A longitudinal analysis of Americans' media sources, risk perceptions, and judged need for action during the Zika outbreak

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The objective of this study is to better understand the effects of media attention on Americans' perceptions of risk by analyzing the different media sources and outlets, or 'repertoires', reported as used during the small 2016-2017 Zika outbreak in the U.S. We analyzed survey data from a four-wave longitudinal panel study over nine months—July 19, 2016 through April 24, 2017 (n = 743)—using an online panel of American adults. Media attention related to ratings of personal risk, U.S. risk, and need for action. Personal risk was enhanced more by reported attention to international coverage, reduced by certain reported website attention, but enhanced by reported attention to public health agency websites. U.S. risk was enhanced by reported attention to both domestic and international coverages, reduced by television. Judged need for U.S. action was enhanced more by exposure to domestic coverage, reduced by reported attention to television and local newspapers, but enhanced by reported exposure to BBC and CNN. Our results demonstrate how the use of different media outlets and sources are related to different perceptions of risk and need for action during the 2016-2017 Zika outbreak.

Keywords: media repertoire; media effects; risk communication; outbreaks.

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Introduction

Media play an important role during public health emergencies, such as a disease outbreak, when people turn to news media, social media, and other online sources to learn more about the disease and related events. The information and messages provided by various media may influence how audiences perceive the risks of the emergency and whether they think actions should be taken. Until recently, most risk- and science-related media research has focused on "traditional" media, such as newspapers, and/or single media types, such as studies that only examine Twitter. While important, this work does not entirely capture how audiences access and engage with all the different media they use. Audiences are no longer only passive recipients of media content, receiving content curated by a professional editor in the form of a nightly news broadcast or print newspaper. Instead, more and more editorial selections are made by algorithms and individual decisions, facilitated by dependence on online platforms that actively tailor the information to which users are exposed to match their preferences (Scheufele and Nisbet, 2013).

In this media environment, lay audiences mostly use more than one media platform to get science-related news (Su, Akin, Brossard, Scheufele, & Xenos, 2015), and the "repertoire" of these media used by lay audiences differs across people according to such factors as demographics, news preferences, and knowledge (Kim, 2016). Such repertoire studies provide a more nuanced understanding of audience perceptions and behaviors (Yuan, 2011). The repertoire approach is even more important as shifts to online and social platforms have fundamentally changed our media systems and the way we get information. Compared to traditional media coverage, online sources allow longer periods of attention and coverage (Michael A Cacciatore et al., 2012) and prompt discussions on online platforms like Twitter that may peak at different times (Shan et al., 2014).

This study uses the 2016-2017 Zika outbreak in the U.S. as a case study to examine how self-reported following of Zika news, versus self-reported use of different legacy media (e.g., TV, newspapers) and online or 'new' media (e.g., social media and online-only sources), and of specific outlets (e.g., CNN, The New York Times, WebMD), relate to varied risk perceptions. These analyses address current gaps in the literature by focusing on the broad repertoire of sources and outlets that comprise individuals' media diets in an evolving media ecosystem, while addressing the implicit assumption that media effects are uniform across risk responses.

Past approaches to analyzing media effects and risk perceptions

Aside from general interest in the agenda-setting and framing effects of media, one rationale for exploring the relation between risk perceptions and the media is concern over their potential biasing of public views, due to media content or presentation. For example, traditional mass media coverage focuses on specific risk-related events, versus long-term or continuous risks (Bakir, 2010; Nisbet and Huge, 2006); often moves from a more optimistic and positive beginning to a later negative, health-focused, and sensationalized presentation (Dudo, Dahlstrom, & Brossard, 2007); or lowers risk perceptions with sustained attention to news coverage of an event (Vyncke, Perko, & Gorp, 2017).

Prior research about media effects on risk views has included diverse theoretical foci. One such approach has focused on the relationship between trends of volume of coverage and public opinion, which is most associated with Mazur's (1981) coverage-attitude hypothesis. The general idea underlying this approach is that the more frequent the coverage, the more risk is perceived, regardless of the coverage's content or sentiment (Mazur, 1981). Those following this and similar approaches have focused on correlations of the number of news stories or social media posts with risk responses from mass cross-sectional surveys over time (e.g., Chan et al.,

2018; Frewer, Miles, & Marsh, 2002). A major weakness of these correlational media studies is that they do not consider relevant individual-level variables, such as media attention or use, or the fact that individuals rarely use one media source to access information.

The approach taken in our study focuses on self-reports of media attention, which we expand in several ways. Past research on several different topics has shown attention to media and news are related to risk perceptions (e.g., Howell et al., 2018). For example, a study on Zika and media use found only frequency (not valence) of media source exposure increased fear (Yang, Dillard, & Li, 2018), echoing past investigations of media effects on fear (e.g., Coleman, 1993). The importance of self-reported attention as a factor is underlined by the fact that many media-frequency or content-focused studies exclude attention, meaning that any associations between those two factors and dependent variables *assume* such attention, which is logically required for such associations to have any causal implications. But as indicated above, media attention questions are often quite simple, potentially yielding misleading results.

