and subsequently, cognitive and emotional processing. It is therefore important for message designers to avoid presenting food-related cues in obesity prevention messages if the goal is to discourage overeating or eating specific foods.

In sum, the current study examines potential detrimental effects of social eating cues in PSAs. While prior information tailoring studies have mainly focused on how individual and social factors moderate the effects of health message frames, this study was conducted to examine cue-elicited responses when watching obesity prevention fear appeals. Our results suggest that those obesity prevention PSAs, which were designed to promote healthy eating behaviors, might have counterproductive effects when including social eating cues. Therefore, this study contributes to existing literature on tailoring health interventions by suggesting that similarity and liking cues may be facilitated by more general social cues. Further, this study provides practical suggestions for message designers and health professionals. If message designers intend to grab attention and soften fear appeals with positive affect-inducing stimuli, social eating cues are not the best choice.

Although the current study has provided some insight into how social eating cues in anti-obesity PSAs influence individuals' emotional experiences, perceived threat, efficacy ratings, and health intentions, limitations should be considered. First, self-reported emotional and behavioral responses were used as outcome variables, which may be subject to social desirability biases. Future studies should use measures less susceptible to these biases, including actual eating behavior. Second, we utilized a convenience sample of college students. While useful for looking at the impacts of social eating cues in this within-subject experimental design, this sample's response pattern may not be generalizable to other groups. Next, though this study did utilize multiple exemplars within each eating cue category across both studies, they were limited to two or three exemplars each. Future work should replicate and expand the number of exemplars to a larger pool of exemplars to better defend against case-category confounds (see O'Keefe, 2015). Lastly, while this study examined the effects of social eating cues on emotional responses, health intentions, and self-efficacy and response efficacy, there may be other factors that also influence the impacts of social eating cues in PSAs. First, this study did not consider reactance, though many previous studies support that reactance is a crucial factor in fear appeal processing (e.g., Clayton et al., 2019b). Secondly, we did not consider weight status of participants, though some data indicate weight status may play a role in anti-obesity message effectiveness (Shentow-Bewsh et al., 2016; So and Alam, 2019). Further, many individual differences may moderate emotional and behavioral responses in the social context of eating. For example, gender seems to be an important factor in social eating scenarios (Mori et al., 1987; Hermans et al., 2008; Young et al., 2009), especially in combination with weight status and diet restriction (De Luca and Spigelman, 1979; Herman et al., 2003). Women are more likely to respond to social eating cues, either eating more or less, depending on the context, social companions, and social norms displayed. While this study was designed to minimize the influence of individual differences by comparing the influence of social eating cues within individual, future work should examine the interaction of these noted and other individual differences with social eating cues in influencing health prevention message effectiveness.

Despite these limitations, these findings contribute to knowledge regarding health messaging, especially in biologically relevant contexts such as discouraging unhealthy eating. Additional research considering how cues that create automatic biological responses are altering the intended effects of health messaging is necessary.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Florida State University Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

RB: writing, experimental design, stimulus, and data cleaning and analysis. TW: writing, experimental design, stimulus, and data collection and cleaning. JL: writing, experimental design, stimulus, and data cleaning. RC: writing, experimental design, and data collection. KK, VD, and FK: writing. All authors contributed to the article and approved the submitted version.

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Facts Tell, Stories Sell? Assessing the Availability Heuristic and Resistance as Cognitive Mechanisms Underlying the Persuasive Effects of Vaccination Narratives

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Online vaccine-critical sentiments are often expressed in appealing personal narratives, whereas vaccine-supporting information is often presented in a non-narrative, expository mode describing scientific facts. In two experiments, we empirically test whether and how these different formats impact the way in which readers process and retrieve information about childhood vaccination, and how this may impact their perceptions regarding vaccination. We assess two psychological mechanisms that are hypothesized to underlie the persuasive nature of vaccination narratives: the availability heuristic (experiment 1, N = 418) and cognitive resistance (experiment 2, N = 403). The results of experiment 1 showed no empirical evidence for the availability heuristic, but exploratory analyses did indicate that an anti-vaccination narrative (vs. expository) might reduce cognitive resistance, decrease vaccination attitudes and reduce attitude certainty in a generally pro-vaccination sample, especially for those who were more vaccine hesitant. Preregistered experiment 2 formally tested this and showed that not narrative format, but prior vaccine hesitancy predicts cognitive resistance and post-reading attitudes. Hesitant participants showed less resistance toward an anti-vaccine text than vaccine-supporting participants, as well as less positive post-reading attitudes and attitude certainty. These findings demonstrate belief consistency effects rather than narrative persuasion, which has implications for scientific research as well as public health policy.

Keywords: childhood immunization, narrative persuasion, availability heuristic, cognitive resistance, vaccination attitudes, attitude certainty, vaccine hesitancy, belief consistency

INTRODUCTION

Childhood immunization has drastically declined the occurrence of vaccine-preventable diseases such as measles. Nevertheless, parents in Western societies are increasingly hesitant about vaccinating their children (Omer et al., 2009; He et al., 2022). "Vaccine hesitant" generally refers to people who do not fall into the polarized categories of unquestioning vaccine acceptors or refusers, but are placed on the continuum between these poles including those who are ambivalent,

experience doubts or concerns, delay vaccination, or accept only some vaccines (Leask et al., 2012; Smith, 2017; Stasiuk et al., 2021). Vaccine hesitancy poses an enormous threat to global health (World Health Organization, 2019).

When deciding on childhood vaccination, parents want balanced information about the benefits and harms, but they experience difficulty in finding unbiased information (Ames et al., 2017). Ongoing debates about vaccinations are confusing to parents, which may lead them to question and re-evaluate their choices (Downs et al., 2008). Although parents perceive health professionals as important sources of information (Ames et al., 2017), they are more likely to turn to the internet (Downs et al., 2008).

On the internet, parents are likely to encounter vaccine-critical information that is not based on scientific evidence (Davies et al., 2002). Such vaccine-critical information is frequently presented in an appealing storytelling format describing parents' negative experiences with vaccination (e.g., Kata, 2010; Sanders et al., 2019). Since personal narratives are known to be a persuasive format (Braddock and Dillard, 2016), hesitant parents' perceptions of vaccine safety are considered to be easily influenced toward negative attitudes regarding vaccination. Attempting to counter such societal developments, professional health communicators have started developing narrative approaches to encourage vaccine-positive attitudes.

To gain insight into the mechanisms underlying the impact of vaccination narratives, research has mainly focused on affective mechanisms (Wroe et al., 2005; Betsch et al., 2010; Sprengholz and Betsch, 2020). However, cognitive processes may play an important role in the formation and change of vaccination-related beliefs (Miton and Mercier, 2015). We address this by studying two cognitive mechanisms that might affect how people process, retrieve, and perceive information from online vaccination narratives; the *availability heuristic* and *cognitive resistance*. Experiment 1 compares a narrative vaccination message with a non-narrative, expository message to test whether it evokes the availability heuristic and to explore whether it elicits other mechanisms (e.g., less resistance against the message) and outcomes (e.g., shifts in attitude certainty). Experiment 2 was designed to further examine the exploratory findings from experiment 1, specifically aimed at examining a mediating role of cognitive resistance and a moderating role of prior vaccine hesitancy in the potentially persuasive effects of anti-vaccination narratives. This research provides an empirical test of two cognitive mechanisms that are hypothesized to underlie the impact of vaccination narratives on individuals' perceptions regarding vaccines, and examines whether pre-reading vaccine hesitancy is a boundary condition for such narrative effects.

THEORETICAL BACKGROUND

Vaccine Information on the Internet

Parents seeking vaccine information on the internet are likely to encounter non-scientific information with a vaccine-critical sentiment (Davies et al., 2002; Jolley and Douglas, 2014; Guidry et al., 2015). As anti-vaccination sources appear to be effective communicators (Lutkenhaus et al., 2019b; Johnson et al., 2020),

this can hinder the dissemination of evidence-based information supporting vaccines. Experimental evidence shows that brief exposure (0.5–10 min) to online information highlighting the potential harm of vaccines or supporting anti-vaccine conspiracy theories negatively impacts people's risk perceptions regarding vaccines and intentions to vaccinate (Betsch et al., 2010; Jolley and Douglas, 2014). Also, network analyses show that social media populations with anti- (vs. pro-) vaccine standpoints are more effective in reaching and communicating with the vaccine hesitant population (Johnson et al., 2020); also, pro-vaccine facts and figures hardly spill over to other communities, whereas vaccine myths do (Lutkenhaus et al., 2019b). Interestingly, evidence shows that the anti-vaccine discourse generally offers a wide variety of—potentially attractive—claims that are critical or negative about vaccines (e.g., Zimmerman et al., 2005; Johnson et al., 2020; Stasiuk et al., 2021), whereas the pro-vaccination discourse tends to be more monothematic in its approach (Johnson et al., 2020; Meppelink et al., 2021; Stasiuk et al., 2021).

The discourse on the opposite ends of the vaccine debate is not only different in terms of reach and thematic content, but also in terms of format or genre. Online texts containing anti-vaccine sentiments often use storytelling formats describing, for instance, parents' negative experiences with vaccination (Kata, 2010; Guidry et al., 2015; Sanders et al., 2019; Haase et al., 2020). Such anti-vaccination narratives are highly appealing because they often use archetypal roles to describe the parent's experiences in a "hero's journey" template and because they place a strong sense of agency on skeptical and refusing parents (Sanders et al., 2019). Texts representing pro-vaccine sentiments, on the other hand, regularly present information in an expository format, using impersonal mode, describing facts, figures, statistics, and displaying scientific evidence (Guidry et al., 2015; Lutkenhaus et al., 2019a,b; Sanders et al., 2019).

Narrative Persuasion

It is likely insufficient to counter the persuasive rhetorical appeals in anti-vaccine messages by using mere factual refutational strategies (Davies et al., 2002). In line with this argument, healthcare providers report that the most effective way to convince vaccine-skeptical parents is to share their personal vaccine choices for their own children and their personal experiences with vaccine safety (Kempe et al., 2011). Consequently, storytelling is proposed as a potentially effective narrative intervention to improve evidence-based communication and stimulate immunization (Cawkwell and Oshinsky, 2016).

Narratives could help prevent the audience from reacting negatively to messages about a controversial topic. Stories about personal experiences are more readily digestible than argumentative, generic expositions and therefore pose fewer obstacles for a broad audience, including people with high and low reading and health literacy skills (Boeijinga et al., 2017a). In the context of health communication, a message is considered a narrative if it has an identifiable structure from start to finish, between which a situation unfolds, events take place, and a problem is addressed (Hinyard and Kreuter, 2007). It is also typical that a character—often an "I"-narrator—experiences the

events and describes them from her or his own perspective (de Graaf et al., 2012). When readers (or listeners, viewers) are "transported" into the story, they are neither motivated nor able to properly perceive any guiding and moralizing intentions of the narrative (Green, 2006). Additionally, recognizable story characters with comprehensible goals and achievable solutions can be relevant role models for their target group (Hoeken et al., 2016; Boeijinga et al., 2017b) and arouse interest through specific story details that lead to deeper processing (Bernstein, 1955).

Experimental studies investigating the persuasive effects of pro- and anti-vaccination narratives so far show mixed evidence. On the one hand, evidence suggests that personal vaccination narratives are persuasive. For instance, research shows that samples of various individual vaccination narratives describing vaccine adverse events affect people's risk perceptions and vaccination intentions (Betsch et al., 2011; Haase et al., 2020). Also, personal narratives promoting adult vaccinations have more impact on people's risk perceptions and intentions to vaccinate than objective statistics promoting vaccination (Wit et al., 2008). On the other hand, evidence indicates that vaccination narratives are not necessarily more persuasive. For instance, studies on science-based vaccination narratives show that narratives aimed at correcting misinformation do not work (Sangalang et al., 2019; Kuru et al., 2021) or can even backfire (Nyhan et al., 2014). Yet other research suggests that combining narrative with statistical evidence in pro- vaccination messages has a greater impact on risk perceptions and intentions than messages presenting either narrative or statistical evidence (Nan et al., 2015).

Given these mixed findings, it is important to further examine whether and how narratives may shape vaccine decisions. Inspired by scholars arguing that vaccine decisions are sensitive to flaws and shortcuts in people's reasoning (e.g., Ball et al., 1998), we first test whether vaccination narratives might elicit the availability heuristic.

The Availability Heuristic in Vaccine Decisions

Decisions regarding childhood vaccines are often insufficiently informed (Lehmann et al., 2017) and deliberations on the decision against vaccines demonstrably suffer from a variety of reasoning flaws (Jacobson et al., 2007). An explanation is that these decisions rely on the assessment of risk (Brewer et al., 2007)—both the risk of obtaining a vaccine preventable disease and the risk of obtaining vaccine side effects. Information about the risks of vaccines and vaccine preventable diseases is often difficult to understand, incomplete, or conflicting, resulting in uncertainty (Serpell and Green, 2006). When people make decisions under uncertainty, they are often susceptible to heuristics and biases. People rely on heuristics ("cognitive shortcuts") when assessing probabilities by reducing complex mental operations to simplified judgmental tasks (Tversky and Kahneman, 1974). Such heuristics lead to numerous biases that affect people's decisions and regularly lead to erroneous judgment (Tversky and Kahneman, 1974).

Following this reasoning, vaccine decisions have been proposed to be prone to heuristics and biases (Ball et al., 1998; MacDonald et al., 2012; Niccolai and Pettigrew, 2016). Content analyses and surveys indeed support an association between various biases and vaccine decisions (e.g., Asch et al., 1994; Zimmerman et al., 2005; DiBonaventura and Chapman, 2008; Brown et al., 2010). One "usual suspect" that has been assumed to underlie vaccine decisions, especially when these are informed by narrative information, is the availability heuristic. The availability heuristic is defined as a mental strategy that is employed when people estimate the probability of an event based on how easily an instance of such an event comes to mind (Tversky and Kahneman, 1973). Thus, if people use this heuristic when assessing the risk of vaccine-preventable diseases like measles, their risk estimations will be higher when a measles-case is easily available from their memory vs. when it is more difficult to retrieve. Analogously, the perceived risk of vaccine-adverse events is affected by the mental availability of such an event, thus whether it is easy or difficult to access an instance of a child suffering from serious vaccine side effects.

The availability heuristic has been proposed to underlie vaccine decisions (Ball et al., 1998; Omer et al., 2017) and stimulate vaccine hesitancy (Jacobson et al., 2015), because it biases toward memories of vaccine adverse events (Stasiuk et al., 2021) and thereby results in increased vaccine risk perceptions (Serpell and Green, 2006; MacDonald et al., 2012). Several scholars have furthermore proposed that particularly vaccination information in a narrative format should induce an availability heuristic (Serpell and Green, 2006; Wit et al., 2008; Kuru et al., 2021). The rationale behind this is that the experiences described in a narrative format (vs. non-narrative vaccine information) present information in an appealing, vivid, and salient manner (Betsch et al., 2010, 2011). As narrative events are more salient and thereby likely more easily retrievable from memory compared to non-narrative information, their probability (e.g., in terms of risk perceptions associated with the described event) will be overestimated when an availability heuristic is adopted. Based on the presented arguments, we hypothesize that vaccination narratives lead to a more pronounced manifestation of the availability heuristic than non-narrative expositories that take a more generic, informative stance (Berman and Katzenberger, 2004):

H1. Narrative texts about vaccination will lead to (a) greater experienced ease of retrieval and (b) increased risk perceptions compared to expository texts about vaccination.

Vaccine-supporting information on the internet is often presented in a narrative format, whereas vaccine-critical information is often presented in a non-narrative, expository manner. As a result, message format and message content are usually confounded in real-life communication about vaccination. Several scholars have argued that an availability heuristic in vaccine decisions is likely driven by the *vaccine-critical content* of these events, rather than the format in which they are presented. For instance, vaccine adverse events might be highly available in our collective memory because

their occurrence has increased (as more vaccines are being administered) relative to the decrease of vaccine-preventable diseases (Omer et al., 2017). Vaccine adverse events might also be more available because negative (vs. positive) portrayals of vaccination are more intuitive and thereby more likely to spread (Miton and Mercier, 2015).

To address any confound between message content (vaccine adverse events) and message format (narrative), we unravel the two by investigating what it is that may drive the availability heuristic. If the narrative format indeed drives an availability heuristic, risk perceptions should increase based on the described situation. That is, risk perceptions should reflect a higher estimated probability *of the described event*, regardless of whether the event describes vaccine adverse effects (increasing risk perceptions of the vaccine) or symptoms of a vaccine preventable disease (increasing risk perceptions of the disease). We therefore present texts focusing on the negative effects of vaccines (referred to as anti-vaccine content) as well as texts focused on the negative effects of a vaccine-preventable disease (referred to as pro-vaccine content) in the various formats. We specifically examine whether a potential availability heuristic not only manifests for anti- but also for pro-vaccine narratives.

RQ1: Does text content (anti- vs. pro-vaccine) affect the relationship between narratives and (a) ease of retrieval and (b) risk perception?

EXPERIMENT 1

The purpose of experiment 1 was two-fold. First, we aimed to empirically test whether the availability heuristic explains the effectiveness of narrative vaccination messages vs. non-narrative expositories with similar arguments. Second, we aimed to examine a potential role of anti- vs. pro-vaccine content in this relation. Additionally, since previous research suggests that narratives can result in less critical message processing and more story-consistent beliefs (e.g., Green and Brock, 2000), we included various exploratory variables, including resistance toward the message, attitudes toward vaccination, and attitude certainty.

MATERIALS AND METHODS
Design and Participants
The experiment consisted of a 2 (format: narrative/expository) * 2 (content: pro/anti) between-subjects design. Participants were recruited through the scientific crowdsourcing community Prolific Academic to take part in an online experiment (for more information about the general Prolific Academic population, see Prolific, n.d.). They were screened on the Prolific platform to reside in the US or UK, be fluent in the English language, have no literacy difficulties (e.g., dyslexia), have not participated in the pre-test, and have no extremely valenced opinions on vaccination (the screening question was "I believe that scheduled immunizations are safe for children: 1 totally disagree—7 totally agree;" people scoring 1 or 7 were excluded from participation. This criterion was based on the notion that people with very

strong vaccine opinions might be insufficiently susceptible to a text regarding vaccination, which could suppress any potential effects of text type on availability-related variables). The 418 participants in our study were each paid £3.75 for their participation which took 24.5 minutes on average ($SD = 9.2$). For participant characteristics, see **Table 1**.

Procedure
Ethical approval was provided by the ethical committee of a large European University (file number 2019-3965). Participants were recruited and participated in December 2020. After completing informed consent procedures, participants were instructed to read a text about a social issue[1], after which they would answer various questions about the text as well as their personal opinion on several issues.

Participants were randomly presented with one of four experimental texts. After reading the text, they first answered several questions about their demographics as well as an instructional manipulation check identifying whether participants attentively participated and followed instructions (Hauser and Schwarz, 2015). This was done to create some time between text reading and a free recall memory task. This memory task was included to facilitate the critical questions regarding ease of retrieval. Next, participants received questions measuring ease of retrieval, risk perceptions, and a manipulation check. Then, they answered questions pertaining to our exploratory variables including resistance, text evaluation, vaccination attitude, attitude certainty, personal relevance, knowledgeability, attitude source, attitude stability, preference for intuition and deliberation, and having children. Finally, participants received an open-ended question about the perceived purpose of the experiment and were carefully debriefed, referred to a government website with reliable and evidence-based information about the workings of vaccinations, and thanked for their participation.

Stimulus Materials
Four text versions were developed that discussed early-childhood vaccination, using measles as an example. All versions were based on often-consulted sources on the internet (including official information from the vaccine-promoting website CDC.org and testimonials from the vaccine-critical website vaxtruth.org). The texts were relatively long (1,652–1,697 words) to increase the probability of participants experiencing narrative transportation (Green and Brock, 2000) and allowing differences between the texts to manifest. All texts contained general information about vaccines, as well as 12 elements describing measles symptoms and 12 elements describing vaccine side effects, each mentioned once. Effort was made to have comparable location and dispersion of these elements across conditions to account for primacy and recency effects on

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[1]We used general wording to avoid recruiting only people with a particular interest in vaccination.

TABLE 1 | Participant characteristics in experiment 1.

Variable	Level	N	%	Min	Max	Mean	SD
Age				18	76	44.83	12.90
Gender	Female	280	67.0				
	Male	136	32.5				
	Other	2	0.5				
Education	Elementary school	2	0.5				
	Middle school	6	1.4				
	High school	83	19.9				
	College without degree	82	19.6				
	Associate's degree	16	3.8				
	Bachelor's degree	162	38.8				
	Graduate degree	67	16.0				
Having children	Yes	236	56.5				
	No	182	43.5				
Age of parents in sample		236		24	76	47.64	12.02
Children's received vaccinations	All	207	87.7				
	Some	27	11.4				
	None	2	0.8				

memory. *Content* was manipulated by (1) replacing vaccine-positive arguments from the pro-vaccine condition (e.g., about herd immunity) with vaccine-critical arguments in the anti-vaccine condition (e.g., about natural immunity) and (2) replacing the emphasis on measles symptoms in the pro-vaccine condition with an emphasis on vaccine side effects in the anti-vaccine condition. *Format* was manipulated by replacing factual contextual information from the expository text (e.g., describing the Center for Disease Control's recommendations to follow the vaccination schedule) with personal contextual information to create a narrative text (e.g., describing how a mother weighed options regarding vaccination to choose, in her specific situation, what is best for her child). This resulted in two pro-vaccine texts arguing the necessity of vaccinating to protect against vaccine preventable diseases such as measles and two anti-vaccine texts arguing the necessity of thinking critical about vaccination to protect against vaccine adverse events, either based on coherent facts (expository version) or personal experiences (narrative version). A pre-test among 20 participants (screened to have similar characteristics as the participants in experiment 1) showed that manipulations worked as intended.

Measures

The response options for all scale questions were on a 7-point Likert scale or 7-point semantic differential, with higher scores indicating a greater extent to which the measured construct was present.

Dependent Variables

Free recall. To facilitate measurement of the availability heuristic, participants were asked to recall as much information from the text as possible. Note that for an availability

heuristic to occur, it is not necessary to actually perform the operation of memory retrieval (Tversky and Kahneman, 1973). By assessing the reported memories we took into account the possibility that experienced ease of retrieval is confounded by biased recall (Iyengar, 1990) which would manifest as greater actual retrieval (Schwarz et al., 1991). Participants were encouraged to specifically report memories about vaccination and vaccine-preventable diseases in the order in which they came to mind. They had 3.5 minutes to perform this task. Participants had the option to proceed to the next question in case they found it difficult to retrieve more memories before the 3.5 minutes had passed. This option was pre-tested and based on the notion that, for an availability heuristic to occur, memory retrieval should not be perceived as too easy or difficult because this might suppress any effects.

Ease of retrieval ($\alpha = 0.86$, $M = 4.64$, $SD = 1.40$) was assessed using three items: "the requested information came to mind easily;" "listing more arguments would have required no effort" (Ruder and Bless, 2003); "how difficult was it to recall the requested information from the text?" (Schwarz et al., 1991).

Risk perception was assessed using eight items. Following Ferguson and Gallagher (2007), half of the items focused on procedural risk (the risk of vaccine side effects) and half on outcome risk (the risk of vaccine preventable diseases). Following Witte (1994), the risk perception questions distinguished between susceptibility (how likely is a situation?) and severity (how serious is a situation?). Two items were derived from Betsch et al. (2010) and the other six were self-constructed. Items on *risk of vaccine side effects* (4 items, $\alpha = 0.83$, $M = 2.75$, $SD = 1.17$) included "vaccinating causes considerable risks;" "how serious are the side effects of vaccines (administered against vaccine preventable diseases, such as measles)?" and on *risk of vaccine preventable diseases* (4 items, $\alpha = 0.79$, $M = 5.18$, $SD = 1.09$)

included "not vaccinating causes considerable risks;" "if a child is unvaccinated, how likely is it that it will get vaccine-preventable diseases (such as measles)?".

Manipulation Check

To check whether the *format* manipulation worked as intended, participants were asked "to what extent did the text provide information in a narrative (personal, experience-based, story-like) manner?" and "to what extent did the text provide information in an expository (general, explanation-based, business-like) manner?" Also, transportation ($\alpha = 0.81$, $M = 5.18$, $SD = 1.09$) was assessed with six items adapted from Green and Brock (2000), including "I had a vivid image of what the text was about" and "the text affected me emotionally."

The *content* manipulation was assessed with two semantic differential items asking "in the text, how negative or positive was the sentiment toward childhood vaccines?" (-3 extremely negative—$+3$ extremely positive) and "how likely do you think it is that the author of the text would vaccinate her own children against infectious diseases?" (-3 very unlikely—$+3$ very likely).

Finally, text evaluation items asked participants to evaluate the text on several characteristics (e.g., logically ordered, boring, easy to understand).

Exploratory Variables

Resistance was divided into three constructs; cognitive resistance, affective resistance, and perceived persuasive intent. *Cognitive resistance* ($\alpha = 0.96$, $M = 3.27$, $SD = 1.87$) was measured with seven items, four on counter arguing (e.g., "I found myself actively disagreeing with the author," cf. Nabi et al., 2007) and three on negative cognitions [i.e., "the thoughts I had about this message were unfavorable; positive (reversed); bad" cf. Reynolds-Tylus et al., 2021]. *Affective resistance* ($\alpha = 0.95$, $M = 3.05$, $SD = 1.84$) was measured with four items assessing anger: "while reading the message, I felt irritated; angry; annoyed; aggravated" (adapted from Dillard and Shen, 2005) and four self-created positive counterparts serving as fillers ("content; good-humored; pleased; calm"). The four items assessing anger were averaged and higher scores indicated more affective resistance. *Perceived persuasive intent* ($\alpha = 0.89$, $M = 4.46$, $SD = 1.61$) was assessed with two items on perceived intent: "I believe the author wants to convince me of her point of view/tries to influence my opinions and behaviors" (based on Scherr and Müller, 2017) and two items measuring freedom threat: "I believe the text tried to pressure me/manipulate me."

Vaccination attitude ($\alpha = 0.82$, $M = 5.73$, $SD = 1.28$) was measured using five items adapted from Horne et al. (2015), with example items including "the risk of side effects outweighs any potential benefits of vaccines" (reverse-coded) and "if I were to make a future decision about vaccinating, I'd plan to vaccinate my child."

Attitude certainty ($\alpha = 0.90$, $M = 5.73$, $SD = 1.14$) was measured with three items: "how certain are you of your opinion toward vaccination?" (Tormala and Petty, 2004); "how likely are you to change your opinion about vaccination?" (reversed); "how certain are you that your opinion about vaccination is right?" (Pomerantz et al., 1995).

Other potentially relevant individual characteristics were assessed with multiple items, being *personal relevance* ("how important to you personally is the issue of vaccination?"), *knowledgeability* ("how knowledgeable do you consider yourself to be about vaccination?"), *attitude source* ("which sources have influenced your opinion about vaccination?"), *attitude stability* ("have you ever changed your opinion about childhood vaccination? If so, please explain briefly how this happened: who or what changed your mind?"). Additionally, *preference for intuition and deliberation* was assessed using eight items from Betsch and Kunz (2008), resulting in a preference for intuition scale ($\alpha = 0.74$, $M = 4.83$, $SD = 1.01$) with four items (e.g., "my feelings play an important role in my decisions") and a preference for deliberation scale ($\alpha = 0.75$, $M = 5.74$, $SD = 0.85$) with four items (e.g., "before making decisions, I first think them through"). *Demographic* items inquired about gender, age, education level, first language, dominant language, having children, whether children received all / some / no vaccination, survey participation environment, and perceived purpose of the study. These variables were explored but did not systematically contribute to the most interesting explorative findings, and are therefore not reported. More information is available upon request. For all reported materials, measures, procedures, data, and syntax, see Vandeberg et al. (2022a).

RESULTS

Randomization Check

Randomization checks showed that age [$F_{(3,414)} < 1$], gender [$\chi^2_{(3)} = 3.78$, $p = 0.29$][2], education level [$\chi^2_{(9)} = 4.28$, $p = 0.89$][3], having children [$\chi^2_{(3)} = 1.33$, $p = 0.72$], and having children vaccinated [$\chi^2_{(6)} = 4.18$, $p = 0.65$] did not significantly differ across the four text conditions, which shows that randomization led to comparable distribution of participants across conditions.

Manipulation Check

The manipulations worked as intended. Three one-way ANOVAs of format on the two perceived narrativity items and the transportation scale showed that narrative texts were indeed rated as more narrative than expository texts [$M_{narr} = 6.57$, $SD_{narr} = 0.68$; $M_{expos} = 2.79$, $SD_{expos} = 1.73$; $F_{(1,267.45)} = 860.18$, $p < 0.001$][4], as less expository [$M_{narr} = 3.07$, $SD_{narr} = 1.70$; $M_{expos} = 5.79$, $SD_{expos} = 1.22$; $F_{(1,381.10)} = 352.85$, $p < 0.001$], and resulted in greater transportation [$M_{narr} = 5.54$, $SD_{narr} = 0.97$; $M_{expos} = 4.81$, $SD_{expos} = 1.09$; $F_{(1,416)} = 52.32$, $p < 0.001$]. Two one-way ANOVAs of content on the two perceived sentiment items showed that texts with anti-vaccination content were rated

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[2]Excluding the non-binary individuals from this check as Chi square testing requires cell counts ≥ 5.

[3]Grouping individuals completing elementary, middle, and high school together and individuals completing an associate's degree and a bachelor's degree together to prevent cell counts < 5.

[4]Because the data of all manipulation check variables except the transportation mean are heteroscedastic and non-normally distributed, Welch's F-statistics are reported (cf. Delacre et al., 2019).

as more negative toward childhood vaccines than those with pro-vaccination content [$M_{anti} = -2.07$, $SD_{anti} = 1.23$; $M_{pro} = 2.48$, $SD_{pro} = 0.85$; $F_{(1,373.33)} = 1949.05$, $p < 0.001$] and resulted in smaller perceived likelihood of the author of the text vaccinating their own children against infectious diseases [$M_{anti} = -2.25$, $SD_{anti} = 1.42$; $M_{pro} = 2.76$, $SD_{pro} = 0.67$; $F_{(1,299.92)} = 2139.80$, $p < 0.001$].

Hypothesis Testing

To test whether format (H1a) and content (RQ1a) might evoke an availability heuristic by affecting ease of retrieval, we performed a 2 (format) × 2 (content) ANOVA on ease of retrieval[5]. The results show no significant main effect of text format [$F_{(1,414)} = 1.30$, $p = 0.26$, $\eta^2 = 0.00$], meaning that participants experienced similar ease of retrieval for narrative and expository texts. However, there was a significant but small effect of content [$F_{(1,414)} = 4.95$, $p = 0.03$, $\eta^2 = 0.01$] which showed that participants reported greater ease of retrieval for pro-vaccine texts ($M = 4.79$, $SD = 1.37$) than anti-vaccine texts ($M = 4.49$, $SD = 1.42$). No significant interaction emerged ($F < 1$).

To test our hypothesis that format (H1b) and content (RQ1b) affect risk perceptions, we performed two-way ANOVAs on the risk of vaccine side effects and risk of preventable diseases. These showed a similar pattern of no significant text format effect [$F_{risk\_vaccine(1,414)} = 1.90$, $p = 0.17$, $\eta^2 = 0.01$; $F_{risk\_disease} < 1$], no significant interaction [$F_{risk\_vaccine} < 1$; $F_{risk\_disease(1,414)} = 2.30$, $p = 0.13$, $\eta^2 = 0.00$], but a significant and large effect of content [$F_{risk\_vaccine(1,414)} = 69.49$, $p < 0.001$, $\eta^2 = 0.14$; $F_{risk\_disease(1,414)} = 62.91$, $p < 0.001$, $\eta^2 = 0.13$]. The content effect shows that, compared to texts with pro-vaccination content, anti-vaccination texts increase vaccine risk perceptions ($M_{anti} = 3.19$, $SD_{anti} = 1.28$; $M_{pro} = 2.31$, $SD_{pro} = 0.85$) and decrease disease risk perceptions ($M_{anti} = 4.79$, $SD_{anti} = 1.16$; $M_{pro} = 5.59$, $SD_{pro} = 0.83$).

With no main effect of text format on ease of retrieval and risk perception, H1a and H1b are rejected: vaccine narratives do not result in greater experienced ease of retrieval and increased risk perceptions compared to expositories. The lack of significant interactions answers RQ1: pro- or anti-vaccine content does not affect any effect of narratives on (a) ease of retrieval and (b) risk perception.

Exploratory Analyses

Various exploratory analyses were performed. The most notable findings from this set of analyses are the theoretically meaningful interaction effects presented below.

Cognitive Resistance

A two-way ANOVA of format and content on cognitive resistance[6] showed no main effect of format [$F_{(1,414)} = 2.55$,

$p = 0.11$, $\eta^2 = 0.01$], but a large effect of content [$F_{(1,414)} = 435.68$, $p < 0.001$, $\eta^2 = 0.51$] demonstrating more cognitive resistance toward texts with anti- ($M = 4.58$, $SD = 1.61$) vs. pro-vaccine content ($M = 1.93$, $SD = 0.92$). A significant interaction [$F_{(1,414)} = 7.45$, $p = 0.007$, $\eta^2 = 0.02$] showed that both pro-texts evoked equally low levels of cognitive resistance ($M_{narr} = 2.00$, $SD_{narr} = 1.02$; $M_{expository} = 1.86$, $SD_{expository} = 0.81$; $p = 0.43$), but anti-texts evoked less cognitive resistance when the text was narrative ($M = 4.31$, $SD = 1.54$) vs. expository ($M = 4.86$, $SD = 1.63$, $p = 0.002$), see **Figure 1**.

Attitude Certainty

A two-way ANOVA on attitude certainty[7] showed a comparable pattern, with no main effect of format [$F_{(1,414)} = 1.87$, $p = 0.17$, $\eta^2 = 0.00$] and a small effect of content [$F_{(1,414)} = 11.49$, $p = 0.001$, $\eta^2 = 0.03$] showing that participants reading a pro-vaccine text were more certain of their attitude ($M = 5.94$, $SD = 0.95$) than those reading an anti-vaccine text ($M = 5.52$, $SD = 1.27$). The significant but small format*content interaction [$F_{(1,414)} = 7.27$, $p = 0.007$, $\eta^2 = 0.02$] showed that participants reading both pro-texts were equally certain about their vaccination attitude ($M_{narrative} = 6.02$, $SD_{narrative} = 0.89$; $M_{expository} = 5.86$, $SD_{expository} = 1.00$; $p = 0.35$), but participants reading anti-texts were more uncertain about their vaccination attitude when the text had a narrative ($M = 5.28$, $SD = 1.37$) vs. expository format ($M = 5.77$, $SD = 1.12$, $p = 0.004$), see **Figure 2**.

Moderated Moderation

Given the interactions of format and content, we explored the possibility that the text effects on attitude certainty might especially hold for those people with weaker vaccination attitudes. As we had no clean measure of people's attitudes toward vaccination before reading the text, we used the assessment of vaccination attitude after reading the text as a proxy. Of course, this analysis requires cautious interpretation given the possibility that people's a priori vaccination attitudes might have potentially shifted in response to the text. We performed a moderated moderation analysis using the PROCESS macro for SPSS (model 3, Hayes, 2018). We used 5,000 bootstrap samples to estimate the 95% bias-corrected confidence intervals and we mean-centered variables[8]. The overall model with attitude certainty as dependent variable, content as independent variable, text format as moderator, and vaccination attitude as continuous moderator was significant [$R^2 = 0.29$, $F_{(7,410)} = 24.66$, $p < 0.001$]. Results showed no significant three-way interaction ($b = 0.18$, $t = 1.04$, BCI [-0.16; 0.51], $p = 0.30$). However, due the exploratory nature of this analysis we did further examine potential conditional effects. Conditional effects analysis of the format*content interaction for different values of vaccination

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[5]Risk of vaccine side effects was right skewed and therefore log transformed; risk of preventable diseases was left skewed and therefore reversed (maximum score + 1 – value) before log transformation. The transformed variables were homoscedastic and normally distributed. In this and the following analyses, whenever data were transformed, the reported test statistics are based on the transformed variables; the reported descriptive statistics are non-transformed to facilitate interpretation.
[6]The cognitive resistance data are platykurtic (kurtosis = −1.11) and heteroscedastic. Because there is no easy solution to deal with the violations of

both assumptions in a two-way ANOVA, the probability of a Type 1 error may be inflated and therefore outcomes should be interpreted cautiously.
[7]Attitude certainty was left skewed and reversed before log transformation, resulting in homoscedastic data with a normal distribution.
[8]Like vaccination attitudes, attitude certainty was left skewed and therefore reversed and log transformed. This resulted in homoscedastic data with a normal distribution. There was no evidence for multicollinearity between the two variables.
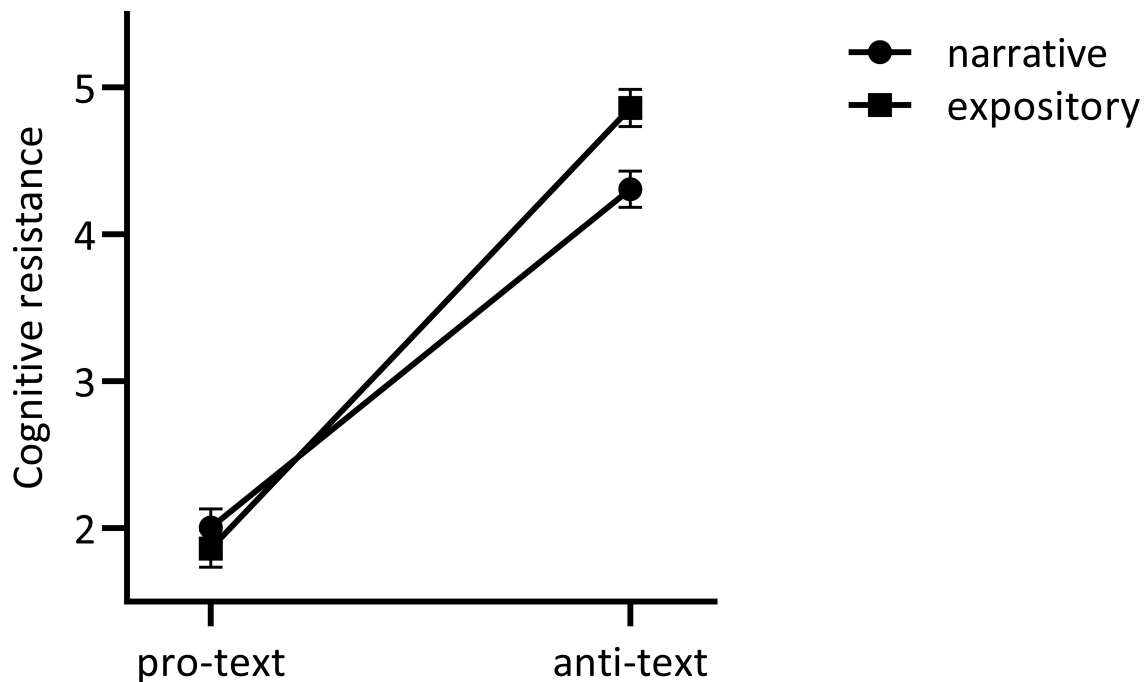
FIGURE 1 | Exploratory format*content interaction on cognitive resistance. Bars reflect standard errors to the mean.
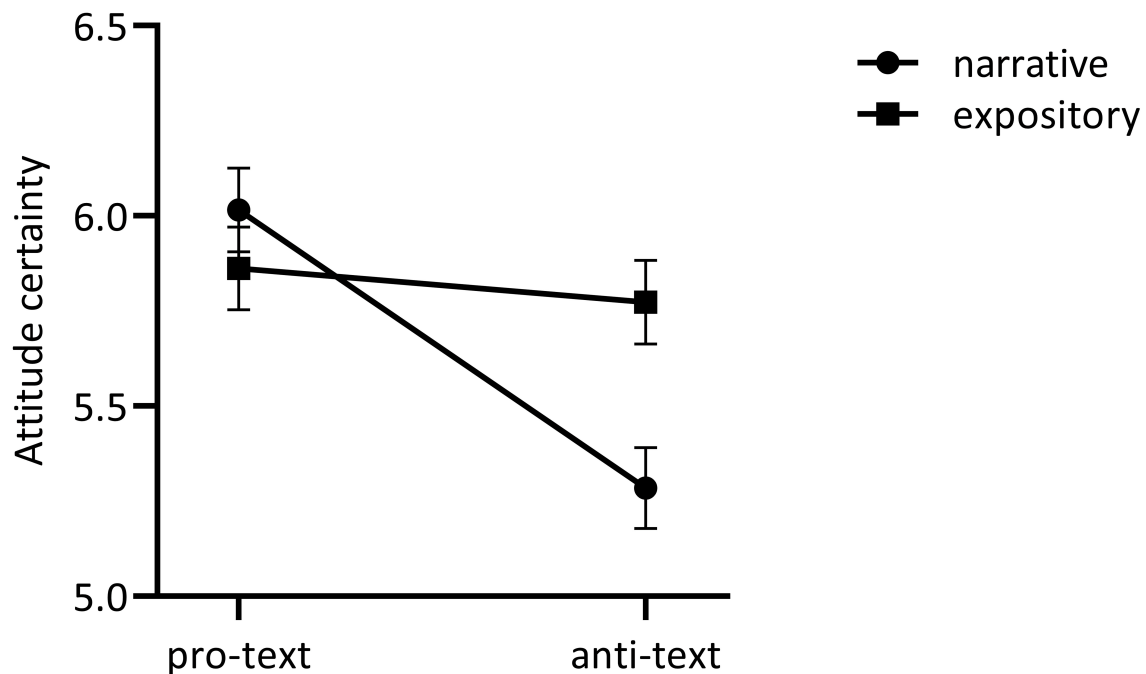
FIGURE 2 | Exploratory format*content interaction on attitude certainty. Bars reflect standard errors to the mean.

attitude showed no significant format*content interaction for participants with extremely positive vaccination attitudes (+ 1 SD above the mean, $M = 7.00$, $t = 0.69$, $p = 0.49$) but did show significant interactions for those with moderately positive vaccination attitudes ($M = 5.73$, $t = 2.03$, $p = 0.04$) as well as those with more neutral (or ambivalent) attitudes around

midpoint of the 7-point 5-item vaccination scale (-1 SD below the mean, $M = 4.45$, $t = 2.10$, $p = 0.04$), see **Figure 3**. Follow-up testing for participants with moderately positive and neutral vaccination attitudes showed that, for the pro-vaccine texts, any differences between format were non-significant ($ps > 0.40$). For the anti-vaccine texts, participants with moderately positive vaccination attitudes ($t = 2.04$, $p = 0.04$) and participants with neutral attitudes ($t = 2.50$, $p = 0.01$) showed significantly less attitude certainty after reading a narrative than an expository text. These findings suggest that people with decreasingly positive vaccination attitudes show increasingly pronounced format*content interaction effects, with less attitude certainty after reading an anti-vaccine narrative vs. expository. This suggests that anti-vaccination narratives might mainly impact the attitude certainty of people with relatively neutral (vs. extremely positive) vaccination attitudes.

DISCUSSION

Overall, the findings show no empirical support for a role of the availability heuristic in response to vaccination information. That is, reading a narrative text about vaccination did not result in greater experienced ease of retrieval (H1a) and increased risk perceptions (H1b) than reading an expository text, even when taking the anti- vs. pro-vaccine content of the text into account (RQ1). These findings are not in line with the theoretical assumptions made in the literature about the effect of narratives on the availability of information in memory (McGregor and Holmes, 1999) and subsequent risk perceptions (e.g., Serpell and Green, 2006; Kuru et al., 2021), nor with the notion that especially information about vaccine adverse events is memorable (Miton and Mercier, 2015; Omer et al., 2017). Our findings by no means disqualify these theoretical assumptions and correlational interpretations, but they do stress the necessity to narrow these assumptions down into concrete, testable predictions regarding the causal role of the availability heuristic. This heuristic might still play a role in the process leading up to a vaccine decision in real life, but the part of the process that was highlighted in our current test found no evidence for such a role. Specifically, our findings suggest that the availability heuristic does not play a *causal* role in the *short-term* effects of *processing information* about vaccines.

With regards to the experimental paradigm, classical experiments demonstrating the availability heuristic usually ask people to retrieve multiple instances from memory based on long-term personal experiences, for instance semantic memory regarding the number of words with the letter R in the first vs. third position (Tversky and Kahneman, 1973) or episodic memory regarding people's personal past assertive or unassertive behavior (Schwarz et al., 1991), after which participants have to produce estimates based on those instances. Our study asked people to retrieve information from memory based on short-term experiences with one text they had just read in an experimental set-up, before producing estimates. It might be the case that an availability heuristic only manifests

when memories are long-term, generalizable (i.e., consist of various instances), accumulated, or more grounded in personally relevant, real-life experiences.

A related but different point is that we assessed people's ease of retrieval and risk perceptions shortly after reading the text, whereas potential availability effects relating to a specific piece of information might manifest over a longer 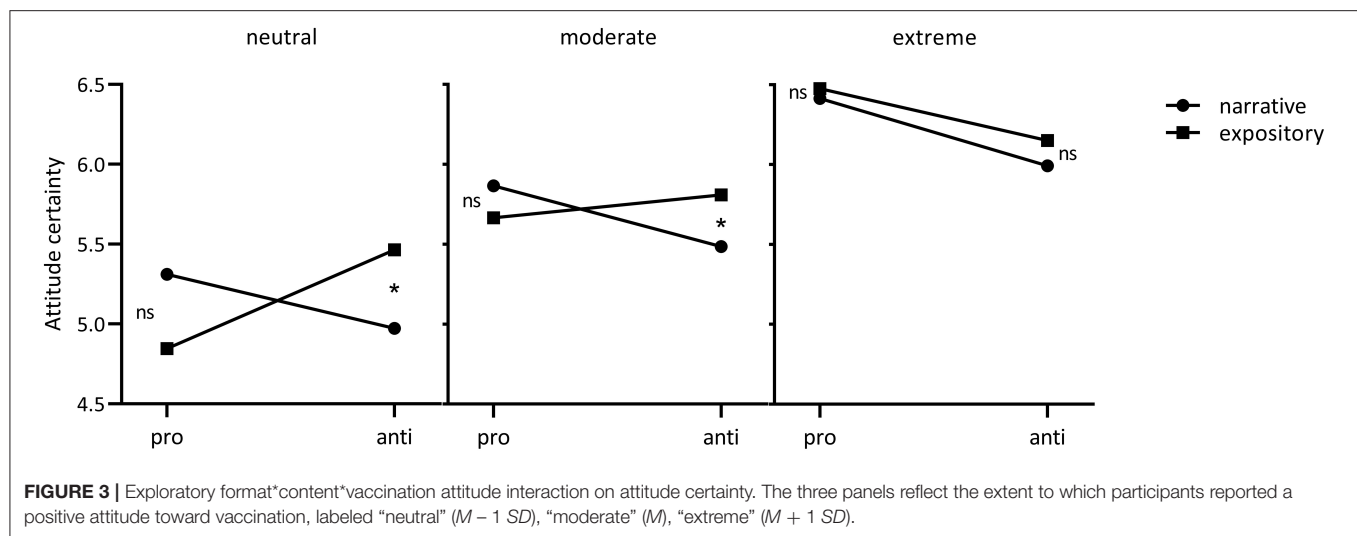time span. Indeed, from the perspective of narrative effect research, this is a viable option, as various lines of research show that narratives might mainly have effects on the longer-term (McGregor and Holmes, 1999; Appel and Richter, 2007; Moyer-Gusé et al., 2011), which we may have missed in the current paradigm testing short term effects.

Regarding our sample, the participants reported generally positive vaccination attitudes ($M = 5.73$, $SD = 1.28$, $Median = 6$, $Mode = 7$). This indicates that our overall sample likely had relatively positive pre-existing beliefs regarding the topic of vaccination, potentially leaving insufficient room for a single forced exposure to a text to reliably alter people's memories of a vaccine-related text and existing risk perceptions. This possibility can be tested in future research, by contrasting peoples' responses to texts about topics for which they do not (vs. do) have pre-existing beliefs or knowledge. However, if an availability heuristic cannot occur in the presence of prior knowledge or beliefs regarding a topic, it is virtually impossible to assess the causal role of this heuristic in the domain of vaccination, as most people will have pre-existing knowledge and beliefs regarding vaccines. Though this complicates the assessment of the availability heuristic, future work should address this given the weight that this heuristic receives in the literature on vaccine decisions.

Interestingly, the dependent variables addressing the availability heuristic did reveal a non-hypothesized main effect of content, showing that pro- (vs. anti-) vaccine texts resulted in greater perceived ease of retrieval, decreased vaccine risk perceptions, and increased disease risk perceptions. This unexpected finding shows that our measures were sensitive to variations in the text. Perhaps, the generally vaccine-positive sample found it easier to recall pro-vaccination information. This would be in line with schema theory and cognitive psychological research evidencing that it is easier to interpret and store new information if it can be associated with existing knowledge in long-term memory (cf. Anderson and Pearson, 1984). Alternatively, the affected ease of retrieval and risk perception measures might be a manifestation of the generally vaccine-positive people strengthening their existing beliefs when reading a pro-vaccine text. In this case, the current data might reflect a confirmation bias, which is "a general tendency for people to believe too much in their favored hypothesis" (Klayman, 1995). Research shows that the confirmation bias indeed affects the processing of information about vaccines (Meppelink et al., 2019). Though confirmation bias is indeed theorized to interact with the availability heuristic (Sunstein, 2006), future research should further explore this relation and identify whether the current effects were a manifestation of the availability heuristic that serves as an antecedent or consequence of confirmation bias, or a result of confirmation bias itself.

FIGURE 3 | Exploratory format*content*vaccination attitude interaction on attitude certainty. The three panels reflect the extent to which participants reported a positive attitude toward vaccination, labeled "neutral" ($M - 1\,SD$), "moderate" (M), "extreme" ($M + 1\,SD$).

Finally, the exploratory findings interestingly suggest that especially anti- (vs. pro-) vaccination narratives increase cognitive resistance and reduce attitude certainty. When people read an anti-vaccine *narrative* they reported less cognitive resistance and less attitude certainty than when they read an anti-vaccine *expository*. Furthermore, the additional conditional effects analysis suggests that anti-vaccination narratives might mainly impact the attitude certainty of people with relatively neutral (vs. extremely positive) vaccination attitudes. However, given that the current vaccination attitude measure may reflect a combination of both a priori vaccination attitude and a potentially shifted post-reading vaccination attitude, a confirmatory experiment will have to distinguish between the two constructs to test the hypotheses derived from the exploratory findings. Hence, we performed a preregistered follow-up experiment to examine whether (1) anti-vaccination narratives are indeed more persuasive than anti-vaccination expositories; (2) this is caused by less cognitive resistance when reading narrative texts; (3) a persuasive effect of anti-vaccination narratives is stronger as people are a priori more neutral or hesitant (vs. vaccine-positive).

EXPERIMENT 2

As outlined above, especially anti-vaccine narratives are argued to affect people's perceptions regarding childhood vaccines. Though experiment 1 showed no effects of an anti-vaccine narrative (vs. expository) on the assessment of the availability heuristic, it did show exploratory effects on cognitive resistance and attitude certainty. This is in line with recent evidence indicating that weak facts (which can be roughly compared to non-scientific anti-vaccine arguments) are more persuasive when presented in stories than when presented in isolation (Krause and Rucker, 2020). It is also in line with ample evidence from various fields showing that narratives in different forms can reduce resistance (e.g., Moyer-Gusé and Nabi, 2010; Niederdeppe

et al., 2011) and—through various mechanisms—result in story-consistent judgments (e.g., McGregor and Holmes, 1999) and attitudes (e.g., de Graaf et al., 2012). A recent meta-analysis presents convincing evidence that narratives indeed generate less resistance than non-narratives (Ratcliff and Sun, 2020). Support for the Entertainment Overcoming Resistance Model (Moyer-Gusé, 2008) further shows that narrative structures can reduce resistance which, in turn, stimulates text-consistent attitudes and behaviors (Moyer-Gusé et al., 2011). Combining this literature with the findings of experiment 1, we hypothesize:

> *H2. An anti-vaccine narrative will result in a) less cognitive resistance and b) more negative vaccination attitudes than an anti-vaccine expository.*
> *H3. Cognitive resistance mediates the effect of text format on vaccination attitudes. That is, reading an anti-vaccine narrative (vs. expository) will result in reduced cognitive resistance, which will in turn result in more negative vaccination attitudes.*

Furthermore, the exploratory findings of experiment 1 suggest that the persuasive effect of anti-vaccine narratives might particularly hold for people with relatively neutral vaccination attitudes, compared to those with extremely positive attitudes. Though the concept of vaccine hesitancy has been used heterogeneously and encompasses a range of attitudes and behaviors (Dubé et al., 2016a), people with attitudes between both ends of the vaccine attitude continuum are considered vaccine-hesitant (Dubé et al., 2016b). Based on this reasoning, our findings can indicate that especially vaccine-hesitant individuals might be affected by anti-vaccine narratives, whereas vaccine-positive individuals might be less susceptible to these effects.

This is in line with literature stating that it is very difficult to change beliefs once they are formed (Slovic, 1986; Pluviano et al., 2017). Evidence shows that pre-existing (accurate and inaccurate) vaccination beliefs indeed stably predict their post-intervention counterparts, which demonstrates belief consistency effects (Kessler et al., 2019). Further evidence shows that attitude ambivalence and attitude certainty predict attitude stability over

time, showing that less valenced and less certain attitudes are less enduring and less resistant to change (Luttrell et al., 2016). Extending these findings to vaccine hesitancy, it is argued that people whose vaccine attitudes are relatively ambivalent or weak are likely more susceptible to persuasive claims (Stasiuk et al., 2021). Finally, especially people who lack strong prior opinions are vulnerable to the format in which information is presented (Slovic, 1986). We therefore hypothesize:

> H4. Prior vaccine hesitancy moderates the effect of text format on vaccination attitudes. That is, the effect of an anti-vaccination narrative (vs. expository) on vaccination attitudes will be stronger for people who are a priori more hesitant.

The dependent variable in the hypotheses is formulated in terms of vaccination attitudes, even though the exploratory findings showed effects on attitude certainty. The reason for this is three-fold. First, empirical findings demonstrate a vital role for vaccination attitude in predicting vaccination intentions (Paulussen et al., 2006; Xiao and Wong, 2020), stressing the importance of vaccination attitudes in vaccine decisions. Second, attitudes consist of various dimensions, including valence/ambivalence (how positive and/or negative attitudes are), strength (how strong attitudes are), and certainty (how certain people are of their attitude). Given that the attitude measure in experiment 1 provided no "clean" measure of pre- or post-reading vaccine attitudes, we reasoned that attitude certainty provided the best proxy for potential attitude shifts in experiment 1. However, with the improved design of experiment 2, we were able to put more focus on the most-often assessed dimension of attitude, being valence. Third, given that valence and certainty are likely to complement each other (with people being very certain of their highly positive or negative attitudes and not so certain of their relatively neutral attitudes) but might also contradict (with people being not so certain of their highly positive or negative attitudes and being very certain of their relatively neutral attitudes), we added both dependent variables to our experiment, extending H4 into the following research question:

> RQ2. Is there an interaction effect between vaccine hesitancy and text format on attitude certainty?

This reasoning results in the conceptual model depicted in **Figure 4**.

Testing the entire model results in the following research question:

> RQ3. Does cognitive resistance mediate a vaccine hesitancy*text format interaction on a) vaccination attitudes and b) attitude certainty?

MATERIALS AND METHODS

Design and Participants

Based on the findings of experiment 1, we focused on the texts with anti-vaccination content and adopted a one factorial (text format: narrative/expository) between-subjects design with three dependent variables (cognitive resistance, vaccination attitude, attitude certainty). The moderator (vaccine

hesitancy) was measured 1–6 days prior to the experiment. Participants were recruited through Prolific Academic and screened on characteristics identical to experiment 1 (including no participation in the prior experiment). However, to ensure a more equal distribution of participants, ranging from vaccine-hesitant to extremely positive, we specifically recruited over 200 participants who reported moderate vaccine opinions in a screening question (scoring 3, 4, 5 on the 7 point scale) as well as over 200 participants with more positive opinions (scoring up to 7).

Based on a power analysis (see preregistration), we recruited minimally 400 participants, which corresponds to a pre-calculated power of almost 0.85. A total of 445 participants completed both parts of the study. Forty-two participants were discarded from the dataset because they spent an insufficient amount of time on the text page to ensure attentive reading of the text as instructed (<50 s, identified as outliers in the histogram plotting time on page) *and* failed either an instructional manipulation check (Hauser and Schwarz, 2015) and/or an attention check regarding content of the text. This is a slight deviation from the preregistered data exclusion criteria, informed by unforeseen practical limitations of the prior criteria.

The remaining 403 participants were each paid £2,75 for their participation in both parts of the online experiment (£0.65 for part 1 with a mean duration of 4.8 min and £2.10 for part 2 with a mean duration of 13.9 min). See **Table 2** for participant characteristics.

Procedure

Ethical approval was provided by the ethical committee of a large European University (file number 2019-3965). The procedure was identical to that in experiment 1, with some exceptions detailed here. The experiment was preregistered at the Open Science Framework (Vandeberg et al., 2022b). Data collection occurred from late April to early June 2021. Participants were recruited to participate in a two-part study, with at least 24 h between part 1 and part 2. In part 1, participants were instructed to complete a survey including the critical vaccine hesitancy measure, as well as filler scales assessing, for example news media skepticism and financial beliefs, and concluded with demographic questions. The instructions and filler questions were designed to conceal our focus on vaccine hesitancy, to minimize the chances of obtaining consistency effects.

Twenty-four hours after completing part 1, participants received an invitation for part 2 to complete within the next 5 days. In part 2, participants were randomly presented with one of two texts. After reading the text, they sequentially received questions pertaining to demographics, an instructional manipulation check, vaccination attitude, attitude certainty, cognitive resistance, perceived purpose of the experiment, manipulation and attention check, having children, and an exploratory variable on whether and how the recent COVID-19 pandemic had changed their views of vaccination. Finally, they were carefully debriefed, thanked, and referred to a government website with reliable and evidence-based information about the workings of vaccinations.

FIGURE 4 | Conceptual model.
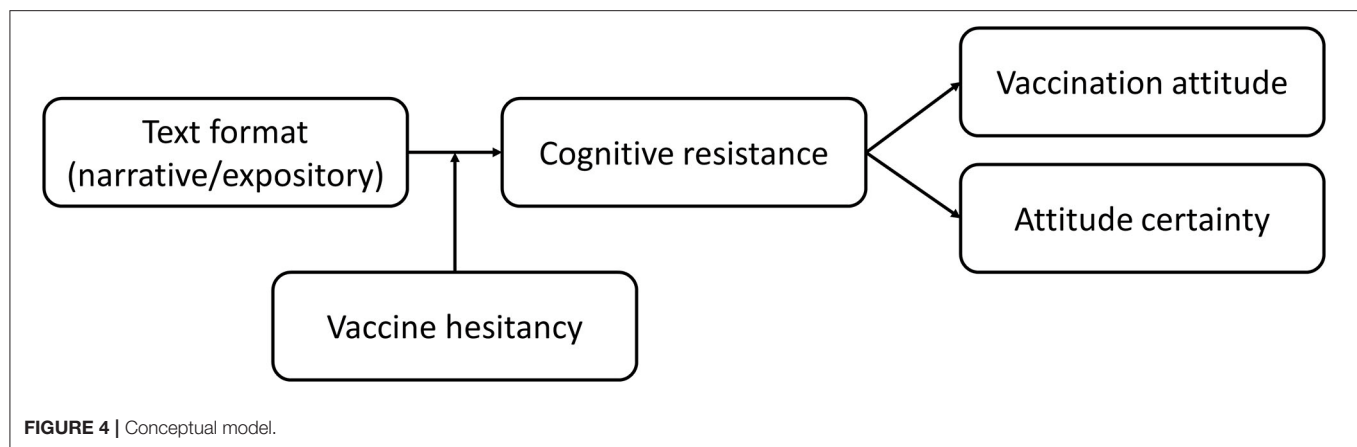
TABLE 2 | Participant characteristics in experiment 2.

Variable	Level	N	%	Min	Max	Mean	SD
Age				18	76	38.21	13.28
Gender	Female	283	70.2				
	Male	115	28.5				
	Other	5	1.2				
Education	Elementary school	1	0.2				
	Middle school	6	1.5				
	High school	89	22.1				
	College without degree	111	27.5				
	Associate's degree	18	4.5				
	Bachelor's degree	128	31.8				
	Graduate degree	50	12.4				
Having children	Yes	193	47.9				
	No	210	52.1				
Age of parents in sample		193		21	76	44.64	11.64
Children's received vaccinations	All	158	81.9				
	Some	32	16.6				
	Ambiguous about whether children were vaccinated	3	1.6				

Stimulus Materials and Measures

The anti-vaccine texts from experiment 1 were used (see Appendix X). The dependent variables (cognitive resistance, vaccination attitude, and attitude certainty), demographic questions, and manipulation and attention checks were assessed as in experiment 1.

Vaccine hesitancy was measured 1–6 days prior to experimental exposure to the text. It was assessed using the same items that were also used to measure vaccine attitudes in experiments 1 and 2 (Horne et al., 2015), but with a different response scale to minimize potential consistency effects. For these 5 items, the 7-point scale was replaced with a slider ranging from −50 (strongly disagree) to 50 (strongly agree). Following the conceptualization from earlier work (Dubé et al., 2016b), we conceptualize individuals with seemingly neutral attitudes (around scale midpoint, e.g., between −25 and 25) as more vaccine-hesitant than individuals with relatively positive attitudes (i.e., between 25 and 50). The scale's reliability was

acceptable ($\alpha = 0.73$) and revealed heterogeneous vaccine hesitancy scores ($M = 24.69$, $SD = 18.37$, with 50% of the sample scoring below 25.50 and 50% scoring above). Again, see Vandeberg et al. (2022a) for all materials pertaining to the methods and results.

RESULTS

Randomization Check

Randomization checks showed that age [$F_{(1,401)} < 1$], gender [$\chi^2_{(1)} = 0.98$, $p = 0.32$][9], education level [$\chi^2_{(4)} = 6.31$, $p = 0.18$][10], having children [$\chi^2_{(1)} = 0.62$, $p = 0.43$], and

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[9]Excluding the non-binary individuals from this check as Chi square testing requires cell counts ≥ 5.

[10]Grouping individuals completing elementary, middle, and high school as highest education level together to prevent cell counts <5.

having children vaccinated [$\chi^2_{(1)} = 0.11$, $p = 0.74$][11] did not significantly differ across the two text conditions.

Manipulation Check

The manipulation worked as intended. Two one-way ANOVAs of format showed that narrative texts were indeed rated as more narrative than expository texts [$M_{narr} = 6.41$, $SD_{narr} = 0.96$; $M_{expos} = 2.91$, $SD_{expos} = 1.62$; $F_{(1,291.89)} = 669.44$, $p < 0.001$][12] and as less expository [$M_{narr} = 3.01$, $SD_{narr} = 1.56$; $M_{expos} = 5.49$, $SD_{expos} = 1.18$; $F_{(1,394.76)} = 329.17$, $p < 0.001$].

Hypothesis Testing

We analyzed the data using the PROCESS macro for SPSS (Hayes, 2018). We used 50,000 bootstrap samples to estimate the 95% bias-corrected bootstrap confidence intervals (BCIs) and used heteroscedasticity-consistent standard errors to account for violation of the homoscedasticity assumption by the cognitive resistance variable[13]. To test the overall model to answer H2 and RQ3, we performed mediated moderation analyses using model 7 with mean-centered products, including format (narrative vs. expository) as independent variable, vaccine hesitancy as continuous moderator, cognitive resistance as mediator and either vaccination attitudes or attitude certainty as dependent variable. See **Figure 5** for an overview of the findings. Text format had no significant effect on cognitive resistance ($b = -0.18$, $t = -1.50$, 95% CI [-0.42; 0.06], $p = 0.14$). This shows that the anti-vaccine narrative did not result in less cognitive resistance than the anti-vaccine expository, thereby rejecting H2a. Interestingly, vaccine hesitancy did significantly predict cognitive resistance ($b = 0.03$, $t = 9.77$, 95% CI [0.03; 0.04], $p < 0.001$). As a higher score on the hesitancy scale indicates a more positive attitude (i.e., less hesitancy), the positive unstandardized b-value shows that individuals with more positive prior vaccine attitudes show more cognitive resistance against the anti-vaccine text. Thus, more hesitant individuals report less cognitive resistance against the anti-vaccine text. The text format*vaccine hesitancy interaction effect on cognitive resistance was non-significant ($b = 0.00$, $t = -0.49$, 95% CI [-0.02; 0.01], $p = 0.62$). Text format did not have a significant direct effect on vaccine attitudes ($b = 0.04$, $t = 0.35$, 95% CI [-0.17; 0.24], $p = 0.72$). As the anti-vaccine narrative did not result in more negative attitudes than the anti-vaccine expository, we reject H2b. However, cognitive resistance did significantly and positively predict vaccination attitudes ($b = 0.62$, $t = 15.58$, 95% CI [0.54; 0.70], $p < 0.001$). The index of moderated mediation was non-significant (index $= -0.00$, boot SE $= 0.00$, BCI [-0.01; 0.01]), thereby answering RQ3a.

Next, the same analysis was performed with attitude certainty as dependent variable, see **Figure 6**. The model showed that cognitive resistance significantly predicts attitude certainty ($b = 0.36$, $t = 8.17$, 95% CI [0.27; 0.45], $p < 0.001$), showing that more cognitive resistance against the anti-vaccine text was associated with greater attitude certainty. The direct effect of

text format on attitude certainty was non-significant ($b = -0.04$, $t = -0.40$, 95% CI [-0.26; 0.17], $p = 0.69$). Also, the index of moderated mediation was non-significant (index $= -0.00$, boot SE $= 0.00$, BCI [-0.01; 0.00]), thereby answering RQ3b.

Then, to test H4 and RQ2 regarding the text format*vaccine hesitancy interactions, we tested model 1[14] with text format as mean-centered independent variable, vaccine hesitancy as mean-centered moderator, and either vaccination attitude or attitude certainty as dependent variable. The format*vaccine hesitancy interaction on vaccine attitudes was non-significant ($b = 0.00$, $t = -0.30$, 95% CI [-0.01; 0.01], $p = 0.77$). Because prior vaccine hesitancy does not moderate any effect of format on vaccination attitudes, we reject H4. Also, the text format*vaccine hesitancy interaction effect on attitude certainty was non-significant ($b = 0.01$, $t = 0.89$, 95% CI [-0.01; 0.02], $p = 0.37$), thereby answering RQ2.

Finally, to test H3 regarding a mediating role for cognitive resistance in the relation between text format and vaccination attitudes, we tested model 4 with 50,000 bias-corrected bootstrapped samples. The total effect of the model with text format as independent variable, cognitive resistance as mediator and vaccination attitude as dependent variable was non-significant [$R^2 = 0.00$, $F_{(1,401)} < 1$], as were the direct effect ($b = 0.04$, $t = 0.35$, $p = 0.72$) and indirect effect ($b = -0.14$, boot SE $= 0.08$, BCI [-0.31; 0.02]). As these results show no evidence for a mediation, H3 is rejected.

In sum, these findings show that text format has no effect on cognitive resistance (rejecting H2a) and vaccination attitudes (rejecting H2b), that cognitive resistance does not mediate an effect of text format on vaccination attitudes (rejecting H3), that vaccine hesitancy does not moderate an effect of text format on vaccination attitudes (rejecting H4), and that the overall proposed moderated mediation on vaccine attitudes does not hold (thereby answering RQ3a). Also, vaccine hesitancy does not moderate an effect of text format on attitude certainty (answering RQ2) and the overall proposed moderated mediation on attitude certainty is not significant (answering RQ3b).

Interestingly, the results do however show that prior vaccine hesitancy predicts cognitive resistance, and that cognitive resistance predicts vaccination attitudes and attitude certainty. To explore whether this results in a significant mediation, we tested an additional model 4 with 50,000 bias-corrected bootstrapped samples. The total effect of the model with vaccine hesitancy as independent variable, cognitive resistance as mediator and vaccination attitude as dependent variable was significant [$R^2 = 0.47$, $F_{(1,401)} = 329.16$, $p < 0.001$], as were the direct effect ($b = 0.04$, $t = 12.29$, $p < 0.001$) and the indirect effect ($b = 0.01$, boot SE $= 0.00$, BCI [0.01; 0.02]). Similarly, the same model with attitude certainty as dependent variable showed a significant total [$R^2 = 0.40$, $F_{(1,401)} = 70.55$, $p < 0.001$], direct ($b = 0.02$, $t = 5.03$, $p < 0.001$) and indirect ($b = 0.01$, boot SE $= 0.00$, BCI [0.01; 0.01]) effect. These mediation outcomes show that individuals who are a priori more vaccine-hesitant show less cognitive resistance when reading an anti-vaccine text,

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[11] Excluding the 3 unclear accounts from this check to prevent cell counts <5.
[12] Reporting Welch's F for both manipulation checks.
[13] All other assumptions were met for all variables.

[14] This model was not mentioned in the pre-registration, as we assumed that model 7 would provide information regarding this interaction.

FIGURE 5 | Moderated mediation on vaccination attitudes. ns, non-significant; **$p < 0.001$.

FIGURE 6 | Moderated mediation on attitude certainty. ns, non-significant; **$p < 0.001$.
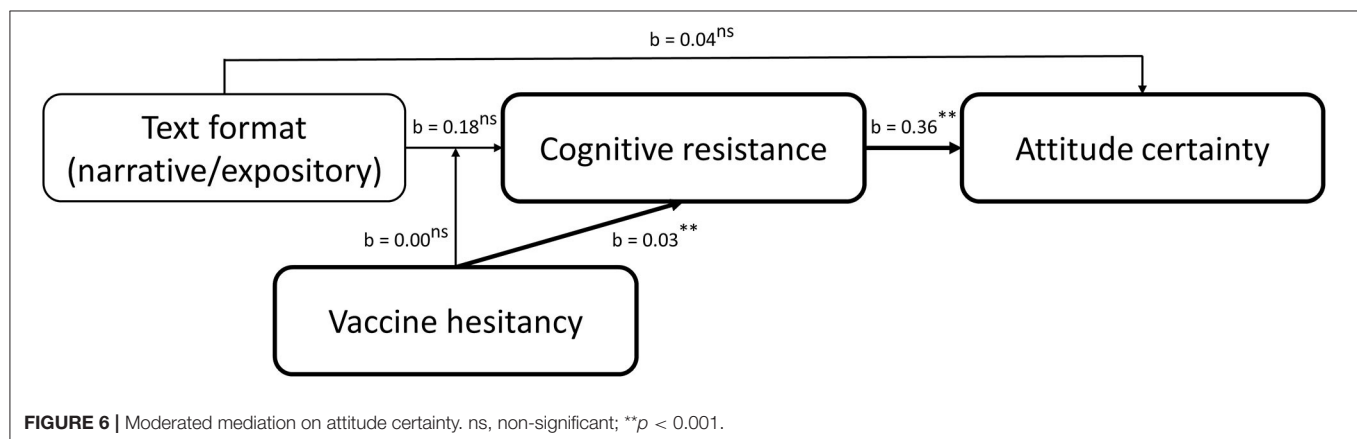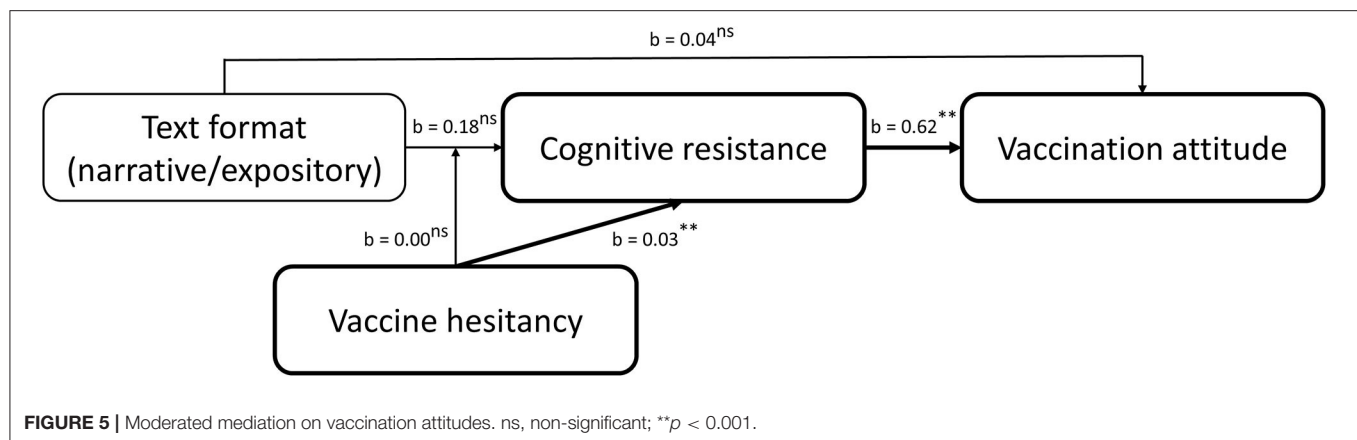
and in turn show less positive vaccination attitudes and less attitude certainty.

DISCUSSION

Experiment 2 shows that an anti-vaccination text in different formats does not differentially affect cognitive resistance, vaccination attitudes, and attitude certainty. Similarly, experiment 1 shows that a narrative format is not more likely to affect ease of retrieval and risk perceptions than an expository format. This is not in line with the literature stressing the persuasive nature of narratives, but rather contributes to the mixed findings on the effectiveness of vaccination narratives.

To interpret our findings, we first zoom out on the narrative persuasion literature as a whole. Experimental research on the impact of narratives about health-related topics is quite heterogeneous (cf., Graaf et al., 2016) in terms of the types of narratives that are used as well as the control conditions to which these are contrasted. A narrative format, for instance, is often compared to various formats containing statistical information (Allen and Preiss, 1997; Zebregs et al., 2015). However, these two conditions often differ in many ways, such as the order in which information is presented, visuals, tone-of-voice, to name a few. In our current work, we have put great effort

into creating narrative and expository texts that were both as comparable and ecologically valid as possible. The described disease symptoms and side effects were identical in both versions, as well as the dispersion of elements throughout the text, overall structure (pro- or anti-vaccine) arguments, visuals, text length, and overall conclusion. This way, we aimed for a clean and stringent test of the effectiveness of a core feature distinguishing narratives from other text formats; personal experiences. Though this worked as intended, as illustrated by the manipulation checks, no differences in narrative impact were revealed. This suggests that the large number of choices that are made in the construction of narratives (for some examples see Braddock and Dillard, 2016; Graaf et al., 2016) as well as the format that narratives are contrasted with might make or break any persuasive narrative effects.

Zooming back in on the studies that have found advantageous effects of a narrative format when communicating about vaccination, we compare those designs to ours as this might indicate under which circumstances vaccine narratives are effective. For instance, Betsch and colleagues (e.g., Betsch et al., 2011, 2015; Haase et al., 2020) provide ample evidence that parents' risk perceptions and intentions to vaccinate their children against a hypothetical disease decline, as the relative frequency of narratives reporting vaccine adverse events increase. Comparing these findings to ours shows several possibilities.

One very viable possibility is that pre-existing knowledge, experiences, attitudes, or beliefs determine how susceptible people are to narrative persuasion. The cited studies have assessed the perceptions of vaccines combatting *hypothetical* diseases, which indicates that narrative effects might mainly occur when people lack prior knowledge, beliefs, or attitudes regarding the specific vaccine-preventable disease that is mentioned in the text. Although we have taken a first step to address this possibility in experiment 2 by taking prior attitudes into account in the operationalization of vaccine hesitancy, our findings show that a more hesitant stance does not make people more prone to persuasion by narratives. However, even the vaccine-hesitant people in our sample likely have ample prior knowledge about and experiences with childhood vaccinations. Thus, perhaps narrative persuasion mainly occurs in the absence of prior experiences with a specific vaccine and disease. This would make a narrative format a less effective tool in the current attempt to effectively provide people with evidence-based information about existing childhood vaccines.

A different but related possibility is that the relative amount of presented (pro- or anti-) vaccination narratives—or the amount of presented experiences within a narrative—determines how susceptible people are to narrative persuasion. Possibly, narrative effects only occur as described experiences with vaccines accumulate, or in other words, anecdotal narrative evidence might only begin to receive weight as more and more evidence is presented. In our experiments, people were exposed to one single-case narrative in a single exposure. Combining our findings with those cited (e.g., Betsch et al., 2011, 2015; Haase et al., 2020) suggests that perhaps narratives are mainly effective when multiple narratives are presented describing various experiences with vaccines. Combining the different points made, the amount of narrative evidence that is needed to have an impact likely depends on the extent to which people have prior experiences with the topic at hand.

Another explanation for our findings is that narratives might mainly elicit affective mechanisms (Wroe et al., 2005; Dunlop et al., 2008; Betsch et al., 2010; Oliver et al., 2012; Sprengholz and Betsch, 2020) rather than cognitive mechanisms (cf. Miton and Mercier, 2015). This finding would be in line with the conclusion by Zebregs et al. (2015) that narrative evidence mainly affects intentions through an affective route, whereas statistical evidence mainly affects beliefs and attitudes through a cognitive route. This is roughly in line with a dual process line of reasoning (cf. e.g., Chen and Chaiken, 1999; Slovic et al., 2004; Kahneman, 2011) by suggesting that formats characterized by personal experiences are likely to elicit more intuitive, fast, automatic processes whereas formats presenting impersonal facts would likely evoke more reflective, effortful, elaborative processes. However, this line of reasoning also suggests that the intuitive processes elicited by narratives are likely to result in the use of heuristics, which we cannot confirm based on our findings from experiment 1. Therefore, this possibility requires further examination in which affective vs. cognitive or intuitive vs. reflective processes are assessed within one experimental paradigm.

Specifically, experiment 2 shows that pre-existing vaccine hesitancy (but not narrative format) predicts cognitive resistance and post-reading vaccination attitudes and attitude certainty. That is, people who are more hesitant create less counterarguments and experience less negative cognitions when reading an anti-vaccination text, and consequently report less positive attitudes and are less certain about these attitudes. This demonstrates belief consistency effects, rather than narrative persuasion effects. This is in line with findings by Kessler et al. (2019) as well as with our earlier observation that prior knowledge, experiences, beliefs and attitudes weigh heavily on the way in which people process, retrieve and perceive information regarding vaccines. Belief consistency could have suppressed potential effects of text format in our study. Research shows that reasons for vaccine belief consistency effects can be attitude bolstering, cognitive consistency, and a preference for complete mental models—even when these are (partly) inaccurate (Pluviano et al., 2017). Our findings show that it is interesting to further examine such (cognitive) mechanisms underlying belief consistency effects to gain further insights into how these can be minimized.

Limitations

Despite our efforts, this research has its limitations. To provide a clean and rigid empirical test of the cognitive mechanisms that might be evoked by a narrative format, we presented participants with well-balanced texts in a single, forced exposure between subjects. However, presenting people with multiple narratives or multiple exposures would have been more likely to elicit narrative effects (cf. Haase et al., 2020), especially because pre-reading attitudes seemed so persistent (cf. Pluviano et al., 2017). This could be done in future research by presenting people with multiple exposures to single-case narratives or single exposure to multiple-case narratives about real-life vaccines and vaccine preventable diseases. Also, the forced exposure to the texts in our experiments was not optimally ecologically valid. Future work might try to present information through voluntary exposure (i.e., when parents have searched for or selected the information themselves, preferably when motivated to do so), though voluntary exposure also has its practical and ecological limitations in an experimental setting.

Additionally, although text conditions in the current experiments were well-controlled and ecologically valid, they may not have been optimally distinctive. Not only the expository versions, also the narrative versions can be considered as argumentative to some extent. That is, the narratives did not only *show* what conclusion should be drawn from narrative events, but they also *argued* for the presented (pro- or anti-vaccine) message, particularly since the narrative character explicitly shares reasons for this point of view based on her experiences. Narratives with explicit reasoning may be more comprehensible for some target groups (de Graaf et al., 2017), but may also increase the perceived subjectivity. Future work might distinguish between narratives with a showing, *demonstrative* style (primarily providing access to observable narrative events) vs. a more telling, *invasive* style (providing additional access to the inner and spoken reasons and evaluations of people in the narrative) (cf. van Krieken and Sanders, 2021). A detached, demonstrative style might increase perceived objectivity and therefore be more acceptable for a

critical audience [as hypothesized by Sanders and van Krieken (2019)].

CONCLUSION

Our two experiments show that vaccination narratives (vs. well-balanced expositories) do not result in (a) greater ease of retrieval, (b) increased risk perceptions, (c) decreased cognitive resistance, and (d) changes in vaccination attitudes or attitude certainty. This does however not rule out the possibility that text format affects the elicitation of an availability heuristic or persuasion through cognitive resistance. The most parsimonious conclusion is that, in the current set-up, these cognitive responses were outweighed by belief consistency processes, which demonstrably affected the way in which people processed information as well as their post-reading vaccine perceptions. This stresses the necessity of taking prior knowledge, experiences, beliefs, and attitudes into account when formally studying the impact of communication on highly debated topics like real-life vaccines. This rationale especially holds now that the current COVID-19 pandemic has made vaccination such a salient, omnipresent, and pressing topic, which has arguably also affected people's risk perceptions and hesitancy regarding routine childhood vaccinations (He et al., 2022). The discussion highlights potentially fruitful ways in which science should further examine whether, how, and to what extent strategic communication has the potential to change pre-existing beliefs. An important implication for stakeholders such as healthcare providers, communication specialists, and policy makers is that they should not blindly trust in storytelling techniques as the solution for current (mis-)perceptions. However, combining our findings with the literature does suggest that vaccine risk communication in a narrative format might help reach affective objectives, especially when people with more experiences and stronger prior vaccine attitudes are exposed to more instances of narrative evidence. Nonetheless, our findings show that a narrative format is not necessarily a more effective way to provide evidence-based information than the more frequently used expository format, as narrative impact is likely context-dependent and relies on many factors that should be further investigated.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: Open Science Framework: https://osf.io/ygxmt/.

ETHICS STATEMENT

AUTHOR CONTRIBUTIONS

LV, MF, CM, and JS: conceptualization, funding acquisition, methodology, resources, and writing. LV: data curation, investigation, project administration, software, supervision, and validation. LV, CM, and MF: formal analysis. All authors contributed to the article and approved the submitted version.

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The Joint Effects of Social Norm Appeals and Fear Appeals in COVID-19 Vaccine Campaign Posters on Self-Perceived Communication Quality and Vaccination Intention

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To understand how different types of cues in vaccine education messages affect attitude toward campaign messages and vaccination intention, this study examined the impact of the presence of social norm appeals (individual vs. group cues) and the presence of fear appeals in coronavirus disease 2019 (COVID-19) vaccine campaign posters on perceived communication quality and vaccination intention. A 2 (social norm appeal: individual cue vs. group cue) $\times$ 2 (fear appeal: absence vs. presence) $\times$ 3 (repetition) within-subject factorial design experiment was conducted in China. Findings demonstrated that the presence of fear appeals in COVID-19 vaccine campaign posters elicited lower levels of perceived communication quality and vaccination intention than those without fear appeals. The interactive effect of fear appeals and social norm appeals was also found to be significant. Specifically, positive-framed messages (i.e., absence of fear appeals) with group cues and fear appeal messages with individual cues elicited higher perceived information quality and stronger vaccination intention than other types of messages. Understanding how these cues function jointly in COVID-19 vaccine campaign messages will help public health practitioners create more effective intervention strategies.

Keywords: vaccine education, social norm appeal, fear appeal, communication quality, vaccination intention

INTRODUCTION

Vaccines are as important to our overall health as diet and exercise. According to the World Health Organization (2021), vaccines help develop immunity and prevent over 2 million deaths every year from diseases, such as diphtheria, tetanus, pertussis, influenza, and measles. After 2 years of living with coronavirus disease 2019 (COVID-19), the pandemic is still far from over and has caused nearly 5.55 million deaths across the world (John Hopkins University Center for System Science and Engineering, n.d.). Getting the COVID-19 vaccine helps reduce the risk of contracting coronavirus (Haynes, 2020). However, as of 19 January 2022, only a total of 3.92 billion people had been fully vaccinated, or 50.4% of the world's population (John Hopkins University Center for System Science and Engineering, n.d.). Beneath the low COVID-19 vaccination rate lurks the

vaccine hesitancy that has taken root in many countries (Dubé et al., 2015). For example, a subset of the population in different countries believe that vaccines harm the immune system and thus hesitate to vaccinate themselves and their children (Cooper et al., 2008; Omer et al., 2009; Edwards et al., 2016). Low vaccination rate and COVID-19 vaccine hesitancy can greatly decrease our ability to curtail the pandemic.

Reasons for COVID-19 vaccine hesitancy are complicated and encompass more than just a knowledge deficit. In China, vaccine hesitancy is also a growing public health problem. People were concerned about the side effects, safety, and lack of risk awareness (Sun, 2021). Current research has also confirmed that age, education, health literacy, rurality, and parental status affect COVID-19 vaccination intention among Chinese people (Wang et al., 2021; Zhang et al., 2021). For example, a study conducted by Wang et al. (2021) found that people from urban and suburban areas had lower vaccination willingness than those from rural areas. Zhang et al. (2021) surveyed $N = 2,463$ parents in China and found that parents of minor children (under age 18 years) were less likely to have their children get vaccinated against COVID-19. Meanwhile, it has been reported that older adults aged 70 and older were less willing to get vaccinated against COVID-19 (Liu, 2021).

Delivering vaccine education messages (e.g., COVID-19 vaccine campaign posters) may help boost vaccination intention. Current studies have found that the use of social norm appeals and fear appeals in vaccine education messages elicit greater vaccination intentions (e.g., Gerend and Shepherd, 2012; Iten et al., 2013; Lau et al., 2019) and higher levels of self-perceived message effectiveness (e.g., Kim et al., 2020). However, absent from the current literature is the interactive effect of fear appeals and social norm appeals. Our study seeks to fill this research gap using an online experiment. Thus, this study examined the main effects and the joint effects of social norm appeals and fear appeals on perceived communication quality and vaccination intention during COVID-19 vaccine campaign message possessing.

Social Norm Appeal

The term "social norm" is defined as the self-perceived standards for what constitutes appropriate behavior that is based on widely shared beliefs about how individual members of a group ought to behave in a given situation (Elster, 1989). In other words, the presence of social norms in COVID-19 vaccine campaign messages may facilitate vaccination compliance intention thereby improving vaccination rates. Current research has found that health professionals, family members, and friends can play a significant role in adult vaccination uptake (e.g., Quinn et al., 2017; Elhadi et al., 2021; Graupensperger et al., 2021). For example, a survey study conducted by Quinn and her colleagues showed that high-risk populations were more likely to be vaccinated if they believed that most people around them wanted them to get vaccinated (Quinn et al., 2017). They also concluded that public health practitioners could reinforce positive social norms about the flu vaccine (Quinn et al., 2017). Graupensperger et al. (2021)

had 647 undergraduate students complete an online survey, and their findings indicated that social norms regarding peers' vaccination behaviors and attitudes were positively related to both the perceived importance of getting a COVID vaccine and vaccination intention. In addition, Elhadi et al. (2021) found that having a family member or friend infected with COVID-19 was positively correlated with the likelihood of vaccine acceptance. However, it is also important to note that they also found that having a family member or friend die due to COVID-19 was negatively correlated with the likelihood of vaccine acceptance.

Current research has also confirmed the influences of social norm appeals in health messages on vaccination intention and behavior (e.g., Gerend and Shepherd, 2012; Juraskova et al., 2012; Nyhan et al., 2012; Iten et al., 2013; Lau et al., 2019). In particular, some research studies explored the effects of different types of social norm cues in vaccine communication. For example, Lau et al. (2019) had participants randomly assigned to different conditions of a web-based experiment (including a control group and seven treatment groups with different vaccination coverage levels). Interestingly, their findings demonstrated that the presence of overall vaccination coverage (i.e., social norm appeal: group cue) did not always improve vaccination intention. Their findings suggest that the average vaccination intention was higher at lower coverage levels but lower at higher coverage levels. Another research study conducted by Iten et al. (2013) had vaccinated and unvaccinated healthcare workers at a Swiss hospital wore badges containing individual cues ("I am vaccinated against influence to protect you" vs. "I wear a mask to protect you") during seasonal influenza epidemic to explain their vaccination choice to patients/visitors. The vaccination rate was significantly improved (to 37%) after a year. Thus, it seems that vaccination intention may vary depending on the presence of different types of social norm appeals (individual vs. group cues). It was not clear, however, whether exposure to different types of social norm cues in vaccine campaign messages alters how the health messages and the importance to get vaccinated are evaluated.

Fear Appeal

The use of fear appeals to promote healthy behaviors is contentious (Avery and Park, 2018; Kim et al., 2020). A fear appeal is a persuasion technique that emphasizes the potential danger and harm that threaten the audience with negative, physical, psychological, and/or social consequences and motivate them to adopt the recommended behaviors (Hale and Dillard, 1995). For example, a typical fear appeal vaccine campaign message portrays negative consequences of vaccine hesitancy and refusal (such as getting sick with COVID-19 or even death). In the extended parallel process model (EPPM), Witte (1992) conceptualized fear appeal as the message depicting the components of threat (i.e., severity and susceptibility) and the components of efficacy (i.e., response efficacy and self-efficacy). Higher levels of perceived threat elicit fear and thereby activate the danger control process if perceived

efficacy is also high (Witte, 1992). However, in the low-efficacy condition, fear arousal may result in defensive reactions, such as risk neglect or denial. Within the theoretical framework of EPPM, people are better motivated to get vaccinated against COVID-19 when both self-efficacy and perceived threat are high.

Previous studies have yielded mixed findings regarding the effect of fear appeals (e.g., So, 2013; Carcioppolo et al., 2017; Ort and Fahr, 2018; Kim et al., 2020; Su et al., 2021). For example, Kim et al. (2020) found that the presence of fear appeals was associated with greater motivation to process human papillomavirus (HPV) protection-related information. While some other research studies demonstrated that individuals self-reported a higher level of discomfort, less attention, and lower level of self-efficacy when seeing fear appeals in vaccine promotion messages (Ort and Fahr, 2018; Su et al., 2021). Thus, it is still unclear how fear appeals in vaccine campaign messages (e.g., the presence of negative pictures and content) affects motivations to control the danger or threat.

Information Quality and Vaccination Intention

Effective information processing depends on communication quality and how the information is processed, among other things. Current research in the field of vaccine education has found that individuals prioritize information quality and are more likely to be vaccinated (Ghezzi et al., 2020; Di Gennaro et al., 2021; Su et al., 2021). Existing literature has also identified three major dimensions of information quality: the amount of information, believability, and interpretability (Lee et al., 2002).

The amount of information refers to "the degree to which the quantity or amount of available information is appropriate" (Kim et al., 2017, p. 694). While the amount of information should be sufficient enough for people to make informed decisions, too much information will cause cognitive overload and lead to information avoidance (Lee et al., 2002; Song et al., 2017). In this case, an appropriate amount of information conveyed in a persuasive message will help the formation of a positive attitude toward certain objects and issues (Baloglu and McCleary, 1999).

Believability refers to the extent to which information is considered true and credible (Wang and Strong, 1996). Information believability has been found to influence risk perceptions and behavioral changes in response to persuasive appeals, including advocacy for vaccination (Trumbo and McComas, 2003; Briñol and Petty, 2006). Fear appeals are likely to reduce information believability because individuals tend to avoid processing high-fear messages and thus consider them incredible (Dunbar et al., 2014).

Interpretability is defined as the extent to which information is explained with clear and unambiguous language (Wang and Strong, 1996). This dimension of information quality is particularly important in health communication messages because medical issues are often too complicated and technical to comprehend for a layperson (Salmon et al., 2021). An unclear message is likely to cause confusion and attitudinal ambivalence,

which will lead to lower intentions to receive vaccines (Hofman et al., 2014; Kim et al., 2019).

COVID-19 vaccine campaign poster is a way of engaging target populations to get vaccinated. Therefore, it is important to examine how the use of fear appeals and social norm appeals in COVID-19 vaccine messages affects people's perceived information quality and the subsequent vaccination intentions.

MATERIALS AND METHODS

Experimental Design

A 2 (social norm appeal: individual cue vs. group cue) × 2 (fear appeal: absence vs. presence) × 3 (repetition) within-subject factorial design experiment was conducted in China. This design was fully crossed. Thus, participants viewed 12 COVID-19 vaccine campaign posters of four types: (1) COVID-19 vaccine campaign posters with both group cues and fear appeals, (2) COVID-19 vaccine campaign posters with both group cues only, (3) COVID-19 vaccine campaign posters with both individual cues and fear appeals, and (4) COVID-19 vaccine campaign posters with individual cues only. These posters were presented in a random order in this experiment.

Participants

Participants ($N = 859$) who were living in China responded to the request to complete the online experiment. They were selected from multiple market research panels and got paid directly through Wenjuanxing (an alternative to Qualtrics in China). Participants' age ranged from 18 to 65 years with an average age of 29.78 ($SD = 7.27$). Among these participants, 58.7% ($N = 504$) were women (refer to **Table 1** for full details on demographic characteristics). Specifying a small effect size (0.15) and an α of 0.05 in the G*Power program (Faul et al., 2007), the proposed design requires at least 97 participants to have a 0.95 power estimate.

Stimuli

A total of 16 COVID-19 vaccine campaign posters presented in China were pretested to control for emotional arousal, positivity, and negativity to identify appropriate stimuli for this study. These posters were originally developed based on the objective criteria of social norm appeals (i.e., number of infected individuals) and fear appeals (absence vs. presence). Self-reported emotion of these 16 posters was collected from $N = 35$ undergraduate students who did not participate in the experimental session reported here. Totally, 12 out of 16 COVID-19 vaccine campaign posters were selected. Specifically, self-reported arousal [from 1 (low) to 7 (high)], positivity [from 1(low) to 7 (high)], and negativity [from 1 (strongly disagree) to 7 (strongly agree)] ratings were collected from 35 undergraduate students in the pretest. The results indicated that the 12 campaign posters selected for the final study did not elicit significant differences in self-reported emotional arousal [$F(2,66) = 1.12$, $p = 0.331$], negativity [$F(2,66) = 2.36$, $p = 0.104$], and positivity [$F(2,66) = 2.54$, $p = 0.088$] between posters within each cue category.