The Zika Outbreak

In the spring of 2015, the first Brazilian cases of the Zika virus were confirmed, but the virus received little international press attention until the number of cases began to rise several months later (World Health Organization, 2016), spreading widely through Latin America and the Caribbean (LA/C). This was coupled with concerns over increased cases of microcephaly in newborns and central nervous system malformation, as well as the first instance in which a mosquito-borne virus was found to have such effects for the fetus of an infected pregnant woman. The WHO declared a Public Health Emergency of International Concern, which combined with the rapid spread of the virus and uncertainties in what was known about Zika to attract much press coverage. While thousands of cases were reported in the U.S. and its

territories, most occurred in Puerto Rico due to local mosquito transmission, with only about 200 from local transmission on the mainland U.S. ("Zika Virus: Case Counts in the US," 2017). Communication surrounding the Zika outbreak of 2016-2017 attracted a great deal of interest from the research community (e.g., Sell et al., 2018), however, for this study we are specifically interested in the relationships among attention and sources and perceptions of risk during the Zika outbreak.

Understanding media attention and perceptions of the Zika virus

Given the previous discussion, it seemed pertinent to communication theory to examine associations between varied reactions to the U.S. Zika outbreak (see next paragraph) and multiple reported aspects of news attention: the geographic focus of news coverage to which one reported being attentive; the types of media sources, whether legacy or online, to which people reported being attentive for Zika news at least once a month; and exposure to specific outlets (e.g., one social media platform, newspaper, or TV channel versus others). Our longitudinal design, tracking the same individuals' Zika reactions over time, allowed us to examine these relations while taking trends into account to provide a more detailed picture of these associations.

Throughout the Zika outbreak, Americans' media use could potentially relate to changes in perceptions of the risk Zika posed to "you and your family" (personal risk), its risks to the U.S. (U.S. risk), or the need for the country to take action to control Zika's spread (need). While individuals are less likely to change their personal risk perceptions than their perceptions of the societal or community risk (Tyler and Cook, 1984), media may have stronger effects on how individuals perceive risk for society or at broader levels (e.g. national or global risks). This relationship may also be further influenced by the frequency, extent, and mode of attention to

media (Li, 2018). We included judged need for U.S. action to address the Zika threat as a dependent variable, as attitudes about risk *management* might be associated differently with media coverage than would risk *perceptions*.

RQ1. *Does self-reported media attention affect personal risk, U.S. risk, and need for action perceptions differently?*

Given that these dependent variables all concern Zika impacts within the U.S., we wanted to ensure that our news attention measures were able to distinguish attentions to different kinds of coverage that might have differential effects or attraction for potential users. Specifically, we asked separate questions about attention to Zika news within the U.S. versus about Zika in LA/C. We expected that domestic coverage would be more salient for mainland Americans:

H1. *Self-reported media attention to U.S.-focused Zika news will affect personal risk, U.S. risk, and need for action perceptions of Zika more than will self-reported attention to Zika news about LA/C*.

Another important aspect for understanding how audiences perceive public health emergencies is time. Outbreaks and public health events often develop over time with new cases, local transmissions, or developments in the medical community's understanding of the disease (Wirz et al., 2018). These mediated events and changes over time may influence media attention and public attention. Our longitudinal study was well-positioned to better understand these dynamics because we collected data from the same people at four different times throughout the outbreak in 2016-2017. Our longitudinal data allow us to ask:

RQ2. *Did self-reported media attention's effects on personal risk, U.S. risk, and need for action perceptions change over time?*

Different media sources seem to yield varied effects on health-related risk perceptions. For example, Zika risk perceptions changed with the volume of tweets, while reported behaviors changed with the volume of legacy media coverage (Chan, et al., 2018). Separate from, but entangled with, possible differences in effects of legacy versus novel media is whether and how different sources within these two overarching categories differ. For example, in press coverage of an A/H1N1 outbreak, tabloids, quality newspapers, and press releases presented varying levels of risk and emotional content (Rossmann, Meyer, & Schulz, 2017). There are also differences across social media platforms in the conversations about public health emergencies (Wirz, et al., 2018). Additionally, the repertoire of media used have also been shown to have an impact on non-risk related issues, such as political participation (Mosca and Quaranta, 2016). Given the wide variety of media now available to Americans and their differences in content, media may play an important role in the amplifying and attenuation of risks related to public health (Kasperson et al., 1988). We controlled for self-reported frequency of media attention to examine whether or not source/outlet attention affects risk perceptions:

RQ3. *Were judgments of personal risk, U.S. risk, and U.S. need for action against Zika amplified or attenuated with specific source/outlet attention? Did any effects persist when controlling for degree of self-reported media attention?*

Finally, we were interested in whether our two news attention measures interacted with certain other factors. Time was included to capture trends in both the dependent variables and news attention; subjective and objective knowledge of Zika because news following might affect the degree of perceived and actual knowledge, and thus alter their effects; and education might modify how people process the news they follow:

RQ4. *Does self-reported media attention interact with time, subjective knowledge, objective knowledge, or education in effects on personal risk, U.S. risk, or judged need for action?*

Methods

Survey Sampling and Measures

Data came from a four-wave longitudinal panel study over nine months—July 19-24, 2016 (Wave 1, n = 1047), August 1-13, 2016 (Wave 2, n = 989), January 25-February 6, 2017 (Wave 3, n = 805), and April 13-24, 2017 (Wave 4, n = 743)—using the Decision Research online panel, a diverse, quota-recruited (gender, age, education) sample of American adults. Its use sharply reduced the longitudinal study's costs relative to use of a nationally representative sample. Wave 1 occurred just before, and Wave 2 immediately after, official announcement of local mosquito transmission of Zika in Miami; Wave 3 began six weeks after the first non-Florida local transmission, in Brownsville, Texas, and Wave 4 when mosquito season had begun in all but the northern-most contiguous states.

Risk perceptions of the Zika outbreak (personal risk, U.S. risk, judged need for action) were collected in all four waves. Gender, age, and education were collected during panel-member recruitment, and political ideology (1 = *very liberal*, 5 = *very conservative*) in Wave 1. Subjective Zika knowledge— "How much do you know about the Zika virus?" (fully labeled scale: 1 = *never heard of it,* 7 = *I am an expert on Zika*)—was collected in three waves. Objective Zika knowledge (e.g., "A person can catch Zika from being bitten by a mosquito that is carrying the Zika virus"; "There is currently an outbreak of Zika infections in Europe") reflected correct responses to eight true/false items ($\alpha = .87$) asked in Wave 3 (Kahan, Jamieson, Landrum, & Winneg, 2016). The specific media measures are listed in the supplemental

materials. The news attention items were asked in three waves. We measured the specific outlets and sources used only in Wave 2. For these questions, we first asked about the news sources used and anyone who said their attention was at least monthly (score ≥ 3) was asked the specific outlet question for that source.

Survey Analysis

Multi-level modeling using maximum likelihood estimation assessed effects of media attention while controlling for time (coded in months from onset), demographics, political ideology, and subjective and objective Zika knowledge. The longitudinal data collection (four waves of DV measures) allows for MLM to nest responses within person, capitalizing on the multiple responses of risk per participant across the survey period. This method allows observance of overall trends in risk perceptions, as well as cross-level interactions with individual trends over time, enabling models to test if news following (measured at the second wave) is related to the slope of an individual's risk perceptions or perceptions of the US need to take action toward Zika over time. This improvement in predictive power of a multilevel over a single-level model replicates that found and advocated by Southwell (2005), who provides a detailed explanation of similar advantages of MLM in communication research, specifically on anti-drug campaign messages interactions' with adolescents' individual differences.

To avoid pseudo-R^2s often produced in reporting mixed linear models (e.g., by simply squaring the correlations between fitted and observed values), we report both marginal R^2s which indicate the effect of fixed factors on their own, and conditional R^2s which indicate the joint effect of fixed and random factors (Nakagawa and Schielzeth, 2013). As R^2s are affected by the number of predictors entered, we also report the Bayesian information criterion (a more conservative alternative to the Akaike information criterion, because it adjusts for model

parsimony) for choosing among alternative models, with the preferred model having the lowest BIC. The observations are reported for each model: their values are much greater than the overall sample size for any one wave of the panel, as we had four measures of the dependent variables from each respondent.

Results

For each dependent variable, we tested five models (Tables 1-3), with alternatives to the last two models also tested. Model 1 included weeks since the first survey as a predictor for change over time, and the demographic variables (gender, age, education). Model 2 added political ideology, and subjective and objective knowledge of Zika. Model 3 added the first media-related variables, self-reported attention to Zika news concerning LA/C and U.S. events, respectively. Model 4 added in the degree of self-reported attention to seven news source types; for those significant at $p < .05$, Model 5 explored effects of self-reported attention to specific outlets within that source category. For both Models 4 and 5 we ran alternative models in which we omitted the two Zika news-attention variables, in case those might obscure otherwise significant effects of media repertoires.