TABLE 1 | Sample characteristics ($N = 859$).

	M(SD)	Percent
Age, year	30.02 (10.05)	
Gender		
Male	355	41.3
Female	504	58.7
Education		
High school grad or less	30	3.5
Occupational certificate or associate's degree	92	10.7
Bachelor's degree	672	78.2
Postgraduate degree	65	7.6
Employment Status		
Student	138	16.1
Employed	712	82.9
Unemployed	2	0.2
Retired	3	0.3
Others	4	0.5
Individual income		
Less than ¥1000/month	60	7
¥1001 – ¥5000/month	197	22.9
¥5001 – ¥10000/month	341	39.7
¥10001 – ¥20000/month	218	25.4
More than ¥20001/month	43	5
Residence situation		
Living alone	210	24.4
Living with parents	309	36.0
Living with roommate(s)	182	21.18
Others	158	18.4
Fully vaccinated		
Yes	691	80.4
No	168	19.6

Measures

Manipulated Independent Variables

Social Norm Appeal

This factor had two levels based on how many infected people were presented in the COVID-19 vaccine campaign posters: individual ($=1$) vs. a group of people (≥ 2). Thus, COVID-19 vaccine campaign posters with individual cues contain only one person; while those with group cues include two or more persons. These social norm cues are assumed to be varied in the intensity of participation in collective action.

Fear Appeal

This factor had two levels: absence vs. presence. The fear appeal was manipulated by varying the presence of negative images and contents in COVID-19 vaccine campaign posters (e.g., unvaccinated people have a higher risk of dying from COVID-19).

Repetition

A total of 12 COVID-19 vaccine campaign posters were selected to represent the combination of manipulations as stated above. This was done to generalize ratings and responses to a type of ad circumstance rather than a specific poster. Health campaign messages are complex media messages that vary in

a number of ways; by utilizing multiple exemplars of each cue type, we randomize extraneous features across conditions (Geiger and Newhagen, 1993).

Dependent Variable

Information Amount

Two items were adapted from a previous study (Lee et al., 2002) to assess information amount (e.g., "This information is of sufficient volume for our needs"). Items were rated on a five-point Likert-type scale, with responses ranging from $1 = $ *Strongly disagree* to $7 = $ *Strongly agree*. Higher scores indicated a greater level of self-perceived information amount ($M = 4.67$, $SD = 1.11$).

Information Believability

Two items from Lee et al.'s (2002) information quality assessment subscale were adapted to assess participants' trust toward those selected COVID-19 vaccine campaign posters (e.g., "This information is believable"). Items were rated on a five-point Likert-type scale, with responses ranging from $1 = $ *Strongly disagree* to $7 = $ *Strongly agree*. Higher scores indicated a greater level of self-perceived information believability ($M = 5.47$, $SD = 0.91$).

Information Interpretability

Two items from Lee et al.'s (2002) information quality assessment subscale were adapted to measure information interpretability (e.g., "It is easy to interpret what this information means"). Items were rated on a five-point Likert-type scale, with responses ranging from $1 = $ *Strongly disagree* to $7 = $ *Strongly agree*. Higher scores indicated a greater level of self-perceived information interpretability ($M = 4.77$, $SD = 1.16$).

COVID-19 Vaccination Intention

A single item was adapted from a previous study (Ernsting et al., 2013) and used to assess participant's vaccination intention after seeing each vaccine campaign poster (i.e., "If I haven't got vaccinated yet, I would like to be vaccinated against COVID-19 within 3 months after seeing this message"). Item was rated on a seven-point Likert scale, with responses ranging from $1 = $ *Strongly disagree* to $7 = $ *Strongly agree*. Higher scores indicated a greater level of self-perceived COVID-19 vaccination intention ($M = 6.1$, $SD = 1.08$).

Analysis Strategy

Data were submitted to a 2 (social cue: individual eating, group eating) $\times$ 2 (fear appeal: absence, presence) $\times$ 3 (repetition) repeated-measures analysis of covariance (ANCOVA). The p-values and degrees of freedom corrected for sphericity assumption violation using the Greenhouse-Geisser method were reported, where appropriate. To control for the possibility that sociodemographic differences in the outcome variables might lead to spurious relationships, gender ($1 = $ male and $2 = $ female), age, education ($1 = $ high school grad or less, $2 = $ occupational certificate or associate's degree, $3 = $ bachelor's degree, and $4 = $ postgraduate degree) were entered as covariates in the repeated measures ANCOVA tests.

FIGURE 1 | The interaction effect of social norm appeals (individual vs. group cues) and fear appeals (absence vs. presence) on information amount.

FIGURE 2 | The interaction effect of social norm appeals (individual vs. group cues) and fear appeals (absence vs. presence) on information believability.
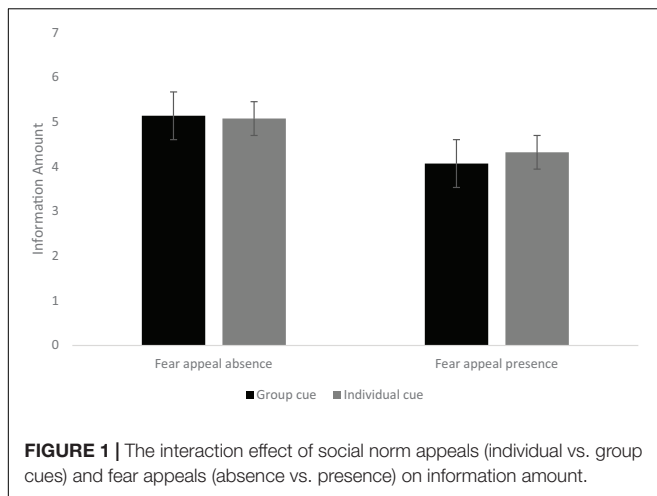
RESULTS

Information Amount

After controlling for age, gender, and education level, the interaction effect of social norm appeals and fear appeals was found to be significant: $F(1,626) = 10.4648$, $p < 0.01$, $\eta_p^2 = 0.02$. As can be seen from **Figure 1**, posters with group cues ($M = 5.14$, $SD = 0.053$) and individual cues ($M = 5.08$, $SD = 0.06$) had significantly higher ratings of information amount compared with those with both social cues and fear appeals (posters with both group cues and fear appeals: $M = 4.07$, $SD = 0.08$, $p < 0.001$; posters with both individual cues and fear appeals: $M = 4.32$, $SD = 0.08$, $p < 0.001$). COVID-19 vaccine campaign posters with individual cues and fear appeals had significantly higher ratings of information amount ($M = 4.332$, $SD = 0.051$) than those with both group cues and fear appeals ($M = 4.08$, $SD = 0.05$, $p < 0.001$). A significant main effect of fear appeals was found on information amount: $F(1,626) = 62.7$, $p < 0.001$, $\eta_p^2 = 0.09$. Posters without fear appeals ($M = 5.11$, $SD = 0.05$) had significantly higher ratings of information amount than those with fear appeals ($M = 4.2$, $SD = 0.08$, $p < 0.001$). However, no significant differences were found between posters with group cues and individual cues ($F < 1$, $p = 0.99$).

Information Believability

After controlling for age, gender, and education level, the interaction effect of social norm appeals and fear appeals was found to be significant: $F(1,626) = 12.92$, $p < 0.001$, $\eta_p^2 = 0.02$. As can be seen in **Figure 2**, posters with group cues had the highest ratings of information believability ($M = 6.01$, $SD = 0.04$, $p < 0.05$). Meanwhile, posters with group cues and fear appeals had the least ratings of information believability ($M = 4.92$, $SD = 0.07$, $p < 0.001$). A significant main effect of fear appeals was found on information believability: $F(1,626) = 43.39$, $p < 0.001$, $\eta_p^2 = 0.07$. Posters without fear appeals ($M = 5.97$, $SD = 0.07$) had significantly higher ratings of information believability than those with fear appeals ($M = 5.03$, $SD = 0.04$, $p < 0.001$). However, no significant differences were found
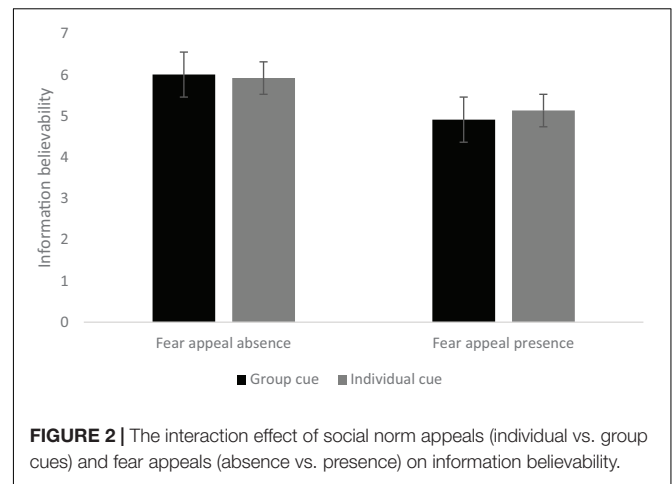
between posters with group cues and individual cues ($F < 1$, $p = 0.35$).

Information Interpretability

After controlling for age, gender, and education level, the interaction effect of social norm appeals and fear appeals was found to be significant: $F(1,626) = 6.23$, $p < 0.05$, $\eta_p^2 = 0.01$. As can be seen from **Figure 3**, posters with group cues ($M = 5.11$, $SD = 0.06$) and individual cues ($M = 5.12$, $SD = 0.06$) had significantly higher ratings of information interpretability compared with those with both social cues and fear appeals (posters with both group cues and fear appeals: $M = 4.27$, $SD = 0.08$, $p < 0.001$; posters with both individual cues and fear appeals: $M = 4.51$, $SD = 0.08$, $p < 0.001$). COVID-19 vaccine campaign posters with individual cues and fear appeals had significantly higher ratings of information interpretability ($M = 4.51$, $SD = 0.08$) than those with both group cues and fear appeals ($M = 4.27$, $SD = 0.08$, $p < 0.001$). A significant main effect of fear appeals was found on information interpretability: $F(1,626) = 38.94$, $p < 0.001$, $\eta_p^2 = 0.06$. Posters without fear appeals ($M = 5.11$, $SD = 0.05$) had significantly higher ratings

FIGURE 3 | The interaction effect of social norm appeals (individual vs. group cues) and fear appeals (absence vs. presence) on information interpretability.

of information interpretability than those with fear appeals ($M = 4.39$, $SD = 0.08$, $p < 0.001$). However, no significant differences were found between posters with group cues and individual cues ($F < 1$, $p = 0.5$).
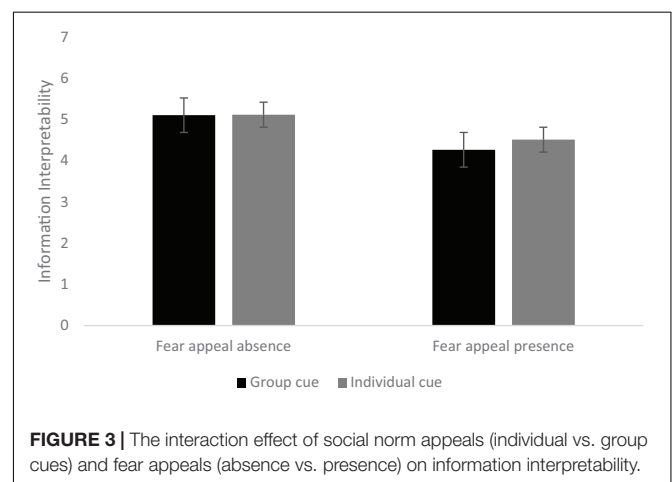
COVID-19 Vaccination Intention

After controlling for age, gender, and education level, the main effect of fear appeals was found to be significant: $F(1,626) = 20.3$, $p < 0.001$, $\eta_p^2 = 0.03$. Posters without fear appeals ($M = 5.11$, $SD = 0.05$) had significantly higher ratings of COVID-19 vaccination intention than those with fear appeals ($M = 4.39$, $SD = 0.08$, $p < 0.001$). However, the interaction effect of social norm appeals and fear appeals ($F < 1$, $p = 0.91$) and the main effect of social norm appeals ($F < 1$, $p = 0.53$) were found to be insignificant.

DISCUSSION

The goal of this study was to investigate the joint effect of social norm appeals (individual vs. group cues) and fear appeals (absence vs. presence) in promoting COVID-19 vaccination. In general, we found that the use of fear appeals would not help increase (or may even discourage) participants' perceived information quality and the subsequent vaccination intentions. Participants self-reported significantly lower levels of information amount, information believability, information interpretability, and COVID-19 vaccination intention after exposure to the posters with fear appeal than those without fear appeals. Our results are consistent with previous studies (Ort and Fahr, 2018; Su et al., 2021). The Chinese government has been using strict control measures (e.g., travel restrictions and a 14-day quarantine strategy for international travelers) to fight against COVID-19 since the pandemic began. Public fear of COVID-19 gets low due to the dramatic decline in COVID-19 cases in China. In this case, giving clear instruction to the general public about why it is necessary to get vaccinated may be more effective than scaring them. Thus, it is important to omit fear appeals to avoid developing counter-productive vaccination campaign messages.

In addition to the main effect of fear appeals, this study also found that fear appeals interact with social norm appeals in affecting perceived information quality and vaccination intentions. On the one hand, the presence of group cues elicited greater self-perceived information quality and vaccination intentions during exposure to positive-framed messages than exposure to fear appeal messages; on the other hand, the presence of individual cues elicited greater self-perceived information quality and stronger vaccination intentions during exposure to fear appeal messages than exposure to positive-framed messages. Consistent with previous studies on the promotion of other vaccines (e.g., Gerend and Shepherd, 2012; Juraskova et al., 2012; Nyhan et al., 2012; Iten et al., 2013; Lau et al., 2019), these findings suggest that *the use of group cues in positive-framed messages* and *the use of individual cues in fear appeal messages* would be effective strategies in the design of COVID-19 promotion materials in China. As suggested by classic economic theories of decision-making (Simon, 1959), people are better motivated to make changes for their own benefit and they often care more about their own welfare under threatening situations. In this case, it is conceivable that fear appeal health messages that emphasize self-interest in COVID-19 vaccination actions would trigger stronger defensive responses (e.g., getting vaccinated) than messages that emphasize cooperative efforts. Instead of emphasizing "we will get infected without vaccination," stressing "I will get infected without vaccination" could better address vaccine hesitancy and motivate vaccination intention. Thus, public health professionals should consider the joint effects of fear appeals and social norm appeals when developing vaccination campaign messages that resonate effectively with target audiences.

Limitations of this study include issues regarding the stimulus and experimental controls. First, the stimuli were presented in an online experiment in which the messages appear as screenshots as opposed to printed posters at public places. This may limit the external validity, although it allowed us to have more control over exposure than other methods to examine the interactive effect of social norm appeals and fear appeals. In addition, we pretested the selected poster stimuli and used a multiple message design [see Geiger and Reeves (1993)] in this study to randomly spread message variance caused by other factors across cells and maximize control of message heterogeneity (Slater et al., 2015). It is possible that confounds may still exist. Thus, these findings should be replicated using other messages in future studies. Finally, this study was conducted among Chinese in Mainland China. It would be interesting to test the messages with other populations, especially those with different cultural backgrounds or those who are at higher risk of getting COVID-19 might perceive the messages differently. Since there are limited studies on investigating the interactive effects of social norm appeals and fear appeals, more research is needed about the joint influences of social norm appeals and fear appeals on individual emotional, cognitive, and behavioral responses.

Taken together, the results of this study have important implications for future research and vaccine promotion in many ways. Our findings suggest that the presence of fear appeals in COVID-19 vaccine campaign messages may not help motivate individuals to get vaccinated. Furthermore, we identified the joint effects of fear appeals and social norm appeals. Both positive-framed messages (no fear appeals) with group cues and fear appeal messages with individual cues elicit greater self-perceived information quality and vaccination intentions (compared with positive framed messages with individual cues and fear appeal messages with group cues). Practically, the findings should provide researchers and public health practitioners with important insights into the design of COVID-19 vaccine campaign messages. Changing the way the COVID-19 vaccination is promoted could improve the uptake of the COVID-19 vaccines, thereby getting coverage rates higher.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Jinan University Institutional Review Board. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

JL contributed to conceptualization, questionnaire design, data collection, data analysis, and manuscript writing. XY contributed to conceptualization, questionnaire design, data collection, and editing. YL wrote and edited the manuscript. XZ wrote the manuscript. All authors contributed to the article and approved the submitted version.

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Sharing Online Health Information With Physicians: Understanding the Associations Among Patient Characteristics, Directness of Sharing, and Physician-Patient Relationship

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Patients increasingly share online health information with their physicians. However, few studies have investigated factors that may facilitate or inhibit such sharing and subsequent impact on physician-patient relationship. This study conducted a cross-sectional survey among 818 Chinese patients to examine if two patient characteristics -communication apprehension and eHealth literacy- influence their ways of sharing online health information with physicians and subsequently impact physician-patient relationship. The results showed that a majority of surveyed participants searched health information online, and about half of them used such information during their doctor visits. Less apprehensive patients tend to share the information with their physicians more directly, which can positively affect perceived physician reactions and patient satisfaction. eHealth literacy, however, is not found to be associated with patients' sharing of online information with physicians. This study underscores the importance of identifying patient characteristic's role in patient-physician interaction.

Keywords: online health information sharing, communication apprehension, eHealth literacy, physician patient communication, patient satisfaction

INTRODUCTION

The rise of the Internet has significantly changed the ways through which that patients acquire health information (Wong and Cheung, 2019). Besides passively receiving information from physicians, patients nowadays can actively search for health information *via* different online outlets (Wang et al., 2020). The easy access of online health information, to a certain extent, has shifted the power in physician-patient relationship. Patients become more informed about their health and take a more active role in health-decision making.

Health information acquired online may serve as a double-edged sword for patients. Although patients can educate themselves *via* online platforms, they may also receive misleading and even false information online (Suarez-Lledo and Alvarez-Galvez, 2021). One way to reduce the confusion over online health information is through open discussion with physicians, yet some research shows that patients do not always share online health information with their physicians

(Matusitz and Spear, 2015). Patients are worried that physicians may feel challenged by the shared information, potentially leading to a relational damage with their physicians. However, the other line of research shows that many patients still choose to strategically reveal such information during doctor visits (Tan and Goonawardene, 2017). The conflicting findings revealed in extant literature might be attributed in part to the complex construct of online health information sharing with physicians. Rather than dichotomizing sharing behaviors into yes and no, patients can differ in their extent of sharing online health information with physicians. Past research showed that some patients explicitly shared the information with their physicians and others covertly compared online information with the information provided by physicians (Sommerhalder et al., 2009). The various ways of information sharing thus differ along the spectrum of directness. Directness of online health information sharing is defined as the extent to which patients explicitly share health information found online with their physicians. This study attempts to examine this overlooked aspect–directness of online health information sharing with physicians–in a nuanced way by specifically focusing on its antecedents and relational outcomes.

Apart from past research which heavily examined situational factors and physician attributes (Tan and Goonawardene, 2017), this study highlights the importance of patient characteristics in their influence on sharing online health information with physicians. Specifically, this study examines two characteristics of patients—communication apprehension and eHealth literacy—in online health information sharing with physicians. Communication apprehension, characterized by anxiety in social interactions (McCroskey, 1984), is highly relevant to the communication activity of online health information sharing. Patients varying in this characteristic are expected to differ in information sharing behaviors with their physicians (Booth-Butterfield et al., 1997), which may subsequently influence physician-patient relationship as well as treatment outcomes (Perrault and Silk, 2015). Given the importance of communication apprehension in health communication, we need to closely look into the role of communication apprehension in sharing Internet search with physicians and shaping physician-patient relationship. In addition, eHealth literacy may serve as a motivation to share online health information with physicians (Briones, 2015). eHealth literacy pertains to patients' abilities to acquire and evaluate online health information. As a well-established construct in health communication, eHealth literacy has been mostly examined in online health information seeking, a solidary activity requiring minimal social interaction (Chang et al., 2015). Its role in health communication, particularly online health information sharing, has been largely overlooked. To fill the gap, this study examines the impact of eHealth literacy on physician-patient interaction.

Besides patient characteristics, this study strives to examine relational outcomes associated with the directness of online health information sharing. Although physician-patient relationship has been a long-standing topic in health communication, the specific ways of sharing online health information with physicians have yet to be linked to the relational outcomes. To fill the gap, this study investigates if and

how the directness of online information sharing affects patients' perceived physician reactions and thereby patient satisfaction.

SHARING ONLINE HEALTH INFORMATION WITH PHYSICIANS

An increase in online health information seeking is likely to lead to a rise in information sharing during doctor visits. As Hu et al. (2012) suggested, patients search for health information online to get prepared for their upcoming doctor visits. Their study found that more than half of the participants planned to ask their physicians questions about the information they found online and roughly one-third of the participants indicated that they had printed out online information to share with the doctors. At the same time, another body of literature acknowledged patients' concerns about sharing online health information and asking questions during doctor visits, due to a fear of challenging the physicians' authority (Matusitz and Spear, 2015).

To understand the extent to which patients would share online health information during doctor visits, past research examined facilitators and barriers to reveal online information with physicians (Tan and Goonawardene, 2017). Factors that motivate patients to share online information include but are not limited to having a family member accompanied during a doctor visit, physicians encouraging patients to discuss online search, and patients feeling a strong need to check online information with physicians (Stevenson et al., 2007; Silver, 2015). In contrast, pre-established view of the physician-patient relationship, perceived authority of physicians, and perceived embarrassment while asking questions pose obstacles to information sharing with physicians (Hart et al., 2004; Silver, 2015).

Research has also suggested that patients adopt different strategies to use and reveal online information during doctor visits (Sommerhalder et al., 2009; Wong and Cheung, 2019). For instance, while some patients choose to silently verify online findings without asking any questions, others may explicitly ask questions or even show physicians their online findings in person (Tan and Goonawardene, 2017). Although the directness of online health information sharing with physicians has not been explicitly examined in prior research, these identified strategies can be differentiated along the spectrum of directness, with one end of not mentioning the Internet search and the other end of directly showing online information to physicians. Given the large variation in using online health information, this study is interested in whether communication apprehension and eHealth literacy may serve as facilitators or deterrents of sharing online information with physicians.

COMMUNICATION APPREHENSION

Communication apprehension is conceptualized as "an individual's level of fear or anxiety associated with either real or anticipated communication with another person or persons" (McCroskey, 1984, p.13). Past research found that highly apprehensive patients would feel a sense of powerlessness

during doctor visits and feel reluctant to communicate with their physicians (Wheeless, 1984). A lack of communication between patients and physicians may lead to negative consequences on relationships and health outcomes (Perrault and Silk, 2015).

To date, research in health communication has only broadly assessed the impact of communication apprehension on physician-patient communication, without looking specifically into the issue of sharing Internet search with physicians. Because heavy reliance on online health information has shown influence on physician patient interaction (Broom, 2005) and patients may concern about challenging physician authority if they share Internet search (Matusitz and Spear, 2015), it becomes important to examine if communication apprehension is related to sharing of online health information during doctor visits, and further affect physician-patient relationship.

Patients varying in their communication apprehension may feel different levels of comfort in sharing information with their physicians and differ in their directness of sharing Internet search. For instance, highly apprehensive patients are less willing to discuss online information with their physicians (Wheeless, 1984). As a result, they are more likely to secretly compare online information with physicians' information without directly sharing it. In contrast, patients low on communication apprehension are less concerned about challenging physician authority and thus may engage with the information in more direct ways, such as directly asking questions or even presenting physicians with online information. Taken together, the following hypothesis is proposed:

H1: Patients' communication apprehension will be negatively associated with directness of sharing online health information with their physicians.

eHEALTH LITERACY

eHealth literacy refers to individuals' skills to effectively obtain, evaluate, and apply online information to health problems (Norman and Skinner, 2006). eHealth literacy has been found to be relevant to individuals' health outcomes (Meherali et al., 2020). So far, much research has focused on the association between eHealth literacy and online health information seeking, a solitary behavior that requires minimal involvement of a communication partner (Chang et al., 2015); little attention has been devoted to the relationship between eHealth literacy and physician-patient interaction.

Past research examining the general health literacy sheds light on the association between eHealth literacy and physician-patient interaction (Katz et al., 2007; Hahn et al., 2015). Relevant studies found that patients with low health literacy tried to avoid situations that might show their limited understanding of health information and tended to report poor communication with their physicians (Sudore et al., 2009). For instance, Katz et al. (2007) found that low-literacy patients asked fewer questions than high-literacy patients during consultation. Diabetes patients with higher health literacy tend to speak more with their physicians to acquire relevant information (Hahn et al., 2015). Building

upon past research which shows a positive relationship between health literacy and physician-patient interaction, it is expected that eHealth literacy will positively impact patients' directness to share online health information with their physicians. Specifically, patients with low eHealth literacy may not feel confident to openly discuss online health information with their physicians. They may covertly compare online information with the information provided by physicians. In contrast, patients with high eHealth literacy are more assertive and willing to discuss online information with their physicians, thus using more direct ways to reveal such information. In fact, patients with high eHealth literacy reported to have presented the physician with the information they retrieved and asked significantly more questions than patients with low eHealth literacy (Neter and Brainin, 2012). Therefore, we assumed that:

H2: Patients' eHealth literacy will be positively associated with directness of online health information sharing with their physicians.

PHYSICIAN REACTIONS AND PATIENT SATISFACTION

Although patients are concerned about physicians' reactions and sometimes choose not to explicitly share Internet search with their physicians, patients who choose to reveal such information generally receive positive feedback from their physicians (Kivits, 2006). For instance, Sleath et al. (1999) found that physicians perceived question-asking in a positive way. Patients who asked questions were perceived to be more interested, but not more irritated than patients who did not ask questions by their physicians. Sommerhalder et al. (2009) found that physicians mostly appreciated their patients openly discuss online information with them, despite that contradictory information found online may sometimes cause conflict during consultation. AlGhamdi and Moussa (2012) reported that the majority of patients who discussed online information with their physicians believed the discussion positively affected their relationships with physicians. Taken together, most physicians tend to respond positively to patients who openly share online health information, albeit incidents of misunderstanding and conflicts. Therefore, it is hypothesized that using more direct ways of sharing online information tends to perceive more positive feedback from physicians.

H3: directness of online health information sharing will be positively related to patients' perceived physician reactions.

Patients' satisfaction has been recognized as an important assessment of health outcomes (Grogan et al., 2000). Patients' satisfaction with their physicians has a significant impact on key health measures such as adherence to medicine and health status (Brown et al., 2003). In addition, patients' satisfaction is closely related to physician-patient interaction (Street et al., 2009). Open and receptive communication tends to create a positive communicative atmosphere and leads to greater satisfaction from patients (Dutta-Bergman, 2005). Greene et al. (1994) found that

physicians' positive feedback, such as supportiveness to patients, leads to greater patient satisfaction. Therefore, it is expected that positive feedback from physicians can enhance patient satisfaction with their physicians.

H4: Perceived physician reactions will be positively associated with patient satisfaction.

The previous section examined the direct links between directness of online health information sharing and its antecedents as well as its relational outcomes. This study strived to take a step further to examine if mediation relationships would be discovered among the variables. Specifically, we wanted to examine if and how two patient characteristics—communication apprehension and eHealth literacy—would affect directness of online health information sharing, and thereby perceived physician reaction and patient satisfaction. Based on the rationale aforementioned, lower levels of communication apprehension is expected to facilitate direct sharing of online health information. Directness of sharing is hypothesized to be positively associated with perceived physician reactions, which is predicted of a positive relationship with patient satisfaction. Taken together, we hypothesize that:

H5: Patients with lower levels of communication apprehension will more directly share their Internet search with physicians, which will positively impact perceived physician reactions and thus patient satisfaction.

In contrast to communication apprehension, eHealth literacy is expected to be associated with directness of online sharing in the oppositive direction. Higher levels of eHealth literacy may lead to more direct sharing of online health information. The associations among directness of sharing, perceived physician reaction, and patient satisfaction are expected to be the same. Therefore, the following hypothesis is proposed.

H6: Patients with higher levels of eHealth literacy will more directly share their Internet search with physicians, which will positively impact perceived physician reactions and thus patient satisfaction.

Put together, the current study integrates these proposed pathways into a comprehensive model shown in **Figure 1**.

MATERIALS AND METHODS

This study surveyed participants (above 18 years old) from China. Anyone who had ever visited a doctor could participated in this study. A total of 1,590 participants were recruited from a Chinese crowdsourcing platform Sojump[1] and received a small amount of payment for their participation. Fifty-three participants (3.3%) failed one or more attention check questions in the survey and were deleted from final analyses, leaving a total of 1,537 valid cases (Female: 56.5%; Age: $M = 30.68$, $SD = 7.84$). Among 1,537 participants, 1,191 (77.5%) individuals reported to have searched for health information online before their doctor visits, and 818 (53.2%) individuals reported to have used online information during doctor visit. Because this study primarily concerned patients who used online health information during doctor visits, subsequent analyses were based on data collected from 818 participants.

Each participant was asked to fill out a questionnaire based on their most recent physician visits. Specifically, each participant was instructed to answer questions about their online health information seeking prior to their doctor visit, whether and how they reveal the information to their physicians, online health literacy, perceived physician reactions, and patient satisfaction with their physicians. Demographic information such as age, sex, health status, and education levels were also asked in the survey.

Measures

Communication Apprehension

This trait was measured with a scale of four items modified from past research (Kim et al., 2000). The items were measured on a 5-point Likert scale (*1 = strongly disagree; 5 = strongly agree*), showing a good reliability ($M = 2.18$, $SD = 0.77$, $\alpha = 0.88$). Sample items include "[I] am not nervous when I have to talk to a physician." and "Ordinarily, I am very tense and nervous when communicating with a physician."

eHealth Literacy

A modified scale based on Norman and Skinner's (2006) research was used to assess patients' online health literacy. Seven questions on a 5-point Likert scale (*1 = strongly disagree; 5 = strongly agree*) were asked. Sample items include "[I] know how to find helpful health resources on the Internet" and "I know what

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[1] http://www.wjx.cn

FIGURE 1 | Schematic overview of the theoretical model and study hypotheses.
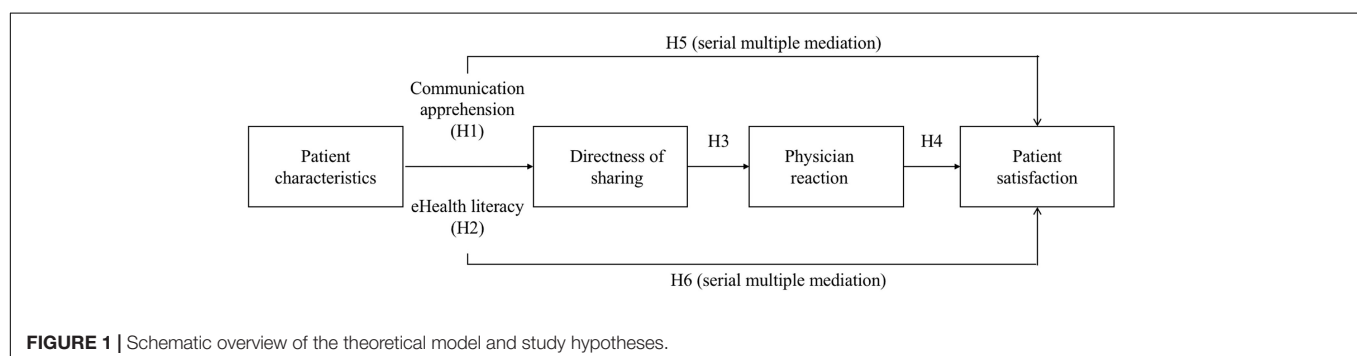
health resources are available on the Internet." The scale reached satisfactory reliability ($M = 3.86$, $SD = 0.55$, $\alpha = 0.77$).

Directness of Online Health Information Sharing With Physicians

Due to a lack of existing measures, this study generated the survey items based on quantitative research on this topic (Tan and Goonawardene, 2017). Each participant was asked to choose only one primary way that they used to share health information during their doctor visits, with four options ranging from the most indirect to the most direct way of sharing online health information with physicians (1 = secretly compared online information with information provided by your physician; 2 = making suggestions to your physician based on online information, without explicitly mentioning the information was found online; 3 = explicitly told your physician that you searched for health information online and asked questions based on online information; 4 = directly showed online information to your physician.) Because these options differ in directness in a progressive manner, a higher score indicated more directness in information sharing. The average was calculated ($M = 2.40$; $SD = 0.997$).

Perceived Physicians' Reactions

Five items based on Tan and Goonawardene's (2017) work were used to assess how patients perceive physician reactions during doctor visits. The items were measured on a five-point Likert scale (1 = strongly disagree; 5 = strongly agree). Sample items include "[T]he doctor was very receptive to online information that you revealed." and "The doctor was open to discuss online information that you revealed." The average scale score is 3.55 ($SD = 0.75$, $\alpha = 0.83$).

Patient Satisfaction

To assess the extent to which patients are satisfied with their physicians, we used a scale of seven items modified from prior research (Loblaw et al., 1999; Grogan et al., 2000). All items (e.g., "[I] have absolute faith and confidence in my doctor"; "I will follow the doctor's advice because I think he/she is absolutely right") were measured on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree) and reached satisfactory reliability ($M = 3.75$, $SD = 0.54$, $\alpha = 0.81$).

Control Variables

We included sex (1 = male, 2 = female), age (by years), educational level, and self-perceived health status as control variables. Education level was assessed by asking about the obtained highest educational degree by five levels (as shown in **Table 1**). For self-perceived health status, participants were asked to rate their health on a 5-point Likert scale (1 = poor; 5 = excellent). The average score of health status is 3.34 ($SD = 0.74$).

Analytical Approach

Descriptive statistics and zero-order correlations were conducted using SPSS 24.0. We used the PROCESS macro model 4 for SPSS for the single path mediation analysis, and model 6 for the serial mediation analysis (Hayes, 2017). The PROCESS macro estimates

TABLE 1 | Sample characteristics.

Gender	n (%)
Female, n (%)	474 (57.9)
Male	344 (42.1)
Age group	
18–25 y	213 (26.0)
26–35 y	446 (54.5)
36–45 y	121 (14.8)
46–55 y	31 (3.8)
>=56 y	2 (0.2)
Education	
Less than a high school diploma	1 (0.1)
High school degree	22 (2.7)
Associate degree	99 (12.1)
Bachelor's degree	614 (75.1)
Master's and doctorate degree	82 (10.0)
Total N	818

direct and indirect effects using 5,000 bootstrap samples. The results are presented as 95% bias correlated confidence intervals. When the confidence intervals do not contain zero, a significant indirect or mediating effect occurs. All control variables were included in the macro as covariates.

RESULTS

Preliminary Analysis

Table 2 presented descriptive statistics and bivariate correlations among the variables. Compared to men, women indicated higher levels of communication apprehension [$t(816) = -2.60$, $p = 0.009$, $M_{men} = 2.10$, $SD_{men} = 0.72$, $M_{women} = 2.24$, $SD_{women} = 0.72$], whereas women indicated lower levels of eHealth literacy [$t(816) = 3.22$, $p < 0.001$, $M_{men} = 3.94$, $SD_{men} = 0.52$, $M_{women} = 3.81$, $SD_{women} = 0.56$]. Older people reported lower levels of communication apprehension ($r = -0.16$, $p < 0.001$) and higher levels of eHealth literacy than younger people ($r = 0.21$, $p < 0.001$). Those who indicated having poorer health status reported higher levels of communication apprehension ($r = -0.14$, $p < 0.001$), more positive physician reactions ($r = 0.12$, $p < 0.001$), higher levels of patient satisfaction ($r = 0.18$, $p < 0.001$), but lower levels of eHealth literacy($r = -0.09$, $p = 0.009$).

Communication apprehension was negatively related to directness of sharing online health information with their physicians ($r = -0.10$, $p = 0.004$). Directness of sharing online health information with their physicians was positively related to perceived physicians' reactions ($r = 0.15$, $p < 0.001$) and with patient satisfaction ($r = 0.11$, $p = 0.001$). Additionally, perceived physicians' reactions were positively related to patient satisfaction ($r = 0.54$, $p < 0.001$). These correlations provided some initial evidence for mediating chain among communication apprehension, directness of sharing online health information with their physicians, perceived physicians' reactions, and patient satisfaction. However, contrary to our expectation,

Variable	M	SD	1	2	3	4	5	6	7	8
1. Communication apprehension	2.18	0.77	–							
2. Online health literacy	3.87	0.55	−0.28***	–						
3. DOHISP	2.40	1.00	−0.10**	0.06	–					
4. Perceived physicians' reactions	3.55	0.75	−0.32***	0.30***	0.15***	–				
5. Patient satisfaction	3.75	0.54	−0.28***	0.28***	0.11**	0.54***	–			
6. Sex	–	–	0.09**	−0.11**	−0.03	−0.02	0.00	–		
7. Age	30.26	7.02	−0.16***	0.21***	−0.03	−0.03	0.06	−0.08*	–	
8. Education level	5.92	0.58	−0.04	0.03	−0.01	−0.00	−0.01	0.04	−0.09*	–
9. Health status	3.34	0.74	−0.14***	0.09**	0.03	0.12***	0.18***	−0.01	−0.05	0.10**

*DOHISP, Directness of online health information sharing with physicians. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.*

the correlation between patients' eHealth literacy was not significantly related to directness of sharing online health information with their physicians ($r = 0.06$, $p = 0.075$). Therefore, further mediation analysis was only conducted on the model with communication apprehension.

Direct Relationships

Communication apprehension was modeled as the predictor and patient satisfaction was the dependent variable. Directness of sharing online health information with their physicians and perceived physicians' reactions were the first and second mediator, respectively. Sex, age, educational level, and health status were included as covariates because preliminary analysis showed meaningful correlation patterns among covariates and variables of interest.

The first hypothesis proposed a negative association between communication apprehension and directness of sharing online health information with their physicians (H1). Results confirmed the negative relationship ($b = -0.136$, $se = 0.047$, $p = 0.004$, 95% CI [−0.227, −0.044]). Due to the non-significant correlation between online information literacy and directness of sharing online health information with their physicians ($r = 0.06$, $p = 0.075$), H2 was not supported. We then proposed a positive association between directness of online health information sharing and perceived physicians' reactions (H3). The results also supported this relationship ($b = 0.092$, $se = 0.025$, $p < 0.001$, 95% CI [0.043, 0.141]). In addition, a positive association between perceived physicians' reactions and patient satisfaction was proposed (H4). Supporting H4, the results found a significant positive relationship ($b = 0.353$, $se = 0.023$, $p < 0.001$, 95% CI [0.308, 0.397]).

Indirect Relationships

H5 proposed a serial mediation model among communication apprehension, directness of sharing online health information with their physicians, perceived physician reactions, and patient satisfaction (see **Figure 2**). Supporting H5, patients' communication apprehension was found to negatively affect the directness to share Internet search with their physicians ($a_1 = -0.136$, $p = 0.004$). Directness of sharing online information with physicians then positively affected patients' perceived physician reactions ($b_1 = 0.092$, $p < 0.001$), which in turn, led to

a positive impact on patient satisfaction ($b_2 = 0.353$, $p < 0.001$). The mediation was confirmed by a 5,000 bootstrapping analysis (effect size = −0.004, Boot $SE = 0.002$, 95% CI [−0.009, −0.001]). H6 was not analyzed because the association between online information literacy and directness of sharing online health information with their physicians was not significant.

DISCUSSION

While becoming more informed with Internet search, patients may also debate if online health information should be shared with their physicians and in what ways. This study contributes to a more comprehensive understanding of online health information sharing through an empirical assessment of the associations among patients' communication characteristics, directness of information sharing, and physician-patient relationship. Supporting the hypotheses, the results showed that less apprehensive patients used more direct ways to share online health information with their physicians (H1), which in turn positively affected perceived reactions from physicians and patient satisfaction (H3–H5). The findings are line with previous research that suggested communication apprehension is a key factor that influences patients' directness of sharing online search with their physicians (Perrault and Silk, 2015).

In contrast with H2, results showed patients' eHealth literacy showed no association with directness of online health information sharing. As such, the serial multiple mediation hypothesis with eHealth literacy was also not supported (H6). Although prior research suggests that a higher level of health literacy tend to motivate more open discussion of health information with physicians (Katz et al., 2007), it is possible that people with higher eHealth literacy feel more competent in evaluating online health information and spotting misinformation (Diviani et al., 2015). Therefore, they may not feel necessary to directly discuss the information with their physicians. Given that this is the first known study that investigated the relationship between eHealth literacy and directness of information sharing with physicians, future research can look into the relationships by examining the possible competing underlying mechanisms mentioned above.
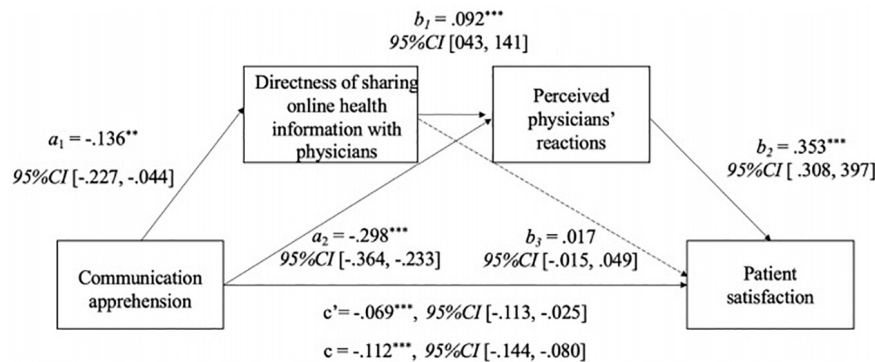
FIGURE 2 | The results for serial multiple mediation model with communication apprehension. Analyses are based on 5,000 bootstrap samples, controlling for sex, age, education level, and health status. Path coefficients are unstandardized coefficient. → significant paths; --→ non-significant paths. Indirect effect ($a_1b_1b_2$): effect size = −0.004, Boot *SE* = 002, 95% CI [−0.009, −0.001]. Indirect effect (a_1b_3): effect size = −0.002, Boot *SE* = 003, 95% CI [−0.009, 0.002]. Indirect effect (a_2b_2): effect size = −0.105, Boot *SE* = 016, 95% CI [−0.137, −0.074]. **$p < 0.01$; ***$p < 0.001$.

Theoretical and Practical Implications

From the perspective of patients, this study develops a preliminary model of online health information sharing. This model presents a process of health communication by taking into account antecedents that motivate online health information sharing and relational outcomes affected by this construct. The model extends previous research that differentiates various ways of online health information sharing by focusing on the dimension of directness in information sharing. Online health information sharing, as a multifaceted construct, can be explored along a variety of dimensions (e.g., frequency, directness). Among the underexplored dimensions of online health information sharing, directness is perhaps one of the most prominent dimensions affecting the communicative process of physician-patient interaction. Directly sharing Internet search with physicians demonstrates patients' sense of control in the medical system (Tan and Goonawardene, 2017). In an era of health consumerism, an emphasis on patient empowerment can facilitate positive communication between patients and physicians, which may further bring optimal outcomes in treatment (Brown et al., 2003).

This study offers some practical implications for sharing online health information with physicians as well as improving physician-patient interaction. Given that health information acquired online may be inaccurate and misleading (Scherer et al., 2021), it is imperative to encourage Internet-informed patients to discuss Internet search with their physicians. This study showed some promising results that could motivate patients to directly share and discuss online health information with their physicians. Past research suggested that a major concern that discouraged patients from sharing online health information with their physicians was physicians' negative feedback (Silver, 2015). This study, however, showed that patients who choose to openly discuss such information tend to perceive positive feedback from their physicians and increase patient satisfaction. Based on the encouraging results revealed in this study, it is necessary to educate patients to not only search for health information online, but more importantly directly share the information with their

physicians, rather than covertly comparing such information with the information provided by physicians.

In order to facilitate more open discussion with physicians and thus improve physician-patient relationship, health professionals and organizations can make an effort to reduce patients' communication apprehension while visiting doctors. For instance, Perrault and Silk (2015) suggested that providing information such as physician biographies to patients prior to their doctor visit can help patients reduce uncertainty toward prospective physicians and ease their communication apprehension during their visit. Besides providing additional information to patients, practitioners can explore alternatives that may reduce patients' communication apprehension and promote more effective physician-patient interaction. For example, supportive attitudes from physicians may help patients to feel less nervous to discuss Internet search. Situational factors such as having a company during a doctor visit may ease a patient's communication apprehension. However, we should be aware that some patients may become cyberchondria and obsessed with online health information-seeking (Zheng et al., 2021). This type of patients may ask physicians endless questions to seek for reassurance. Their sharing of Internet search, if excessively, may not be welcomed by physicians. Future research can try to test the boundaries of information sharing frequency and physician-patient interaction outcomes.

Limitations and Future Research

This study has several limitations that point to directions for future research. First, data were collected through a cross-sectional survey and thus may limit our ability to make causal claims between online health information sharing and relational outcomes. We have tried to eliminate this concern by considering time sequence in question-asking. For example, perceived physician reactions toward information sharing have to take place after patients shared Internet search with them. In addition, eHealth literacy and communication apprehension as patients' characteristics, were more reasonably treated as antecedents rather than outcome variables. In the future, research

could strive to conduct longitudinal surveys or experiments to closely examine the causal effects between online health information sharing and physician-patient relationship.

Second, data were collected through an online crowdsourcing platform and thus may not match the demographic characteristics of the entire population. For instance, the majority of the sample were below the age of 60, making it difficult to generalize our findings to the elderly population. The low proportion of elderly participants is partially due to the low accessibility of this population on the recruiting platform. In addition, elderly people are less active in online health information seeking (Bennett et al., 2009; Jacobs et al., 2017), leaving a small size of eligible sample to participate in this study. Future research may target specifically the elderly population and examine their online health information seeking and sharing behaviors.

Third, how patients share online health information with their physicians can be affected by many factors, not limited to the two patient characteristics examined in this study. For instance, participants varying in cultural backgrounds could differ in their sharing behaviors. This study used Chinese participants who are embraced by a culture with high uncertainty avoidance. As a result, these participants tend to be less straightforward in sharing online health information with their physicians compared with those from a culture with low uncertainty avoidance. It would be interesting to compare patterns of health information sharing across cultures. Further, online health information sharing can be mutually influenced by contextual factors, patient characteristics, and physician characteristics (Tan and Goonawardene, 2017). It is meaningful to investigate how different factors work together to achieve a comprehensive understanding of the communication process. In addition, this study only examined physician-patient interaction as the outcome variable. Future research should examine how online health information sharing with physicians may affect patients' health outcomes.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Zhejiang University. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

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Check for updates

Extracting Additional Influences From Physician Profiles With Topic Modeling: Impact on Ratings and Page Views in Online Healthcare Communities

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How physicians can get better ratings and more page views in online healthcare communities is an important issue. Based on 38,457 physicians' profiles from a popular online healthcare community in China, we used Latent Dirichlet Allocation model, which is a common topic model, to analyze the non-English text to obtain more doctor's latent characteristics. We found five of the most frequently mentioned topics. In addition to the first topic (doctor's academic rank and practice name), "research ability," "foreign experience," "committee position," and "clinical experience" were included as unstructured descriptions in the doctor's profile. Inferences about physician ratings and page views could be improved if these themes were set as characteristics of physicians. Specifically, in our findings, Physicians' mentions of their "research ability" and "foreign experience" had a significant positive impact on physician ratings. Surprisingly, physicians mentioning more "clinical experience" had a significant negative impact on physician ratings. Moreover, while descriptions about "foreign experience" and "committee position" had a significant positive impact on page views, physician mentions of "research ability" had a significant negative impact on page views. These results provide new insights into the ways in which online healthcare community managers or physicians create their personal online profiles.

Keywords: online healthcare community, text mining, topic modeling, ratings, page views

INTRODUCTION

Online healthcare communities (OHCs) can help patients get more medical information, find the right hospital or clinic department, and choose the right doctor based on their profile and relevant online reviews. In addition, many OHCs provide medical consultation services, allowing patients to receive medical assistance by phone or video. Thus, OHCs can help reduce stress across the healthcare system and improve rural-urban health disparities (Tu et al., 2015; Goh et al., 2016), which have important functions in the wake of the COVID-19 epidemic. However, in the development of successful OHCs, physicians play a crucial role due to the inherent expertise of medical knowledge (Guo S. et al., 2017; Wang et al., 2017). For OHC managers who are responsible for setting policies, designing user interfaces, and managing members, further parsing various

characteristics or information about physicians is a key challenge for OHC development. Such features are useful to identify highly qualified physicians or identify ways to make physicians more attractive to users.

In other words, we would like to know what characteristics doctors possess to be most influential in OHC. Specifically, this study measures physician influence in OHC from two perspectives. First, if physicians' electronic word of mouth (eWOM) is better, it will help OHC in the long run. Physician ratings are the most widely used proxy for the value of eWOM[1] (Liu, 2006; Dellarocas et al., 2007). Previous studies usually show a positive correlation between average ratings and sales of different products (You et al., 2015; Rosario et al., 2016). Secondly, the most important question is whether physicians can attract more people to participate in this community and thus increase the number of page views on the website. From the perspective of OHC managers, more website visitors may be one of the most important indicators of OHC development (Demers and Lev, 2001; Dewan et al., 2002; Luo et al., 2013).

Based on the above discussions, which characteristics of physicians can be associated with better ratings and attract more users to participate in OHC is a topic worth exploring. In past studies, the available information about physician characteristics mainly come from two sources. First, most OHCs reveal the physician's name, title, education, and the hospital department to which the physician works for. Second, the user-generated data in OHCs should be noted. The ratings and views mentioned in the previous paragraph belong to such features. In addition, prior studies have used text analysis to extract certain information from reviews provided by patients as characteristics of doctors, for example, by calculating the average sentiment score of reviews. It is worth noting that OHC usually enables physicians to fill in a personal profile, which provides additional explanation and context to increase the diagnostic nature of the information (Mudambi and Schuff, 2010). We believe that personal profiles may contain a wealth of information about a physician's academic, foreign, administrative, and clinical experience, yet limited research has been conducted in the past literature to focus on this component. This study intends to extract additional features from physician profiles using text mining, as well as analyze whether these features can be used to explain physician ratings and page views in OHC.

We collected 38,457 physician profiles from the Haodf website (http://www.haodf.com/)[2], which is one of the most popular OHCs in China, and then extract physician characteristics from this text data. Intuitively, if a doctor's profile expresses a

latent characteristic, then some specific words will appear more frequently. The topic model in text mining is a statistical method used to discover abstract topics from a large amount of text. This study adopts Latent Dirichlet Allocation (LDA) to perform the analysis (Blei et al., 2003), which is one of the most common topic models. After extracting the new characteristics of doctors by LDA, we use regression models to verify whether these features have an impact on the ratings and page views of doctors.

LITERATURE REVIEWS

Online Healthcare Community Development Status

The online healthcare community (OHC) has become a new venue for online physician-patient interaction (Goh et al., 2016). As OHC users, patients can search for health-related information, exchange experiences, benefit from social support, and conduct online consultations with professional physicians (Johnston et al., 2013; Atanasova et al., 2018). As an Internet-based platform, the OHC connects people with information relevant to their health-related interests or problems; therefore, OHC sites are important venues for people to connect with others who have similar health conditions. In general, OHC sites can be divided into two types. The first is OHC sites, used primarily in peer support groups and often referred to as online support group sites (Barak et al., 2008). There are a variety of health-related online support groups, such as those for people living with HIV/AIDS (Mo and Coulson, 2010), breast cancer (Høybye et al., 2005; Radin, 2006), food allergy (Coulson and Knibb, 2007), and so on. The second type of site, usually associated with the term OHC, is comprised of online sites used by patients and health professional moderators, typically health care professionals or physicians. In the latter type of OHC, health professional moderators provide reliable health-related information and professional health consultations (Johnston et al., 2013; Zhao et al., 2013; Petrovčič and Petrič, 2014). The most popular OHC sites in China (i.e., Haodf, Chunyuyisheng, and WeDoctor) usually offer professional health-related information and physician-patient interaction.

The importance of the OHC is growing and changing users' conceptions of face-to-face medical encounters, broadening professional-patient interaction channels (Guo S. et al., 2017). There are three primary groups of OHC stakeholders: purveyors, patients, and physicians. We define purveyors as planners or designers of the platform. Due to the friendly online interaction environment provided by the purveyors, these platforms attract physicians and patients to participate actively in them (Blut et al., 2015). Users and patients of OHC can not only interact with their personal physicians, but also consult with other health professionals (e.g., specialty physicians), they are able to receive increased amounts of information (Atanasova et al., 2018). Physicians can share medical or healthcare knowledge with patients through the OHC, and the benefits of the OHC for participating physicians include social returns and economic returns (Guo S. et al., 2017). Previous research on the OHC has primarily been conducted from the users' (or

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[1]The most common definition of eWOM is "any positive or negative statement made by potential, actual, or former customers about a product or company, which is made available to a multitude of people and institutions via the Internet" (Hennig-Thurau et al., 2004).

[2]The Haodf website (hao dai fu means "good doctor" in Chinese) was the earliest online physician review website and has been in operation in China since 2006. As of October 2021, the Haodf website contains information of 860,000 doctors from 9,780 hospitals. Among them, 240,000 doctors are registered in their real names on the platform and has served more than 74 million patients in total. Users can conveniently reach doctors through multiple platforms such as APP, PC version website, mobile version website and WeChat mini-program to solve various medical problems in the form of online service and offline consultation.

patients') perspectives (Vennik et al., 2014; Yang et al., 2015) and from physicians' perspectives (Guo S. et al., 2017; Guo et al., 2018), while limited studies explore OHCs from purveyors' perspectives. This study which analyzes unstructured data to extract information can provide purveyors with more ideas about website design management and advertising strategies.

Applications of Text Mining

The variety of text analysis tools and approaches for managing and analyzing unstructured data is growing rapidly (Balducci and Marinova, 2018). These options provide exciting new ways to gain insights into some of the problems and questions that have been identified as new areas for research. Text mining is the most fundamental approach which involves the extracting of meaningful information from text. Traditionally, text-based analysis of user-generated content (UGC) has drawn much attention in the recent marketing literature. Most previous studies using textual consumer reviews have involved various goals in the area of marketing research, such as eliciting product attributes and consumers' preferences by mining consumer reviews (Decker and Trusov, 2010; Archak et al., 2011; Lee and Bradlow, 2011), predicting the impact of consumer reviews on consumers' purchase decisions using the valence of sentences (Berger et al., 2010), predicting the product sales and market performance of a product based on review content and sentiment (Dellarocas et al., 2007; Ghose et al., 2012; Tirunillai and Tellis, 2012; Goes et al., 2014), and analyzing the conversion rates resulting from changes in affective content and linguistic style of online reviews (Ludwig et al., 2013). In addition, the topic model involves the use of well-known and important modern machine learning technology that has been widely used in text mining, latent data discovery, and the finding of relationships among data and text documents.

There are various methods for topic modeling; Latent Dirichlet Allocation (LDA; Blei et al., 2003) is one of the most popular methods in this field and has been widely used in various marketing applications (Tirunillai and Tellis, 2014; Büschken and Allenby, 2016; Jacobs et al., 2016; Trusov et al., 2016; Guo Y. et al., 2017; Puranam et al., 2017). For example, Puranam et al. (2017) analyzed the effect of calorie posting regulations based on an LDA with informative priors. Trusov et al. (2016) used the LDA to trace online surfing behavior, allowing online businesses to make profile predictions when limited information is available. Guo Y. et al. (2017) employ a similar approach to extract latent dimensions of customer satisfaction from rich online review data in the hospitality industry. Tirunillai and Tellis (2014) apply the LDA to consumer reviews to discover the potential dimensions of product quality, to understand the brand's position along these dimensions, and to estimate how dimensions and brand position change over time. Büschken and Allenby (2016) propose an LDA that uses the sentence structures found in reviews to improve prediction of online customer ratings. Finally, Jacobs et al. (2016) apply the LDA to the assessment of buying patterns and prediction of future purchase probabilities. In recent years, researchers have conducted text mining studies in healthcare field (Hao and Zhang, 2016; Speier et al., 2016; Shah et al., 2021a), especially during the COVID-19 pandemic, leading to a

dramatic increase in the literature on LDA (Liu et al., 2020; Xue et al., 2020; Shah et al., 2021b). For example, Xue et al. (2020) analyzed the public sentiment associated with 11 selected topics identified using LDA on COVID-19 tweets. Liu et al. (2020) used a topic modeling approach to extract nine major primary themes from Chinese social media. In addition, the study by Shah et al. (2021b) conducted a number of investigations of patient online reviews in US physician rating websites to examine trends in patient attention due to COVID-19, using LDA-based topic modeling to generate topics and corresponding keywords. However, few studies have used the LDA method to analyze the profiles provided by physicians. The current research aims to fill this gap in the application of LDA.

RESEARCH METHODOLOGY

Data Collection

Our sample was collected from the Haodf website (http://www.haodf.com/), which is one of the most popular OHC in China. To ensure that physicians in our sample really were engaged in this site, the current study adopted data filtering rules as follows. First, only physicians with personal pages were used in our sample; this allowed us not only to reliably verify the identity of physicians but also to obtain more of their characteristics. Second, in order to avoid effects contributed by new users, all physicians in our sample joined the Haodf website before June 25, 2017. In addition, to ensure that each physician was still active on the website, the latest login time for each had to be within 1 month of the study date. Third, since this study intended to use text mining to analyze each physician's introduction, the length of the physician's introduction should be longer than 10 characters. With these restrictions, we used web crawler technology to generate the related public information on this site from May 29, 2018, to May 30, 2018. With the above filtering rules, we have a total of 38,457 physicians in our sample from a variety of different divisions. According to the classification of the Haodf website, it contains internal medicine, surgery, gynecology-obstetrics, pediatrics, orthopedics, ophthalmology, oral health, cancer, Chinese medicine, and others, a total of 10 categories.

LDA Implementation

This study applies the LDA model to investigate what kinds of content are included in physicians' profiles in the OHC. LDA model adopts a sophisticated text-mining technique to fit a topic model (Blei et al., 2003). It regards each document as a mixture of different topics and treats each topic as a mixture of different words. We estimate these hidden parameters by implementing the variational expectation-maximization algorithm for the LDA model in R (Grün and Hornik, 2011). Regarding the use of the LDA model in our context, three points should be explained clearly. First, a physician's personal profile usually included a variety of topics, such as degree, experience, or expertise. Our goal was to discover what different topics can be found in one physician's personal profile, rather than to categorize the profile as including one specific topic. In this case, each physician's personal profile is split into several sentences by the symbol "°",

which is used as a full stop symbol in Chinese documents. Then each sentence is regarded as one individual document in the LDA model and assigns a possible topic for the profile. In this way, we investigate what kinds of topics appear in physicians' personal profiles, and the corresponding results allow us to extract additional information on the physicians' characteristics, beyond the standard information in the OHC.

Second, while a single character in Chinese generally has a complete meaning by itself, it is often necessary to combine two or more characters to obtain a meaningful token. Just as in the process of text mining in the English language, we need to remove certain stop words in Chinese (e.g., we, is, of). We also remove certain highly frequent words (e.g., hospital, doctor, China) and professional medical words (e.g., diabetes, internal medicine, cancer). This is necessary to extract meaningful topics rather than merely distinguish physicians' medical specialties. This study is implemented with the use of jiebaR, which is a well-known Chinese text segmentation tool (https://github.com/qinwf/jiebaR). Third, since the number of topics in the LDA model is assumed to be known and fixed a priori, we determine the optimal number of topics according to the perplexity (Blei et al., 2003). Specifically, the whole sample is randomly divided into two parts: 90% for the training dataset and 10% for the testing dataset. The training data are used to estimate the parameters of the LDA models, then the predictive perplexities of these trained models are calculated by using the testing dataset.

The Empirical Model

In this study, we investigate the factors that influence the physicians' ratings (HOT) and page views (VIEW). We describe the base model as follows.

$$HOT_i = \alpha_i + \sum_{j=1}^{J} \beta_j DC_{ij} + \sum_{k=1}^{K} \gamma_k DIV_{ik} + \varepsilon_i \text{ (Model 0a)}$$

$$VIEW_i = \alpha_i + \sum_{j=1}^{J} \beta_j DC_{ij} + \sum_{k=1}^{K} \gamma_k DIV_{ik} + \varepsilon_i \text{ (Model 0b)}$$

where $i = 1, 2, \ldots, N$; $j = 1, 2, \ldots, J$; $k = 1, 2, \ldots, K$; $\varepsilon_i \sim iidN(0, \sigma_i^2)$

In the above equation for Model 0a, HOT on the left of the equal sign is the mean of overall ratings by patient reviews of physicians, the subscript i denotes the i-th physician, and there are N physicians in total. Next, α denotes the intercept, and β and γ are vectors of the parameters to be estimated. DC is a vector of multiple physician characteristics as a set of independent variables, and the superscript j indicates different items, of which there are six in total ($J = 6$) in this study: length of profile (WORD), online contribution (CONTR), tenure with Haodf (TIME), clinic title (CT), academic rank (AT), and hospital level (HL). DIV represents the physician's division, and the superscript k represents the different sources, of which there are ten in total ($K = 10$) in this study: internal medicine, surgery, gynecology-obstetrics, pediatrics, orthopedics, ophthalmology, oral health, cancer, Chinese medicine, and others. The distribution term ε follows the normal distribution, which makes the regression a multiple linear regression. Model 0b replaces HOT with VIEW, and the other independent variables are the same.

We determined there to be five topics through the LDA method. One of the topics is already included in the DC variables. The other four topics are research ability (RESEARCH), foreign experience (FEXP), committee position (COMM), and clinical experience (CEXP). The LDA allows us to know the keywords in each topic. When a keyword for a topic appears in a physician's profile, we label that physician as having "mentioned this topic." For example, when the word SCI appeared in a physician's profile, we labeled that physician as having mentioned research ability in the profile and set the dummy variable RESEARCH to 1. We build these topics into four dummy variables and estimate models with the following form:

$$HOT_i = \alpha_i + \sum_{j=1}^{J} \beta_j DC_{ij} + \sum_{k=1}^{K} \gamma_k DIV_{ik} + \lambda_i RESEARCH_i$$
$$+ \varepsilon_i \quad \text{(Model 1a)}$$

$$HOT_i = \alpha_i + \sum_{j=1}^{J} \beta_j DC_{ij} + \sum_{k=1}^{K} \gamma_k DIV_{ik} + \theta_i FEXP_i$$
$$+ \varepsilon_i \quad \text{(Model 2a)}$$

$$HOT_i = \alpha_i + \sum_{j=1}^{J} \beta_j DC_{ij} + \sum_{k=1}^{K} \gamma_k DIV_{ik} + \tau_i COMM_i$$
$$+ \varepsilon_i \quad \text{(Model 3a)}$$

$$HOT_i = \alpha_i + \sum_{j=1}^{J} \beta_j DC_{ij} + \sum_{k=1}^{K} \gamma_k DIV_{ik} + \rho_i CEXP_i$$
$$+ \varepsilon_i \quad \text{(Model 4a)}$$

RESEARCH is designated as a binary dummy variable, giving 1 when the physician mentions research ability (e.g., "SCI" or "National Natural Science Foundation" or "project") in his/her profile, and otherwise 0. FEXP is a binary dummy indicating the physician mentions foreign experience (e.g., "international" or "America" or "Japan" or "Germany") in his/her profile. COMM is a binary dummy indicating the physician mentions committee position (e.g., "editorial board" or "standing committee" or "chairman" or "standing committee") in his/her profile. Finally, CEXP is also a binary dummy variable set to 1 when the physician mentions clinical experience (e.g., "experience" or "many years" or "long-term") in his/her profile, and otherwise 0. The only difference between Models 1a−4a and 1b−4b is that Models 1b−4b replace HOT with VIEW. The names, definitions and constructions of the variables and the descriptive statistics are all listed in **Table 1**. **Table 1** also shows that the physicians received an average rating (HOT) of 3.89. The standard deviation of the rating is 0.34. The average number of views per physician's personal page is ∼12, and their standard deviation is 1.83.

RESULTS

Topic Modeling Result

We apply the LDA to extract and label the dimensions of product introduction across all of the physicians' profiles collected in our sample. According to the predictive perplexity, we determined

TABLE 1 | Variable measurements and descriptive statistics.

Code	Variable	Measurement	Mean	S.D.
HOT	Ratings	Mean of overall ratings by patient reviews of physicians.	3.892	0.340
VIEW	Page views	Natural logarithm of the number of views for each physician's personal page on the Haodf website.	11.987	1.827
Control variables				
WORD	Length of profile	Natural logarithm of the number of words in the physician's personal profile.	5.218	0.992
CONTR	Online contribution	Natural logarithm of the score of the physician's contribution reported on the Haodf website.	7.632	2.415
TIME	Tenure with Haodf	Natural logarithm of the physician's tenure with the Haodf website (days), calculated by the data download date minus this physician's registration date on the website.	5.017	2.836
Structured information				
CT	Clinic title	Clinic title for physicians. Dummy variable, CL = 1 if the physician's position is chief physician or associate chief physician; 0 otherwise.	0.707	0.455
AT	Academic rank	Academic rank for physicians. Dummy variable, AR = 1 if the physician's academic rank is professor or associate professor; 0 otherwise.	0.516	0.500
HL	Hospital level	Dummy variable, HL = 1 if the physician is from a tertiary hospital in China; 0 otherwise.	0.783	0.412
DIV	Division	Physician's division, categorized by the Haodf website, including internal medicine, surgery, gynecology-obstetrics, pediatrics, orthopedics, ophthalmology, oral health, cancer, Chinese medicine, and others.	-	-
Unstructured information (Latent topic)				
RESEARCH	Research ability	Dummy variable, RESEARCH = 1 if the physician mentions research ability (e.g., "SCI" or "National Natural Science Foundation" or "project") on his/her profile; 0 otherwise.	0.221	0.415
FEXP	Foreign experience	Dummy variable, FEXP = 1 if the physician mentions foreign experience (e.g., "international" or "America" or "Japan" or "Germany") in his/her profile; 0 otherwise.	0.265	0.441
COMM	Committee position	Dummy variable, COMM = 1 if the physician mentions committee position (e.g., "editorial board" or "standing committee" or "chairman" or "standing committee") in his/her profile; 0 otherwise.	0.177	0.382
CEXP	Clinical experience	Dummy variable, CEXP = 1 if the physician mentions clinical experience (e.g., "experience" or "many years" or "long-term") in his/her profile; 0 otherwise.	0.449	0.497

All sample were collected from the Haodf website. S.D. denotes standard deviation.

the number of topics to be 5 in this empirical study. The LDA identified 5 topics in which each topic showed the top-15 words by frequency. The naming of the dimensions was first carried out by one researcher and then confirmed by a second researcher. Naming was based on the identification of logical connections between the most frequently used words within the topic. **Table 2** presents the results of the 5 topics generated by the model for the physicians' profiles; each topic is represented by a group of keywords. The five topics are "academic rank and clinic title," "research ability," "foreign experience," "committee position," and "clinical experience." It is worth mentioning that in the physicians' profiles, only the first extracted topic (i.e., the physician's academic rank and clinic title) represents a structured description in his/her profile. Other topics are part of the unstructured description in the physician's personal profile. Therefore, only the four topics that are part of the unstructured description in the physician's personal profile will be further described.

Applications in Information Disclosure

We conducted regression analysis of our sample data according to our proposed model, and the results are shown in **Table 3**. We report the standardized regression coefficients, standard errors, and significant levels for all variables. First, we examine factors that affect user/patient ratings (HOT) that are under

the control of the physicians' divisions. As indicated by the corresponding outcomes shown in the column for Model 0a, the length of the physician's profile (WORD) and the physician's online contribution (CONTR) have a significant and positive impact on user/patient ratings (HOT), with coefficients of 0.052 ($p < 0.001$) and 0.060 ($p < 0.001$), respectively. However, the physician's tenure with Haodf (TIME) shows a significantly negative impact on user/patient ratings (HOT) ($\beta = -0.010$, $p < 0.001$). In addition, we also find positive effects of the physician's clinic title (CT) ($\beta = 0.051$, $p < 0.001$), academic rank (AT) ($\beta = 0.061$, $p < 0.001$), and hospital level (HL) ($\beta = 0.148$, $p < 0.001$) on user/patient ratings (HOT). The R-Squared of Model 0a is 33.0%; that is, the model is able to explain a substantial amount of the variance in the dependent variable (i.e., HOT). Second, we further examine factors that affect page views (VIEW) under the same control of other variables. The relevant results are shown in the column for Model 0b. The coefficients of length of the physician's profile (WORD), physician's online contribution (CONTR), and physician's tenure with Haodf (TIME) have significantly positive impacts on page views (VIEW). We also find that the effects of the coefficients of clinic title (CT) and academic rank (AT) are significantly positive, and the effect of the coefficient of hospital level (HL) is significant negative. The R-Squared of Model 0b is 88.3%, which means that these variables can effectively

TABLE 2 | Most relevant words related to topics in the physicians' personal profiles.

Topics	Top 15 words in each topic (in English)	Top 15 words in each topic (in Chinese)
Academic rank and Clinic title	Graduate, professional, chief physician, professor, work, associate chief physician, master, graduate student, advisor, director, engaged, PhD, attending physician, learn, associate professor	毕业, 专业, 主任医师, 教授, 工作, 副主任医师, 硕士, 研究生, 导师, 主任, 从事, 博士, 主治医师, 进修, 副教授
Research ability	Publish, article, award, project, participation, host, SCI, project, technology, fund, access, journal, National Natural Science Foundation, research, core	发表, 论文, 等奖, 课题, 参与, 主持, SCI, 项目, 科技, 基金, 获得, 期刊, 国家自然科学基金, 科研, 核心
Foreign experience	Research, study, America, center, international, participation, technology, learn, visiting scholar, conduct, training, influence, Japan, Germany, conference	研究, 学习, 美国, 中心, 国际, 参加, 技术, 进修, 访问学者, 进行, 培训, 影响, 日本, 德国, 大会
Committee position	Member, committee, branch, professional, association, society, medical association, chairman, expert, youth, school group, editorial board, standing committee, member, standing committee	委员, 委员会, 分会, 专业, 协会, 学会, 医学会, 主任委员, 专家, 青年, 学组, 编委, 常委, 会员, 常务委员
Clinical experience	Be expert in, work, rich, engaged, technology, experience, clinical experience, development, patient, long- term, proficiency, first, special, more than 10 (or twenty) years, many years	擅长, 工作, 丰富, 从事, 技术, 经验, 临床经验, 开展, 患者, 长期, 熟练掌握, 率先, 特别, 余年, 多年

explain even more of the variation of the dependent variable (i.e., VIEW).

Table 4 presents the results of the four models, with the other variables being the same, focusing on the topic model variables. The results indicate that REAEARCH and FEXP had a significant positive impact on HOT, with coefficients of 0.074 ($p < 0.001$) and 0.090 ($p < 0.001$), respectively. However, CEXP showed a significant negative impact on HOT ($\beta = -0.014$, $p < 0.001$). Finally, COMM had no significant impact on HOT.

Table 5 displays the results of the VIEW associated regression analysis under the same control of other variables. REAEARCH had a significant negative impact on VIEW ($\beta = -0.055$, $p < 0.001$). Conversely, FEXP and COMM had a significant positive impact on VIEW, with coefficients of 0.027 ($p < 0.01$) and 0.077 ($p < 0.001$), respectively. However, CEXP had no significant impact on VIEW.

DISCUSSIONS

Theoretical Implications

This study is the first to use the LDA approach to extract latent dimensions from physicians' profile-generated data. It provides several theoretical contributions to the literature. First, we found that the introductions provided by physicians in the OHC allowed for the extraction of five primary topics, namely "academic rank and Clinic title," "research ability," "foreign experience," "committee position," and "clinical experience." Other than the first topic (the physician's academic rank and clinic title), the topics are unstructured descriptions in the physician's profile. These findings advance our knowledge of information quality and have practical implications for purveyors of the OHC.

Second, the quality of the physician is very important to both purveyors and patients. We use the ratings to assess previous users' satisfaction with the quality of the physician (Li and Hitt, 2008). We conduct a regression analysis to test our proposed model. The results show that physicians'

mentioning "research ability" and "foreign experience" was significantly positively correlated with the ratings. Overall, our findings suggest that physicians' "research ability" and "foreign experience" are signals of the quality of physicians to patients. The higher the quality of the physician, the higher the levels of patient satisfaction. These results are similar to those of recent meta-analysis studies (Blut et al., 2015). Surprisingly, physicians' mentioning "clinical experience" has a significant negative correlation with the ratings. This negative effect may come from the disconfirmation of belief, which is the difference between perceived performance and expectations (Richins and Bloch, 1991; Foumier and Mick, 1999). Intuitively, higher expectation or lower perceived performance induces greater disconfirmation of belief. According to Expectation-Confirmation Theory (ECT; Oliver, 1980), patients often collect and evaluate physicians' information from their profiles before making a decision, and then they form their own expectations. When a patient receives information that a physician has more clinical experience, he/she has a higher expectation for the physician, which may lead to negative disconfirmation of belief. Therefore, when a physician mentions that he/she has rich clinical experience, there is a significant negative impact on the patient's satisfaction.

Finally, from the perspective of the purveyors (i.e., Haodf), physicians' attracting more page views can create higher firm values (Demers and Lev, 2001; Dewan et al., 2002; Luo et al., 2013). Thus, we further explored the factors that affect page views. We found that physicians' mentioning "foreign experience" and "committee position" has a significant positive correlation with page views. However, "research ability" has a significant negative correlation with page views. Generally speaking, when a physician mentions that he/she has published an SCI article, or has received project support, the patient may not understand that this implies the physician's hard work and professional performance. If the physician's profile uses too many technical terms, the patient will not understand them and will not be attracted to browse. This may be the cause of the significant negative correlation between research ability and page views.

TABLE 3 | Results of the basic regression model.

Variables	Model 0a: HOT Coefficient (SE)	Model 0b: VIEW Coefficient (SE)
Intercept	3.002*** (0.009)	6.154*** (0.025)
WORD	0.052*** (0.002)	0.102*** (0.005)
CONTR	0.060*** (0.001)	0.539*** (0.002)
TIME	−0.010*** (0.001)	0.234*** (0.002)
CT	0.051*** (0.004)	0.032*** (0.010)
AT	0.061*** (0.003)	0.076*** (0.008)
HL	0.148*** (0.004)	−0.074*** (0.009)
DIV: Surgery	−0.007 (0.005)	−0.099*** (0.013)
DIV: Gynecology and obstetrics	−0.005 (0.007)	0.158*** (0.019)
DIV: Pediatrics	0.067*** (0.006)	−0.027 (0.016)
DIV: Orthopedics	0.028*** (0.006)	−0.095*** (0.017)
DIV: Ophthalmology	0.032*** (0.008)	0.040 (0.021)
DIV: Oral health	0.162*** (0.008)	0.126*** (0.022)
DIV: Cancer	0.071*** (0.009)	−0.119*** (0.023)
DIV: Traditional Chinese medicine	0.204*** (0.006)	0.190*** (0.016)
DIV: Others	−0.012* (0.005)	0.085*** (0.014)
Adjusted R-squared	0.330	0.833

*** Significant at 0.1%; ** significant at 1%; * significant at 5%.
SE denotes standard error.

TABLE 4 | Results for the topic model applied to HOT.

Variables	Model 1a Coefficient (SE)	Model 2a Coefficient (SE)	Model 3a Coefficient (SE)	Model 4a Coefficient (SE)
RESEARCH	0.074*** (0.004)			
FEXP		0.090*** (0.004)		
COMM			−0.005 (0.004)	
CEXP				−0.014*** (0.003)
Intercept	3.050*** (0.009)	3.072*** (0.010)	3.000*** (0.009)	2.999*** (0.009)
WORD	0.039*** (0.002)	0.036*** (0.002)	0.052*** (0.002)	0.053*** (0.002)
CONTR	0.060*** (0.001)	0.059*** (0.001)	0.060*** (0.001)	0.060*** (0.001)
TIME	−0.010*** (0.001)	−0.011*** (0.001)	−0.010*** (0.001)	−0.010*** (0.001)
CT	0.054*** (0.004)	0.051*** (0.004)	0.051*** (0.004)	0.053*** (0.004)
AT	0.057*** (0.003)	0.057*** (0.003)	0.062*** (0.003)	0.061*** (0.003)
HL	0.144*** (0.004)	0.144*** (0.004)	0.148*** (0.004)	0.148*** (0.004)
DIV: Surgery	−0.008 (0.005)	−0.011* (0.005)	−0.007 (0.005)	−0.007 (0.005)
DIV: Gynecology and obstetrics	0.001 (0.007)	0.002 (0.007)	−0.005 (0.007)	−0.004 (0.007)
DIV: Pediatrics	0.073*** (0.006)	0.071*** (0.006)	0.067*** (0.006)	0.068*** (0.006)
DIV: Orthopedics	0.027*** (0.006)	0.018** (0.006)	0.028*** (0.006)	0.027*** (0.006)
DIV: Ophthalmology	0.033*** (0.008)	0.025** (0.008)	0.031*** (0.008)	0.032*** (0.008)
DIV: Oral health	0.163*** (0.008)	0.155*** (0.008)	0.162*** (0.008)	0.161*** (0.008)
DIV: Cancer	0.067*** (0.009)	0.066*** (0.008)	0.071*** (0.009)	0.070*** (0.009)
DIV: Traditional Chinese medicine	0.213*** (0.006)	0.218*** (0.006)	0.204*** (0.006)	0.203*** (0.006)
DIV: Others	−0.009 (0.005)	−0.008 (0.005)	−0.012* (0.005)	−0.012* (0.005)
Adjusted R-squared	0.337	0.340	0.330	0.330

*** Significant at 0.1%; ** significant at 1%; * significant at 5%.
SE denotes standard error.

Managerial Implications

The study has several valuable implications for management practices. First, for website managers, this study has analyzed unstructured data to extract physician information, a technique which can provide practitioners with information about website management and design strategies. For example, extracted topics can be utilized in addition to structural data. In addition, we found that academic achievement has a negative impact on page views, which may result from patients not understanding physicians' academic achievement, implying that website managers might consider explaining these terms in more detail.

Second, for physicians or hospitals, the dimensions of physician's introductions can be taken as a basis for determining consumer satisfaction, physician page views, and ad content design. In our context, exploring what kind of physician's image can bring greater satisfaction or attract more patients, provide website hosting or hospital managers understand how to properly improve the image of physicians.

Finally, for marketers in general, although this study was conducted in the context of OHC, the LDA can be used to analyze the unstructured information provided about other products. By extracting useful information from unstructured data, more accurate product positioning and appropriate marketing strategies can be developed to help companies win against the competition.

TABLE 5 | Results for the topic model applied to VIEW.

Variables	Model 1b Coefficient (SE)	Model 2b Coefficient (SE)	Model 3b Coefficient (SE)	Model 4b Coefficient (SE)
RESEARCH	−0.055*** (0.010)			
FEXP		0.027** (0.010)		
COMM			0.077*** (0.011)	
CEXP				−0.014 (0.008)
Intercept	6.119*** (0.026)	6.175*** (0.026)	6.196*** (0.025)	6.151*** (0.025)
WORD	0.111*** (0.005)	0.097*** (0.005)	0.093*** (0.005)	0.103*** (0.005)
CONTR	0.539*** (0.002)	0.539*** (0.002)	0.539*** (0.002)	0.539*** (0.002)
TIME	0.234*** (0.002)	0.234*** (0.002)	0.234*** (0.002)	0.234*** (0.010)
CT	0.030*** (0.010)	0.032** (0.010)	0.026** (0.010)	0.034*** (0.010)
AT	0.079*** (0.008)	0.074*** (0.008)	0.070*** (0.008)	0.075*** (0.008)
HL	−0.071*** (0.009)	−0.076*** (0.009)	−0.074*** (0.009)	−0.075*** (0.009)
DIV: Surgery	−0.099*** (0.013)	−0.100*** (0.013)	−0.096*** (0.013)	−0.100*** (0.013)
DIV: Gynecology and obstetrics	0.153*** (0.019)	−0.160*** (0.019)	0.161*** (0.019)	0.159*** (0.019)
DIV: Pediatrics	−0.032* (0.016)	−0.026 (0.016)	−0.026 (0.016)	−0.027 (0.016)
DIV: Orthopedics	−0.094*** (0.017)	−0.098*** (0.017)	−0.092*** (0.017)	−0.096*** (0.017)
DIV: Ophthalmology	0.039 (0.021)	0.038 (0.021)	0.047* (0.021)	0.041 (0.021)
DIV: Oral health	0.125*** (0.022)	0.124*** (0.022)	0.128*** (0.022)	0.123*** (0.022)
DIV: Cancer	−0.116*** (0.023)	−0.120*** (0.023)	−0.120*** (0.023)	−0.120*** (0.023)
DIV: Traditional Chinese medicine	0.183*** (0.016)	0.194*** (0.016)	0.186*** (0.016)	0.190*** (0.016)
DIV: Others	0.083*** (0.014)	0.086*** (0.014)	0.086*** (0.014)	0.085*** (0.014)
Adjusted R-squared	0.833	0.833	0.833	0.833

*** *Significant at 0.1%;* ** *significant at 1%;* * *significant at 5%.*
SE denotes standard error.

Limitations and Future Research Directions

There are some limitations to this study as well as indications of possible directions for future research. First, all the empirical data were collected from www.haodf.com. This website is a representative OHC in China, which means that our findings may reflect only the Chinese OHC context. Past research indicates that culture is an important key factor affecting consumer behavior (De Mooij, 2010; De Mooij and Hofstede, 2010). Therefore, future study should be conducted with more diverse samples

to improve the generalizability of the research results (Tang, 2017) and to make possible a comprehensive understanding of the marketing communication mix in a cross-cultural setting. Second, this study focuses only on physicians' profiles in the OHC, but it could be extended to other products (i.e., books, CDs, and DVDs). Future research can obtain unstructured data related to other products from news reports, advertisement copy, and other textual documents to extract useful information. Finally, different types of social media may affect the nature of interactions and influence consumers' perceptions and beliefs about advertising (Prendergast et al., 2009). Johnston et al. (2018) provide an insight into the potential of social media types to moderate the effect of belief on attitude and value. A possible extension of this work would be to investigate across products to shed light on which products are most affected by which communication channels (e.g., online forums of products, blogs, social media, email, and online catalogs); this would help businesses to efficiently allocate their resources.

CONCLUSION

Understanding strike of the factors that influence physician ratings and page views is important for the continued growth of online healthcare communities. This study used the LDA model to obtain five latent physician characteristics from a large number of physician profiles collected, i.e., physician's academic rank and clinic title, research ability, foreign experience, committee position, and clinical experience. Except for the first one, which is a frequently used characteristic in past OHC studies, others were less frequently mentioned. Through regression analysis, we found that physicians' mention of their research ability and foreign experience had a significant positive effect on physician ratings but mentioning of clinical experience had a significant negative effect on physician ratings. In addition, physician mentions of foreign experience and committee position had a significant positive impact on page views, but physician mentions of research ability had a significant negative impact on page views. For OHC managers, these findings could be incorporated into the recommended system to improve physician ratings and page views. Overall, this study provides a new perspective on OHC-related research, in that text mining can be used to extract new features from physician profiles for further analysis.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

XW: writing—reviewing and editing and conceptualization. Y-TH: investigation, resources, data curation, methodology, formal analysis, investigation, visualization, and writing— original draft preparation. Both authors

contributed to the article and approved the submitted version.

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The Effects of Embedded Skin Cancer Interventions on Sun-Safety Attitudes and Attention Paid to Tan Women on Instagram

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Background and Objectives: Because of high skin cancer risks for young women, it is vital that effective interventions reach and influence this demographic. Visual social media platforms, like Instagram, are popular with young women and are an appropriate intervention site; yet, they also host competing images idealizing tan skin. The present study tested the ability of digital sun-safety interventions to affect self-control-related emotions and visual attention to subsequent tan-ideal images as well as sun-safety attitudes.

Methods: Women were recruited from a large public Mid-Atlantic university in the United States. Participants ($N = 120$) were randomly assigned to view an appearance benefits intervention, a self-control emotions intervention, or a control message, each designed to look like an Instagram sponsored story. After self-reporting self-compassion and anticipated pride, participants then viewed seven pairs of Instagram posts featuring either tan or pale women while an eye tracker assessed visual attention. Finally, participants self-reported their responses to questions assessing sun-safety-related norms, efficacy, and attitudes.

Results: A mixed design analysis of covariance revealed that women who first viewed the appearance benefits intervention story spent less time visually fixated on Instagram images of tan women than did those who viewed the self-control emotions intervention or control message ($p = 0.005$, $\eta_P^2 = 0.087$). Regressions also revealed interactions between the intervention conditions and feelings of anticipated pride on both visual attention and sun-safety attitudes.

Conclusion: Sponsored stories on Instagram can promote sun-safety attitudes, depending on the emotional responses they generate. Additionally, sponsored interventions can affect subsequent visual attention.

Keywords: social media, health campaigns, cancer communication, emotions, pride, attention

INTRODUCTION

Preventing skin cancer, which can be caused by exposure to ultraviolet (UV) light from the sun, is an urgent concern: each year in the United States, there are more new cases of skin cancer than cases of breast, prostate, lung, and colon cancer combined and is one of the most common cancers among young women under the age of 30 (American Cancer Society, 2017, 2021; Siegel et al., 2020). Because of higher skin cancer risks for young women compared to young men (Raimondi et al., 2020), it is vital that effective interventions reach and influence this demographic. Yet, the medium that is most popular with young women, social media (Pew Research Center, 2018), is also filled with content (user- and industry-generated) that promotes tan skin as the cultural ideal (Ricklefs et al., 2016; Banerjee et al., 2018; Waring et al., 2018). Although notable research has begun testing social media-based interventions to encourage young women to avoid UV exposure (Buller et al., 2022), research has not yet examined if those interventions prevent young women from also paying attention to the pro-tanning content that, contrary to the goal of interventions, promotes cancer-causing behaviors in young women.

As such, we need to develop theoretically sound sun-safety messages that can also capture the attention of college-age women, even amid a cacophony of pro-tanning messages on social media. The value of an intervention, no matter how theoretically sound, may quickly dissipate after women also view content promoting tan skin as the ideal. The purpose of this paper is, therefore, 3-fold: (1) test how well an established skin cancer intervention approach applies in the visual social medial context of Instagram; (2) compare this established intervention approach to an alternative one informed by the literature on positive psychology; and (3) integrate research on the role of visual attention to media content that contradicts the intervention's purpose into this research area.

Notably, previous research has found that discussing the appearance harms of tanning, such as premature skin aging, and suggesting behavioral alternatives for improving one's appearance (e.g., using make-up and spray tans) can effectively promote healthier skin-related behaviors (Sontag and Noar, 2017), in line with the Behavioral Alternatives Model (BAM) in the health behavior change literature, because appearance motivations are a strong predictor of tanning behavior (Hillhouse et al., 2008, 2017). Theoretically, these interventions have been shown to shape important psychological predictors of behavior change, like self-efficacy, norms, and attitudes (Hillhouse et al., 2000, 2016), with self-efficacy, norms, and attitudes important predictors of behavior based on the Theory of Planned Behavior (Ajzen, 2011).

Another approach to persuading young women to avoid skin-harming behavior is to apply lessons from positive psychology to social media interventions. Emotions motivate individuals to take action, with specific emotions associated with specific action tendencies, according to the Appraisal Theory of Emotions (Lazarus, 1991). Some positive emotions, like self-compassion and authentic pride, promote self-control in the face of temptation, helping people take the actions they need to achieve difficult goals (Williams and DeSteno, 2010; Valdesolo and DeSteno, 2014; DeSteno, 2018). Self-compassion involves viewing oneself with care and support when one is suffering (Neff, 2003b). Instead of getting upset for past failures (e.g., tanning that increased cancer risk or resulted in comically dark burns) or becoming defensive about those failures, the self-compassion literature suggests an approach whereby individuals are prompted to think of themselves with warmth, connection, and concern and to avoid harsh self-judgment (Raes et al., 2011). Self-compassion is associated with increased self-improvement motivation (Breines and Chen, 2012). Additionally, authentic pride (as opposed to hubris) can motivate individuals to persist in their goal pursuit, even in the face of obstacles (Williams and DeSteno, 2008, 2009). Anticipating pride about performing a healthy behavior has been shown to serve a self-regulatory function by promoting stronger behavioral intentions (Onwezen et al., 2014).

These emotions are theoretically promising for the context of sun-safety interventions because researchers have found that emotional expectations (e.g., tanning will feel good) are often better predictors of tanning behavior than are beliefs about the health threat, appearance benefits, or even social approval/disapproval (Noar et al., 2014; Carcioppolo et al., 2019). Therefore, effective social media interventions could promote positive emotional associations with avoiding tan skin to foster the pursuit of sun-safety behaviors.

Because appearance benefit interventions have been effectively used in print and website formats, we expect they will also help young women avoid focusing too much on subsequent tan-ideal content. Moreover, the previous work tying self-compassion and anticipated pride to self-control, suggests the self-control emotion approach should do the same. However, it is unknown which approach will be most strongly related to the avoidance of visual temptation, leading to both a hypothesis and a research question:

> H1: Interventions (appearance benefit and self-control) will predict decreased subsequent visual attention to tan women on Instagram compared to the control condition.

RQ1: Which intervention type (appearance benefit and self-control) will be associated with less subsequent visual attention to tan women on Instagram?

While previous interventions have assessed outcomes grounded in the Theory of Planned Behavior, emotional responses, particularly positive emotions, are understudied in this area but should, theoretically, motivate individuals to pursue health-related goals, leading to another hypothesis:

> H2: Emotional responses to the intervention (i.e., self-compassion and anticipated pride for future sun-safety behavior) will be negatively related to subsequent visual attention to tan women on Instagram.

However, it is less clear how the type of intervention and emotional responses may interact with each other to shape

subsequent attention to tan images on social media, leading to a second research question:

RQ2: Will the type of intervention and self-control-oriented emotional responses to it (self-compassion and anticipated pride) interact to affect subsequent visual attention to tan women on Instagram?

It is likely, though, that the effects of the interventions and subsequent emotions operate alongside previously established psychosocial predictors of attitudes, leading to two final hypotheses:

H3: Appearance motivations, social norms, and self-efficacy will be positively related to sun-safety attitudes.

H4: Emotional responses to the intervention (i.e., self-compassion and anticipated pride for future sun-safety behavior) will be positively related to sun-safety attitudes.

Finally, research in this area of intervention effects has relied heavily on self-reports and is yet to integrate biometric markers of attention, leading to a final research question:

RQ3: Will visual attention to subsequent images of tan women predict sun-safety attitudes?

In sum, the present study offers an initial feasibility test comparing two theoretically sound intervention types in the context of a highly visual social media platform while also integrating biometric assessments of visual attention to competing content in the same platform as an additional outcome to consider when weighing the effectiveness of such interventions at shifting attitudes about skin health behaviors.

MATERIALS AND METHODS

Participants

Students ($N = 120$) ages 18–22 years enrolled at a large public university in the mid-Atlantic United States were recruited to participate in a study (a three-condition experiment) about women and health messages. Potential participants were drawn from a list of all female students on the main university campus.

Procedures

Sixty women participated in the study in April of 2019, and another 60 took part in September of 2019 (see **Figure 1**; $N = 120$). Prior to the main study, participants completed an online questionnaire to provide demographics, skin type information, and incentive preferences. At their later laboratory appointment, after providing consent, participants were seated at a chair in front of a computer with a webcam and a Tobii X2-60 eye-tracking device (integrated *via* iMotions software). They were told they were participating in two separate studies, one examining responses to health messages and the second analyzing responses to common media messages. Participants initially did a calibration activity to ensure the eye tracker was functioning and then began the study. Participants viewed either an intervention or control message designed to look like an Instagram story. Next, they took an online questionnaire to report their responses to the intervention message.

Then, they were told they would begin the second study about media messages. Participants redid the calibration exercise and then viewed a blank grey screen for 6 s before viewing seven sets of paired Instagram images featuring one tan and one pale woman. Next, participants responded to a Qualtrics questionnaire to report their beliefs and attitudes. Participants received $40 USD in the form of either monetary credit on their university identification card or an Amazon.com gift card. A university Institutional Review Board approved all procedures.

Intervention Materials

The intervention materials are designed to look like Instagram stories, which are a platform feature that allow users to post a series of photos or videos, often edited with text overlays, on their account for their followers to view. Each photo or video slide can last for up to 15 s. The slides automatically advance to the next one as soon as the previous one's time has elapsed (like to an automated slide show). The intervention messages and control message each included 10 slides featuring relevant text and images, each appearing on screen for 15 s (2 min 30 s total). See **Table 1** for sample text from the treatment groups (the control condition features slides listing health-related resources available to students on campus, like medical clinics, counseling, and fitness facilities). Focus groups were conducted to help refine our initial materials. The slides used colors and fonts available *via* Instagram to increase the ecological validity of the materials.

Instagram Images

Fifty screenshots of actual Instagram images were compiled by searching through publicly viewable Instagram posts with tags related to tanning (e.g., #tan, #tanning, #sun, and #sunbathing), 25 featuring tan women and 25 featuring women with pale skin. A pretest with 39 female participants, recruited from Amazon's Mechanical Turk and who viewed and rated all 50 Instagram posts, allowed us to form seven pairs of Instagram posts for use in the main study that were perceived as equally attractive and likeable where one woman had tan skin and the other had pale skin.