Insert Table 1

For personal risk Model 1 showed a statistically significant negative trend over time, which endured over the remaining models, and women and the educated rated risk higher, but this model explained little variance. Model 2 improved substantially on both explained variance and model fit (BIC), with the more informed (objectively) exhibiting lower risk ratings and the more informed (subjectively) exhibiting higher ones, with political liberals and (marginally) the more educated also seeing higher risk. Model 3 did not improve as much on the prior model as

had the ideology and knowledge measures, but both attention measures were statistically significant, and in fact this was the best-fitting model (BIC).

Attention to LA/C (in particular) and U.S. news, in addition to subjective knowledge and liberal ideology, boosted personal risk judgments, while objective knowledge and age decreased them. Models 4 and 5 increased R^2 slightly, but reduced fit. In model 4, most Model 3 predictors retained their effects (age was no longer significant, ideology and U.S. Zika news attention became marginal), with exposure to online topical sources reducing judged personal risk relative to other sources. When the attention variables were removed, a marginal reduction in perceived risk for those reportedly exposed to TV occurred. In Model 5, we substituted the online topical outlets for Model 4's sources, given that they were the only consistently significant source. This model revealed that people attending to WHO and CDC websites on Zika, and to WebMD and Wikipedia websites on Zika when the attention variables were omitted, were at least marginally more likely to see high Zika risk than others.

Insert Table 2

Turning to U.S. risk judgments, we again found a consistently significant temporal trend downward over time across models, and little overall explanation of variance in Model 1, with women tending to downplay this kind of risk here and in the other models. There was more variance explained and better model fit with Model 2, although the change was less than observed for personal risk. Again, objective knowledge diminished, and subjective knowledge increased, perceived risk. Model 3 is the best-fitting model overall again, and again increased explained marginal variance substantially, although again less relative to the prior model than accomplished by adding ideology and knowledge variables. Both news attention variables increased judged U.S. risk, roughly equally in contrast to personal risk; objective Zika

knowledge and education reduced it. Models 4 and 5 again slightly increased explained marginal variance while fitting worse than Model 3. While the prior model's variables continued their effects in Model 4, reported television exposure reduced U.S. risk judgments, an effect not altered if attention variables were removed. Model 5 shows that reported CNN exposure consistently increased U.S. risk perceptions.

Insert Table 3

Judgments of need for the US to address Zika exhibited the lowest R^2s and worst fit of the three dependent variables, with again a significant negative trend over time. Model 1 showed older people more likely to express this need; Model 2 added a positive effect of subjective knowledge, while political liberals here and in subsequent models were less likely to avow such a need. Model 3 added a negative effect of education while removing the influence of subjective knowledge, with both attention variables (particularly to U.S. news) increasing judged need. Here news attention increased explained variance more than did the earlier addition of ideology and knowledge variables. Model 4 weakened but did not eliminate the effects of attention, while indicating that exposure to TV and to local newspapers reduced judged need. Omitting attention variables made subjective knowledge significant again, but did not change results otherwise. As noted earlier, our sampling made it impossible to explore effects of specific local-newspaper outlets, so in Model 5 we examined TV outlet associations only. Reported exposure to CNN consistently, and BBC and Fox when attention variables were omitted, increased judged need for action.

The best-fitting model in each case, according to the BIC, was Model 3, which included demographics, knowledge, political ideology, and the news following measures. For news-following, the magnitude of news attention effects was stronger for LA/C news attention for

personal risk perceptions and for U.S. news attention for judgments of need for action, while the two kinds of news attention had about equal effects on U.S. risk perceptions. Furthermore, repertoire effects differed for the three dependent variables, with only TV effects and those for CNN attention within that category being shared (across U.S. risk and need). Collectively, these findings indicate that media attention indeed differed in its effects across dependent variables, answering RQ1. By contrast, H1 about the greater impact of U.S. news attention was only partly supported: it was true for judged need for action, attention to international Zika news was more important for personal risk perceptions, and attention to both kinds of news exhibited substantively similar effects on U.S. risk perceptions.

As for news following's effects over time on dependent variables (RQ2), judged personal risk and US risk showed significant cross-level interactions: greater LA/C news following attenuated the decline in risk perceptions over time. For RQ3, including the media source (Model 4) and outlet (Model 5) attention measures helped identify how reported exposure to specific sources and outlets affected these judgments. Personal risk judgments were reduced by topical (i.e., Zika-focused) website attention overall versus other sources, but elevated for attention to information from public health agencies and sources. U.S. risk judgments were reduced by television attention versus other sources, but elevated for CNN viewers. Need for action judgments were reduced by television and local newspaper attention; with regard to TV outlets, attention to CNN particularly, but also to some extent to BBC and Fox, increased perceived need for action relative to other TV outlets. Probing significant contrasts across local newspapers was not feasible, given that respondents indicated exposure to unique outlets. Removing news attention measures in Models 4 and 5 did reveal some source/outlet associations not otherwise observable, indicating some shared variance across these measures of attention.