Participants viewed each pair of images for 10 s. They were shown side-by-side, following the procedures used by Marquart et al. (2016). After seeing a pair, participants then saw a slide with a grey background featuring a crosshair (like a plus sign) in the middle to help reorient visual attention to the center of the screen (this avoids locational bias in where visual attention begins on subsequent slides). Three random orders of the seven pairs were created and presented randomly to participants to guard against order effects. These random orders included different versions of the pairs so that sometimes the tan woman was on the left and sometimes she was on the right. The presenting of multiple images on a screen at the same time was employed to help approximate real-world social media use. While using Instagram, people do not typically view any one image in isolation for very long. Instead, they see multiple images in a row, and they make (largely implicit) decisions about where to direct their visual attention.

FIGURE 1 | Procedures overview.
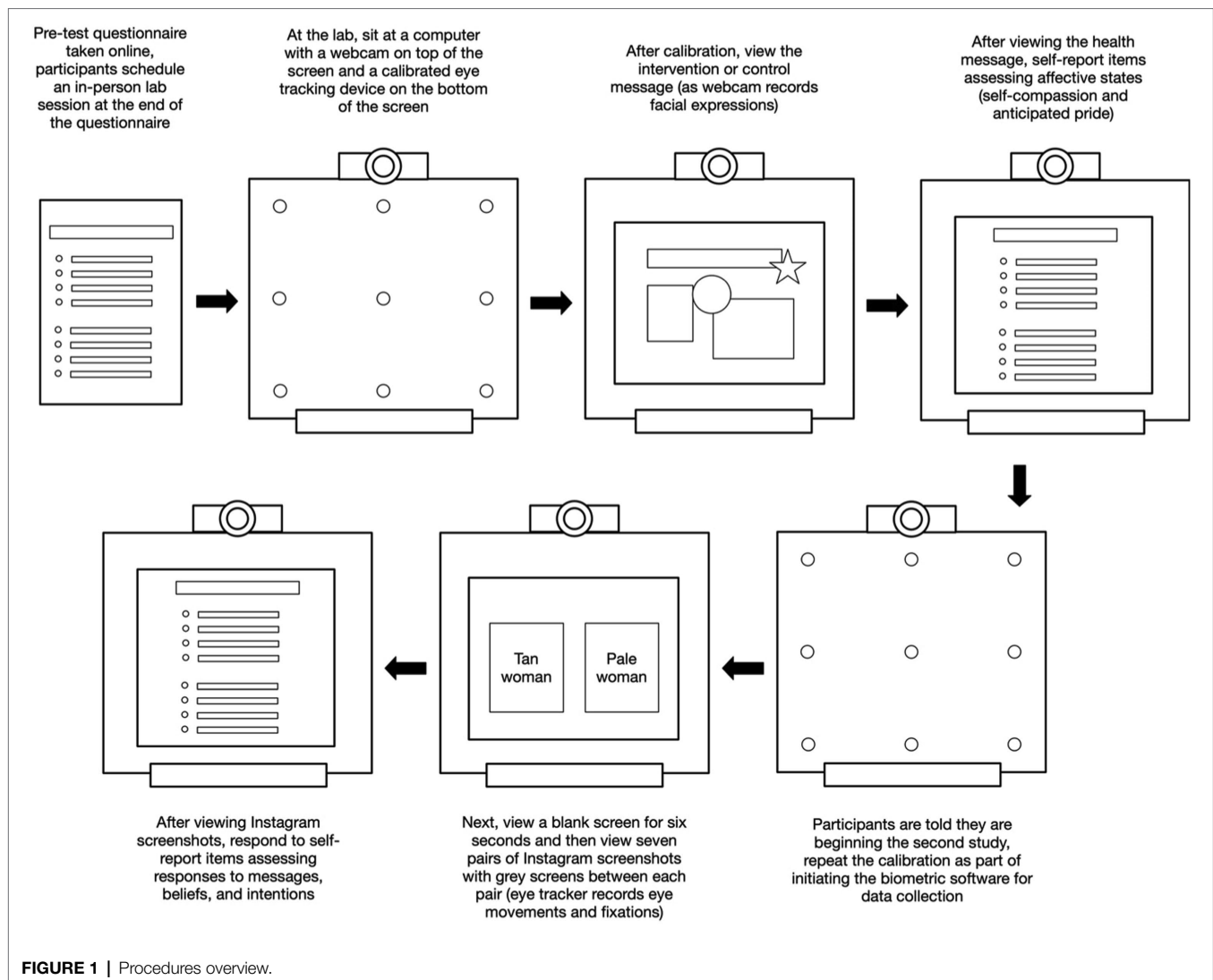
Measures

Skin type was assessed during the pretest with a single item (Fitzpatrick, 1988) where individuals chose which of the following six options (coded 1 through 6) best described their skin type: always burn, never tan; usually burn, tan with difficulty; sometimes mild burn, tan about average; rarely burn, tan with ease more than others; rarely or never burn, my skin is brown; or rarely or never burn, my skin is black ($M = 3.25$, SD = 0.98).

Appearance motivations to tan were assessed during the pretest with five items (Cafri et al., 2008) measured on a scale from 1 (strongly agree) to 7 (strongly disagree): "How I look is important to me"; "It is important that others view my physical attractiveness positively"; "I would do whatever it takes to look good"; "It is important that I always look good"; and "I spend what others consider a large amount of time on my appearance daily" ($M = 3.90$, SD = 1.21, $\alpha = 0.89$).

Self-compassion was assessed after exposure to either an intervention message or a control message and measured with three items adapted from Neff (2003a). Participants were asked

"After viewing the message, please indicate the extent to which you currently feel" and then given three statements (patient toward myself, kind to myself, and tender toward myself) on a 1 (strongly disagree) to 7 (strongly agree) scale ($M = 5.11$, SD = 1.23, $\alpha = 90$).

Anticipated pride was assessed after exposure to either an intervention message or a control message and assessed by asking participants to respond to the following prompt, adapted from previous work (van der Schalk et al., 2012): "Imagine that you are about to go outside on a warm sunny day, and you decide to protect your skin beforehand (you apply sunscreen before, or you wear protective clothing). How would you feel after protecting your skin?" They then rated their responses on a 1 (strongly disagree) to 7 (strongly agree) scale for the items proud, accomplished, confident, satisfied, and worth-while ($M = 4.61$, SD = 1.48, $\alpha = 0.90$).

The total fixation time on all tan images was captured *via* the eye tracker while viewing the seven pairs of Instagram screenshots ($M = 10,345.69$ milliseconds; SD = 8,162.26 s).

TABLE 1 | Sample intervention text.

Appearance focused intervention	Self-control emotions intervention
Have you ever tanned or laid out in the sun without sunscreen? Researchers have learned that exposure to ultraviolet radiation (sunlight) causes skin cancer and 90% of skin aging. Things to do to prevent skin aging: 1. Avoid laying out in the sun to tan, 2. Use sunscreen every day, 3. Cover your skin, 4. Try alternative beauty approaches. We'll provide tips on how to do these… 1. Laying out in the sun causes skin aging. Skin aging = wrinkles, sun spots, and leathery-looking skin. Your skin doesn't forget. A healthy approach is laying out in the sun less than once a month. 4. Try alternative beauty approaches. Check out sunless tanning options. Get the look without the wrinkle-causing UV rays with spray tans. Or, try at-home sunless tanning products (sprays, creams, bronzers). In conclusion… If you want to look good and be healthy, avoid tanning. Instead, use SPF 15+ sunscreen, reapply after 2 hours, cover up, try beauty alternatives	Have you ever tanned or laid out in the sun without sunscreen? Researchers have learned that exposure to ultraviolet radiation (sunlight) causes skin cancer and 90% of skin aging. That's okay. You're human. Most everyone has gotten too much sun before. We are all human. You can't change the past, and you can't always avoid the sun, but you can learn and grow. Things to do to be kind to your skin: 1. Avoid laying out in the sun to tan, 2. Use sunscreen every day, 3. Cover your skin, 4. Embrace your future health. We'll provide tips on how to do these… 1. Avoid laying out and keep your skin safe. Be kind to yourself by being kind to your skin. You deserve to be healthy, now and in the future. A healthy approach is laying out in the sun less than once a month. 4. Embrace your future health. Confidence looks good on you. Check out other activities that make you feel strong and confident. Try physical activity or spending time in nature. Hang out with friends who support your health and goals. In conclusion… Be kind to yourself and your skin. You deserve it. Remember, use SPF 15+ sunscreen, reapply after 2 hours, cover up, be proud of your efforts to take care of yourself!

Norms were assessed after viewing the Instagram images with six responses, adapted from Rimal and Real (2005), on a scale from 1 (strongly disagree) to 7 (strongly agree), to the following statements: "Most women my age tan outdoors"; "The most popular women my age tan outdoors"; "It is appropriate to tan outdoors"; "Society in general considers outdoor tanning an acceptable behavior"; "Most women my age in general consider outdoor tanning acceptable"; and "Most people in general consider outdoor tanning an appropriate behavior" ($M = 5.71$, SD $= 0.82$, $\alpha = 0.72$).

Efficacy was assessed after viewing the Instagram images and measured with six items adapted from Noar et al. (2015) on a scale from 1 (not at all confident) to 7 (extremely confident) in response to asking participants to indicate how confident they are that they could perform the following behaviors when it is sunny: "Use sunscreen whenever you are out in the sun for more than 15 min"; "Use sunscreen when no one else you are with is using sunscreen"; "Use sunscreen even if you do not like how it feels"; "Stay in the shade when all your friends are enjoying themselves in the sun"; "Cover up with protective clothing even when it is hot outside"; and "Avoid going outside in the sun during midday hours" ($M = 3.60$, SD $= 1.33$, $\alpha = 0.81$).

Sun-safety attitudes were adapted from Hillhouse et al. (2017) and assessed after viewing the Instagram images. Participants responded on a scale from 1 (strongly disagree) to 7 (strongly agree) to the following five statements that were based on behaviors mentioned in the interventions: "I feel good about laying out in the sun less than once a month"; "I feel good about wearing a sunscreen of SPF15 or higher every day"; "I feel good about re-applying sunscreen about every 2h"; "I feel good about wearing a cover-up or other clothing when outside in the sun"; and "I feel good about finding alternative behaviors besides outdoor tanning" ($M = 4.05$, SD $= 1.22$, $\alpha = 0.68$). See **Supplementary Material** for correlations between variables in the analyses.

RESULTS

H1 predicted the interventions would decrease time spent fixated on subsequent social media images of tan women, and RQ1 asked which intervention would have the strongest effect. To determine which variables should serve as covariates in the analysis, we first ran bivariate correlations between the total summated time spent fixated on all seven of the tan images with participant skin type, data collection wave (April or September), and two dummy coded variables representing the three possible orders of presentation of the Instagram posts. Skin type was the only significant variable ($r = -0.34$, $p < 0.001$; meaning participants with skin that easily burns were less likely to spend time fixated on the tan images) and was, therefore, retained as a covariate.

Because participants viewed multiple images, a mixed design analysis of covariance (ANCOVA) was used with the seven tan images as the within-subjects factor, intervention condition (appearance benefits, pride and self-compassion, or control) as the between-subjects variable, skin type as the covariate, and fixation time on the images of tan women as the dependent variable.

Mauchly's test of sphericity was significant ($p < 0.001$, Greenhouse-Geisser estimate $= 0.730$). As such, the Greenhouse-Geisser correction was used on degrees of freedom in interpreting effects. The test of within-subjects effects was not significant for the tan images, $F(4.380, 503.68) = 0.859$, $p = 0.497$, $\eta_p^2 = 0.007$, indicating that participants did not spend significantly different amounts of time fixated on any one of the seven images of tan women. Additionally, there was not a significant interaction between the particular tan image seen and intervention condition, $F(8.760, 503.68) = 1.625$, $p = 0.107$, $\eta_p^2 = 0.027$, meaning that effect of the intervention condition did not vary for different tan images. Additionally, there was not a significant interaction between the tan images and skin type, $F(4.380, 503.68) = 0.472$, $p = 0.773$, $\eta_p^2 = 0.004$, suggesting that people with different skin types did not respond differently to each tan images.

The test of the between-subjects effect of the intervention condition on time spent fixated on tan images was significant: $F(2, 115) = 5.484$, $p = 0.005$, $\eta_p^2 = 0.087$ (see **Figure 2**). For all seven pairs of Instagram images, participants who first viewed the appearance benefits intervention spent less time visually fixated on the image of the tan woman than did people who viewed the self-control emotions intervention or the control message, partially supporting H1.
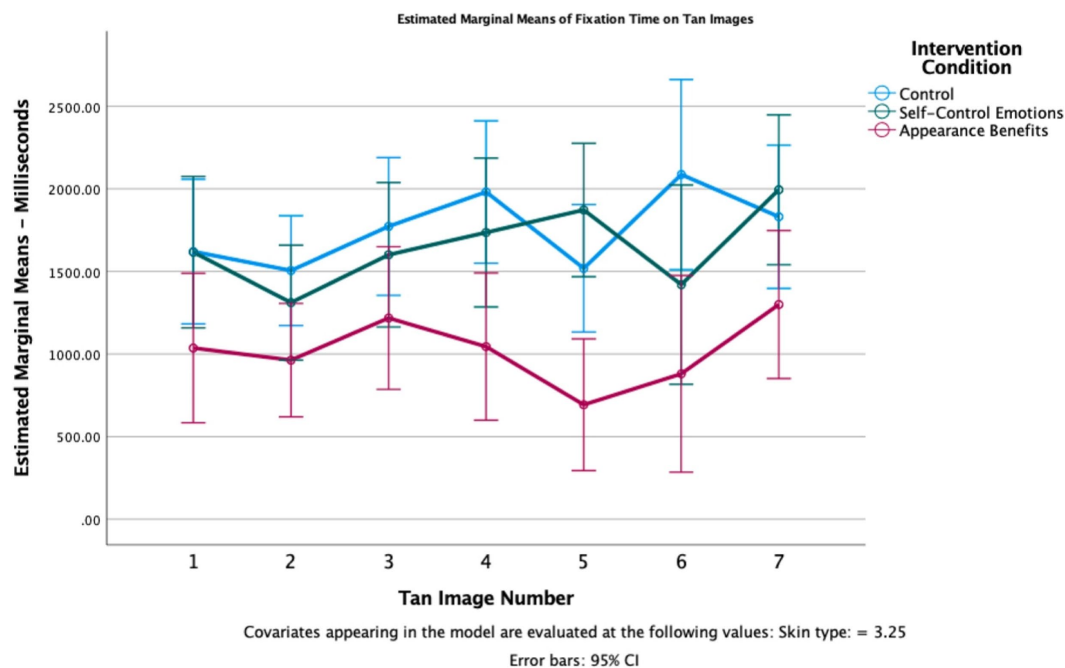
FIGURE 2 | Fixation time on the tan images by condition for each pair of Instagram screenshots.

TABLE 2 | Standardized beta coefficients of the stepwise regressions.

	Time fixated on tan images			Sun-safety attitudes		
	Model 1	**Model 2**			**Model 1**	**Model 2**
Predictors	β	β	**Predictors**		β	β
Skin type	−0.40***		Wave		0.12	
Self-compassion	0.16		Efficacy		0.50***	
Anticipated pride	−0.07		Self-compassion		−0.10	
SCE condition	−0.02		Anticipated pride		0.28***	
AB condition	−0.30**		SCE condition		0.07	
SCE X self-comp		−0.12	AB condition		0.04	
SCE X ant-pride		0.50	Time Fixated		−0.04	
AB X self-comp		−0.15	SCE X self-comp			0.62
AB X ant-pride		1.00**	SCE X ant-pride			−0.81*
			AB X self-comp			0.49
			AB X ant-pride			−0.41

SCE, Self-control emotions; AB, Appearance benefits.
*p < 0.05; **p < 0.01; ***p < 0.001.

H2 (self-control emotions would be negatively related to visual attention to tan women) and RQ2 (the interaction of emotions and intervention type) asked about the role of self-compassion and anticipated pride responses to the intervention in potentially shaping the effects of the intervention on subsequent attention to images of tan women. A stepwise regression was run to address them. We retained skin type as a control variable prior to introducing the main effects of condition (a dummy coded variable for the appearance benefit condition and a dummy coded variable for the self-control emotions condition), self-compassion, and anticipated pride. In the second block, four interaction terms

were entered between the two condition variables and the two emotion variables (see **Table 2**). Model 1, with only the main effects, was significant: $F(5, 113) = 6.05$, $p < 0.001$, $R^2 = 0.21$. This model revealed significant main effects of skin type ($\beta = -0.40$, $p < 0.001$) and the appearance benefits condition ($\beta = -0.30$, $p = 0.003$), but none for the main effect of emotions, meaning H2, was not supported. Model 2, the block with the interactions, also approached significance: $\Delta F(4, 109) = 2.43$, $p = 0.052$, $\Delta R^2 = 0.07$. In Model 2, the interaction between the appearance benefits condition and anticipated pride ($\beta = 1.00$, $p < 0.001$) was significant. That is, for participants who viewed the appearance benefits intervention, as anticipated pride increases, there is more visual attention paid to tan women. However, when participants do not view the appearance benefits intervention, as anticipated pride increases, less visual attention is paid to tan women.

H3 predicted that appearance motivations, social norms, and self-efficacy would predict attitudes while H4 predicted emotional responses would do the same, while RQ3 asked if visual attention would also predict attitudes. To address these issues, we ran a stepwise linear regression predicting with sun-safety attitudes as the dependent variable. We started by running bivariate correlations with the same potential control variables tested prior to the analyses predicting fixation time (participant skin type, data collection wave, and dummy codes for the presentation order of the Instagram posts) with sun-safety attitudes. Only wave and efficacy were significantly correlated and kept in the final analysis in the first block. We also included the main effects of self-compassion, anticipated pride, appearance benefits intervention, self-control emotions intervention, and time spent fixated on the tan woman images in the first block. In the second block, we included the four interaction terms (see **Table 2**).

Model 1, with the main effects, was significant: $F(7, 111) = 14.52$, $p < 0.001$, $R^2 = 0.48$. In this model, efficacy ($\beta = 0.50$, $p < 0.001$) and anticipated pride ($\beta = 0.28$, $p < 0.001$) were significant predictors of positive attitudes; as such, H3 and H4 were only partially supported. Additionally, Model 2, the interactions block, was not significant: $\Delta F(4, 107) = 1.86$, $p = 0.122$, $\Delta R^2 = 0.03$. In Model 2, the interaction between the self-control emotions condition and anticipated pride was significant ($\beta = -0.81$, $p = 0.011$). When people see the self-control intervention, as anticipated pride increases, there is more positive sun-safety attitudes. But, when they do not see the self-control emotions intervention, as anticipated pride increases, they report lower attitudes.

DISCUSSION

By combining eye tracking and self-report assessments, we were able to determine that different interventions and emotional responses to them can shape attention and attitudes. In a world where young women spend a lot of time on social media, where there are many images of the tan-ideal, it is crucial to consider how to best promote attentional, attitudinal, and, eventually, behavioral change in the midst of content that may undermine intervention efforts.

In the highly visual context of Instagram, our data suggest that using an appearance benefits-focused intervention lessens women's gaze on the tan ideal. However, this finding comes with a caveat: If participants also report feeling greater anticipated pride for performing sun-safety behaviors in the future, then the appearance benefits story actually promotes greater visual attention to tan women. It could be that when the appearance benefits condition generates pride for future healthier behaviors, young women then scrutinize others who are clearly not performing sun-safety behaviors. Additional interviews and focus groups could help clarify the nuances of the quantitative findings.

Anticipated pride also played a role in understanding attitudinal effects. If participants viewed the self-control intervention and felt higher levels of anticipated pride, then they reported more positive sun-safety attitudes. However, without seeing the self-control emotions intervention, stronger feelings of anticipated pride resulted in less positive attitudes. This suggests interventions focusing on self-control emotions would be wise to promote pride, while other interventions with other goals may want to avoid sparking that emotion. Together, these findings suggest that anticipated emotional responses related to a health behavior are important variables that could be included in future models of planned behavior change, particularly since many interventions ask participants to explicitly think about their future (e.g., have healthier and prettier skin).

These findings are not without their limitations. The small sample was isolated to one university and women and improvement in internal reliability is needed for some measures. We also did not track longitudinal behavior change after our interventions. Give the novelty of the approach combining biometrics and self-report responses to interventions, there are benefits to continuing this line of work. Future research could combine longer data collection periods with biometric assessments of emotional responses, too, to better capture dynamic changes in responses to social media, which is also a dynamic environment.

These results point to the need to understand self-control-related emotional responses and when they might facilitate attitudinal change after viewing social media and when they may, instead, stymie efforts to motivate young women to avoid UV exposure. Additional research is needed to probe the complex interplay of health messaging, visual attention, and attitudes resulting from social media use, but the present data provide an important starting point for this effort.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Pennsylvania State University Institutional Review Board. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.838297/full#supplementary-material

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Health Literacy and Personality Traits in Two Types of Family Structure—A Cross-Sectional Study in China

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Objective: The level of health literacy is one of the important factors affecting health outcomes. Family is an important place to shape personality traits, and people with different personalities will adopt different lifestyles, which will lead to variations in health outcomes. Therefore, this article aims to explore the relationship between health literacy and personality and its influencing factors in different family structures.

Methods: This was a cross-sectional study with 1,406 individuals. A questionnaire was utilized to measure health literacy, personality and demographic variables, including family structure. Canonical correlation analysis (CCA) and hierarchical multiple regression analysis were used to examine the relation between health literacy and personality traits between two types of family structure.

Results: CCA showed that the canonical correlation coefficients were 0.309 ($p < 0.001$) and 0.347 ($p < 0.001$), in two-parent family and single-parent family, respectively. The openness of personality traits exhibited the highest correlation with health literacy. Compared with the remaining personality traits, openness yielded the strongest effect ($\beta = 0.485$ and $\beta = 0.830$) in two types of family structure, respectively. Education and monthly income were significantly associated with health literacy.

Conclusion: Our results support the relation between health literacy and personality traits in two types of family structure.

Keywords: health literacy, personality traits, family structure, health outcomes, health promotion

INTRODUCTION

People are more sensitive and pay more attention to health information after COVID-19. The interpretation of health information is an important part of health literacy, which includes three dimensions: healthcare, disease prevention, and health promotion (Duong et al., 2019). Health literacy is a necessary skill and resource for people to seek, understand, evaluate, communicate, and use health information and services throughout their lives to promote health (Sorensen et al., 2012). Health literacy can be an independent factor influencing health outcomes. Those with a low level of health literacy are related to poor health outcomes such as insufficient use of healthcare services, high hospitalization rates, and high mortality rates according to some studies (DeWalt et al., 2004; Baker et al., 2007; Huang et al., 2017; Iwasa and Yoshida, 2020). In addition, it is difficult for people

with low health literacy to update their health knowledge or obtain the best medical advice from health experts to change their health-related lifestyle. Individuals who have higher awareness of health literacy are more willing to establish health behavior and lifestyle. Some studies reported that socioeconomic status (SES) had closely links to health literacy (Adler and Newman, 2002; Bonaccorsi et al., 2019). SES may become a predictor of health literacy (Iwasa and Yoshida, 2020).

In 2020, the health literacy level of Chinese residents reached 23.15%, an increase of 3.95 percentage points from 2019, and the growth rate is the largest in history (National Health Commission of the People's Republic of China, 2021). People have taken the initiative to assume social responsibilities, learn the knowledge and skills of epidemic prevention and control during the COVID-19 pandemic. Some methods and information can be transmitted to those who have lower health literacy, and thus they are encouraged to identify health information, master health promotion skills, and develop health behaviors. Health caregivers should pay attention not only to the transmission of health knowledge, but also to the training of health skills (e.g., strengthening the awareness of physical examination, quitting smoking, maintaining a good mental state, and avoiding natural disasters) in health promotion. Some studies on health literacy have revealed that health outcomes are associated with factors such as personality traits and family structure (Huang et al., 2017; van Scheppingen et al., 2019; Iwasa and Yoshida, 2020; Sentell et al., 2020; Soutter et al., 2020; Harsch et al., 2021).

A previous study reported the relationship between personality traits and health literacy among older adults living in Japan, and pointed out some factors of personality traits (e.g., extraversion, openness, and conscientiousness) may influence the health literacy (Iwasa and Yoshida, 2020). The Big Five Personality traits include five categories: extraversion (being positive and confident), agreeableness (being trusting and generous), conscientiousness (being rational and self-disciplined), neuroticism (being anxious and depressive) and openness (being curious and audacious) (Norman, 1963; McCrae and John, 1992; Getzmann et al., 2021). Compared with introverts, extroverts respond more strongly to positive emotions and are more likely to experience delightful mood (Soutter et al., 2020). Those with a high level of agreeableness can make good use of problem-focused and positive emotion-focused strategies, such as seeking social support and searching comprehensive information online and reducing negative emotion (Connor-Smith and Flachsbart, 2007; Carver and Connor-Smith, 2010; Getzmann et al., 2021). Additionally, people high in conscientiousness are more likely to search health information of recent health concerns for a family member (Bogg and Vo, 2014). Neuroticism is related to negative emotions, such as anxiety and depression. Individuals with a high level of neuroticism are more likely to rely on negative emotion-focused coping strategies that can easily lead to mood changes, eating disorders and drug abuse (Aschwanden et al., 2020; Herke et al., 2020; Getzmann et al., 2021). People with a high level of openness are full of curiosity, imagination and creativity and are more likely to take action emotionally. They are interested in new ideas and new experiences, so that they

are more willing to search and collect health information (Bogg and Vo, 2014).

Family structure is an important factor that influences children's health literacy, personality traits, economic, and social resources (Bloom and Dawson, 1991; Bogg and Roberts, 2004; Chae, 2016; Berger-Sieczkowski et al., 2019; Lastrucci et al., 2019; Segerstrom, 2020). In our study, we focused on two types of family structure: two-parent family and single-parent family. The two-parent family is composed of parents and unmarried children for the entirety of childhood. A single-parent family is held by one biological parent and the other is divorced, remarried, or widowed. People who grow up in two-parent family may have fewer internalizing (e.g., fearfulness, depression, and social withdrawal problems) and externalizing (e.g., aggression, hyperactivity, and oppositionality behaviors) problems than those from single-parent family (Campbell, 1995; Amato and DeBoer, 2001; Christopher et al., 2017). Low scores of conscientiousness and agreeableness have been shown to have associations with externalizing and internalizing behavior problems (Roberts et al., 2009; Laursen et al., 2010; Kim and Kochanska, 2019). Adolescents can be more extroverted and agreeable in a warm, understanding, and supportive family (Bloom and Dawson, 1991; Yong-bao and Jing, 2019).

Different than Iwasa's study that focused on the relationship between SES and health literacy among older adults living in Japan, the present study looks into the relationship between health literacy and personality traits. Factors such as extraversion, agreeableness, conscientiousness, neuroticism and openness may be predictors of health outcomes and clarify the mechanism between health literacy and personality traits in Chinese population. As such, this study aims to explore the relationship between health literacy and personality traits among two types of family structure, and provides a basis for studying the mechanism of personality traits and health literacy.

MATERIALS AND METHODS

Participants and Procedure

This is a subproject of the Survey on Health Index Among Chinese Families [SHIACF] (2021) that aims at studying the health status among Chinese families. A cross-sectional study in mainland China was conducted between July and September 2021. According to the data of "Seventh National Census in 2020," 120 cities in 23 provinces, 5 autonomous regions, and 4 municipalities directly under the Central Government were randomly selected. Teams were recruited to ensure the implementation of the investigation in each city. The study was conducted between July and September 2021 using an online questionnaire. A total of 1,406 individuals were selected to participate in this study using multistage random sampling method. Participants then outlined their family structure (e.g., single-parent family or two-parent family). Demographic variables such as gender, age, educational level, residential area, and monthly income were inquired and used as factors associated with health literacy in hierarchical multiple regression analysis. The inclusion criteria for participants were age ≥ 12, living in

TABLE 1 | Sample characteristics (N = 1,406).

Characteristics of participants	Variables	Number (%)
Gender	Male	610 (43.4)
	Female	796 (56.6)
Age group	<19	156 (11.1)
	19–59	1, 173 (83.4)
	>59	77 (5.5)
Education	Illiteracy	33 (2.3)
	Primary school	89 (6.3)
	Middle school	193 (13.7)
	High school	278 (19.9)
	Junior college	163 (11.6)
	Undergraduate or higher	650 (46.2)
Family structure	Two-parent family	994 (70.7)
	Single-parent family	412 (29.3)
Residential area	Urban area	1, 016 (72.3)
	Rural area	390 (27.7)
Monthly income	<1,501	152 (10.7)
	1,501–4,500	573 (40.8)
	4,501–9,000	465 (33.1)
	>9,000	216 (15.4)

China, volunteering to participate in the research and completing the consent form. The exclusion criteria were participants with severe mental illness and unwillingness to cooperate. All participants provided consent form and this study was approved by the Ethics Committee of Jinan University, Guangzhou, China.

Among 1,406 respondents, 610 (43.4%) were male and 796 (56.6%) were female; 994 (70.7%) were from two-parent family and 29.3% (412) were from single-parent family. A total of 156 (11.1%) of participants were under 18 years old, 1,173 (83.4%) were between 19 and 59, and 77 (5.5%) were over 60 (**Table 1**).

Measures
Health Literacy
Health literacy was measured by a 12-item short-form health literacy questionnaire (HLS-SF12), which was developed and based on the 47-item European health literacy questionnaire (HLS-EU-Q47) (Duong et al., 2019). The HLS-SF12 was a self-report questionnaire comprising three domains: healthcare, disease prevention, and health promotion. The difficulty of HLS-SF12 was rated on a four-point Likert scale (1, very difficult; 2, difficult; 3, easy; 4, very easy). The cumulative score of each domain comprises the total score of HLS-SF12. Higher scores indicated a higher level of health literacy. Cronbach's alpha was 0.937 for the present study. The HLS-SF12 was proved to have adequate reliability and validity.

Personality Traits
The Big Five Inventory-10 (BFI-10) offered a sufficient evaluation of personality traits including extraversion, agreeableness, conscientiousness, neuroticism and openness. Respondents rated each item on a five-point Likert scale (1, disagree strongly; 2, disagree; 3, neither disagree nor agree; 4, agree; and 5, agree

strongly). Cronbach's alpha was 0.486 for the present study. The BFI-10 retained significant levels of validity and reliability (Rammstedt and John, 2007).

Statistical Analysis
Data were analyzed using IBM SPSS version 25. First, we computed the descriptive statistics and measured the health literacy score using ANOVA between demographic variables. Student's t-test was performed to identify the personality score in two types of family structure. Next, to assess the association between personality traits and health literacy, Pearson correlation and canonical correlation analysis (CAA) were computed in two-parent family and single-parent family, respectively. Extraversion, agreeableness, conscientiousness, neuroticism, and openness were selected as dependent variable set owing to describe the personality traits. Healthcare (HC), disease prevention (DP), and health promotion (HP) were selected as independent variable set owing to health literacy. Furthermore, hierarchical multiple regression analysis was used to test health literacy as a dependent variable and residential area, monthly income, gender, education, family structure, and personality traits as predictors. Significance was set at $p < 0.05$ (two-sided).

RESULTS

Differences of Health Literacy by Demographic Variables
The demographic characteristics of the study are presented in **Table 2**. There were significant differences between health literacy and variables of family structure, residential area, monthly income, and education ($p < 0.05$).

Personality Traits in Two Types of Family Structure
Table 3 shows the comparison of personality scores between two-parent family and single-parent family. The mean ± SD of A (agreeableness) was significantly different between the two groups ($p = 0.003$). This result indicated that individuals in the two-parent family had a higher level of agreeableness than those in the single-parent family.

Bivariate Correlation Between Health Literacy and Personality Traits
Bivariate correlations among variables of health literacy and personality traits are shown in **Table 4**. All variables related to personality traits exhibited positively significant correlations with health literacy such as HC, DP, and HP ($p < 0.05$).

Results of Canonical Correlation Analysis
Although the bivariate correlation showed a positively significant correlation between the variables of health literacy and personality traits, it was difficult to interpret the relation between

TABLE 2 | Comparison of health literacy between demographic characteristics (N = 1,406).

Demographic characteristics	(Mean ± SD)	F	p
Family structure		2.962	0.003
Two-parent family	37.23 ± 5.41		
Single-parent family	36.25 ± 6.26		
Residential area		5.319	<0.001
Urban area	37.44 ± 5.40		
Rural area	35.65 ± 6.21		
Monthly income (RMB)		11.615	<0.001
≤1,500	34.80 ± 0.55		
1,500–4,500	36.65 ± 0.23		
4,501–9,000	37.58 ± 0.28		
≥9,001	37.82 ± 0.36		
Education		19.363	<0.001
Illiteracy	31.58 ± 1.37		
Primary school	33.07 ± 0.61		
Middle school	36.03 ± 0.37		
High school	37.33 ± 0.35		
Junior college	37.31 ± 0.38		
Undergraduate or higher	37.75 ± 0.22		
Gender		0.738	0.461
Male	37.07 ± 6.01		
Female	36.84 ± 5.43		

two sets of variables. Thus, CCA may offer an efficient way to assess this association between two sets of variables.

Results of Canonical Correlation

The present study defined the variables of personality traits as the independent variables and health literacy as the dependent variable. **Table 5** shows that the first canonical correlation was 0.309 in the two-parent family and 0.347 in the single-parent family. The first canonical correlation interpreted the highest possible correlation between all linear combinations for two sets of variables. The second canonical correlations were 0.131 and 0.071, respectively. Although the canonical correlation of 0.131 was significant, the proportion of variance explained was less than the first canonical correlation. Therefore, our study considered retaining the first canonical correlation coefficient.

The standardized canonical coefficients of E, A, C, N, and O as the variables of personality traits in the parent family were −0.150, −0.359, −0.410, −0.111, and −0.641, respectively, for the first canonical variate (VT_1). HC, DP, and HP were the variables of health literacy, and the standardized canonical coefficients were 0.192, −0.195, and −0.973, respectively, for the first canonical variate (WT_1). The coefficients of O (−0.641) and HP (−0.973) indicated that they contributed the most to personality traits and health literacy in the two-parent family, respectively.

In the single-parent family, the standardized canonical coefficients of E, A, C, N, and O were −0.337, −0.424, −0.050, −0.015, and −0.659, respectively, for the first canonical variate (VS_1). The first canonical variate (WS_1) of health literacy, such as HC, DP, and HP were 0.273, −0.780, and −0.497, respectively. It

demonstrated that O (−0.659) and DP (−0.780) contributed the strongest to personality traits and health literacy (**Table 6**).

The optimal linear equations were:

$$VT_1 = -0.150*E-0.359*A-0.410*C-0.111*N-0.641*O$$
$$WT_1 = 0.192*HC-0.195*DP-0.973*HP$$
$$VS_1 = -0.337*E-0.424*A-0.050*C-0.015*N-0.659*O$$
$$WS_1 = 0.273*HC-0.780*DP-0.497*HP$$

Results of Canonical Loading

According to canonical loading results in the two-parent family, O (−0.745) had a stronger effect than E (−0.314) and N (−0.337) to form the first pair variable for personality traits (VT_1). Additionally, HP (−0.992) for health literacy had greater effect than HC (−0.621) and DP (−0.792) to form the first pair (WT_1). Similarly, canonical loading of O (−0.839) played a role in personality traits compared to other factors in the single-parent family (VS_1). However, canonical loading for health literacy indicated that DP (−0.957) and HP (−0.915) had a greater effect than HC (−0.739) in forming the first pair (ST_1) (**Table 7**).

Thus, a related structural illustration of the first canonical correlation on personality traits and health literacy in two-type family structures is shown in **Figures 1**, **2**.

Determinants of Health Literacy in Two Types of Family Structure

A hierarchical multiple regression analysis, which was based on the results of CAA, was used to examine the factors associated with health literacy. The current study selected residential area, monthly income, gender, education, and personality traits as the independent variables. Regression coefficients were performed in **Table 8**.

First, all factors, except personality traits, were selected into model 1 (two-parent family without personality traits factors) and model 3 (single-parent family without personality traits factors). Education proved to be statistically significant in both regression models. As the educational level increased, health literacy increased. Additionally, monthly income was another factor that influenced health literacy in the single-parent family.

Next, all factors including personality traits selected through CCA, were included in model 2 (two-parent family with personality trait factors) and model 4 (single-parent family with personality trait factors). Education remained a predictor in the regression model of the two-parent family. All five personality trait factors were statistically significant in model 2, which that they were predictors of health literacy in the two-parent family. The coefficient of determination, R^2, varied from 0.094 to 0.160 in model 1 and model 2. Monthly income (for 4,501–9,000), agreeableness and openness of personality traits were significant in model 4. However, education was no longer significant in this regression. The R^2 was 0.134 in model 4 (**Table 8**).

DISCUSSION

To our best knowledge, the present study is the first to focus on the relationship between health literacy and

TABLE 3 | Comparison of personality traits between two-parent family and single-parent family.

	E	A	C	N	O
Two-parent family	6.32 ± 1.69	7.10 ± 1.48	6.82 ± 1.68	6.28 ± 1.53	6.44 ± 1.57
Single-parent family	6.47 ± 1.66	6.84 ± 1.49	6.68 ± 1.55	6.19 ± 1.47	6.54 ± 1.52
t	1.482	3.013	1.493	0.944	1.131
p	0.139	0.003*	0.136	0.346	0.258

*$p < 0.05$.

E, extraversion; A, agreeableness; C, conscientiousness; N, neuroticism; O, openness.

TABLE 4 | Correlation matrix for the variables of health literacy and personality traits.

Variables	E	A	C	N	O	HC	DP	HP
E	1.000	–	–	–	–	–	–	–
A	−0.015	1.000	–	–	–	–	–	–
C	0.139*	0.262*	1.000	–	–	–	–	–
N	0.162*	0.239*	0.123*	1.000	–	–	–	–
O	0.199*	0.128*	0.075*	0.090*	1.000	–	–	–
HC	0.082*	0.128*	0.061*	0.116*	0.175*	1.000	–	–
DP	0.126*	0.151*	0.106*	0.118*	0.218*	0.792*	1.000	–
HP	0.117*	0.182*	0.146*	0.097*	0.235*	0.709*	0.781*	1.000

*$p < 0.05$.

E, extraversion; A, agreeableness; C, conscientiousness; N, neuroticism; O, openness; HC, healthcare; DP, disease prevention; HP, health promotion.

TABLE 5 | Results of canonical correlation in two types of family structure.

Pair	Canonical correlation	Eigenvalue	Wilks statistic	F	p	PVE (set 1/set 2)
Two-parent family						
1	0.309	0.105	0.887	8.037	0.000	0.310/0.729
2	0.131	0.017	0.981	2.404	0.014	0.185/0.266
3	0.046	0.002	0.998	0.701	0.552	0.200/0.072
Single-parent family						
1	0.347	0.137	0.873	3.766	0.000	0.330/0.858
2	0.071	0.005	0.992	0.422	0.908	0.131/0.125
3	0.057	0.003	0.997	0.440	0.724	0.164/0.110

PVE, proportion of variance explained.

TABLE 6 | Standardized canonical coefficients for personality traits and health literacy in two types of family structure.

	Personality traits variable set						Health literacy variable set		
	E	A	C	N	O		HC	DP	HP
Two-parent family									
VT$_1$	−0.150	−0.359	−0.410	−0.111	−0.641	WT$_1$	0.192	−0.195	−0.973
VT$_2$	−0.205	0.025	0.642	−0.813	−0.065	WT$_2$	−0.915	−0.717	1.146
VT$_3$	−0.885	0.403	−0.157	0.181	0.112	WT$_3$	1.334	−1.711	0.531
Single-parent family									
VS$_1$	−0.337	−0.424	−0.050	−0.015	−0.659	WS$_1$	0.273	−0.780	−0.497
VS$_2$	−0.762	−0.543	0.004	0.330	0.788	WS$_2$	1.331	0.339	−1.429
VS$_3$	−0.118	0.594	−0.964	0.061	−0.010	WS$_3$	1.188	−1.772	0.894

E, extraversion; A, agreeableness; C, conscientiousness; N, neuroticism; O, openness; HC, healthcare; DP, disease prevention; HP, health promotion; VT$_1$, VT$_2$, and VT$_3$, personality traits variables for two-parent family; WT$_1$, WT$_2$, and WT$_3$, health literacy variables for two-parent family; VS$_1$, VS$_2$, and VS$_3$, personality traits variables for single-parent family; WS$_1$, WS$_2$, and WS$_3$, health literacy variables for single-parent family.

personality traits in China. We found that education, extraversion, agreeableness, conscientiousness, neuroticism, and openness were significantly related to health literacy in two-parent family. However, monthly income, agreeableness, and openness were influencing factors of health literacy in single-parent family.

	Personality traits variable set						Health literacy variable set		
	E	A	C	N	O		HC	DP	HP
Two-parent family									
VT_1	−0.314	−0.558	−0.581	−0.337	−0.745	WT_1	−0.621	−0.792	−0.992
VT_2	−0.263	−0.006	0.501	−0.759	−0.124	WT_2	−0.695	−0.550	−0.027
VT_3	−0.872	0.448	−0.151	0.112	0.032	WT_3	0.362	−0.264	0.124
Single-parent family									
VS_1	−0.568	−0.561	−0.282	−0.227	−0.839	WS_1	−0.739	−0.957	−0.915
VS_2	−0.487	−0.359	−0.158	0.150	0.488	WS_2	0.523	0.277	−0.147
VS_3	−0.220	0.323	−0.803	0.119	−0.037	WS_3	0.425	−0.090	0.375

E, extraversion; A, agreeableness; C, conscientiousness; N, neuroticism; O, openness; HC, healthcare; DP, disease prevention; HP, health promotion; VT_1, VT_2, and VT_3, personality traits variables for two-parent family; WT_1, WT_2, and WT_3, health literacy variables for two-parent family; VS_1, VS_2, and VS_3, personality traits variables for single-parent family; WS_1, WS_2, and WS_3, health literacy variables for single-parent family.

FIGURE 1 | Correlations between variables set of personality traits and variables set of health literacy and among their canonical variables in two-parent family.
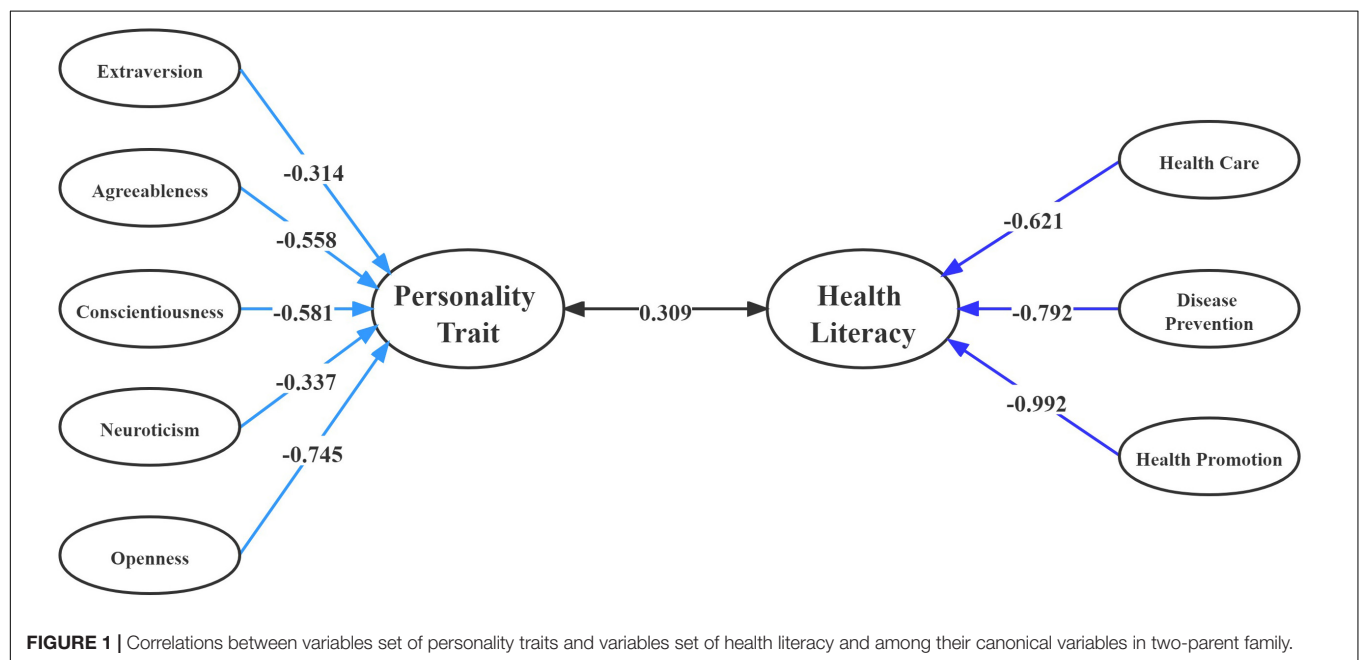
The average score of health literacy was 36.94 ± 5.69 in our study. Comparing the results with Duong, people in mainland China had a higher level of health literacy than the other six countries or areas in Asia (*p* < 0.05) (Duong et al., 2019). Our study identified that health literacy was associated with education. Health literacy is considered to be able to collect, read, comprehend, and utilize health resources (Zarcadoolas et al., 2005; Manganello, 2007). Education for health was considered to be a health promotion action for the general population (Nutbeam, 2000). Those with a higher level of education have been confirmed to have higher cognitive functions, which are an effective skills to collect health information (Iwasa and Yoshida, 2020). Monthly income is another factor that influenced the health literacy. Individuals with a reasonable economic status are more likely to make good use of healthcare resources and to collect health information in the right way (Nutbeam, 2000; Wharf Higgins et al., 2009; Sorensen et al., 2012; Rask et al.,

2014; Martin and Chen, 2015). In addition, high monthly income indicates that people can widely select health resources, health insurance, and healthcare systems (Ishikawa et al., 2018).