The control variables, subjective knowledge and objective knowledge of Zika, influenced judgments of risk and need for action in other analyses (Johnson, 2018). These results imply that media attention variables are not simply reflections of these other variables (see next section). At the same time, we caution that changes in explained variance, particularly for conditional (fixed plus random effects) rather than marginal (fixed only) R^2, were small, so media attention is not a powerful predictor when controlling for these other variables.

Finally, other than temporal interactions discussed earlier for RQ2, there were mixed answers for RQ4 (Table 4), although all involved attention to coverage of Zika in LA/C, not U.S., media. Two-way and three-way interactions effects of news following with time, knowledge, and education on DVs are reported in Table 4. Subjective knowledge had no statistically significant interactions. Figure 1 provides a simple slopes analysis to illustrate the cross-level interaction of time and news following on U.S. risk perceptions, and the interaction of objective knowledge and news following on judged need. The relationship of objective knowledge with judged need for US action was moderated by LA/C news following: when news following was high, an inverse relationship was present between knowledge and judged need for action, when news following was low, knowledge and need for action were positively related. Latin American and Caribbean news following also interacted with the time variable for perceived US risk: lower levels of LA/C news following was associated with a quicker decline in risk perceptions over time.

Insert Table 4 and Figure 1

Discussion

First, we underline that accounting for people's attention to legacy and novel media is vital for the larger question of agenda-setting effects. This may seem like an unexceptionable and obvious

statement, but the great number of studies that do not measure attention at all or in relatively crude ways suggest that it is not quite so obvious. Some works that demonstrate varying effects (e.g., on interpersonal trust; Lee, Cappella, & Southwell (2003)) of exposure to different types of media content underline that point. Ensuring that such studies always include at least one measure of attention would be an important step.

Additionally, by using two measures of news following—for coverage of LA/C versus U.S. experience of Zika—we were able to determine that not all attention to Zika-related information has equal impact. Not all hazards will provide parallel opportunities to distinguish between types of attention, but researchers should be alert to this possibility just as elsewhere they have contrasted media to interpersonal effects. Exploring why these differences arise—e.g., could LA/C attention's greater effect in most cases here derive from the greater incidence of cases outside the mainland U.S., even though these would presumably feel more psychologically distant (Liberman and Trope, 2008)—would enhance our understanding of information seeking and processing about hazards.

Our identification of information sources, and specific outlets within these source types, from which people reported obtaining Zika information allowed us to open up a new front in examining attention effects. The tasks remaining are formidable: why were these differing risk views associated with different source and outlet effects, and do they generalize to other hazards? For example, we might argue *post hoc* it is plausible that personal risk perceptions might be shaped particularly, and in fact reduced, by online Zika-specific websites relative to other sources, as they might be less sensationalist than other sources. Similarly, we might argue that it is plausible that official public health agency websites, and particularly the WHO website covering global Zika incidence, might amplify personal risk perceptions relative to other Zika-

specific websites due to some combination of their perceived trustworthiness, factual focus, and breadth of coverage. But these speculations obscure alternative hypotheses for Zika, and ignore equally plausible but reversed relationships that might apply to other hazards. But one cannot explore these questions in the depth they merit unless one asks about a range of both sources and outlets in the first place.

Measurement Implications

Incorporating media attention questions into future research instruments on media-risk perception associations is warranted. This would enhance projects which also include media volume and/or content analysis approaches. We also used three types of attention measures: news following, media sources, and media outlets. If survey-instrument space is a constraint, using the news attention measures would be more efficient for exploring whether self-reported attention to topical news is associated with risk perceptions than asking about sources/outlets. The attention items take less room, and here they usually explained a similar amount of variance while providing better model fit than, while retaining statistical significance even when included with, source/outlet variables.

Additionally, we appear to be the first to have two news attention questions, distinguishing whether the focus of the news is domestic or international, raising the question of whether similar distinctions—geographical or otherwise—would inform other research on media attention effects when a hazard is widely distributed across space. To our knowledge, other Zika media studies have not made such distinctions, so we do not know whether they would have made a difference in those studies too. As noted earlier, some hazards may not yield such bifurcated attention by media or media users, but how useful multiple news attention measures

might be will be revealed only if researchers begin considering their potential benefits for their respective projects.

The use of multiple measures of hazard perception and attitudes not only allowed us to probe the generalizability of media attention effects, but also revealed that these dependent variables differed in how they were affected by both geographically-focused attention variables and source/outlet measures. Inclusion of risk perception and/or topical risk experts in research teams might aid media scholars in determining salient dependent variables for their studies, but even without such collaborations they should consider whether a single dependent variable is useful for their purposes. In some cases personal protective behavior and/or policy support effects may be worth including; we asked such questions here, but not across enough survey waves to include them as dependent variables in this study.