This study found that individuals with higher agreeableness were more likely to have higher level of health literacy. Agreeableness plays an important part in children's, adolescents', and adults' social functioning (Kochanska and Kim, 2020). Agreeableness was positively related to parental warmth, responsiveness and authoritative parenting in general, which could promote more positive emotion regulation in children (Coplan et al., 2009). Remarkably, agreeableness was related to lower levels of stress, depression, and anxiety (Qian and Yahara, 2020; Al-Omiri et al., 2021; Nikcčvić et al., 2021). Agreeable individuals are generous, trusting and compliant, and are more likely to seek social support, and exhibit active coping and reappraisals when encountering a stressful experience (Afshar et al., 2015; Getzmann et al., 2021). Those with high levels of

FIGURE 2 | Correlations between variables set of personality traits and variables set of health literacy and among their canonical variables in single-parent family.
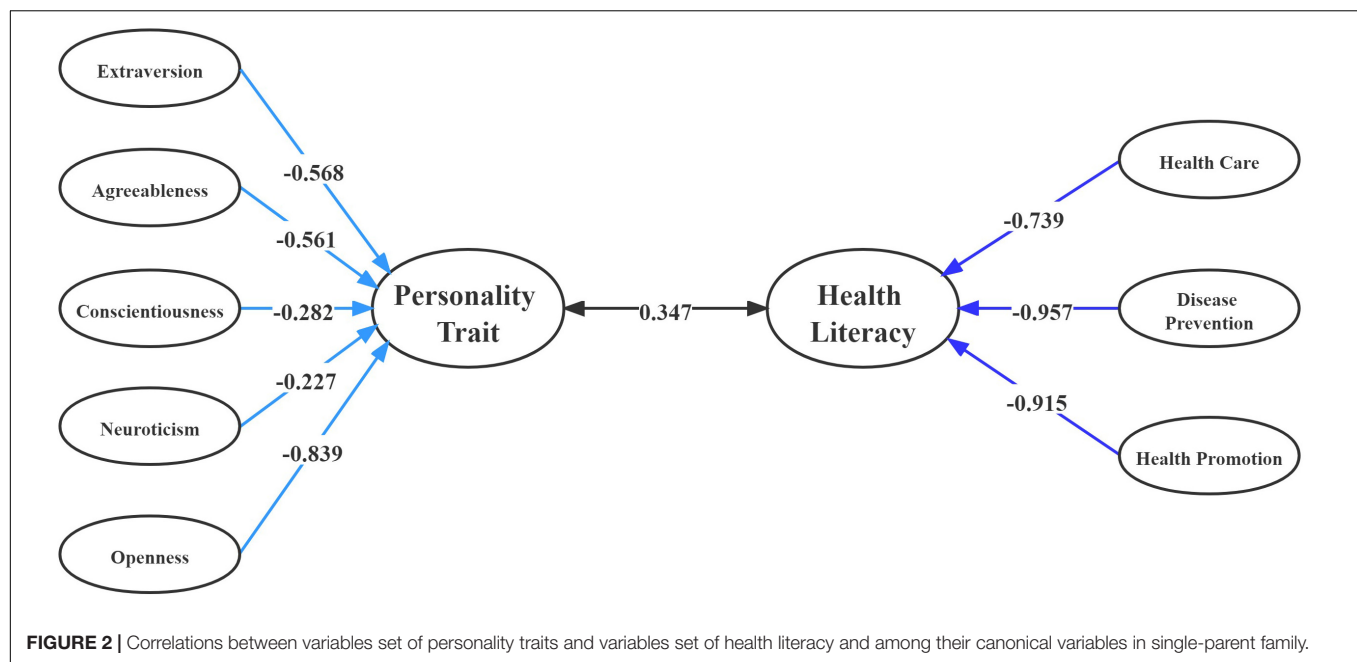
TABLE 8 | Factors associated with health literacy in two types of family structure.

	Two-parent family				Single-parent family			
	Model 1		Model 2		Model 3		Model 4	
	β	*P*	β	*P*	β	*P*	β	*P*
Constant	31.595	<0.001	21.227	<0.001	31.626	<0.001	20.391	<0.001
Residential area (ref. = urban area)	−0.522	0.237	−0.593	0.167	−0.418	0.612	−0.586	0.466
Monthly income (ref. = <1,500)	—	—	—	—	—	—	—	—
Monthly income (1,500–4,500)	0.197	0.762	0.203	0.747	1.910	0.033	1.523	0.080
Monthly income (4,501–9,000)	0.676	0.313	0.550	0.395	2.504	0.012	2.141	0.027
Monthly income (≥9,001)	0.752	0.316	0.711	0.326	2.121	0.088	1.590	0.188
Gender (ref. = female)	−0.401	0.311	−0.400	0.300	0.323	0.640	0.136	0.840
Education (ref. = illiteracy)	—	—	—	—	—	—	—	—
Education (primary school)	2.432	0.110	2.331	0.114	0.349	0.849	0.112	0.950
Education (middle school)	4.829	0.001	4.678	0.001	3.631	0.033	2.650	0.114
Education (high school)	6.995	<0.001	6.818	<0.001	1.961	0.235	1.587	0.329
Education (junior college)	6.034	<0.001	5.886	<0.001	3.810	0.030	2.997	0.080
Education (undergraduate or higher)	6.752	<0.001	6.563	<0.001	3.687	0.020	2.818	0.072
Extraversion	—	—	0.222	0.025	—	—	0.270	0.162
Agreeableness	—	—	0.288	0.014	—	—	0.529	0.015
Conscientiousness	—	—	0.325	0.002	—	—	0.080	0.702
Neuroticism	—	—	0.259	0.021	—	—	0.083	0.696
Openness	—	—	0.485	<0.001	—	—	0.830	<0.001
R^2	0.094	—	0.160	—	0.064	—	0.134	—

agreeableness were good at problem-focused coping (i.e., efforts to improve a given situation), and able to deal with the health problems resulting from negative emotion (Agbaria and Mokh, 2021). The McMaster model of family functioning, including dimensions such as problem solving, communication, roles, affective responsiveness, affective involvement and behavioral control, that has impact on the health of family members (Bello

et al., 2018). Two-parent family may have sufficient family functioning which would lead to better family health status. In contrast, single-parent family may have fewer resources including time, money and social networks that might lead to poor health outcomes (Christie-Seely and Talbot, 1985; Bello et al., 2018).

The results also showed that openness was associated with health literacy. According to the definition, openness

should be positively associated with searching for health-related information (Bogg and Vo, 2014). Openness broadly reflects a person's ability to accept new experiences, both exploring internal emotions or ideas and exposing to new or unfamiliar things (Oie et al., 2020). Individuals a with high level of openness were sensitive to health information and more likely to benefit from training programs and accept health-related behaviors for health promotion (Salgado, 1997; Wagner et al., 2017). Low openness was related to personal adaptation problems and inability to understand or express one's own feelings (Oie et al., 2020). Additionally, parents with high openness are more likely to comprehend and adjust the needs of their children in different situations (Slade, 2005). Some studies have shown that parents high in openness could sustain a satisfactory relationship and be willing to share feelings with children (Neyer and Voigt, 2004; Zhou et al., 2017).

Extraversion, as a critical predictor for parenting warmth, was labeled energetic and assertive. Extraversion had a positive correlation with physical activity, which could improve health literacy and lead to better health outcomes (Wilson et al., 2005; Krueger et al., 2009). Extroverted parents are more willing to share health information with their children, observe their children's daily health status, and make better health decisions. Additionally, the family atmosphere could be more harmonious by exercising together. A previous study demonstrated that adolescents from a single-parent family may have remarkably higher odds of risky health behaviors (e.g., smoking and high alcohol consumption) and mental health issues (e.g., depression and suicidal ideation) (Park and Lee, 2020). Parents who scored higher on extraversion were related to positive emotional expressions interacting with children, and providing a more intimate environment and cultivating health behaviors (Prinzie et al., 2009). In contrast, negative emotions such as depression have been proven to be related to low extraversion (Chioqueta and Stiles, 2005).

Of the Big Five Personality constructs, conscientiousness reflected the extent to which a person was organized, goal directed, and followed rules (Prinzie et al., 2009; Eisenberg et al., 2014). High conscientiousness was more likely to follow social norms toward health information or health behavior, and should help family member to contribute more to the health outcome (Barrick et al., 1998; Hirsh, 2010). A previous study demonstrated that lower conscientiousness has potential explanatory relevance to risky health behavior (e.g., smoking) and childhood maltreatment (e.g., childhood neglect) (Collado et al., 2019). For example, cigarette smoking represents a risky health behavior that leads to high morbidity of lung cancer. Parents with high conscientiousness and health literacy always obey the norms and exhort their children not to smoke. However, parents may pay less attention to their children who are more likely to be exposed to the risk of poor health behavior and mental health in a single-parent family (Park and Lee, 2020).

Neuroticism is vulnerable to negative emotions such as anxiety, depression and fear (McCrae and John, 1992). Most studies demonstrated that individuals with a low level of neuroticism were more likely to have a high level of health literacy. However, our study showed that neuroticism had

a positive relationship with health literacy. One possible reason for this difference could be that people with moderate neuroticism may pay more attention to health conditions, to search for health information and to use health resources rationally to maintain health and wellbeing. Neurotic people tended to have strong negative emotions to adverse events in life. Therefore, negative emotions such as anxiety and worry were inclined to cause emotional instability. Studies have shown a positive relationship between neuroticism and internalizing problems among children, adolescents, and adults, which may destroy the intimate relationship between parents and children (Malouff et al., 2005; Prinzie et al., 2009; Kotov et al., 2010). Lower neuroticism was related to more autonomy support, warmth and behavior control, which was a critical factor in maintaining positive interactions. In addition, two-parent family spent more time participating in activities with children which could improve intimate relationships (Stephan et al., 2014; Wilson and Dishman, 2015).

The present study had several limitations. First, as a cross-sectional study, it was difficult to prove causation from the findings related to health literacy and personality traits. This study found that people with high neuroticism tended to have a high level of health literacy, which was opposite to some studies. The personality score was influenced by several factors, such as age, health status, social support, and life events when they were investigated (Costa and McCrae, 1988). A longitudinal study is needed to ensure the relationship between health literacy and personality traits in two types of family structure in the future. Second, this study used a multistage random sampling method, and the number of single-parent family was much smaller than that of two-parent family. Considering the problem of ratio, two-parent family was randomly sampled at approximately 1,000, as the ratio of two-parent family to single-parent family was 2:1. Therefore, the representation of the results of two-parent families may need to be further confirmed.

CONCLUSION

Overall, the results of the current study demonstrated a positively significant association between health literacy and personality traits in two types of family structure. Openness provided the strongest contribution to the related structure of canonical correlation on the personality trait set. On the other hand, healthcare and health promotion had stronger effects on the health literacy set. Hierarchical multiple regression analysis showed that education, extraversion, agreeableness, conscientiousness, neuroticism, and openness were the factors influencing health literacy in the two-parent family. Additionally, monthly income, agreeableness and openness were the factors influencing health literacy in a single-parent family. These results may offer an effective, practical and instructive approach to explaining the relation between health literacy and personality traits in two types of family structure.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of Jinan University, Guangzhou, China. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

ACKNOWLEDGMENTS

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Predictors of Persistent Participation in Youth Sport: A Systematic Review and Meta-Analysis

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There are many factors affecting decisions to persistent participation in sports and various approaches have been used to frame these antecedents. The aim of this paper was to systematically review and quantify the primary factors of persistent participation and to assess their respective strengths of association with persistent participation in youth sport. Adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes (PRISMA) guidelines, a comprehensive search was implemented on 31st December 2021 in five databases and meta-analytic procedures were applied to data from studies meeting inclusion criteria. The results revealed that sports enjoyment (meta $r = 0.45$, 95%CI [0.42, 0.49]) was highly correlated with persistent intention, while persistent intention (SMD $= 1.13$, 95%CI [0.70, 1.56]) was highly correlated with persistent behavior. In addition, parental support, coach support, peer support, basic psychological needs and sports competence were the primary factors associated with persistent intention and persistent behavior, respectively. This study identified the key factors related to persistent participation and provide a complete understanding of children and adolescents' decisions to continue their participation in organized sports. Referring to the key factors, it can provide information for sports clubs and policy makers to develop strategies to increase youth participation in organized sport.

Systematic Review Registration: PROSPERO, identifier: CRD42021229397.

Keywords: factors, meta-analysis, persistent participation, sport, systematic review

INTRODUCTION

Sport is defined as a structured, goal-oriented, competitive and contest-based form of physical activity. A growing body of studies have confirmed that persistent sports participation not only has a positive effect on the skills, physical development and social adaptation of adolescents, it also plays a significant role in reducing the risk of chronic diseases, cancer and obesity and in preventing psychological problems (Lindwall et al., 2014; Morris et al., 2019). In contrast to individuals who do not participate in sports, persistent participants experience less psychological difficulties and higher quality of life related to health (Vella et al., 2014a,b). In addition, exercise in adolescence increases the likelihood of physical activity in adulthood, thereby enabling the maintenance of a lasting and beneficial effect on their physical and mental health (Huotari et al., 2011). Despite these potential benefits, young athletes may be struggling with the decision to quit sports. Studies indicate that ∼20–50% of young athletes between the ages of 10 and 17 dropout in sports each year (Balish et al., 2014). In Sweden, 77% of children aged 6–12 participate inorganized sports. However, between the ages of 13 and 25, this proportion dropped to 41% (Eliasson and Johansson, 2021). The portion of

this dropout may reflect that the teenagers in the sample are trying to transfer between different sports, or quit sports in order to enter other fields such as music, STEM classes, etc. However, some withdrawal from sports may reflect dissatisfaction or negative experience. Sport dropout among young people has become such a common phenomenon in the world that the research on the behavior of persistent sports participation has been given more attention to by many clubs and researchers (Monteiro et al., 2018a; Eime and Harvey, 2019; Silva et al., 2019). Identifying the influencing factors of persistent sports participation in youth becomes more important.

From a measurement standpoint, dropout was primarily assessed on whether youth participants registered for their sport in subsequent seasons (Balish et al., 2014; Crane and Temple, 2015). Using registration in the subsequent season provides a minimalist view of dropout. Therefore, persistent participation is defined as participants go on their sport in the following season. The duration shall be at least 1 year. Many studies have attempted to explain sport persistence and dropout in relation to participants' underlying psychological characteristics, and various theories have been applied to frame this phenomenon. In previous studies, self-determination theory (SDT), achievement goal theory (AGT) and theory of planned behavior (TPB) are highly appropriate conceptual framework from which to study sport persistence and dropout. For example, Gardner et al. (2016) explored the antecedents of enjoyment and intention to continue in youth sports based on the theory of the AGT. Their study indicated that the social climate profiles were linked with intention to continue through enjoyment and the positive coach relationship quality profiles were relatively higher levels of enjoyment and intention to continue (Gardner et al., 2016). Joesaar and Hein (2011) integrated the AGT and SDT theories to confirm that youth athletes' task-involving peer motivational climate and intrinsic motivation predict sport persistence among the athletes (Joesaar et al., 2011). Gucciardi and Jackson (2015) integrated the theories of planned behavior (TPB) and basic psychological needs (BPN) to identify factors associated with young adults' continuation in organized sport. The results indicated that the satisfaction of basic psychological needs, intention and perceived behavioral control predicted sport continuation (Gucciardi and Jackson, 2015). In addition, researchers explored other factors of persistent participation in youth sports, such as demographic, biological, psychological, cultural, environmental (Boiche and Sarrazin, 2009; Bouffard, 2017; Wendling et al., 2018; Soares et al., 2020). Many cross-sectional and longitudinal studies have also shown that persistent sports participation is associated with higher perceived competence, self-esteem, and better emotional and social adaptation (Duda, 2013; Smith et al., 2016).

Although numerous studies identify the factors of persistent participation in youth sports, few researchers have conducted systematic review and meta-analysis of available articles to my knowledge. Due to the different research perspectives and theories adopted by researchers, the understanding of persistent participation in youth sports also differs, making it difficult to fully reflect the influencing factors of persistent participation. The strength or significance of some factors are also inconsistent

TABLE 1 | Search terms used for systematic review.

Database	Search terms
Web of science 504	TI = (sustained or prolonged or maintained or continu* or persist*) AND TS = (sport* or athlet*) AND TS = (child* or adolescen* or youth or teenager)
PubMed 761	((sustained[Title] OR prolonged[Title] OR continu*[Title] OR maintained[Title] OR persist*[Title]) AND (sport* OR athlet*[MeSH Terms])) AND (child* OR adolescen* OR youth OR teenager[MeSH Terms])
PsycINFO 100	TI (sustained OR prolonged OR continu* OR maintained OR persist*) AND AB (sport* OR athlet*) AND AB (child* OR adolescen* OR youth OR teenager)
SPORT Discus 125	TI (sustained OR prolonged OR continu* OR maintained OR persist*) AND AB (sport* OR athlet*) AND AB (child* OR adolescen* OR youth OR teenager)
ScienceDirect 215	TI (sustained OR prolonged OR continu* OR maintained OR persist*) AND AB (sport* OR athlet*) AND AB (child* OR adolescen* OR youth OR teenager)

in different articles. Therefore, it is essential to analyze the factors associated with persistent participation in youth sports through a systematic review and meta-analysis. The aims of this study are as follows: (a) to systematically review the factors of persistent sports participation in the empirical papers and (b) to assess their respective strengths associated with persistent participation in organized sport through the method of meta-analysis. This study can provide a complete understanding of children and adolescents' decisions to continue or discontinue their participation in organized sports. An overview of these factors can provide information that is useful for sports clubs and policy makers for developing new interventions to increase participation in organized sport among these adolescents.

METHODS

The present review was register on the international platform of PROSPERO (Booth et al., 2012) (registration number: CRD42021229397) and was reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) (Moher et al., 2015).

Search Strategy

A comprehensive search was implemented on 31st December 2021 in five databases: Web of Science, PubMed, PsycINFO, SPORT Discus and ScienceDirect. Secondary literature was screened in the reference lists of included articles. To reduce the risk of removing relevant literature in the initial e-journal search, the author used broad search terms and rationalized the excluded terms in advance to reduce the risk of removing relevant literature in the initial (Gledhill et al., 2017). The search items focused on three key elements: (1) study population; (2) the context; and (3) outcome measure. The Boolean search terms were seen in **Table 1**.

The flow diagram (**Figure 1**) summarizes the process for identification and selection of eligible studies. A total of 1,705 studies were searched from the electronic database, including

WOS, PubMed, PsyCINFO, SPORT Discus, and Science Direct. Another 15 articles were identified through back referencing. All data were exported to EndNote X9 software. A total 908 duplicates were automatically removed through the Endnote X9 software. Following the title and abstract screening of the remaining records, 726 studies were removed for irrelevance. The full text of the remaining 86 articles was examined by two independent reviewers, resulting in 65 articles being excluded against the inclusion criteria. Finally, 21 articles were included for systematic review.

Inclusion and Exclusion Criteria

Inclusion criteria: (1) Empirical studies pertaining to intention or behavior of persistent participation in sports; (2) Observational studies including cross-sectional or longitudinal research; (3) Contained correlation coefficient r or other effect values that could be converted into correlation coefficients, such as beta coefficient β; (4) The participations were children and/or adolescents aged between 5 and 19 years; (5) The extracted factors were mentioned three or more in papers. Studies were excluded if they: (1) were written in non-English; (2) did not contain original data or statistical analysis and (3) were reviews, dissertations or conference papers.

Data Extraction

Two independently reviewers examined the full-text of the remaining 21 studies against the inclusion criteria and independently extracted and cross-checked them. All data were saved in an MS Excel spreadsheet. A data extraction form was used to obtain the authors, year of publication, country, research types, average age, sample size and related factors. Of the 21 articles included, 9 were cross-sectional studies and twelve were longitudinal studies. In the cross-sectional studies, the outcome variable was the intention of persistent participation, and the results provided the correlation coefficient r or β. In the longitudinal studies, the outcome variable was the behavior of persistent participation, and the results provided the mean and standard deviation of the different factors between persistent participation and sports dropout.

The Comprehensive Meta-Analysis (CMA) Version 3.0 software developed was used for meta-analysis and calculated the effect sizes and 95%CI. In the longitudinal studies of data analysis using ANOVA or t-test, the standard mean difference (SMD) and 95% confidence intervals (CIs) were calculated to evaluate the difference of all factors between persistent and dropout behaviors (Gillett, 2003). In the cross-sectional studies, the meta r was selected as the effect size to evaluate the relationship between different factors and persistent participation intention (Rosenthal and Dimatteo, 2001). When a regression β coefficient was reported, it would be converted into correlation r according to the formula recommended by Brown ($r = \beta + 0.5\lambda$, where λ equals 1 when β is non-negative and 0 when is negative) (Peterson and Brown, 2005). Based on the r and the sample size, the meta r was calculated using by CMA 3.0 software.

Assessment of Study Quality

A quality appraisal was performed to minimize bias and improve the reliability of our findings. Two reviewers (MZ and XCW) independently assessed the quality of each study through the Quality in Prognosis Studies (QUIPS) checklist, which includes 6 domains: study participation, study attrition, prognostic factor measurement, outcome measurement, study confounding, statistical analysis and reporting (Hayden et al., 2006, 2013) (**Supplementary Table 2**). According to the evaluation criteria of the QUIPS, if any of the six domains was high risk, the quality was rated as "high" risk. Meanwhile, if none of the six domains was high risk or at least four domains were low risk, the quality was rated as "low" risk; Any cases other than these two rules were rated as "moderate" risk (Rabiee et al., 2021). Disagreements were discussed in a consensus meeting and agreement was reached by consulting a third reviewer (BS).

Heterogeneity among the studies was examined through a Q-test followed by the I^2 statistic (Higgins et al., 2003). If $I^2 \leq 50\%$ and $P > 0.05$ in the Q-test, the heterogeneity was considered as not important and the fixed-effects model was performed. On the contrary, if $I^2 > 50\%$ and $P < 0.05$ in the Q-test showed substantial heterogeneity, then the random-effects model was performed. The sensitivity was examined by comparing the difference in the effect sizes between the fixed-effects model and the-random effects model. The results are reliable if no difference was observed.

Assessment of publication bias was performed with Nfs (Fail safe number). The higher the Nfs value, the more unpublished studies needed to reverse the meta-analysis results, which meant that the publication bias was smaller and the meta-analysis results were more stable. According to the recommendation, no publication bias would occur if the value of Nfs was greater than $5k + 10$ ($k \geq 3$; k refers to the number of included studies).

RESULTS

Overview of the Studies

Tables 2, **3** show that 21 articles (published from 2001 to 2021) were included, with a total sample size of 1,199. The surveyed countries included the USA (19.04%), Australia (19.04%), Spain (14.29%), Portugal (4.76%), Iran (4.76%), Finland (9.52%), France (14.29%), Estonia (9.52%), and Canada (4.76%). Among the 21 articles retained, 9 were cross-sectional studies (42.86%) and 12 were longitudinal studies (57.14%). The motivation theories adopted in these articles were mainly AGT and SDT. In the cross-sectional studies, the major outcome was persistent intention, which was measured in the form of questionnaire, such as PMCSQ, SMS, SCM and so on (seen in the **Table 2**). There were eight factors mentioned in included articles, including sports enjoyment, parental support, coach support, peer support, basic psychological needs, sports competence, task-involved climate and task orientation. In addition, 12 longitudinal studies were on persistent participation behavior, which compared the differences between several factors between persistent participation and dropout in sports. In these studies, the outcome was encoded with 1 (indicated persistent participants) and 0 (indicated dropouts). The duration of the longitudinal study ranged from 8 to 24 months, with an average of 14 months. There were 18 factors were mentioned in included articles, including: task-involved climate, ego-involved climate, basic psychological needs, persistent intention, intrinsic motivation,

FIGURE 1 | Flow diagram.
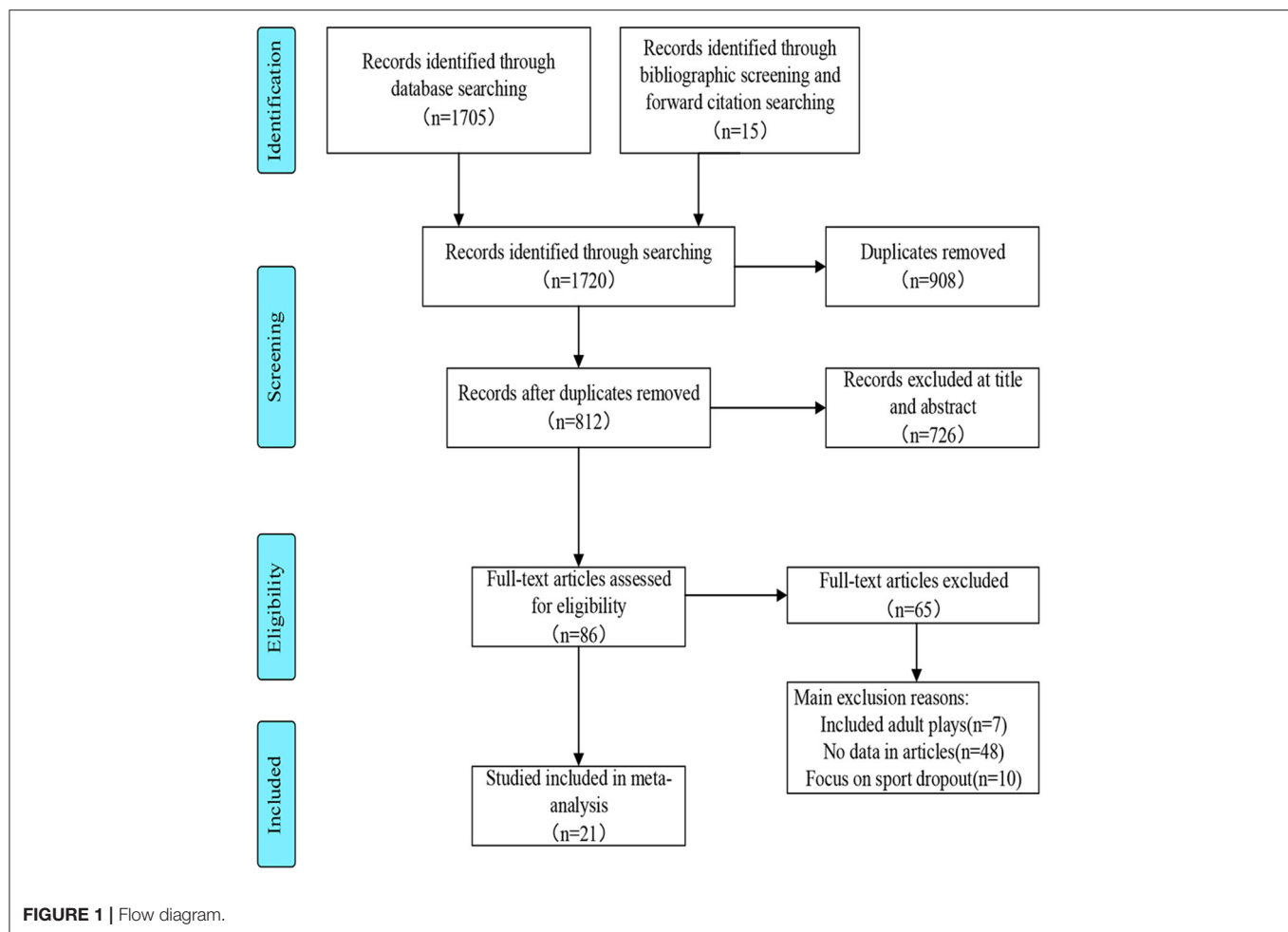
introjected regulation, amotivation, identified regulation, external regulation, parental support, coach support, peer support, sports competence, task orientation, ego orientation, years of involvement, amount of training and sports enjoyment.

Heterogeneity

In the longitudinal studies, given the substantial heterogeneity of persistent intention ($I^2 = 89\%$), parental support ($I^2 = 61\%$), coach support ($I^2 = 95\%$), peer support ($I^2 = 82\%$), and intrinsic motivation ($I^2 = 98\%$), a random-effect model was used to analyze the difference between persistent participation and sports dropout. A fixed-effect model was used to analysis for basic psychological needs ($I^2 = 48\%$) and sports competence ($I^2 = 0\%$) as low heterogeneity was observed. In the cross-sectional studies, for coach support ($I^2 = 98\%$) and basic psychological needs ($I^2 = 92\%$), a random-effect model has used to analyze the correlation between factors and participation intention. A fixed-effect model was used to analysis for sports enjoyment, parental support, peer support and sports competence as low heterogeneity was observed.

Sensitivity and Publication Bias

In the statistical process with a fixed-effects or random-effects model, no significant difference among effect sizes was observed

after removing each article in turn, nor was 95%CI. The significance of all factors did not change. Hence, the sensitivity of the included article was low, and the result of the meta-analysis was more reliable. **Tables 5**, **6** showed that the Nfs of parental support, peer support and sport competence were low, indicating that more articles were needed to revise the results of meta-analysis. In addition, the Nfs of other factors were greater than the recommended values ($5k + 10$), indicating the absence of publication bias in these studies. The final assessment showed that 12 articles were low risk, five articles were moderate risk, and two articles were high risk (**Table 4**). A high risk of bias was awarded to two studies mainly because inclusion and exclusion criteria were failure to report, participants lost to follow-up were not adequately described, and important potential confounders were not accounted for in the analysis and selective reporting of results.

Meta-Analysis

According to the calculation results of meta r, six factors were significantly related to the intention to persist (shown in **Table 5**). Following the recommendation in Lipsey et al., the meta $r < 0.25$ represented weak correlation, $0.25 < r < 0.4$ represented moderate correlation, and $r > 0.4$ represented high correlation (Lipsey and Wilson, 2000). The results showed that among

TABLE 2 | Basic characteristics of cross-sectional studies.

No.	Study	Country	Age	Sample	Sports	Theory	Tools	Factors related to persistent intention
1	Alvarez (2012)	Spain	14.77	370	soccer	SDT; AGT	PMCSQ-2; SMS	Task-involved climate ($\beta = 0.10$), Competence needs ($\beta = 0.11$), Autonomy needs ($\beta = 0.16$), Relatedness needs ($\beta = 0.06$)
2	Atkins (2013)	USA	12.7	227	volleyball, track, basketball, soccer	N/A	PDPR; MCYSQ; PSDQ; SCM	Sports enjoyment ($\beta = 0.40$), Sport competence ($\beta = 0.1$), Sport enjoyment ($\beta = 0.34$)
3	Atkins (2015)	USA	13.8	405	football, basketball, golf, hockey, swimming	AGT	MCYSQ; TEOSQ; PIMCQ-2; SCM	Peer support ($\beta = 0.16$), Parental support ($\beta = 0.24$), Task orientation ($\beta = 0.51$), coach support ($\beta = 0.13$), Sport competence ($\beta = 0.20$), Sport enjoyment ($\beta = 0.48$)
4	Gucciardi and Jackson (2015)	Australia	17.03	292	archery, golf, rugby triathlon, tennis, football, basketball	TPB; BPN	Not reported	Attitude, Perceptual behavior control
5	Gardner (2016)	Australia	13.03	313	soccer, netball, dancing, swimming	AGT	SCM; PPSS; SFQS; CARTQ	Parental support ($r = 0.18$), Coach support ($r = 0.33$), Friendship quality ($r = 0.17$), Peer acceptance ($r = 0.16$), sports enjoyment ($r = 0.50$), Social climate ($\beta = -0.18$), Friendship quality ($\beta = -0.14$)
6	Gardner (2017a)	Australia	13.03	327	soccer, netball, dancing	AGT	CNAAQ-2	Incremental beliefs ($\beta = 0.02$), Entity beliefs ($\beta = 0.001$)
7	Keshtidar (2017)	Iran	12.93	269	N/A	SDT; AGT	BRSQ	Task orientation ($r = 0.21$), Ego orientation ($r = 0.24$), Autonomous motivation ($r = 0.37$), Controlled motivation ($r = 0.12$)
8	Teixeira (2020)	Portugal	16.65	799	swimming	SDT	MCSYS; BPNES; BRSQ; PACES	Task-involved climate ($r = 0.085$), BPN satisfactory ($r = 0.358$), Sports motivation ($r = 0.165$), Sports enjoyment ($r = 0.452$)
9	Wekesser (2021)	USA	13.83	148	basketball, baseball	SDT	CARTQ	Coach support ($\beta = 0.341$)

the factors related to participation intention, sports enjoyment reached high correlation; basic psychological needs and coach support reached moderate correlation, parental support, peer support and sports competence reached low correlation.

By calculating the effect sizes (shown in **Table 6**), the results indicate that the seven factors had significant differences in terms of persistent participation and dropout, including: persistent intention, parental support, coach support, peer support, basic psychological needs, intrinsic motivation and sports competence. According to the recommendation of Cohen, the benchmarks of SMD = 0.3, 0.5, and 0.8 represent low, moderate and high effects, respectively (Field and Gillett, 2010; Thompson et al., 2018). The above results indicated that persistent intention reached a large effect; coach support, peer support and intrinsic motivation reached medium effects; parental support, basic psychological needs and sports competence reached small effects.

DISCUSSION

Although numerous studies identify the factors of persistent participation in youth sports, this review synthesizes the factors of persistent participation by using the methods of meta-analysis. Due to the different research perspectives and theories adopted by researchers, the understanding of persistent participation in

youth sports also differs, making it difficult to fully reflect the influencing factors of persistent participation. The strength or significance of some factors are also inconsistent in different articles. In this review we summarized the primary factors of persistent participation and conducted a meta-analysis of available effect sizes to assess their respective strengths of association with persistent participation in youth sport. Our findings showed that sports enjoyment was highly correlated with persistent intention, while persistent intention was highly correlated with persistent behavior. In addition, parental support, coach support, peer support, basic psychological needs and sports competence were the primary factors associated with persistent intention and persistent behavior, respectively.

Consistent with previous studies, sports enjoyment and persistent intention were the two important variables for studying sports behavior (Quested et al., 2013; Gardner et al., 2016). Many researchers have also confirmed that sports enjoyment and intention were the key motivational processes that affected teenagers' persistent participation in sports, and lack of enjoyment was the main reason for dropout (Gardner et al., 2017). In the present study, sports enjoyment was highly correlated with persistent intention. However, among the factors of persistent behavior, the factor of sports enjoyment was not identified. The main reason for this finding was that among the 12

TABLE 3 | Basic characteristics of longitudinal studies.

No.	Study	country	Age	Sample	Sports	Theory	Tools	Factors related to persistent participation
1	Bars et al. (2009)	France	16.9	104	Judoka	AGT	SOGIRSQ; POSQ; GSE; PCJ	Coach support, parental support, peer support, task orientation, ego orientation, sport competence, self-esteem, physical condition, competition level
2	Calvo (2010)	Spain	14.3	492	Soccer	SDT	SMS	Amotivation, intrinsic motivation, identified regulation, introjected regulation, external regulation
3	Guillet et al. (2002)	France	16.06	253	Handball	SEM	SMS	Basic psychological needs, coach support, persistent intention, years of involvement, amount of training, sports commitment
4	Joesaar (2011a)	Estonia	12.7	659	Basketball, volleyball, soccer, swimming, badminton	AGT; SDT	MCYSQ; SCQ; SMS; BPNES	Coach support, parental support, basic psychological needs, task-involved climate, self-determination motivation
5	Joesaar (2011b)	Estonia	13.19	424	Basketball, soccer, volleyball	AGT; SDT	MCYSQ; BPNES; SMS	Task-involved climate, ego-involved climate, autonomy needs, competence needs, relatedness needs, intrinsic motivation
6	Pelletier (2001)	Canada	15.6	369	Swimming	SDT	SMS	Intrinsic motivation, identified regulation, introjected regulation, external regulation, amotivation, coach support
7	Rottensteiner (2015a)	Finland	15.09	1962	Soccer, ice hockey, basketball	AGT; SDT	PPCS; SMS	Task orientation, ego orientation, sport competence, persistent intention, self-determination motivation
8	Rottensteiner (2015b)	Finland	15.5	2235	Football, ice hockey, basketball	AGT	CART-Q; PMCSQ	Coach support, task-involved climate, ego-involved climate, years of involvement, amount of training, competition level
9	Ullrichfrench (2009)	USA	11.7	186	Soccer	SDT	SFQS; SEC; SMS	Parental support, peer support, sport competence, sports enjoyment, sports stress
10	Gardner (2017b)	Australia	13.01	373	N/A	FIT; TPB	SCM	Enjoyment, intention, perceived competence, parental support, coach support, peer support, friendship quality
11	Guzman (2012)	Spnish	15.3	857	Multiple sports	SDT	BPNS; SMS	Basic psychological needs, intention, perceived conflict
12	Sarrazin (2002)	Franch	14.07	335	Handball	SDT	SMS; PMCSQ	Intention, self-determination motivation

PMCSQ-2, perceived motivational climate in sport questionnaire-2; SMS, sport motivation scale; SCMAM, social-cognitive model of achievement motivation; CNAAQ-2, conceptions of the nature of athletic ability questionnaire-version 2; MCYSQ, motivational climate in youth sport questionnaire; PSDQ, physical self-description questionnaire; SCM, sport commitment model; TEOSQ, task and ego orientation in sport questionnaire; PIMCQ-2, parental initiated motivational climate questionnaire 2; PPSS, perceived parental support scale; SFQS, sport friendship quality scale; CART-Q, coach athlete relationship questionnaire; BRSQ, behavioral regulation in sports questionnaire; MCSYS, motivational climate sport youth scale; BPNES, basic psychological needs exercise scale; BRSQ, behavioral regulation in sport scale; PACES, physical activity enjoyment scale; SOGIRSQ, significant others' goal-involving roles in sport questionnaire; POSQ, perception of success questionnaire; GSE, global self-esteem scale; PCJ, perceived competence in judo; BPNES, basic psychological needs in exercise scale; SCQ, sport climate questionnaire; PPCS, perceived physical competence scale; SFQS, sport friendship quality scale; SEC, sport enjoyment scale.

longitudinal studies, only two articles demonstrated the influence of sports enjoyment on persistent behavior. Hence, it did not meet the criteria of selection, which should be mentioned in more than two articles. There was a medium effect between intrinsic motivation and persistent behavior, but the extrinsic motivation including three forms of regulation had no significant effect. Although many researchers confirmed that intrinsic motivation and amotivation were the main factors that affect athletes' persistent participation in sports, the conclusions of the studies on the influence of different forms of extrinsic motivation on participation behavior were inconsistent. For example, Vallerand and Rousseau (2001) found that identity regulation was also an important part of athletes' performance, in addition to intrinsic motivation. Pelletier et al. (2001) also believed that a significant difference in identity regulation between persistent and dropout athletes existed, but no significant difference in introjected regulation.

Many researchers indicated that parental support, coach support and peer support were significantly correlated with persistent intention and behavior (Harwood et al., 2015; Monteiro et al., 2018b). In the current study, parental support weakly correlated with persistent intention and persistent behavior. The reason might be children with parental support tended to experience more enjoyment and intrinsic motivation, and thus, they were more likely to continue to participate (Fredricks and Eccles, 2002). However, as children grow older, parents' support gradually decreased because the learning tasks increased.

The relationship between coach support and persistent intention was moderately correlated along with the behavior of persistent participation. The factor of coach support was a key component of the motivational climate, which was characterized by a high sense of intimacy, commitment, complementarity and common orientation (Jowett and Ntoumanis, 2004). Many

TABLE 4 | QUIPS risk of bias assessment.

Study	Study participation	Study attrition	Factor measurement	Outcome measurement	Confounding measurement	Statistical analysis	Overall quality
Alvarez (2012)	Moderate	N/A[a]	Low	Low	N/A	Low	Low
Atkins (2013)	Low	N/A	Low	Low	Moderate	Low	Low
Atkins (2015)	Low	N/A	Low	Low	N/A	Low	Low
Gucciardi and Jackson (2015)	Moderate	N/A	Low	Low	Moderate	Low	Moderate
Gardner et al. (2016)	Low	N/A	Low	Low	Moderate	Low	Low
Gardner (2017a)	Low	N/A	Low	Low	Moderate	Low	Low
Keshtidar (2017)	Moderate	N/A	Moderate	Low	N/A	Moderate	Moderate
Teixeira (2020)	Moderate	N/A	Low	Low	N/A	Low	Low
Wekesser (2021)	Low	N/A	Low	Low	N/A	Low	Low
Bars et al. (2009)	Moderate	N/A	Low	Low	N/A	Moderate	Moderate
Calvo (2010)	Moderate	N/A	Low	Moderate	N/A	Moderate	Moderate
Guillet et al. (2002)	Moderate	N/A	High	Low	N/A	Low	High
Joesaar (2011a)	Moderate	N/A	Low	Low	N/A	Moderate	Moderate
Joesaar (2011b)	Moderate	N/A	Low	Low	N/A	Low	Low
Pelletier et al. (2001)	Moderate	N/A	Low	Low	Moderate	High	High
Rottensteiner (2015a)	Moderate	N/A	Low	Low	N/A	Low	Low
Rottensteiner (2015b)	Low	N/A	Low	Low	N/A	Low	Low
Ullrich-French (2009)	Low	N/A	Low	Low	Moderate	Low	Low
Gardner (2017b)	Low	N/A	Low	Low	Moderate	Low	Low
Guzman (2012)	Low	N/A	Low	Low	Moderate	Low	Low
Sarrazin et al. (2002)	Low	N/A	Low	Low	Moderate	Low	Low

[a] N/A, Not applicable.

TABLE 5 | Meta-Analysis of factors related to persistent participation intention.

Factors	k	I^2	p	Model	Meta r	95%CI	z	p	Nfs	Strength
Sports enjoyment	4	47%	0.128	Fixed-effects Model	0.45	0.42–0.49	20.32	0.000	395	High
Basic psychological needs	3	92%	0.000	Random-effects Model	0.41	0.27–0.50	5.37	0.000	305	Medium
Coach support	4	98%	0.000	Random-effects Model	0.43	0.08–0.69	2.34	0.020	185	Medium
Parental support	3	0%	0.410	Fixed-effects Model	0.20	0.13–0.26	5.98	0.000	23	Low
Sport competence	3	0%	0.372	Fixed-effects Model	0.18	0.11–0.24	5.10	0.000	17	Low
Peer support	3	0%	0.933	Fixed-effects Model	0.17	0.10–0.23	5.02	0.000	17	Low

psychological outcomes in sports, including motivation and intention to participate, were related to coach support (Riley and Smith, 2011; Rocchi et al., 2017). However, low-quality coach-athlete relationships, including coach conflict, coach's control styles, lack of encouragement, and an overemphasis on victory were usually associated with sports dropout behavior (Gearity and Murray, 2011).

A significantly positive relationship between peer support and intention and behavior of persistent participation was also observed. In sports, young people regarded the perceived peer acceptance and friendship as one of the driving forces for persistent participation (Keegan et al., 2010). Ullrichfrench and Smith (2006) found that peer support was significantly correlated with persistent participation intention, and high-quality friendship could buffer negative results related to acceptance.

The relationship between basic psychological needs and persistent intention was moderately correlated but weakly correlated with persistent behavior. For example, Guillet et al. (2002) confirmed that persistent players perceived themselves as significantly more competent, more autonomous and more related to their team than dropout players. Joesaar et al. (2011) also supported the results in which dropout athletes' satisfaction with autonomy, competence and relatedness needs were lower than that of persistent athletes. According to the self-determination theory, only when the 3 basic psychological needs (competence, autonomy and relatedness) were satisfactory could athletes maintain the motivation of self-determination. On the contrary, uncertain motivation and incentive forms were promoted, which might lead to sports dropout (Sarrazin et al., 2002).

The results of the research on the relationship between sports competence and persistent participation were inconsistent. Athletes with better sports competence were generally believed to be more likely to continue to participate in sports, and

TABLE 6 | Meta-Analysis of factors related to persistent participation behavior.

Factor	k	I^2	p	Model	SMD	95%CI	z	p	Nfs	Strength
Coach support	5	95%	0.000	Random-effects Model	0.68	0.27–1.10	3.22	0.001	288	Medium
Peer support	3	82%	0.004	Random-effects Model	0.50	0.07–0.92	2.28	0.022	20	Medium
Parental support	4	61%	0.050	Random-effects Model	0.37	0.11–0.62	2.79	0.005	20	Low
Sport competence	3	0%	0.396	Fixed-effects Model	0.33	0.24–0.43	6.62	0.000	25	Low
Basic psychological needs	4	48%	0.123	Fixed-effects Model	0.29	0.21–0.38	6.81	0.000	43	Low
Intrinsic motivation	5	98%	0.000	Random-effects Model	0.74	0.18–1.31	2.58	0.010	322	Medium
Persistent intention	3	89%	0.000	Random-effects Model	1.13	0.70–1.56	5.12	0.000	246	High

the perceived competence was considered to be an important predictor of persistent behavior (Soderstrom et al., 2018). The comparative study of persistent behavior and sports dropout indicated that the score of sports competence of dropout athletes was significantly lower than that of persistent athletes. On the contrary, Bars et al. (2009) and Calvo et al. (2010) believed that sports competence was not an important predictor of persistent participation, and relatedness and autonomy might be more important than sports competence in explaining persistent participation or dropout behavior. The reason for the above inconsistency might be that different methods and tools were used to evaluate sports competence. For example, the tool with only 1 item used in Calvo's study might not be the best way to assess the sports competence of athletes.

In this study, among the included articles, although 2 ones studied years of involvement, meta-analysis was not carried out because they did not meet the criteria. In previous studies, years of involvement were significantly associated with persistent participation. Rottensteiner et al., 2015 suggested that persistent athletes appeared to show a higher level of competition, long years of participation and higher exercise frequency in sports than dropout athletes. However, Guillet et al. (2002) showed that although the years of involvement of persistent athletes were higher than those of dropout athletes, no difference in weekly exercise frequency could be observed between the two groups, and no significant correlation between years of involvement and persistent participation behavior. To sum up, not much evidence was found to prove the causal relationship between the years of involvement and persistent participation. In the future, the relationship between years of involvement and persistent participation behavior should be discussed further by expanding the sample of athletes.

CONCLUSION AND LIMITATIONS

The paper systematically reviews the different viewpoints and conclusions on the influencing factors of persistent participation in youth sports. By utilizing techniques of meta-analysis, this study synthesizes 6 factors related to the intention of persistent participation and seven factors related to the behavior of persistent participation in sports. It can provide a reference

for researchers to further understand the relationship between influencing factors and persistent participation in youth sports. In addition, this study strictly follows the principle of meta-analysis to collect and analyse data, making the analysis and results more standardized and reliable. It not only enriches the research content of persistent participation in youth sports but also provides insights into future research in this field.

Although the collected articles come from many important databases, it is still incomplete because the conference database was not retrieved. Second, there are inherent limitations in meta-analysis methods and the software used. For example, the selected factors must be mentioned more than twice in papers, resulting in incomplete factors. In addition, the effect size of some factors is small because few articles and samples related to these factors were found, and the results need to be confirmed further by more articles. Finally, this study only includes the independent variables directly related to the dependent variables as influencing factors, and future research should further consider the effects of mediating or moderating variables and the interaction of independent variables.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/**Supplementary Material**.

AUTHOR CONTRIBUTIONS

MZ draft almost the manuscript. X-CW did data collection and coding and data analysis. BS contributed to study design, supervision, and paper review. All authors contributed to the article and approved the submitted version.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.871936/full#supplementary-material

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The Role of Positive and Negative Information Processing in COVID-19 Vaccine Uptake in Women of Generation X, Y, and Z: The Power of Good is Stronger Than Bad in Youngsters?

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Background: Positive and negative focus in information processing associated with age has a diverse role in COVID-19 vaccine uptake. The aim of the study was the exploration of the generational diversity among psychological predictors of COVID-19 vaccine uptake.

Methods: A cross-sectional research was conducted. The sample included 978 Hungarian women. Based on former literature findings, the COVID-19 vaccine uptake predictors were chosen from the health beliefs model, COVID-19 vaccine hesitancy, and psychological flexibility. Multivariate logistic regression analysis was conducted to investigate the predictors of COVID-19 vaccine uptake in women of Gen X, Gen Y, and Gen Z.

Results: In Gen X women, the influence of significant predictors are more prone to the positivity in COVID-19 vaccine uptake behavior, *perceived benefits* being the most relevant, increasing the likelihood of vaccine uptake more than four times. In Gen Y women, *perceived barriers, lack of confidence/skepticism* and *avoidance* significantly reduce the probability of vaccine uptake, showing an accentuated negative focus in information processing related to COVID-19 vaccination. The vaccine uptake in Gen Z is predicted only by the *perceived benefits*, and the likelihood of COVID-19 vaccine uptake is heightened in chance more than 19 times.

Conclusion: Women belonging to Gen X or Gen Y, the *perceived benefits* hold the key to vaccine uptake, while in women of Gen Z, low risks, lack of threats, and accessibility could motivate the decision of vaccine uptake. The findings are useful in generation-adapted vaccination campaigns and can also serve as inspiration for evolutionary psychology studies on health behavior and the broad area of study in cognitive biases in health information processing.

Keywords: vaccine uptake, vaccine hesitancy, psychological flexibility, generational identity, health belief model, women, cognition, health

INTRODUCTION

The COVID-19 disease control is a still ongoing worldwide phenomenon in 2022. All global epidemiological waves of the disease, even the Omicron variant, were targeted effectively with the help of the COVID-19 vaccines, which significantly reduced the emergency cases and hospitalization risk of ill patients (Embi et al., 2021; Thompson et al., 2022). The government in many countries introduced the booster vaccine protocol, with the third and fourth dose (Falsey et al., 2021; Patalon et al., 2021), for lowering the risk of severe symptoms in their population. Despite the presence of scientifically significant data on the beneficial effects of the COVID-19 vaccines, the uptake intention of individuals globally is far from ideal, even if the vaccines are available.

Age and Information Interpretation Bias in Health Behavior

Psychologically, individual illness prevention behavior is influenced by negative and positive information processing (Taylor et al., 2000; Baumeister et al., 2001). The role of different factors varies across domains of health behavior. In different areas of COVID-19 disease prevention with a medical priority (social distancing and hygiene) negative information processing factors (linked to health threats, e.g., infection prevention), whilst in other areas (information seeking and health behavior/ healthy lifestyle) positive information related seemed to count more (Marschalko et al., 2021). The vaccination intention and actual uptake decision were predicted in many COVID-19-related studies by an amalgam of psychological factors which have personal beliefs, attitudes, and cognitive evaluations as a consolidating base. These factors were targeted in former studies through comprehensive models, for example, the health belief model, in the context of intra-individual variables which favor optimism and appreciation of personal resources, for example, psychological flexibility, and also in vaccine-specific approaches, for example, vaccine hesitancy.

Age is a positive predictor of COVID-19 vaccine uptake (Bish et al., 2011) and older individuals tend to listen more to the physician's vaccine recommendations (Coe et al., 2012; Shmueli, 2020; Wong et al., 2020; Hossain et al., 2021). Furthermore, older individuals tend to favor positive over negative information, a preferential shift toward emotionally positive information was highlighted in the literature (Carstensen and Mikels, 2005; Carstensen, 2006; Reed et al., 2014). In case of elderly individuals, the underlying mechanisms were linked especially to better emotional regulation skills (Kensinger and Schacter, 2008; Leclerc and Kensinger, 2008; Brassen et al., 2011) and to a more adapted assessment of reality. Due to the passing of time, older people perceive the positive side of personal circumstances and interpret happenings in the social and emotional contexts in a more positive way (Carstensen and Mikels, 2005; Carstensen, 2006).

A quantitative meta-analytic study, that included 100 studies and more than 7,000 participants, concluded that the negativity bias is more likely in youth (Reed et al., 2014). The results are consistent with evolutionary-focused findings (Baumeister et al., 2001). The age-related positivity effect on cognition is highlighted in many studies (Isaacowitz and Blanchard-Fields, 2012; Chowdhury et al., 2013). Optimism, as the tendency to overestimate future positive events over negative ones (Weinstein, 1980; Chowdhury et al., 2013), however, goes against this age-related progressive positivity effect, as it was evinced in younger individuals, as well (Isaacowitz, 2005; Lachman et al., 2008). The explanation of the presence of optimism in young adults was linked to age-related brain development processes, which favor the positively biased assessment of desirable outcomes (Sharot et al., 2011, 2012a,b). Reed et al. (2014) argue that behavior, cognition, and emotion, potentially holding a bias risk, are influenced by personal motivation. Murphy and Isaacowitz (2008) argued that in the case of emotional stimuli, there were rather a few age-related differences in positive and negative interpretation if results were compared to neutral stimuli, and smaller effects were found for emotion salience and negativity preferences in older individuals compared to younger adults.

The Role of the Health Belief Model in COVID-19 Vaccine Uptake Prediction

In an integrated framework on general and specific health behavior, the *health belief model (HBM)* includes a variety of positive and negative factors which can contribute to personal decisions. HBM states that general prevention and health maintenance behavior is influenced by individual beliefs and benefits/risk assessments in which the personal cognition processing is conclusive for action. The model presents the following factors: *perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy* (Rosenstock, 1974; Champion and Skinner, 2008; Orji et al., 2012). The HBM suggests that individual characteristics of a patient (e.g., demographics and knowledge) directly impacts individual beliefs and lead to individual intentions and health behavior decisions. The HBM model was highlighted as an important role in vaccine uptake in the case of the H1N1 Influenza vaccine (Bish et al., 2011; Coe et al., 2012), Swine Flu vaccine (Myers and Goodwin, 2011), Hepatitis B vaccine (Huynh et al., 2021), and COVID-19 vaccines (Mercadante and Law, 2020; Shmueli, 2020; Wong et al., 2020; Hossain et al., 2021; Zampetakis and Melas, 2021). A systematic review pointed toward the important role of HBM in the case of general vaccine uptake in adults with a high-risk physical health condition (Borthwick et al., 2020). Perceived benefits, along with perceived barriers, were evinced having a significant role in the vaccine uptake decision of individuals (Myers and Goodwin, 2011; Mercadante and Law, 2020; Shmueli, 2020; Wong et al., 2020; Hossain et al., 2021). Risk perception or susceptibility influenced the vaccination intent (Bish et al., 2011; Coe et al., 2012; Shmueli, 2020; Wong et al., 2020; Hossain et al., 2021; Zampetakis and Melas, 2021). Past flu vaccine uptake was predictive of new vaccine uptake, highlighting a general beneficial attitude toward vaccines as a method of prevention of illnesses (Bish et al., 2011; Myers and Goodwin, 2011; Coe et al., 2012).

The Role of Vaccine Hesitancy in COVID-19 Vaccine Uptake Prediction

In vaccine-specific approach, the *vaccine hesitancy (VH)* is defined on a behavior continuum in the literature, which comprises the possibility of total refusal of vaccine intake on one side and the acceptance of vaccine intake on the other. If the hesitancy is very strong then the uptake of the jab is refused by the patients (Dubé et al., 2013). The COVID-19 vaccine hesitancy was linked to the possibility of vaccine conspiracy beliefs (Freeman et al., 2020), lack of confidence in beneficial effects, and vaccine risk appreciation (Rodriguez et al., 2021). Vaccine hesitancy is also defined by skepticism, vaccine risk, and fear of the COVID-19 vaccine (Kotta et al., 2021a). Many recent studies evinced the significant role of hesitancy on COVID-19 vaccine uptake (Bhopal and Nielsen, 2020; Lucia et al., 2020; Machingaidze and Wiysonge, 2021; Solís Arce et al., 2021). Demographic variables also play their role in VH, and often older, well-educated individuals or those who suffer from chronic diseases are more open to accepting the vaccines (Freeman et al., 2020; Al Janabi and Pino, 2021; Al-Mohaithef et al., 2021; Paul et al., 2021; Truong et al., 2021).

The Role of Psychological Flexibility in COVID-19 Vaccine Uptake Prediction

From an intra-individual perspective, an important role in vaccine uptake is played by *psychological flexibility* (Wang and Zhang, 2021). This variable is defined through the individual's ability to accept rather than avoid negative thoughts and emotions about life circumstances (Hayes et al., 2006). Psychologically flexible individuals feel less anxiety and can cope resiliently in ambiguous circumstances even in health-related contexts. Individuals with chronic respiratory disease with higher reported levels of psychological flexibility were more likely to receive the seasonal influenza vaccination (Cheung and Mak, 2016). Psychologically more flexible parents tend to see the beneficial effects of COVID-19 vaccines in the case of their children (Wong et al., 2021). Psychological flexibility favors lifestyle-related prevention behavior in the COVID-19 pandemic (e.g., healthy diet and weekly exercise) and tends to have a stronger influence in the case of younger generations (Kotta et al., 2021b; Marschalko et al., 2021).

Aim of the Study

COVID-19 variants are continuously raising concerns in some parts of the world. COVID-19 vaccines will be necessary annually in some segments of the population. The personal cognitive interpretation tendencies (e.g., positive and negative bias/ focus), which guide health behavior and decisions like vaccine uptake, are diversely augmented in older and younger individuals. Based on results highlighted in the literature on positive and negative cognitive bias and shift in information processing associated with age, we assume a higher impact on COVID-19 vaccine uptake of benefits and positive interpretation-related variables in older individuals (Isaacowitz and Blanchard-Fields, 2012; Chowdhury

et al., 2013) and a higher role of negative information processing-related variables in younger adults (Baumeister et al., 2001; Reed et al., 2014).

The aim of the study was the exploration of the generational diversity among psychological predictors of COVID-19 vaccine uptake. Considering the predictive role of the health-related beliefs (e.g., susceptibility, severity, benefits, barriers, cues to action), psychological flexibility (avoidance, acceptance, harnessing), COVID-19 vaccine hesitancy (skepticism, risk perception, fear) on vaccine uptake, as formerly highlighted in the literature, and the age-related vulnerability, the present study proposed the analysis of these variables in Gen Z, Gen Y, and Gen X. The differential predictive weight of these psychological variables at different ages can bring new insight to the literature.

MEASUREMENT AND METHODS

Participants

The sample was recruited from the general population of Hungary and Ethnic Hungarians in Romania (Transylvania), and the participants were Hungarian speakers. The snowball sampling method was used online, and the gathered participants included <15% males. For generalizability error avoidance purposes, the authors decided on the inclusion of female participants only. A total of 978 women were included in the study, and the authors grouped the participants into three distinct categories using a generation criteria list presented in the Dimock (2019) and the Beresford Research (n.d.) studies. A generation is a group of people born around the same time with similar characteristics, preferences, and values over their lifetimes: Gen Z (born 1997–2012, ages 10–25 years), Gen Y or Millennials (born 1981–1996, ages 26–41 years), and Gen X (born 1965–1980, ages 42–57 years). In the present study, the Gen X age interval was expanded (ages 42–64) so that the three examined generation sample size is approximately the same. Descriptive statistics of the participants are presented in **Table 1**, separately for the three generations (Gen Z, Gen Y, and Gen X).

Measurements

Demographic Information and COVID-19-Related Variables

A structured online questionnaire was elaborated to measure basic demographic information (age, country, and education), health-related variables (chronic disease, BMI, and flu vaccine past), and COVID-19-related variables (former or present COVID-19 diagnosis and vaccine uptake). The vaccine uptake was divided into two categories (not vaccinated and vaccinated).

Health Belief Model

The following constructs of the HBM model were measured: *perceived susceptibility* (subjective assessment of the risk of developing a health problem, e.g., "I am at risk of getting COVID-19"), *perceived severity* (subjective assessment of the severity of a health problem and its potential consequences, e.g., "I believe that COVID-19 is a severe health problem"), *perceived benefits* (individual and community benefits of taking action, e.g., "COVID-19 vaccines will work in preventing the disease"),

TABLE 1 | Baseline characteristics of the participants (*N* = 978).

	Gen Z (*n* = 227)	Gen Y (*n* = 363)	Gen X (*n* = 388)
Age	21.31 ± 1.85	34.92 ± 4.88	49.62 ± 5.21
Education (*n*, %)			
8 grades or less	-	1 (0.3%)	-
Professional school/10 grades	1 (0.4%)	1 (0.3%)	5 (1.3%)
High school without baccalaureate	1 (0.4%)	4 (1.1%)	18 (4.6%)
Baccalaureate	124 (54.6%)	67 (18.2%)	84 (21.6%)
College, university	81 (35.7%)	163 (44.9%)	183 (47.2%)
Master degree	20 (8.8%)	114 (31.4%)	76 (19.6%)
Doctoral degree	-	11 (3.0%)	17 (4.4%)
Other	-	3 (0.8%)	5 (1.3%)
Country (*n*, %)			
Ro	191 (84.1%)	98 (27%)	60 (15.5%)
Hu	36 (15.9%)	265 (73%)	328 (84.5%)
Chronic disease (*n*, %)			
No	197 (86.8%)	291 (80.2%)	268 (69.1%)
Yes	30 (13.2%)	72 (19.8%)	120 (30.9%)
BMI	21.93 ± 4.01	24.31 ± 5.09	26.41 ± 5.29
Diagnosed_COVID-19 (*n*, %)			
No	155 (68.3%)	267 (73.6%)	282 (72.7%)
Yes	36 (15.9%)	58 (16%)	79 (20.4%)
Not sure	36 (15.9%)	38 (10.5%)	27 (7%)
Flu vaccine past (*n*, %)			
No	165 (72.7%)	301 (82.9%)	301 (77.6%)
Yes	62 (27.3%)	62 (17.1%)	87 (22.4%)
Susceptibility	3.16 ± 1.09	3.11 ± 1.17	2.68 ± 1.04
Severity	3.54 ± 1.11	3.68 ± 1.15	3.60 ± 1.22
Benefits	3.35 ± 1.39	3.26 ± 1.42	3.15 ± 1.51
Barriers	2.58 ± 1.06	2.63 ± 1.12	2.66 ± 1.15
Cues to action	3.27 ± 1.64	3.51 ± 1.79	3.68 ± 1.92
Avoidance	4.93 ± 1.35	5.25 ± 1.46	5.47 ± 1.44
Acceptance	4.73 ± 1.14	4.65 ± 1.24	4.64 ± 1.26
Harnessing	3.73 ± 1.12	3.34 ± 1.29	3.33 ± 1.29
Skepticism	2.79 ± 1.37	2.88 ± 1.42	2.97 ± 1.52
Risk	2.64 ± 1.10	2.65 ± 1.11	2.80 ± 1.25
Fear	1.49 ± 0.91	1.54 ± 0.95	1.59 ± 1.12

perceived barriers (safety and cost concerns of taking action, e.g., "Not enough research done on COVID-19 vaccines"), and *cues to action* (a trigger, an internal or external cue that is necessary for promoting engagement in health-promoting behaviors, e.g., "Family or close friend tested positive for COVID-19"). The context-specific/situational HBM items related to the exposure to COVID-19 were elaborated by Chu and Liu (2021). The Cronbach's alpha values in this study were as follows:0.89 for susceptibility, 0.91 for severity, 0.97 for benefits, 0.86 for barriers, and 0.66 for cues to action.

Multidimensional COVID-19 Vaccine Hesitancy Scale (CoVaH) is a 15-item self-report measure elaborated by Kotta et al. (2021a). The scale assesses the beliefs and attitudes beneath vaccination hesitancy and reasons for vaccine refusal in the context of COVID-19 through three subscales: *vaccine risk* [e.g., "COVID-19 vaccines can lead to severe allergic reactions (anaphylactic shock)"] measures the hesitancy due to possible adverse effects of the vaccines, *fear* [e.g., "I have chills (goosebumps) when I think about being vaccinated with one of the COVID-19 vaccines"] reflects the individual emotional and physiological reactions related to being vaccinated, and *lack of confidence/skepticism* [e.g., "COVID-19 vaccines are effective (R)"] is the hesitancy due to lack of confidence in the vaccine's beneficial effect on health and community. The scale was shown to have very good psychometric properties, Cronbach's alpha values were $\alpha = 0.94$ for skepticism, $\alpha = 0.89$ for risk, and α

= 0.89 for fear subscales, while the internal validity of the total scale is also excellent $\alpha = 0.94$ (Kotta et al., 2021a). In this study, Cronbach's alpha values were 0.95, 0.90, and 0.90 for skepticism, risk, and fear, respectively.

COVID-19 Health-Related Personal Psychological Flexibility Index (PPFI)

The 15 items of the Personal Psychological Flexibility Index (Kashdan et al., 2020) were used for measuring the trait-like ability to pursue valued life aims and daily goals despite the presence of distress. In the present research, a COVID-19 pandemic and health-related distress were targeted, and therefore the scale instruction was reformulated accordingly: "*Please take a few moments to think of an important goal that you are working on related to your health maintenance during COVID-19 pandemic. It must be one and only one goal. Don't choose too quickly. Take a few moments to think about it. After you choose the goal, please write it in the following blank: __. For each statement below, select the rating that best describes your thoughts and feelings about this goal.*" The PPFI targets flexibility on three subscales: acceptance (e.g., "I accept the setbacks when pursuing this goal"), avoidance (e.g., "I avoid the most difficult goal-related tasks"), and harnessing (e.g., "When faced with obstacles related to this goal, my frustration serves to energize me"). A 7-point Likert scale was applied for recording the answers from strongly disagree to strongly agree. The alpha coefficient of the total scale was 0.84, while test-retest reliability was also appropriate (Kashdan et al., 2020). In this study, Cronbach's alpha was 0.75, 0.88, and 0.72 for acceptance, avoidance, and harnessing, respectively.

Procedure

A cross-sectional study was carried out between May and June 2021, a year after the outbreak of the pandemic, when mass vaccination had already became available for almost everyone in Europe. A convenience sampling method, namely the snowball technique was applied; the online survey was promoted on social media platforms. After confirming eligibility (18 years of age or over) and providing informed consent to participate in the study, respondents completed the survey on Google Forms containing the demographic, health, and COVID-19-related queries and the COVID-19 Health-Related Personal Psychological Flexibility Index, the HBM Scale, and the CoVaH *Scale.* Anonymity was assured, and no personal identifiers were provided. Survey completion took ~15–20 min.

Data Screening

The online sampling method provided <15% male participants, and the authors decided upon a woman-focused analysis and data interpretations in a gender-specific manner, to lower the chance of bias in the generalizability of results. To investigate the established relations, SPSS (Statistical Package for the Social Sciences) version 23.0 was performed. The first set of analyses included screening data based on Field's (2009) and Tabachnick and Fidell's (2019) work. There were no variables with 5% or more missing values. Standardized z-scores were created for the major continuous variables to assess the outliers.

There were 95% of cases with an absolute value <1.96, and none of the cases had a value higher than 3.29. Due to the large sample size ($N = 978$), the normality distribution was checked using visual analysis and it revealed a mostly normal distributed sample.

Data Analysis

For statistically appropriate sample size calculation, a priori power analysis was performed using G*Power3 (Faul et al., 2007). All the data were presented as mean (M) and standard deviation (SD) for continuous variables and frequencies/percentages for categorical variables (see **Table 1**). The internal consistency of scales and subscales was assessed by calculating Cronbach alpha's reliability values. The probability value was set at 0.05. Three multivariate binary logistic regression analyses were conducted on three different generational groups (Gen X, Gen Y, and Gen Z) to establish the predictors of vaccine uptake. These predictors were chosen based on the literature. The assumptions were tested and the data fit the regression model. In the regression models, categorical variables were introduced as dummy variables and the unstandardized regression coefficients (*B*), standard errors (*SE*), WALD statistics, odds ratio [Exp (B)], and Nagelkerke R^2 value were calculated.

RESULTS

To investigate the generational diversity among psychological predictors of COVID-19 vaccine uptake, three logistic regression models were calculated for each generation. The binary outcome variable of the predictor model was the participant's COVID-19 vaccine uptake, in the following way: (1) *not vaccinated* and (2) *vaccinated.* Based on the theoretical background of the study that proves the importance of the health-related variables (e.g., flu vaccination or having a chronic disease) of the HBM model, psychological flexibility, and the vaccine hesitancy in predicting vaccination, no presumption on the differential importance was considered beforehand in the predictor analysis. Therefore, the enter method of the regression analysis was chosen, which is the most recommended method for building theories. The enter method is a forced entry method, where all the input variables are included simultaneously. This was considered by the authors to be the most suitable choice because all the predictors were given equal importance in this explorative research. Age and gender were not included in the analysis, because the generation grouping was made on age intervals, and there were only women participants included in this research, with similar ethnical backgrounds. **Table 2** and **Figure 1** present the results of the multivariate binary logistic regression.

The logistic regression model included as predictor variables, the following: the participants' education level, health behavior-related factors (chronic disease status, BMI value, being diagnosed or not with this disease, getting other flu vaccines in the past), the factors of vaccine hesitancy, the components of the HBM model, and the psychological flexibility.

The analyzed model for Gen Z explained 91% (Nagelkerke R^2) of the variance in COVID-19 vaccine uptake. Of all the psychological predictors, only the *perceived benefits (HBM)* were

TABLE 2 | Multivariate binary logistic regression results on COVID-19 vaccine uptake in women of Gen Z, Gen Y, and Gen X.

Predictor	Gen Z (n = 227)					Gen Y (n = 363)					Gen X (n = 388)				
	B	S.E. B	Wald	Exp (B)	CI (95%)	B	S.E. B	Wald	Exp (B)	CI (95%)	B	S.E. B	Wald	Exp (B)	CI (95%)
(Constant)	−6.80	9.38	0.53	0.01		20.75	6.19	11.26	1030651243.00		16.11	5.19	9.65	9925714.79	
Chronic disease (no = 0, yes = 1)	−0.44	1.34	0.11	0.64	0.05, 8.85	−1.27	0.78	2.66	0.28	0.06, 1.29	2.02	0.87	**5.42**	7.56	1.38, 41.50
BMI	0.26	0.14	3.43	1.30	0.99, 1.72	−0.02	0.06	0.08	0.98	0.87, 1.11	0.04	0.06	0.50	1.04	0.93, 1.17
Diagnosed COVID-19 Yes	1.20	1.25	0.90	3.28	0.28, 78.00	−1.92	0.78	**6.07**	0.15	0.03,0.68	0.28	1.15	0.06	1.32	0.14, 12.69
Not sure	0.24	1.42	0.03	1.27	0.08, 20.44	−2.71	1.11	**5.98**	0.07	0.01,0.58	−2.51	1.54	2.66	0.08	0.01,0.1.66
Flu vaccine uptake (in the past) (no = 0, yes = 1)	−2.82	1.18	**5.73**	0.06	0.01,0.60	−1.91	1.03	3.41	0.15	0.02, 1.12	−2.83	1.40	**4.14**	0.06	0.01, 0.90
Perceived susceptibility	0.11	0.53	0.04	1.11	0.39, 3.17	−0.48	0.29	2.71	0.62	0.35, 1.10	−0.88	0.38	**5.37**	0.41	0.20, 0.87
Perceived severity	−0.63	0.51	1.56	0.53	0.20, 1.44	0.52	0.33	2.49	1.69	0.88, 3.23	−0.43	0.40	1.12	0.65	0.30, 1.44
Perceived benefits	2.99	1.29	**5.21**	19.20	1.52, 242.55	0.06	0.55	0.01	1.06	0.36, 3.14	1.47	0.66	**4.90**	4.33	1.18, 15.85
Perceived barriers	−0.75	0.74	1.03	0.47	0.11, 2.02	−1.16	0.41	**8.02**	0.31	0.14,0.70	−0.34	0.54	0.39	0.71	0.25, 2.06
Cues to action	−0.04	0.34	0.01	0.96	0.49, 1.88	0.02	0.19	0.01	1.02	0.70, 1.47	0.03	0.23	0.02	1.03	0.66, 1.61
Avoidance	−0.43	0.36	1.45	0.65	0.32, 1.31	−0.49	0.22	**4.72**	0.61	0.39,0.95	−0.20	0.26	0.62	0.82	0.50, 1.35
Acceptance	0.72	0.57	1.63	2.06	0.68, 6.22	−0.06	0.25	0.05	0.94	0.58, 1.54	−0.31	0.27	1.31	0.73	0.43, 1.25
Harnessing	0.23	0.40	0.32	1.25	0.57, 2.75	−0.24	0.22	1.19	0.79	0.51,1.21	0.11	0.26	0.20	1.12	0.68, 1.86
Lack of confidence/ skepticism	−0.61	0.95	0.42	0.54	0.08, 3.50	−2.79	0.67	**17.17***	0.06	0.02,0.23	−2.31	0.65	**12.68***	0.10	0.03,0.35
Vaccine risk perception	−0.01	0.69	0.01	1.00	0.25, 3.85	0.67	0.44	2.36	1.96	0.83, 4.64	−1.22	0.48	**6.44**	0.30	0.11,0.76
Fear of vaccine	−1.37	0.83	2.74	0.25	0.05, 1.29	−0.73	0.41	3.25	0.48	0.22, 1.06	0.05	0.30	0.03	1.05	0.58, 1.91
Nagelkerke R^2	0.91					0.88					0.91				

*** $p < 0.001$, ** $p < 0.01$. We examined the predictor role of Health belief model (perceived severity, perceived benefits, perceived barriers, cues to action), Psychological flexibility (avoidance, acceptance, harnessing), and COVID-19 Vaccine hesitancy (vaccine risk/skepticism, vaccine risk perception, fear of vaccine) on COVID-19 vaccine uptake, in the women of Gen Z, Y, and X.

Statistically significant predictors are presented with bold style and accompanied by stars.

FIGURE 1 | Predictors of COVID-19 vaccine uptake in women of Gen X, Y, and Z. Values represent unstandardized beta (B) values from multivariate binary logistic regression results.
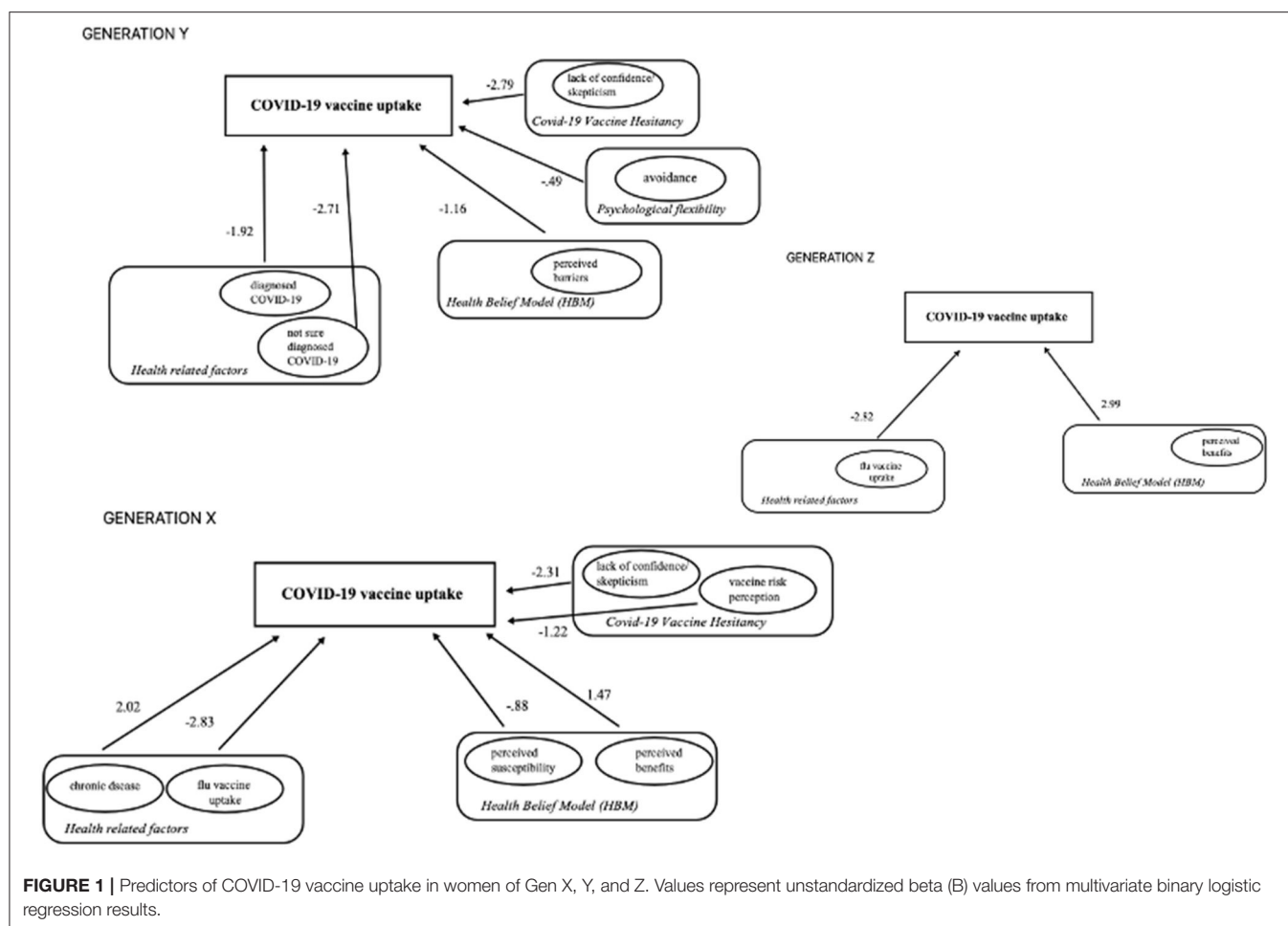
associated with the increased likelihood of the vaccine uptake. In health behavior-related variables, past flu vaccine uptake was a negative predictor of COVID-19 vaccine uptake chance in this generation (see **Table 2** and **Figure 1**).

Gen Y had many significant predictors of COVID-19 vaccine uptake. The model explained 88% (Nagelkerke R^2) of the variance of this behavior. *Perceived barriers* (HBM), *avoidance* (psychological flexibility), and *lack of confidence/skepticism* (CoVaH) in COVID-19 vaccine beneficial effects lowered the probability of getting the vaccine. As a health behavior-related predictor, being diagnosed with COVID-19 disease in Gen X women is associated with a reduction in the likelihood of COVID-19 vaccine uptake behavior. None of the analyzed predictors contoured as positive predictors in this case.

In the case of the oldest generation of women, Gen X, the model explained 91% (Nagelkerke R^2) of the variance of COVID-19 vaccine uptake. From the analyzed psychological predictors, the *perceived susceptibility* (HBM) and *perceived benefits* (HBM) played an important positive role in increasing the chance of COVID-19 vaccine uptake behavior. On the other hand, the COVID-19 vaccine hesitancy-related variables, like *lack of confidence/skepticism* in the vaccine's beneficial effect and the *vaccine risk* perception were significantly associated with a reduction in the likelihood of COVID-19 vaccine uptake. Health behavior-related predictors also hold an important role in this generation. The participants' chronic disease, the actual COVID-19 disease diagnosis, had a positive impact on the likelihood of COVID-19 vaccine uptake, and the seasonal/past flu vaccine uptake played a negative role in the chance of COVID-19 vaccine uptake behavior.

DISCUSSION AND CONCLUSION

COVID-19 disease control and prevention is efficiently targeted with vaccination. The newest variants, like Omicron, were targeted with booster dose application (Embi et al., 2021; Thompson et al., 2022), and there is a high chance of implementing COVID-19 vaccines in prevention schedules, similarly to the seasonal flu management. The present study was motivated by the scarcity of literature on generational diversity related to COVID-19 vaccine uptake, in the context of psychological predictors related to HBM, COVID-19 vaccine hesitancy, and psychological flexibility. The chosen variables were interpreted in the context of positive and negative information processing preferences associating age, in three generations of women: Gen X, Gen Y, and Gen Z.

The Role of Demographic and Health-Related Variables on COVID-19 Vaccine Uptake

From the assessed demographic and individually relevant variables (education, BMI), none contoured in a statistically significant way.

The only health behavior-related predictor which was important in at least two generations of women (Gen Z, Gen X) was the previous flu vaccine uptake. In both cases, this is a significant negative predictor of the likelihood of COVID-19 vaccine uptake. This result is in contradiction with former results in the literature, which have shown a positive association between past flu vaccine uptake and new vaccine uptake (Bish et al., 2011; Myers and Goodwin, 2011; Coe et al., 2012).

The presence of chronic disease was a significant predictor of vaccine uptake only in the case of Gen X, making the chance of COVID-19 vaccination higher than seven times. The result is in line with other findings on chronic disease and vaccine uptake (Freeman et al., 2020; Al Janabi and Pino, 2021; Al-Mohaithef et al., 2021; Paul et al., 2021; Truong et al., 2021), but none of these studies focused on generational diversity. Further studies are needed to analyze the potential moderator role of generational identity on the relationship between chronic disease and vaccination uptake.

The actual COVID-19 infection and related consequences had a diverse role in predicting the likelihood of COVID-19 vaccine uptake in two generations. Interestingly, in the case of Gen Y, the infection with the coronavirus made the vaccine uptake less likely.

Health Belief Model and COVID-19 Vaccine Uptake

The results of the study show a significant diversity especially in the case of perceived benefits from HBM, which is the strongest predictor in Gen Z and Gen X in actual COVID-19 vaccine uptake decision. The perception of benefits raises the chance of getting vaccinated more than 19 times in the case of Gen Z and more than 4 times in the case of Gen X. This variable from HBM is the strongest in both cases in the context of all considered psychological predictors, showing the important role of positive information processing-related aspects in COVID-19 vaccine uptake behavior. A new insight on the topic is related to the marked weight of positive information linked to the benefits of the vaccine in youngsters.

In the case of Gen X women, an important feature is the role of perceived susceptibility, and it is lowering the odds of getting the COVID-19 vaccine by 0.4 chance. Perceived barriers played a significant role only in the women of Gen Y, making it less probable for getting the jab with a 0.3 odds ratio.

The results on the HBM predictor role in COVID-19 vaccine uptake of different generations give partial support to the literature on the positive shift in information processing in the case of older adults (Carstensen, 2006; Isaacowitz and Blanchard-Fields, 2012; Chowdhury et al., 2013; Reed et al., 2014). The presence of such an important predictive power of perceived benefits in the case of individuals in their early twenties (Gen Z) is an intriguing result, because there is a scarcity of explanations

and also of similar results in health psychology. Former studies indicate mostly the presence of negative information processing power over positive ones in young people (Baumeister et al., 2001; Reed et al., 2014), which in our case was present only in the case of Gen Y (age above 26). One possible explanation of the high power of benefit perception in the COVID-19 vaccine uptake in Gen Z can be linked to brain developmental phases in young adults, which may trigger optimism around future estimations of desirable outcomes (Sharot et al., 2011, 2012a,b). The benefits promised by vaccines linked to restrictions of COVID-19 lockdown being potentially abolished could have triggered motivationally the youngest of the participants in favor of positive perception and the usage of extensively positive bias in health-related decisions, like vaccine uptake. The rare context of COVID-19 lockdown probably could trigger the future time-limited perspective approach even in the youngest, activating the positivity bias effects in information processing. The relationship between limited time perspective and positivity was found in former studies (Henry et al., 2017). Erbey et al. (2020) highlighted the role of a complex interplay of psychosocial and emotional features in positivity effects in information interpretation, evidencing limited future time perspective with a significant role even in young participants. In this context, we can argue that if specific health-related situation puts at risk the individually motivating environments, and if the young adult faces situations in which he/she perceives his or her future time (life) as being limited, positive bias is likely to appear, in concordance with the social-emotionality theory, which was formerly highlighted in case of the life-span theory (Carstensen and Mikels, 2005; Carstensen, 2006).

In COVID-19 prevention behavior, the perceived benefits were highlighted in many studies (Myers and Goodwin, 2011; Coe et al., 2012; Mercadante and Law, 2020; Shmueli, 2020; Wong et al., 2020; Hossain et al., 2021), but the literature is scarce on age and generational identity-related results. Generational diversity was shown in COVID-19 prevention behavior (Kotta et al., 2021b; Marschalko et al., 2021), but there is a high need for further understanding of this phenomenon.

Vaccine Hesitancy and COVID-19 Vaccine Uptake

COVID-19 vaccine hesitancy variables, such as skepticism, risk perception (on adverse effects), and fear contours only in two cases in COVID-19 vaccine uptake prediction, namely in Generation Y and Generation X. In the case of Gen Y, lack of confidence/skepticism lowered the chance of getting vaccinated by.06 times. In the case of Gen X, lack of confidence/skepticism and vaccine risk perception linked to COVID-19 vaccines lowered the COVID-19 vaccine uptake chance by 0.10 times. No predictor related to COVID-19 vaccine hesitancy was evidenced in the case of Gen Z women, and this data are pinpointing rather a lack of hesitancy in the women of the youngest generation.

Psychological Flexibility and COVID-19 Vaccine Uptake

Our findings on psychological flexibility highlighted only one predictor related to this variable, namely in the case of Gen Y

women, only the avoidance contoured as a significant negative predictor of COVID-19 vaccine uptake behavior. This variable lowers the chance of COVID-19 vaccine uptake by .06 times. Our study failed to show the results on the positive role of psychological flexibility on health behaviors and vaccine uptake, as in former studies (Cheung and Mak, 2016; Kotta et al., 2021b; Marschalko et al., 2021).

The Role of Information Interpretation Bias in COVID-19 Vaccination of Women Belonging to Different Generations

Generation Z

Gathering all significant predictors in every analyzed generation of women, we can say that the most pronounced focus is on the benefits of the COVID-19 vaccine, and positivity focus shows up in the case of the adults up to 25 years (Gen Z). In youngsters, besides the seasonal flu vaccine uptake (negative predictor), only the perceived benefits count positively in the likelihood of COVID-19 vaccine uptake, raising the odds more than 19 times. The role of positive information (e.g. benefits) linked to benefits from HBM is pointing toward an extremely positive shift in health-related perceptions, cognitions, and emotions in the youngsters (see **Figure 1**). No vaccine hesitancy variable was highlighted significantly in this generation. The extensive positivity can be justified in the context of age-related brain development aspects, which favor optimism (Sharot et al., 2012a,b). This finding on the exclusive role of positive information in Gen Z's COVID-19 vaccine uptake needs further research because it could hold information on specific health-related circumstances in which evolutionary gains are reinterpreted by young individuals, and negative information interpretation could be reframed from "bad is stronger than good" (Baumeister et al., 2001) in the context of perceived limited future time and individual approaches (Henry et al., 2017; Erbey et al., 2020) into "good is much better than bad, if my time is limited." The possible moderation effect of extreme lockdown could be in focus in this specific case and further studies are needed for the clarification of this new insight.

Generation Y

In the case of Gen Y, the chance of COVID-19 vaccine uptake is controlled mostly from a negative perspective. Those who got the infection tended to refuse the vaccine. Perceived barriers also played a role in lowering the probability of COVID-19 vaccine uptake behavior. Lack of confidence/skepticism in the beneficial effects of the COVID-19 vaccine lowered significantly the probability of COVID-19 vaccine uptake (see **Figure 1**). Every significant predictor contoured as a negative one for COVID-19 vaccine uptake in the case of women in the 26–42 years age categories (Gen Y). Even in the case of psychological flexibility, the only significant variable was related to avoidance and held a negative role in the likelihood of COVID-19 vaccine uptake. In the case of Gen Y women, an extended negative information process and focus were more present in general. Evolutionary gains (e.g. adaptation)

are served with this negative focus (Baumeister et al., 2001; Reed et al., 2014), and in the case of older adults, in their middle adulthood, these are shown in our study as well (Reed et al., 2014).

Generation X

The predictors of COVID-19 vaccine uptake in Gen X are a mixture of positive and negative information processing-focused variables (see **Figure 1**). In this case, chronic disease is more likely, and it did hold a significant positive role in the uptake decision, heightening its chance more than seven times. From the analyzed significant psychological predictors, the perceived susceptibility (negatively) and the perceived benefits (positively) predicted the likelihood of the COVID-19 vaccine. Furthermore, the lack of confidence in the benefits and the vaccine risk perception of COVID-19 vaccine benefits both predict negatively the COVID-19 vaccine uptake behavior. Evaluating the weight of each predictor in the total regression model, we can say that, the positive predictor of perceived benefits is the most relevant, increasing the chance of actual vaccine uptake more than four times. In the case of Gen X women, the influence of significant predictors is more prone to positive information processing and positivity effect on cognition. The positive focus on the information processing of older adults was highlighted before in the literature, being backed up also by social-emotional theory (Carstensen and Mikels, 2005; Carstensen, 2006). Even if the risk is perceived and helps in health behavior adjustment (Marschalko et al., 2021), most of the time, the cognition and health behavior in older adults are influenced by positivity (Weinstein, 1980; Isaacowitz and Blanchard-Fields, 2012; Chowdhury et al., 2013; Reed et al., 2014). The present studies' positivity findings can also point toward the presence of better emotional regulation skills, which favors optimism (Brassen et al., 2011; Erbey et al., 2020). The presence of chronic disease can be interpreted in this case also in the context of personal remaining time or limited future time, which posits a higher emphasis on positive assessment and on emotionally and socially relevant and positive aspects (Carstensen, 2006) in which a COVID-19 vaccine potentially can bring benefits.

Taking all psychological predictors into account, it can be concluded that there is significant diversity across generations Z, Y, and X regarding important predictors of actual COVID-19 vaccine uptake. In the case of the youngest generation, only Gen Z perceived benefits seem to matter in the decision of getting vaccinated, and these individuals seem to focus only on positive information. This finding was not underlined before in the literature in health-related outcomes. Mostly positive information processing is guiding the vaccine uptake decision in Gen X as well, with negative predictors having a low weight in total. Gen Y is an exceptional case, in which exclusively negative information processing-related variables seem to count, and all significant predictors are more relevant in the vaccine uptake refusal. These details could be useful in generation-adapted vaccination campaigns and also can serve as inspiration for cognitive bias and evolutionary perspective studies on health behavior. In the case of Gen Z and X, benefits hold the key to the

decision, while in the case of Gen Y, low risks, lack of threats, and accessibility could help in the actual decision of vaccine uptake.

Limitations and Future Direction

Beyond the new findings of the study on generational diversity in the psychological predictors of COVID-19 vaccine uptake, some limitations need to be considered too. First, the psychological factors were assessed by self-reported measures, which potentially can induce bias in the interpretation of the results. Second, the cross-sectional, one-time measurement design cannot provide information about the dynamics of the behavior. Furthermore, the recruitment of the sample was made online, by convenience sampling method, without any control or prior assessment of psychological wellbeing. All results can be interpreted only in gender-specific manner focusing on females. Further studies are needed on male samples or a more heterogeneous sample, from gender perspective. Although the total sample was adequate for analyses, the sample sizes of the three-generational cohorts were not suitable for detecting small effect sizes. The participants were recruited from different European countries, with the same ethnic background, but there might be cultural characteristics that could influence some aspects of vaccine uptake decisions. The results do not allow inferring any causality; thus future research could explore the mechanisms behind the generational diversity of COVID-19 vaccine uptake decision. For example, further studies are needed to analyze the potential moderator role of generational identity on the relationship between chronic disease and vaccination uptake, previous flu vaccine and new vaccine uptake, and also between actual disease and future vaccine uptake. Further studies are needed on possible explanations on the uplifted role of positive information (benefits related) on vaccine uptake decisions in Gen Z, and also on the highlighted generational diversity.

DATA AVAILABILITY STATEMENT

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethical Committee of Babes-Bolyai University (reference number 4140/04.05.2021, Research Project: Factori psihologici predictivi ai ezitării de vaccinare împotriva COVID-19). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

All authors have contributed equally to the conception and design of the study, statistical analysis, writing, manuscript revision, and approved the submitted version.

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When freedom of choice leads to bias: How threat fosters selective exposure to health information

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Selective exposure to online health information can be ascribed to two related defense motives: the motivation to confirm one's subjective perceptions and the motivation to protect relevant parts of the self-image, such as physical integrity. Our aim was to identify how these motives come into effect in the context of a health threat (fictitious feedback on an alleged heart disease risk). In a preregistered online study with $N = 763$ participants, we analyzed the impact of perceived and suggested risk on the degree of bias in selecting risk-related information on a fictitious Google search results page. Applying a 2×2 design with the experimental factor "risk feedback" and the quasi-experimental factor "perceived risk," we formulated six hypotheses. First, we expected a main effect of perceived risk on selective exposure to information suggesting no risk, and second, we hypothesized a main effect of perceived risk on mean quality rating of information suggesting a risk. Third, we proposed a main effect of risk feedback on selective exposure to information which suggests no risk, and fourth, we proposed a main effect of risk feedback on mean quality rating of information suggesting a risk. Fifth, we expected an interaction effect between perceived and suggested risk, and sixth, we proposed an interaction effect between perceived and suggested risk in different forms for each of the four conditions on quality ratings. Only the third hypothesis was confirmed: Receiving information which suggested a health risk increased the tendency to select information denying the risk. Additional exploratory analyses revealed moderator effects of health information literacy and participant age on the aforementioned relationships. In sum, our results underline the crucial role of defense motives in the context of a suggested health threat.

KEYWORDS

selective exposure, health information, health threat, experimental study, information-seeking

Introduction

Health information plays a major role in everyday life. It influences, for example, how you shape your nutrition, how and how often you brush your teeth, or the amount of sleep you try to get each night. It also helps you to recognize potential alarm symptoms, and it may shape your opinions on political agendas (e.g., on vaccination programs or on coronavirus quarantine regulations). Nowadays, vast amounts of health information are freely accessible through all kinds of information sources, most notably through the internet (Fox and Duggan, 2013). However, health information is often multifaceted, and health information sources vary considerably in their quality and scope. Therefore, the question of how and why humans consider specific information while rejecting other information is of utter importance to improve individual access to helpful, objective, and scientifically sound health information.

A number of explicit and implicit intentions shape health information seeking due to the self-responsibility of an independent information search and the peculiarities of the health domain, which, for example, can threaten psychological well-being as well as physical integrity. So-called defense motives are triggered in response to threatening information and lead to favoring and specifically searching for information corresponding to one's self-image (Kunda, 1990; Olson and Stone, 2005; Sherman and Cohen, 2016). Sometimes, defense motives can also provoke a devaluation of non-conforming or threatening information (Ditto and Lopez, 1992; Edwards and Smith, 1996). These defensive mechanisms, which emerge as behavioral consequences from defense motives, oppose aspirations of a holistic, accurate, and complete search (Albarracin et al., 2005; Hart et al., 2009). Correspondingly, bias within the information selection, consideration, and evaluation process are observed in many studies (Schweiger et al., 2014; Greving and Sassenberg, 2015; Sassenberg and Greving, 2016). As threat plays a huge role in triggering defense motives, the present paper investigates the relationship between different types of health threats and the selection of health information. In order to induce threat, fictitious connections between a personality disposition and a health issue were suggested. In the literature, the phenomenon of a biased selection of information (primarily with a preference for non-threatening information that serves one's self-image) is referred to by varying terminologies. In the present paper, we will use the term "selective exposure" (Frey, 1986) to indicate bias related to the selection and consideration of information, as we think it is best suited to function as a generic term for these phenomena.

Defense motives and selective exposure

Health information can be threatening in various ways. For example, it may implicate that a health condition is present, or it may suggest a necessity of changing beloved everyday routines to maintain one's health. Different defense motives may be triggered by different kinds of threats. In this context, Knobloch-Westerwick et al. (2013) Klicken oder tippen Sie hier, um Text einzugeben. introduce the term of self-defending motivation, which implies discrediting, ignoring, and avoiding information that (potentially) implies a threat to one's health and physical wellbeing. For example, fear-appeal information suggesting an increased risk of developing cancer tends to be avoided by smokers—a classic example of selective exposure triggered by self-defending motivation. Empirically, health threats seem to be a strong driver of self-defending motivation, as is evidenced by a study by Greving et al. (2015), in which they showed that Internet search behavior is positively biased when there is an experimentally induced health threat. More specifically, after a fake diagnosis on the intolerance of a food additive, participants selected more positive links (e.g., that the intolerance also protects against diabetes) and less negative links (e.g., that the intolerance leads to a weakened immune defense) on a fictitious search engine results page (compared to a control condition with no health threat). While the exact theoretical mechanisms behind such effects are still unclear, they are in line with the notion of positive illusions (e.g., "unrealistically positive self-evaluations, exaggerated perceptions of control or mastery, and unrealistic optimism"; Taylor and Brown, 1988, p. 193), which are caused by a set of filters in the cognitive system that lead to individuals discarding or devaluating threatening information.