We also observed differential impacts of reported attention to a wider variety of media source types and specific outlets within those source categories than used in previous studies, with source/outlet effects differing across dependent variables. This underlines the importance of exploring differential effects across diverse media repertoires, using similar measures, unless survey-instrument constraints make these infeasible. A similar argument about the limited ability to learn from single-medium studies has also been made in the context of research echo chambers (Dubois and Blank, 2018). We acknowledge in the next section that measuring source/outlet attention is only the start if such work is to be productive. Finally, the pattern observed for our repertoire models (Models 4 and 5) was that a source type weakened effects on *all* dependent variables (if a different type across dependent variables in most cases) relative to other sources, but the sign became positive for analyses at the outlet level. It is unclear to us

whether this is a methodological artifact, a general pattern for source versus outlet comparisons, unique to Zika judgments, or due to some other factor.

Thus a lot of progress in understanding media-risk perception relations can be made by more fully incorporating diverse media attention measures into such research projects. However, several limitations of the current study must be addressed in future research to fulfill its promise, to which we now turn.

Limitations and future directions

Several factors limit our ability to generalize from this particular study's results, categorized here as sampling, media measures, and predictive modeling issues. Sampling issues involve the populations and hazards involved. First, this study involved a U.S. sample of respondents, so its results may not generalize to other societies or even Americans at other time periods. Replication will be important. Second, it was an opportunity sample, though nationally diverse, so we cannot extrapolate from their repertoire responses to what might be a representative distribution of media source/outlet use. This common problem in budget-constrained social science research is particularly problematic here because without such plausible generalization we cannot answer other questions, such as whether a given repertoire is topic-specific. Third, that last point highlights that we have applied these media attention innovations as yet only to Zika at a particular time and place, so even beyond the repertoire issue just mentioned we cannot generalize the particular effects found here (e.g., relative impact of geographically-based news attention measures across diverse risk responses) without applying it to other hazards as well.

Media-measure constraints include the phrasing and variety of media attention questions themselves, but the larger issue involves integration of attention with volume and content

measures. In this study we only had the opportunity to systematically analyze attention effects, so the intriguing and diverse repertoire differences observed here cannot be explained easily. What is it about topical (Zika-focused) websites or TV or local newspapers that make their effects on Zika risk views diverge from those of other media sources? What made CNN coverage in particular amplify U.S. risk perceptions and judged need to act relative to other TV channels? Media volume and content analyses may not be sufficient or comprehensive explanations of these results, as the nature of media content processing may be among other contributors to these results. But without such independent measures the attention-measure results are not directly interpretable. We suspect that content differences across media sources/outlets will probably end up being more important than media volume differences, but this speculation must be tested. We also note that we elicited source/outlet usage only once in this longitudinal project, so we cannot say whether that usage varies across time.

Predictive modeling constraints involve both predictor-dependent variable relationship assumptions and associations among predictive variables. On the first, a major challenge is determining the causal order and relevant facets of relationships involved, by no means a new critique (Wahlberg and Sjoberg, 2000). Media use may impact how individuals think and feel about a hazard, through attention to the frequency or content of media risk coverage. Or people who perceive more risk may use media more to address their concerns, or regular media users could perceive lower levels of risk through being more informed about the issue. Moderating factors in the relationship between media and risk perceptions include how reliant or dependent individuals are on different news sources for information (Lin and Lagoe, 2013), and the extensity of media attention, how inclusive its scope is, such as multiple attributes of epidemic coverage (Li, 2018). While our testing to answer RQ2 on varying effects of the attention

measures across time partly answers these questions, it is not conclusive. One example of the inter-predictor challenge here involves source/outlet effects and objective Zika knowledge. Use of different media platforms may enhance or narrow knowledge gaps between individuals (Michael A. Cacciatore, Scheufele, & Corley, 2014). In the current analyses we control for objective knowledge when assessing source/outlet effects, so the latter are effects *net* of objective knowledge variations produced in part by various source/outlet differences. This is an appropriate limitation here, but potential cross-variable interactions should be explored as well.

Conclusions

Among approaches to studying media effects on public hazard responses, news attention has received somewhat less attention by researchers than media frequency and content approaches. All are valuable, but we deploy multiple attention measures to identify varying effects on diverse dependent variables in a novel longitudinal design to indicate that attention merits increased attention in conjunction with frequency, content and other approaches. Despite study limitations, our findings of varying effects for both media attention and source/outlet usage across personal and U.S. risk perception, and judged need for U.S. action against Zika infections, should prompt wider use of such measures to examine media attention effects, including for identifying their boundary conditions. Although including media attention measures does not require longitudinal panel designs—a cross-sectional survey would advance our understanding as well—there are advantages to a longitudinal design that should be attractive to researchers despite the cost and difficulty of such designs.

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Tables

Table 1. Personal risk perceptions as a function of control variables, news attention, exposure to major sources, exposure to specific media outlets.