While the defense motives described above are specific for the health context, more general motives for selective exposure may play a role in health information seeking behavior, too. For example, one may selectively search for, and select information to confirm one's opinion or expectation about a specific topic (Hart et al., 2009), or one may try to confirm one's specific self-image as a way of self-affirmation (Munro and Stansbury, 2009). In line with this is the motivation to devaluate and downplay information that disconfirms opposing attitudes and opinions. These different motives may, in addition to health-related self-defending, lead to biased approaches to health information seeking. According to Hart et al. (2009), such motives fulfill a specific goal that is not related to finding out the facts and approaching the "truth," but to protecting an intact self-image (Hart et al., 2009). Hart et al. (2009) argue that the psychological process behind this is cognitive dissonance (Festinger, 1957), a negative affective state that arises when external information is not in line with prior conceptions. More specifically, Hart et al. (2009) argue that "after people commit to an attitude, belief, or decision, they gather supportive information and neglect unsupportive information to avoid or eliminate the unpleasant state of post decisional conflict known as cognitive dissonance" (p. 556).

One crucial similarity can be identified in all of these different motives: They strive to protect parts of the self, be it the self-image, attitudes, and opinions (general motives), or the physical integrity (health-specific motives), as a consequence

of a potential (health) threat and as a precondition for biased information seeking and/or appraisal (Munro and Stansbury, 2009; van 't Riet and Ruiter, 2013). Threat, however, is highly subjective and dependent on one's perceived risk. For example, leaflets suggesting an increased risk for lung cancer in smokers do not imply a threat for non-smokers. Therefore, non-smokers would not have any motivation to discredit or ignore the leaflets, while smokers, on the other hand, may well try to actively disregard them. Thus, a threat can be regarded as a necessary precondition for selective exposure to information in health contexts. Therefore, perceived risk for a certain disease should be considered as a principal basis to appraise health information as threatening or not. In this line of reasoning, the higher the perceived risk, the higher should be the perceived threat and thus, a greater bias in information seeking should occur as various defense motives are activated.

However, taking "risk" into account as a precursor for selective exposure requires a differentiated look at the concept of risk. While perceived risk represents a potential precondition to perceiving a threat, suggested risk (i.e., by an information leaflet) must also be considered. A suggested risk implies that a certain individual characteristic like the body mass index (BMI), for example, is suggested to be associated with an increased risk of suffering from a health impairment (e.g., in an information leaflet on high BMI as a risk factor for cardiovascular disease). Depending on your individual BMI, this message might thus involve a threat (if your BMI is high) or not (if your BMI is low). Moreover, you may or may not have perceived a high risk for cardiovascular diseases in the first place. Hence, with suggested as well as perceived risk taken into account, several scenarios that may or may not trigger defense motives (and selective exposure) are conceivable. In fact, combining perceived and suggested risk (or risk feedback) leads to four possible combinations in individuals who are confronted with health information: *perceived risk* (low or high) crossed with *risk feedback* (suggested risk or no suggested risk).

The present study

The present study aims to investigate the effects of defense motives on selective exposure to health information when a threat is induced *via* risk feedback—depending on the individual's perceived risk. Based on our aforementioned theoretical considerations, we distinguish between the following two types of defense motives: First, the general motive to defend one's opinion and attitudes by approaching confirming information and avoiding disconfirming information (see Hart et al., 2009), which we label "opinion-defending motive," and, second, the more (health-)specific motive to maintain or defend a positive view of one's health (Taylor and Brown, 1988; Greving and Sassenberg, 2015), which we label "health-defending motive." Based on prior research, we argue that the

opinion-defending motive is likely triggered by information that contradicts one's opinion (Hart et al., 2009; Knobloch-Westerwick et al., 2013) whereas the health-defending motive should be triggered by information that suggests a health risk (Greving et al., 2015).

To put it bluntly, we consider the opinion-defending motive to be about being right, whereas the health-defending motive may be more about feeling healthy. Of course, everyone wants to be healthy *and* right—but in everyday life, a multitude of cases are conceivable where we are confronted with information that threatens either one or both of these motives. For example, the tendency to engage in selective exposure following a confrontation with information suggesting a health threat (which would trigger the health-defending motive) may be additionally boosted when this information is not in line with one's opinion about one's health status (which would trigger the opinion-defending motive). In contrast to this example where opinion-defending and health-defending motives are consistent, they may, however, also be dissonant. For example, imagine a person who believes that his diet is rather unhealthy. If this person receives information on the health-damaging effects of this diet, the person's opinion is supported by the external information—even though the information itself is threatening to the person's physical integrity. This congruence between the external information and the person's opinion, in turn, may possibly buffer the effects of the health-defending motive that would usually lead to selective exposure to information denying the diet's health risks. However, although generally acknowledged as two central precursors of a biased search for information, both types of defense motives have—to our knowledge— never been considered in one study simultaneously, let alone in the context of health information seeking. This is puzzling given the potential for a complex interplay between both motives, and corresponding experimental research may help us better understand the psychological dynamics that underlie selective exposure to health information.

For this reason, we applied a 2 × 2 design with one experimental factor "risk feedback" (suggested risk vs. no suggested risk) and one quasi-experimental factor "perceived risk" (high vs. low). With this, we tested the notion that feedback of a higher health risk (threat to self in the form of health/physical integrity; Knobloch-Westerwick et al., 2013) and feedback mismatching the self-assessed health risk (threat to self in the form of opinion or attitude; Hart et al., 2009) leads to selective exposure to health information. Crossing the two factors results in four different groups, each of which implies different conditions for showing selective exposure. The first group (*no* risk feedback and *low* risk perception = NL; see **Figure 1**) is characterized by the absence of an experimentally suggested risk and consists of participants who perceive themselves at low risk. Thus, in this group, there is an accordance between self-assessment and risk feedback, which is

FIGURE 1
Overview of the experimental design.

why the opinion-defending motive may not be triggered. The health-defending motive should not play a role either, as no risk feedback is given. No risk feedback is also given in another group (NH), which is, however, characterized by risk self-assessment (high risk) not corresponding to the given feedback (no risk). In this case, an opinion-defending motive would be conceivable since potentially long-established beliefs about the self are challenged, and the participants want to protect their own beliefs. The two other groups, in contrast, received risk feedback. In one of these two groups (risk feedback: *yes*, perceived risk: *high*; YH), the reported risk corresponds to one's own perception, which is why the opinion-defending motive has no relevance. However, for the protection of one's own physical integrity, as a reaction to the risk feedback, the health-defending motive may be relevant. While the health-defending motive maintains relevance in the last group (YL), the opinion-defending motive also becomes relevant. This group receives risk feedback, although individuals in this group perceive a rather low risk for themselves. Therefore, a conflict between risk self-assessment and risk feedback arises, which is the precondition for the opinion-defending motive. An overview of the four resulting groups can be found in **Figure 1**.

The study, including research design, study hypotheses, and statistical analyses, was preregistered at PsychArchives before data collection (Wedderhoff et al., 2019).

The dependent variables (DVs) are (1) the amount of selective exposure to information which suggests no risk in an information selection task on a fictitious Google results page, and (2) the quality ratings of every piece of information at participants' disposal. Based on this, six hypotheses were formulated, one for each main effect of the two factors on each of the two dependent measures for selective exposure, and respectively, one for the interaction between the two factors. To induce the perception of a health threat in an experimental

study, a scenario that is realistic, relevant, and understandable is essential. We opted to suggest an increased risk for developing heart disease caused by a specific degree of achievement motivation, which we had measured beforehand. This ensures a certain level of comprehensibility: The background is understandable and credible while, at the same time, purely fictitious (without the participants being aware of it). Moreover, from an ethical standpoint, an experimental manipulation based on the suggestion of a risk is not as problematic as a more direct induction of a health threat (e.g., by means of a fake medical exam suggesting that participants indeed *have* a health condition). The suggested risk may trigger both defensive motives. First, it may be a threat to physical integrity. Second, it poses a threat to participants' self-image as it may contradict, depending on the experimental condition, their opinion about the individual risk (i.e., perceived risk). This leads to the following hypotheses:

> *Hypothesis 1[1]: We expect a main effect of the perceived heart disease risk on selective exposure to information that suggests no risk: In the higher perceived risk conditions (YH and NH), selective exposure to information suggesting no risk will be stronger compared to the lower perceived risk conditions (YL and NL).*

> *Hypothesis 2: We expect a main effect of the perceived heart disease risk on mean quality rating of information that suggests a risk: In the higher perceived risk conditions (YH and NH), the average quality rating of information suggesting a risk is lower compared to the lower perceived risk conditions (YL and NL).*

The psychological mechanism we expect to be behind these first two hypotheses is the health-defending motive. We expect that individuals who perceive themselves at a higher health risk generally strive for soothing or reassuring information, as a health threat is associated with a preferential processing of positive information (Greving et al., 2015; see section "Defense motives and selective exposure"). It should be noted that depending on the experimental group, the opinion-defending motive may well reduce these effects since searching for reassuring information counters the opinion-defending motive in individuals who perceive themselves at higher risk. Nevertheless, we argue that the opinion-defending motive is mainly triggered by external feedback (e.g., risk feedback), since such feedback constitutes a strong incentive to *defend* one's opinion. Therefore, we argue that the health-defending motive should trump the opinion-defending motive when risk feedback is kept constant across conditions (as it is when analyzing

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1 As a minor deviation from the preregistration, all hypotheses have been slightly adapted for clarity and precision.

main effects). Hence, overall, we expect a higher amount of selective exposure in the groups which perceive themselves at a higher heart disease risk (NH and YH) compared to the groups perceiving a lower risk (NL and YL).

> *Hypothesis 3: We expect a main effect of the risk feedback on selective exposure to information that suggests no risk: In the conditions with risk feedback (YH and YL), selective exposure to information suggesting no risk will be stronger compared to the conditions with "no risk" feedback (NH and NL).*

> *Hypothesis 4: We expect a main effect of the risk feedback on mean quality rating of information that suggests a risk: In the conditions with risk feedback (YH and YL), the average quality rating of information suggesting a risk is lower compared to conditions with "no risk" feedback (NH and NL).*

Again, the main diver behind these hypothesized effects is the health-defending motive. Even if it is in line with one's opinion (YH group), risk feedback implies a threat to one's physical integrity, which is why it should lead to stronger selective exposure compared to "no risk" feedback. In addition, external risk feedback constitutes a strong driver of selective exposure if this feedback is not in line with one's opinion (YL group) because of the opinion-defending motive. This is because such a constellation gives an incentive to defend one's opinion against an "attack" from the outside. Overall, we therefore expect a higher amount of selective exposure in the groups which receive "high risk" feedback (YH and YL) compared to the groups which receive "no risk" feedback (NH and NL).

> *Hypothesis 5[2]: We expect an interaction effect between the perceived and the suggested risk of heart disease in different forms for each of the four conditions on selective exposure: Given that individuals with a low self-perceived risk who receive risk feedback should be most motivated to reject threatening information (i.e., because both motives are triggered), we expect that the direction of the main effect of self-perceived risk specified in Hypothesis 1 will reverse in individuals who are given risk feedback.*

> *Hypothesis 6: We expect an interaction effect between the perceived and the suggested risk of heart disease in different forms for each of the four conditions on quality ratings. Given that individuals with a low self-perceived risk who receive risk feedback should be most motivated to reject threatening*

> *information, we expect that the direction of the main effect of self-perceived risk specified in Hypothesis 2 will reverse in individuals who are given risk feedback.*

These two interaction hypotheses are based on our expectations regarding the combined effects of the opinion-defending and the health-defending motive. In the case of risk feedback, more selective exposure should arise with decreasing self-perceived risk since a discrepancy between risk feedback and self-perceived risk likely prompts an opinion-defending motive (e.g., Hart et al., 2009), possibly through mechanisms such as cognitive dissonance. Additionally, risk feedback is likely to directly prompt a health-defending motive (e.g., Greving et al., 2015) in order to protect a healthy self-image (cf. positive illusions in section "Defense motives and selective exposure"). In this case, the opinion-defending and the health-defending motive thus act in concert. In contrast, if there is no risk feedback, both motives will become less and less important with decreasing self-perceived risk since this implies an increasing consistency between risk feedback and self-perceived risk (thus reducing the opinion-defending motive), and since there is no prompting of the health-defending motive *via* threatening information. We therefore expect the main effects specified in Hypotheses 1 and 2 (e.g., increased selective exposure with increased risk perceptions) to reverse when individuals are given risk feedback.

Materials and methods

Sample

To determine the sample size, we conducted a power analysis in GPower 3.1 (Faul et al., 2009). With power set to 0.80 and alpha to 0.05, a sample size of $N = 787$ is required to detect a small effect ($f = 0.10$) in a 2×2 ANOVA (numerator $df = 1$) when testing for main effects and interactions. We therefore aimed for a sample size of 800 participants (see preregistration; Wedderhoff et al., 2019). Overall, 847 German-speaking participants, aged between 30 and 65 years and with no medical history of heart disease, participated in the study. Eighty-four participants showed conspicuous response patterns. More specifically, $n = 44$ participants took less than 1,140 s to complete the study (which was less than half the median of the processing time), $n = 36$ participants did not respond to the DV, and $n = 4$ participants stated that they chose the eight snippets "at random" when asked to justify their responses on the DV (see below) in a free-text field at the end of the study[3]. These $n = 84$ participants were removed from the analysis, which resulted in a final sample of $N = 763$ (52.2%

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2 It should be noted that in the preregistration, the interactions are specified with regard to expected mean differences across groups, and thus in greater detail.

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3 While we consider these deviations as major protocol deviations justifying the elimination of cases, the preregistration mentioned more

women; M_{age} = 51.17, SD_{age} = 10.42). The distribution of educational attainment levels was representative of Germany's population. Age distribution was slightly skewed to the left, meaning that older participants were slightly more frequent than younger participants, thus also approximating the age distribution in the German general population. Considering the restricted age range of our sample (30–65 years) as specified in our inclusion criteria (see preregistration), this variable was not normally distributed. The sample was recruited through a panel, administered by a professional agency, and data collection was performed solely online.

Procedure and materials

Ethical approval for the study was granted by the ethics committee of the German Psychological Society (DGPs). After completing an informed consent form and a check on whether the inclusion criteria were met, participants were told that current research is investigating how to explain the relationship between achievement motivation and heart disease. This was followed by an explanation that the study ties in and investigates how achievement motivation is distributed among the population and how people assess their personal risk of heart disease.

After this introduction, a number of covariates (i.e., potential moderators) were measured. Health information literacy (HIL) was assessed by a slightly adapted version of the Health Information Literacy Knowledge Test (HILK) (Mayer et al., 2018), and self-efficacy was measured by the Self-Efficacy Scale for Information Searching Behavior (Behm, 2018), using an instruction adapted to the search for health information. Additionally, for potential exploratory analyses, behavioral inhibition and behavioral approach system sensitivity (Carver and White, 1994) were assessed by a short-form of the ARES (Action Regulating Emotion Systems) scales (Hartig and Moosbrugger, 2003). Furthermore, a self-report instrument for the assessment of emotion-specific regulation skills (SEK-ES) (Ebert et al., 2014) was administered. To control whether the threat induction worked, the Positive and Negative Affect Schedule (PANAS) (Breyer and Bluemke, 2016) was applied before and after the induction, which would allow detecting potential affective changes. Next, the quasi-experimental factor "perceived risk" was measured by a self-developed single item ("*My risk of developing heart disease in the next 5 years…*") with six response levels (1 = "*…is much lower compared to other people my age*" to 6 = "*…is much higher compared to other people my age*"). Participants reported a mean perceived

risk of M = 3.09 (SD = 1.11), and a visual inspection revealed a normal distribution of the corresponding variable. Before the statistical analyses, the variable was median-split (median = 3), resulting in n = 430 participants in the low perceived risk group and n = 273 participants in the high perceived risk group. Finally, dispositional achievement motivation was assessed by the subscale "achievement motivation" of a German instrument measuring occupation-related personality variables, the "Bochumer Inventar zur berufsbezogenen Persönlichkeitsbeschreibung" (BIP; Hossiep and Krüger, 2012).

After completing these questionnaires and tests, a 50-s loading screen was presented along with the explanation that the inputs are processed, analyzed, and compared with a norm sample. This was to ensure a higher fidelity of the upcoming threat intervention. The participants were then randomly assigned to one of two conditions of the experimental factor "risk feedback," which should induce a threat or no threat. Every participant's real score and result of the BIP were displayed as well as the notion if it was higher or lower than average. This statement was combined with a text indicating a higher risk or indicating no risk for developing heart disease (depending on the experimental condition), which also included a reference to a fictitious research report that makes this assumption. Besides the PANAS, three self-constructed items were presented as an additional manipulation check, which assessed subjective feelings of threat and the corresponding information need (e.g., "*I find the information disturbing*" and "*I need more information on the subject*") with five response options each (1 = "*Strongly disagree*" to 5 = "*Strongly agree*"). A mean score (variable *perception of threat*) was calculated before the statistical analyses; scale reliability was high with a Cronbach's Alpha of α = 0.90.

Finally, participants completed a selection task to assess the DV selective exposure. The task is a variation of the task used by Adams et al. (2018) Klicken oder tippen Sie hier, um Text einzugeben. and was framed as an opportunity to obtain additional information about the relationship between heart disease and achievement motivation. They were presented with a (fictitious) Google results page including 16 search results drawing on a combination of the words "achievement motivation" and "heart disease," from which they were asked to select eight results for further research. At the same time, they were asked to rate each search result concerning the quality of the information it provides (values from 1 to 6, with 6 corresponding to the highest quality). The search results included a title and short text snippets and were as realistic as possible in length and wording as well as in visual appearance, thus mimicking an actual Google page. The results differed in that they suggested either an increased or a reduced risk for the respective participant's development of heart disease and, furthermore, whether they were serious (e.g., scientific articles, universities, public submissions) or dubious sources (e.g., yellow press, individual reports). They represented the best selection from a twice as large pool of snippets, which were checked

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than 50% missing data per case as the only example for a major protocol deviation (which did not occur in our dataset). As a further deviation from our preregistration, we did not compute Mahalanobis distances to screen for multivariate outliers given the high complexity of our data structure and the fact that it is rather unusual to do so.

for credibility and comprehensibility in a preliminary pilot study ($N = 56$). Using the data gathered from this task, our DV were computed. First, we calculated a selective exposure score by subtracting the number of selected results suggesting a risk from the number of selected results suggesting no risk. Since participants had to choose eight results, this results in a score ranging from –8 (all selected results suggest a risk) to +8 (all selected results suggest no risk). A score of 0 suggests a balanced selection of snippets, as it indicates that four snippets of each kind had been selected. Regarding the quality ratings of the different search results, the average quality rating of snippets suggesting a risk constituted the first quality rating DV (quality rating DV 1), and the average quality rating of snippets suggesting no risk constituted the second quality rating DV (quality rating DV 2).

After completion of the task, participants were asked to rate the perceived authenticity of the snippets and were presented with the final page of the survey containing a comprehensive debriefing. An overview of the study procedures can be found in **Figure 2**.

Results

Preliminary analyses

Table 1 reports the descriptive statistics and intercorrelations of the study variables. To test whether the manipulation of induced risk through the feedback of potential risk for heart disease worked, the mean score of the variables for the perception of threat was investigated. The score ranged between 1 ("*no threat*") and 5 ("*high threat*"). The two groups, "no risk feedback" and "risk feedback," differed significantly in their perception of threat ($t = -11.53$, $df = 735$, $p < 0.001$). The average score for the "no risk feedback" group was $M = 1.55$, with 58% of the participants having a score of 1. In the "risk feedback" group, the average score was $M = 2.40$, with 28% of the participants having a score of 1. Concerning the PANAS scores, only the "risk feedback" group showed a significant reduction of positive affect between the two measurement points ($t = 6.18$, $df = 414$, $p < 0.001$, $M_{T1} = 3.10$, $SD_{T1} = 0.80$ $M_{T2} = 2.95$, $SD_{T2} = 0.82$). Therefore, it seems that the induction of risk for the corresponding condition was successful. To additionally investigate whether the effects of the threat induction varied over participants depending on their perceived risk, we conducted a two-factorial ANOVA with the independent variables *risk feedback* and *perceived risk* (median-split; see above) and the DV *perception of threat*. While the main effect of risk feedback remained significant and of large effect size ($F[1,759] = 141.077$, $p < 0.001$, $\eta^2 = 0.157$), we also found a small but significant main effect of perceived risk ($F[1,759] = 21.506$, $p < 0.001$, $\eta^2 = 0.028$) and a small but significant interaction between both factors ($F[1,759] = 7.824$, $p < 0.01$, $\eta^2 = 0.010$). This interaction, according to a visual inspection of the corresponding plots, suggested that individuals with high perceived risk were more susceptible to the risk feedback (in terms of an increased perception of threat) compared to individuals with low perceived risk. Finally, all
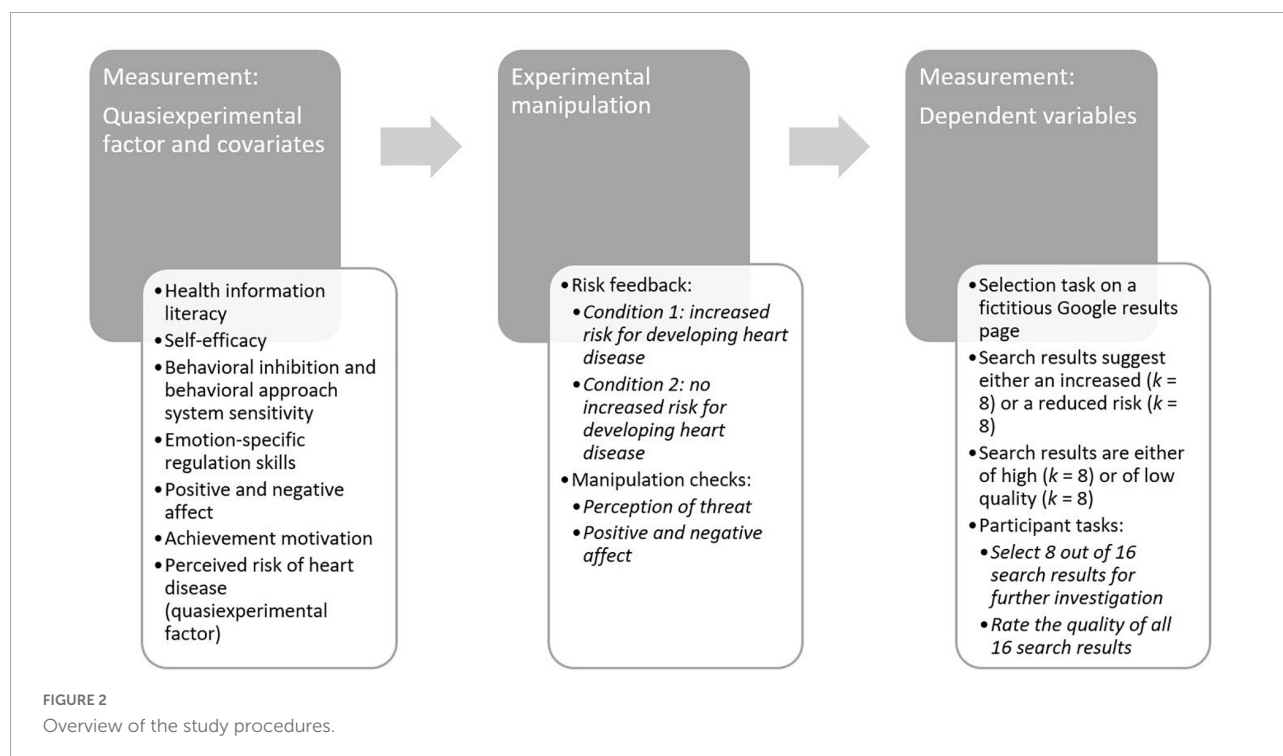
FIGURE 2

Overview of the study procedures.

TABLE 1 Descriptive statistics and intercorrelations of study variables.

Variable	M	SD	1	2	3	4	5	6
(1) Age	51.17	10.42						
(2) HIL	0.69	0.13	−0.094**					
(3) Emotion Regulation	3.55	0.77	0.001	0.259**				
(4) Self-Perceived Risk	3.09	1.11	0.026	−0.028	−0.166**			
(5) Selective Exposure	0.37	2.93	−0.100**	0.077*	0.071	−0.017		
(6) Quality Rating of Snippets Suggesting No Risk	3.18	0.69	0.018	−0.007	0.035	0.062	0.001	
(7) Quality Rating of Snippets Suggesting a Risk	3.17	0.74	0.007	0.016	0.066	0.068	0.018	0.633**

$N = 763$.
HIL, Health Information Literacy.
*$p < 0.05$; **$p < 0.01$.

prerequisites (independence of groups, normal distribution of the dependent variable [DV], and homogeneity) for further analyses were tested and were fulfilled.

Confirmatory analyses

To examine the impact of perceived risk (high vs. low) and risk-feedback (yes vs. no) on respondents' selective exposure, univariate analyses of variance were conducted with these two factors.

Effects on selective exposure

A descriptive overview of selective exposure scores across experimental conditions, including error bars with 95% confidence intervals, can be found in **Figure 3**. Effects on the selective exposure DV were tested in a two-factorial ANOVA with the independent variables *risk feedback* and *perceived risk* (median-split; see above). In this analysis, a main effect for risk feedback was found, with $F(1,759) = 52.92$, $p < 0.001$, $\eta^2 = 0.065$. Examination of estimated marginal means indicated that participants with feedback of a higher risk selected more snippets that communicate no risk than participants with no risk feedback ($M_{noRisk} = -0.45$, $SE_{noRisk} = 2.80$ vs. $M_{Risk} = 1.06$, $SE_{Risk} = 2.86$), thus supporting hypothesis 3. Neither the hypothesized main effect of perceived risk ($F[1,759] = 0.182$, $p = 0.67$, $\eta^2 = 0.0002$), nor the postulated interaction between perceived risk and risk feedback became significant ($F[1,759] = 0.71$, $p = 0.40$, $\eta^2 = 0.001$). Hypotheses 1 and 5 thus were not confirmed.

Effects on quality rating

Effects on the two quality rating DVs were tested in two separate two-factorial ANOVAs with the independent variables risk feedback and perceived risk (median-split; see above). With regard to the average quality rating of snippets suggesting a risk (quality DV 1), results revealed no significant main effect for risk feedback ($F[1,759] = 2.068$, $p = 0.15$, $\eta^2 = 0.003$), no significant main effect for perceived risk ($F[1,759] = 1.203$, $p = 0.27$, $\eta^2 = 0.002$), and no significant interaction between

both factors ($F[1,759] = 0.245$, $p = 0.62$, $\eta^2 = 0.0003$). With regard to the average quality rating of snippets suggesting no risk (quality DV 2), results again revealed no significant main effect for risk feedback ($F[1,759] = 0.554$, $p = 0.46$, $\eta^2 = 0.001$), no significant main effect for perceived risk ($F[1,759] = 2.672$, $p = 0.10$, $\eta^2 = 0.004$), and no significant interaction between both factors ($F[1,759] = 1.193$, $p = 0.28$, $\eta^2 = 0.002$). Thus, hypotheses 2, 4, and 6 were not confirmed.

Exploratory analyses

Exploratory analyses aimed at gaining further insight into factors that moderate how the two independent factors (perceived risk and risk feedback) influence the DVs of selective exposure and quality assessment. In this regard, two influential and often mentioned constructs come into mind: HIL (Meppelink et al., 2019) and emotion regulation (Das, 2012; van 't Riet and Ruiter, 2013). As we had found a significant main effect of risk feedback on selective exposure, we investigated the corresponding interactions for the risk feedback factor. Hayes' PROCESS macro (Hayes, 2013) was used to test for the potential moderation of both HIL and emotion regulation on the relation between risk feedback and selective exposure and quality rating (see **Table 2**). In addition, we investigated whether participant age may have affected our confirmatory hypotheses tests.

Health information literacy

Health information literacy is defined by the Medical Library Association as "*the set of abilities needed to recognize health information need; identify likely information sources and use them to retrieve relevant information; assess the quality of the information; and analyze, understand, and use the information to make good health decisions*" (Shipman et al., 2009). Although the notion "set of abilities" is a bit unspecific, HIL is necessarily involved in every health information gathering process. Hence, HIL should also play an important role in the phenomenon of selective exposure, as it supports searching and selecting specific information. Yet it remains unclear exactly how HIL influences the incidence of selective exposure. Two possibilities
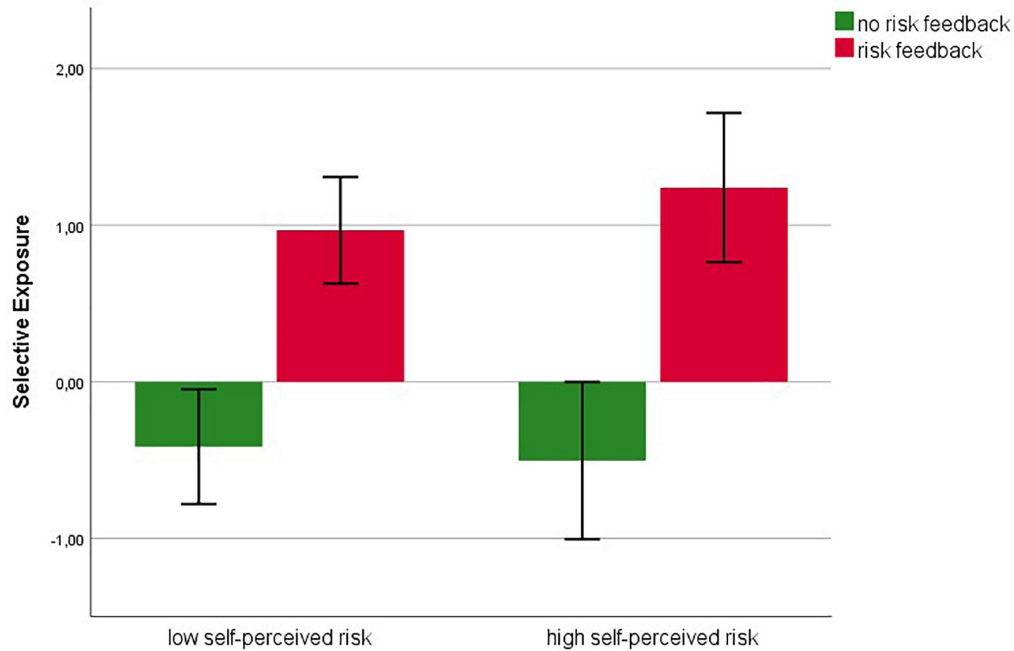
FIGURE 3
Descriptive overview of selective exposure scores across experimental conditions, including error bars with 95% confidence intervals.

are conceivable: (1) A more pronounced HIL promotes a balanced search, as all relevant information is considered and used for good health decisions; or (2) with higher HIL, the well-developed ability to search and evaluate information enables a stronger selection of information according to the objectives of the defensive motives (Meppelink et al., 2019). Empirically, we found a significant interaction between risk feedback and HIL ($b = 6.70$; $p < 0.001$; R^2 change when adding the moderator = 0.023, see **Table 2**) as predictors of selective exposure, while the direct effect of risk feedback also remained significant. Closer inspection of this interaction showed that with increasing HIL, selective exposure became increasingly stronger when participants were confronted with risk feedback compared to no risk feedback. Interaction probing using the Johnson–Neyman technique (see **Table 3**) revealed that this was significant for all HIL values below the cut-off value of 0.265 (with 1.18% of cases scoring lower than this value) and for all HIL values above the cut-off value of 0.554 (with 87.55% of cases scoring higher than this value). For quality ratings, no significant results were found.

Emotion regulation

Emotion regulation is the ability to leave or alter an emotional state (Baumann and Kuhl, 2002; Koole, 2009). In a state where a health threat is present, the discussed defensive motives aim to minimize negative feelings through reassuring or confirming information (Hart et al., 2009), which may be in contrast to a comprehensive search. In previous studies, a

negative affective state was found to predict health information seeking behavior (Hastall and Wagner, 2018). A neutral or less negative affective state should therefore promote a more balanced and comprehensive search. In relation to this, it is important, for an adequate search while facing a threat, that one has a certain ability to regulate potentially negative emotions that may arise (Das, 2012). Accordingly, van 't Riet and Ruiter (2013) Klicken oder tippen Sie hier, um Text einzugeben. state that emotion regulation ability affects the exposure to

TABLE 2 PROCESS results for moderator analyses with selective exposure as outcome.

Model	Variable	R^2	Coefficient	t	p
1		0.31			0.00
	Constant		0.80	0.99	0.32
	(X) Risk Feedback		−3.13	−2.90	0.00
	(W) HIL		−1.79	−1.57	0.12
	Interaction		6.70	4.38	0.00
2		0.28			0.00
	Constant		−0.65	−0.91	0.36
	(X) Risk Feedback		−0.21	−0.21	0.83
	(W) Emotion Regulation		0.06	0.29	0.77
	Interaction		0.49	1.83	0.06

Results are from concurrent regression analyses. The resulting coefficients are unstandardized B parameters. X, independent variable; W, moderator; HIL, Health Information Literacy.

TABLE 3 PROCESS results for interaction probing according to the Johnson–Neyman technique with HILK as moderator and selective exposure as outcome.

HILK score	Effect	SE	t	p
0.0714	−26.498	0.9753	−27.170	0.007
0.2552	−14.178	0.7026	−20.180	0.044
0.2653	−13.503	0.6879	−19.631	0.050
0.3012	−11.098	0.6356	−17.461	0.081
0.5309	0.4301	0.3226	13.332	0.183
0.5536	0.582	0.2965	19.631	0.050
0.5769	0.7381	0.2716	27.176	0.007
0.8066	22.780	0.2656	85.785	< 0.001

HILK, Health Information Literacy Knowledge Test.

various kinds of health-promoting information. Hence, we also assume a moderating effect on the relation of the regarded factors with selective exposure and quality rating. As negative emotions have a higher relevance for defense motives (Jonas et al., 2016), we only considered emotion regulation for negative emotions. However, only a marginally significant effect on the interaction of risk feedback and emotion regulation to predict selective exposure was found ($b = 0.49$; $p = 0.06$; R^2 change when adding the moderator $= 0.004$; see **Table 2**), and the main effect of risk feedback that was found before disappeared when including the interaction term. While these results must be considered with some caution because the interaction (narrowly) missed the $p < 0.05$ criterion, a closer inspection revealed that the participants in the risk feedback condition tended to select more information which denies a threat (i.e., higher selective exposure) with increasing emotion regulation ability. In contrast, participants in the no risk feedback condition seemed not to be affected by different levels of emotion regulation ability, as they did not differ in their selective exposure results.

Age

Older individuals often have more health problems and often feel more threatened by disease compared to younger persons (e.g., Szabo et al., 2020). In addition, there is evidence for age-related biases with regard to information processing (e.g., Teuscher, 2009; Carstensen and DeLiema, 2018). For this reason, we investigated whether our findings may vary with regard to different age groups. Since the age variable in our dataset was not normally distributed, we decided to conduct a median-split (median = 53 years) and calculate three separate three-factorial ANOVAs (i.e., using our three DVs, see above). These analyses were identical to our confirmatory hypotheses tests, but additionally included the age variable as well as two two-way interactions between age and risk feedback respectively age and perceived risk, and a three-way interaction between age, risk feedback, and perceived risk. Similar to our confirmatory analyses, we found no significant main effects or interactions

with regard to the two quality DVs (all $p > 0.066$). However, with regard to the selective exposure DV, we found a significant interaction between age and perceived risk ($F[1,755] = 4.003$, $p = 0.046$, $\eta^2 = 0.005$), as well as a significant three-way interaction between age, perceived risk, and risk feedback ($F[1,755] = 9.135$, $p = 0.003$, $\eta^2 = 0.012$). In addition, the pattern of results regarding risk feedback was very similar to our confirmatory analyses (see above). To investigate this further, we conducted the exact same analyses as we did when testing our confirmatory hypotheses (see above), but this time separately for younger and older participants. These analyses revealed a marginally significant main effect of perceived risk on selective exposure in older adults ($F[1,388] = 3.836$, $p = 0.051$, $\eta^2 = 0.010$), but not in younger adults ($F[1,367] = 0.924$, $p = 0.337$, $\eta^2 = 0.003$). This effect was in the expected direction (i.e., older adults with a higher perceived risk showed more selective exposure compared to older adults with a lower perceived risk), thus providing partial and tentative support for hypothesis H1. In addition, the two-way interaction between perceived risk and risk feedback was significant in younger adults ($F[1,367] = 7.252$, $p = 0.007$, $\eta^2 = 0.019$), but not in older adults ($F[1,388] = 2.132$, $p = 0.145$, $\eta^2 = 0.005$). However, the specific pattern of the interaction in younger adults was contrary to our expectations because, at least on a descriptive level, the main effect of perceived risk was negative in the no risk feedback condition (i.e., more perceived risk led to less selective exposure) and positive in the risk feedback condition (i.e., more perceived risk led to more selective exposure). Hypothesis 5 is not supported.

Discussion

The present paper aimed to gain further insight into the effects of two defense motives—a self-confirming and a self-defending motive—on respondents' selective exposure to health information. Overall, our findings indicate that a suggested health risk influences selective exposure to health information, while a self-perceived risk seems to have no significant effect in this context. As predicted in our preregistration, we found that risk feedback leads to stronger bias toward the preference of information which denies the risk: Receiving feedback which suggests a potential health risk shifted task performance from a rather balanced selection of snippets to a biased selection of snippets that deny a particular risk. Furthermore, it seems that in the context of one's own health, the motivation to defend one's self-image from a threat (which we labeled the health-defending motive; see above) is superior to the motivation to confirm one's opinion (i.e., the opinion-defending motive). This is because, in the condition of no risk feedback, respondents showed no significant bias in either direction—even in the case of a high perceived risk. While it should be noted that we found some tentative and exploratory evidence for a corresponding

bias in older participants, it generally seems that participants neither confirmed their own risk perception when they saw themselves as being at higher risk, nor did they deny a risk and therefore confirm the "no risk" feedback. Together with the significant effects of the risk feedback, this can be interpreted as an indication that in such an essential and potentially existentially relevant context as the health context, coping with a health threat has a higher implicit value than the need to confirm one's opinion.

This is in line with other findings from the field of coping research that, in general, suggest that there is a stronger bias when individuals are in a negative emotional state, which may be more strongly triggered by an unexpected and immediate risk feedback compared to self-perceptions that have probably been present for a long time (Johnson and Case, 2012). Moreover, selective exposure seems to be stronger when the focus lies more on losses instead of gains (Rothermund et al., 2008). In this case, the threat of physical integrity can be seen as a loss (losing health status), while the defense of one's own opinion is mentally represented rather as a gain (one wants to be proven correct) and thus, is less susceptible to bias.

In this sense, an opinion-defending motive seems less likely to come into effect in the case of health threats and the associated autonomous search for information. Rather, it is conceivable that potential risks and threats are avoided *via* the self-directed (biased) choice of information channels, a process which is described in the theory of counter-regulation (Rothermund, 2011). According to this theory, negative states, elicited, for example, through health-threatening information, are "counteracted" by actively turning toward positive (e.g., reassuring or unrelated) information. Our explorative findings also partly support this claim: Participants with a higher ability to regulate their negative emotions showed a more biased selection toward positive information, which may provide reassurance thereby allowing them to downregulate their negative feelings.

Our results regarding the moderating effect of HIL further support these assumptions. In fact, higher HIL led to a stronger selective exposure. This means that with a higher HIL, less balanced information is considered, which at first may seem counter-intuitive. In general, HIL is associated with positive health outcomes (Berkman et al., 2011; Hirvonen et al., 2016), which initially does not seem to match with an unbalanced consideration of relevant health information. However, because the performance test that we used to measure HIL primarily addresses the abilities to search, acquire, and evaluate suitable sources and health information (according to the definition of HIL), this effect suggests that basic abilities of information processing may be "misused" in the present case to meet one's needs and motives. In this regard, Meppelink et al. (2019) also showed a biased selection of messages that were in line with their own beliefs concerning vaccination (regardless of the line of argumentation against or in favor of) for participants with

higher health literacy. They also showed a higher prevalence of biased perceptions of message convincingness for people with higher health literacy. Similarly, a study by Drummond and Fischhoff (2017) found that science literacy was associated with greater political and religious polarization, which is, according to the authors, "consistent with ... the motivated reasoning account, by which more knowledgeable individuals are more adept at interpreting evidence in support of their preferred conclusions" (p. 9590). Accordingly, future research should dive into what may be considered the "dark side of information literacy," and interventions on HIL should consider extending their aims to include the aspect of a balanced search.

Furthermore, the non-significant results for perceived risk indicate a need for further research. As stated before, the opinion-defending motive may not be as important when one's own health is threatened. Nevertheless, our experiment shows an overall tendency toward biased information selection when it comes to health topics, and, furthermore, we concede that our claims that the opinion-defending motive would be less important are based on the interpretation of non-significant results. To disentangle the effects of the two defense motives in future studies, some adjustments to the paradigm and evaluation task are advisable. In contrast to the currently used cover story, it could be beneficial to use a more ambivalent and controversial health topic where the own opinion is held at high stake. At the same time, the cover story should not induce such a large threat in order to prevent triggering *only* the self-defending motive—at least for a portion of the participants. Such topics could include, for example, the efficacy of homeopathic drugs or vaccine hesitancy (Meppelink et al., 2019). This makes it possible to develop scenarios in which the two motives are activated both separately and simultaneously (e.g., in different experimental groups). In the case of homeopathy, for example, risk feedback based on a homeopathic "assessment" may be perceived as much more threatening to physical well-being by homeopathy supporters. In contrast, homeopathy skeptics would supposedly rather doubt the content and see their own convictions threatened.

Another potential explanation of why only one of our hypotheses was confirmed could be ascribed to the nature of the selection task. With eight to-be-selected snippets out of a total of 16 snippets, the resulting cognitive load when performing the task might have been excessive, which could have almost automatically led to a rather balanced selection. A significant reduction of the number of snippets should force a selection on the basis of the currently active motive(s). However, a disadvantage of this procedure would be that the lower number of selected snippets leads to a lower variance in the DV because possible resulting values are restricted. Our initial idea was that the relatively high number of eight selected snippets would result in more detailed differences in the extent of selective exposure, depending on the independent variables and moderators. Another solution to this problem was recently

implemented by Kerwer et al. (2021). In their study, only four snippets were presented at a time, from which one had to be selected for further reading. This was done four times so that a total number of 16 snippets were presented while simultaneously reducing cognitive load. Two final limitations that should be considered when interpreting our findings pertain to our risk feedback manipulation. First, it is rather likely that individuals with a higher perceived risk or with a poorer health status (e.g., high BMI) are more susceptible to a threat induction. We tested this empirically in an exploratory analysis on the threat perception variable from the manipulation check, and indeed found support for the notion that individuals with higher perceived risk are more susceptible to risk feedback. However, these effects were rather small, while the effect size on the experimental manipulation itself (i.e., the induction of threat through risk feedback) was large. Nevertheless, the issue warrants caution when interpreting our results. Second, related to this issue, an inconsistency between perceived risk and risk feedback may not only lead to the triggering of an opinion-defending motive, but also (or instead) to a desire to resolve the inconsistency (e.g., by changing one's opinion), or it may simply lead to doubt in the experiment itself. Future research should strive to straighten out which motives come into effect in which case, and also try to discern the cognitive processes (e.g., dissonance) behind the emergence of different motives – for example by using techniques such as think-aloud protocols.

Implications

Some rather ambivalent implications can be gleaned from the findings of the present study. In line with Sassenberg and Greving (2016) Klicken oder tippen Sie hier, um Text einzugeben., our results suggest that an autonomous selection of information may help patients react to a health threat *via* consulting reassuring information about their health. One could argue that this is a positive implication in the sense that it may help them to develop a more positive view of their body and make them feel better. However, the findings also implicate that a suggested health threat leads to a bias in information selection. This might be because, as we have discussed, a suggested risk increases negative affective states like anxiety, which trigger defense motives to feel better and/or reassured. This is also in line with previous research that states that the likelihood of a unilateral selection of positive information is higher when a negative affective state is present, which is also referred to as "counter-regulation" (Rothermund et al., 2008; Schwager and Rothermund, 2013, 2014). Research on health message perception and on the effects of fear appeals in health-promoting information also supports our findings and points to further implications (van 't Riet and Ruiter, 2013; Ruiter et al., 2014). In fact, health information that emphasizes individual risk factors does not automatically cause the recipient

to implement appropriate behavior to reduce the risk (i.e., giving up smoking). On the contrary, such information often evokes defensive cognitive and behavioral reactions, such as ignoring, denying, or downplaying it (van 't Riet and Ruiter, 2013). In contrast, messages that, besides pointing to a significant health threat, suggest ways to diminish the threat and enhance the recipients' self-efficacy seem to be more effective with regard to changes in health behavior (Schwarzer, 2008; Ruiter et al., 2014). Positive affect and a substantial amount of confidence to be able to deal with the threat thus seem to be essential in order to avoid a bias toward positive information and to select information in a less biased manner (Das, 2012; Ruiter et al., 2014). It is therefore conceivable that, as a consequence, individuals who are in a negative affective state because they have been threatened by risk suggesting information have a biased (positive) picture of their own health, resulting from biased information retrieval in the past. This poses the danger that they underestimate potential health risks and do not consider necessary interventions. In this respect, Sassenberg and Greving (2016) Klicken oder tippen Sie hier, um Text einzugeben. also refer to the risk of a potential negative impact on the doctor–patient relationship, as patients could be too confident about their health status, and become impervious to reasonable arguments that point in another direction.

Conclusion

Our study provides evidence for selective exposure and bias in health information seeking. In the presence of an externally suggested threat to their health, individuals tend to reassure themselves and therefore show a selective exposure to positive information. This may also override a potential motivation to defend one's own opinion when it is in conflict with the reassuring information. However, further research and adjustments to the information selection task are required to investigate these rather tentative conclusions.

What is certain, however, is that an independent search for health information is increasingly deemed necessary and seems to be implicated by modern health care systems in terms of the promotion of patient empowerment and informed decision making. Nevertheless, the wide availability of health-related information to the general population also creates new risks for imbalanced information acquisition and use. Selective exposure might help patients to reassure themselves and cope with their emotional states, but it may also lead to an incorrect assessment of their individual health (risk) status.

Data availability statement

The original contributions presented in the study are publicly available. This data can be found here: doi: 10.23668/ PSYCHARCHIVES.2770.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee of the German Psychological Society (DGPs). The patients/participants provided their written informed consent to participate in this study.

Author contributions

OW, AC, and TR conceived and planned the study. OW and AC conducted the data collection, analyzed the data, and prepared a first draft of the manuscript. TR reviewed and revised the manuscript and prepared it for publication. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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