	Models				
Variables	**1**	**2**	**3**	**4**	**5**
Intercept	2.56***	3.75***	3.58***	4.01***/4.63***	3.32***/3.34***
Time (months)	-.04***	-.01***	-.04***	-.04***/-.04***	-.04*** /-.04***
Gender (female)	.17*	.03	.02	.05/.07	.03/.04
Age	-.00	-.00	-.01**	-.00/-.00	-.00†/-.00
Education	.09***	.04†	.01	-.00/.01	-.00/.02
Political ideology (liberal)		.05*	.05*	.04†/.03	.05*/.04†
Subjective Zika knowledge		.45***	.16**	.12*/.26***	.10*/.31***
Objective Zika knowledge		-.61***	-.53***	-.40***/-.38***	-.42***/-.43***
Attention to LA/C Zika news			.33***	.27***	.29***
Attention to US Zika news			.16**	.11†	.13*
National newspapers				.03/.00	
Local newspapers				-.03/-.03	
Online news				.03/.02	
Online topic				-.08**/-.10**	

Radio/podcasts				-.04/-.04	
Television				-.01/-.05†	
Social media				-.02/-.02	
Web_CDC					.16†/.22*
Web_WHO					.39*** /.48***
Web_Wikipedia					.08/.16†
Web_WebMD					.08/.20*
Web_Other					.18/.34
Marginal R^2	.03	.21	.25	.26/.24	.26/.23
Conditional R^2	.59	.61	.61	.61/.61	.61/.61
BIC	10846.3	9080.7	9003.0	9005.5/9040.7	9018.3/9072.6
Observations	3520	3036	3032	3020/3024	3032/3036

Unstandardized coefficients. Marginal R^2 = Proportion of variance explained by fixed effects alone; Conditional R^2 = Proportion of variance explained by fixed and random effects. Observations reflect total over 4 waves. LA/C = Latin American/Caribbean; US = United States. Models 4 and 5 show results for specific outlets with and without inclusion of attention variables.

† $p < .10$ * $p < .05$ ** $p < .01$ *** $p < .001$ **** $p < .0005$

Table 2. U.S. risk perceptions as a function of control variables, news attention, exposure to major sources, exposure to specific media outlets.

	Models				
Variables	**1**	**2**	**3**	**4**	**5**
Intercept	3.51***	3.87***	3.72***	4.04***/4.76***	3.75***/3.83***
Time (months)	-.03***	-.03***	-.03***	-.03***/-.03***	-.03***/-.03***
Gender (female)	-.16*	-.23***	-.23***	-.20**/-.19**	-.23***/-.22**
Age	-.00*	.00	.00	-.00/.00	.00/.00
Education	.02	-.03	-.06**	-.06*/-.05†	-.07**/-.04
Political ideology (liberal)		.01	.01	.01/.00	.01/.00
Subjective Zika knowledge		.35***	.03	.02/.18***	.01/.28***
Objective Zika knowledge		-.31***	-.24***	-.20***/-.16**	-.23***/-.27***
Attention to LA/C Zika			.30***	.25***	.27***
Attention to US Zika news			.26***	.22***	.25***
National newspapers				.01/-.02	
Local newspapers				-.02/-.03	
Online news				.03/.02	
Online topic				-.02/-.04	
Radio/podcasts				.02/.02	
Television				-.06**/-.10***	
Social media				-.01/-.02	
TV_ABC					-.04/.05
TV_CBS					.04/.07
TV_NBC					-.04/-.04
TV_Fox					.02/.09
TV_CNN					.18*/.23**
TV_MSNBC					.08/.08
TV_BBC					.01/.12
TV_Other					.05/.05
Marginal R^2	.02	.11	.17	.18/.15	.18/.12
Conditional R^2	.52	.54	.54	.54/.54	.54/.54
BIC	10411.6	8809.7	8699.5	8707.1/8764.8	8753.3/8845.6
Observations	3521	3035	3031	3019/3023	3031/3035

Unstandardized coefficients. Marginal R^2 = Proportion of variance explained by fixed effects alone; Conditional R^2 = Proportion of variance explained by fixed and random effects. Observations reflect total over 4 waves. LA/C = Latin American/Caribbean; US = United States. Models 4 and 5 show results for specific outlets with and without inclusion of attention variables.

† $p < .10$ * $p < .05$ ** $p < .01$ *** $p < .001$ **** $p < .0005$

Table 3. Judged need for U.S. action as a function of control variables, news attention, exposure to major sources, exposure to specific media outlets.

	Models				
Variables	**1**	**2**	**3**	**4**	**5**
Intercept	4.56***	4.25***	4.14***	4.67***/5.37***	4.12***/3.34***
Time (months)	-.02***	-.02***	-.02***	.01*/-.02**	-.02***/-.04***
Gender (female)	-.03	-.04	-.04	.01/.02	-.03/.04
Age	.01***	.01***	.01*	.01*/.01**	.01**/-.00
Education	.04	-.03	-.07*	-.06†/-.05	-.07*/.02
Political ideology (liberal)		-.06*	-.06*	-.08**/-.08**	-.07**/.04
Subjective Zika knowledge		.36***	-.00	-.02/.16**	-.02/.31***
Objective Zika knowledge		-.08	-.02	.06/.12	.01/-.43***
Attention to LA/C Zika news			.23**	.15†	.19*
Attention to US Zika news			.41***	.34***	.39***
National newspapers				.03/.01	
Local newspapers				-.07*/-.07*	
Online news				.02/.01	
Online topic				-.00/-.02	
Radio/podcasts				.01/.01	
Television				-.07*/-.11***	
Social media				-.03/-.04	
TV_ABC					.01/.13
TV_CBS					-.03/.04
TV_NBC					-.05/-.07
TV_Fox					.10/.18†
TV_CNN					.17†/.23*
TV_MSNBC					.13/.12
TV_BBC					.12/.25*
TV_Other					-.18/-.17
Marginal R^2	.02	.06	.12	.14/.11	.13/.08
Conditional R^2	.54	.54	.54	.54/.54	.54/.54
BIC	12028.2	10249.1	10166.2	10167.0/10203.5	10219.6/10284.9
Observations	3521	3035	3031	3019/3023	3031/3035

Unstandardized coefficients. Marginal R^2 = Proportion of variance explained by fixed effects alone; Conditional R^2 = Proportion of variance explained by fixed and random effects. Observations reflect total over 4 waves. LA/C = Latin American/Caribbean; US = United States. Models 4 and 5 show results for specific outlets with and without inclusion of attention variables.

† $p < .10$ * $p < .05$ ** $p < .01$ *** $p < .001$ **** $p < .0005$

Table 4. Personal risk perceptions, US risk perceptions, and judged need for US action as a function of interactions between news following and subjective knowledge, objective.

	Models					
	Personal Risk		**US Risk**		**Need for US Action**	
Variables	1	2	1	2	1	2
Intercept	2.52**	3.390	2.32**	-0.751	3.22**	3.53
Time (months)	-0.043***	-0.043***	-0.061***	-0.061****	-.055**	-0.055**
Gender (female)	0.008	0.007	-0.249**	-0.252**	-0.05	-0.049
Age	-0.006*	-0.005*	0.001	0.001	0.008**	-0.008**
Education	0.012	-0.059	-0.063**	0.538	-0.066*	-0.119
Political ideology (liberal)	0.050*	0.042*	0.012	0.011	-0.064*	-0.065*
Subjective Zika knowledge	-0.039	0.001	-0.153	-.166	-0.112	-0.084
Objective Zika knowledge	-0.138	-0.297	0.242	0.925	0.295	0.251
Attention to LA/C Zika news	0.867†	-0.08	1.691***	1.173	1.11†	-0.454
Attention to US Zika news	0.057	-0.55	-0.626	1.065	-0.137	1.03
Time * LA/C Zika news	0.022**	0.022**	0.020**	0.020**	0.010	0.010
Time * US Zika news	-0.018*	-0.018*	-.007	-0.007	0.003	0.003
Subjective * LA/C Zika news	0.098	0.076	0.003	0.006	0.046	0.026
Subjective * US Zika news	-0.019	-0.015	0.060	0.063	-0.007	-0.001
Objective * LA/C Zika news	-0.232*	-0.313	-0.339**	-0.223	-0.249*	0.049
Objective * US Zika news	0.088	0.503	0.157	-0.219	0.129	-0.094
Education * LA/C Zika news		-0.048		0.086		0.276
Education * US Zika news		0.304		-0.312		-0.205
Educ * Obj * LA/C Zika news		0.025		-0.019		-0.049
Educ * Obj * US Zika news		-0.076		0.069		0.038
Marginal R^2	0.252	0.263	0.184	0.187	0.127	0.128
Conditional R^2	0.610	0.608	0.541	0.538	0.826	0.550
BIC	9119	9052	8807	8754	10285	10344
Observations	3032		3031		3031	

Unstandardized coefficients. Marginal R2 = Proportion of variance explained by fixed effects alone; Conditional R2 = Proportion of variance explained by fixed and random effects. Observations reflect total over 4 waves. News following and subjective knowledge measured at wave 2. LA/C = Latin American/Caribbean; US = United States. † p < .10 * p < .05 ** p < .01 *** p < .001 **** p < .00

Figure 1. Interaction Examples. Left: US Risk as a Function of Time and LA/C News following. Right: Judged Need to Take Action as a Function of Objective Knowledge and LA/C News Following

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