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ABSTRACT

Parental concerns over the safety or necessity of childhood vaccination have increased over the past decades. At the same time, there has been a proliferation of vaccine-related information available through a range of health information sources. This study investigates the associations between evaluations of health information sources, parental perceptions of childhood vaccination benefits, and the maintenance of vaccination schedules for their children. Specifically, this study aims to (a) incorporate social media into the battery of health information sources and (b) differentiate households with a childhood autism diagnosis and those without, given unsubstantiated but persistent concerns about vaccine safety and autism. Analyzing a sample of U.S. households, a total of 4,174 parents who have at least one child under the age of 18 were analyzed, including 138 of parents of households with a childhood autism diagnosis. Results show that the more the parents value interpersonal communication and magazines as sources of health information, the more they perceive vaccination benefits, and the more the value they put on television, the better they keep vaccination schedules up-to-date for their children. On the other hand, social media are negatively associated with their perceptions of vaccination benefits. Although parents of children diagnosed with autism are less likely to perceive vaccination benefits, no interaction effects with evaluations of health information sources are found on parental perceptions of vaccination benefits or maintenance of schedules.

Childhood vaccination has proven to be one of the most effective public health strategies to control and prevent disease (CDC, 2011). The high rates of recommended immunizations among children have kept vaccine-preventable diseases at low levels in the past decades in the United States (Seither et al., 2016). Despite high childhood vaccine coverage in general,[1] there are growing concerns about parental vaccine refusal, especially in light of state-level increases in the rates of kindergarten nonmedical exemption, or opting out due to personal, philosophical, or religious beliefs (CDC, 2017).[2] These shifts may indicate that parents hold vaccine safety concerns that hinder them from vaccinating their children (Brown et al., 2010; Kennedy, Basket, & Sheedy, 2011). Previous studies have identified common reasons given for childhood vaccine refusal as parental concerns about safety and effectiveness as well as general mistrust of vaccines (Smith, Humiston, Parnell, Vannice, & Salmon, 2010).

Many parents who face vaccination schedules for their children may not be fully aware of the seriousness of vaccine-preventable disease, nor the true risks of vaccine-adverse incidents (Lee & Kim, 2015; Serpell & Green, 2006). These parents use information from a variety of health information sources (Jones et al., 2012; Lee & Kim, 2015) to inform their senses of the risks and benefits of vaccination. There are several ways to measure the degree to which health information sources are used. Many studies (e.g., Jones et al., 2012; Lee & Kim, 2015) have focused on information seeking, with parents deliberately obtaining vaccine-related information using health information sources. On the other hand, other studies (e.g., Moran, Frank, Chatterjee, Murphy, & Baezconde-Garbanati, 2016) have examined how routine patterns of communication, such as health information scanning, are associated with vaccine safety concerns. Given the fact that information for childhood vaccinations can be accumulated via health information seeking and health information scanning, this study considers the value placed on a range of mass media and interpersonal health information sources. In addition, although several studies (e.g., Dunn, Leask, Zhou, Mandl, & Coiera, 2015; McKeever, McKeever, Holton, & Li, 2016; Shoup et al., 2015; Witteman & Zikmund-Fisher, 2012) have examined the topic of childhood vaccinations in relation to the use of social media, few studies have investigated social media alongside other health information sources. Thus, we aim to incorporate social media into the battery of health information sources.

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[1]For instance, during the 2015–2016 school year, median kindergarten vaccination coverage was 94.6% for 2 doses of measles, mumps, and rubella vaccine (MMR) and 94.2% for local requirements for diphtheria, tetanus, and acellular pertussis vaccine among 49 states and the District of Columbia (DC) (see Seither et al., 2016).

[2]According to 2009–2010 through 2016–2017 school year, vaccination exemptions trend report (Centers for Disease Control and Prevention, 2017), kindergarten nonmedical exemption rates of Oregon, for instance, has increased from 5.2% (2009–2010), to 5.8% (2014–2015), to 6.5% (2016–2017).

To explore the associations between evaluations of health information sources and parental perceptions and behaviors, this study uses the O_1-S-O_2-R model (Markus & Zajonc, 1985). The O_1-S-O_2-R (Pre-orientation—Stimulus—Post-orientation—Response) model integrates mass and interpersonal communication into processes predicting responses to mediated communication (Cho et al., 2009). Since parents consider mass communication as well as interpersonal communication to make decisions on childhood vaccination, the O_1-S-O_2-R model is an appropriate approach to explore the associations. Specifically, the present model accounts for how parents' preexisting orientations, which include demographic and health-relevant variables, (O_1) determine their evaluations of health information channels (S), which form their perceptions of childhood vaccination benefits (O_2), and eventually influence their maintenance of childhood vaccination schedules (R).

Misinformation about vaccination and autism has prompted concerns about the safety of recommended vaccinations as well as recommended vaccination schedules (Kennedy, Lavail, Nowak, Basket, & Landry, 2011). Despite a number of reviews rejecting a postulated relationship between autism and the measles–mumps–rubella (MMR) vaccine (e.g., Fombonne & Chakrabarti, 2001), the persistent controversy has made many parents skeptical about the safety of childhood vaccinations (Young, Elliston, & Ruble, 2015). Parents of children diagnosed with autism are often the biggest opponents of childhood vaccinations (Brown et al., 2010). This tendency leads us to consider parents of children diagnosed with autism as a key variable to examine the associations.

Therefore, this study (a) examines how evaluations of health information sources related to parental perceptions of childhood vaccination benefits and the maintenance of vaccination schedules and (b) explores whether parents of children diagnosed with autism have different relationships between health information sources and those outcomes. We propose several contributions to the literature. First, we expand the applicability of the O_1-S-O_2-R model into the context of health communication, particularly, into the processes of vaccination behaviors. Second, we diversify health information sources by incorporating social media into them. Third, we try to capture not only information seeking but also information scanning by examining evaluations of a wide range of sources.

The O_1-S-O_2-R model for health communication studies

Although several studies have examined the relationship between health information sources and parents' perceptions (e.g., Jones et al., 2012; Kennedy et al., 2011) or decisions (e.g., Lee & Kim, 2015) regarding childhood vaccination, few studies have examined parental perceptions of the risks and benefits of childhood vaccination, and in turn, the maintenance of vaccination schedules. Thus, this study adopts an O_1-S-O_2-R framework so that we can explore perceptions and behaviors, considering them post-orientation (O_2) and response (R) respectively, while including whether parents of this study have a child or children diagnosed with autism as one of the pre-orientations.

Expanded beyond the simple relationship of S-R (Markus & Zajonc, 1985), the O_1-S-O_2-R model emphasizes the relationships between antecedents and outcomes that are mediated by stimuli. This model defines the pre-orientation as "structural, cultural, cognitive, and motivational characteristics the audience brings to the reception situation that affect the impact of the message" and the post-orientation as "what is likely to happen between reception of message and response of the audience member" (McLeod, Kosicki, & McLeod, 1994; pp. 146–147; see also Cho et al., 2009). In particular, the stimuli have an important role in that they include both media consumption and interpersonal communication, focusing on how they mediate the effects of demographic dispositional and structural factors on cognitive and behavioral outcomes (Cho et al., 2009). Lastly, the response represents the final outcome, which merges the influence of these interactions on viewers' social responses.

Since the O_1-S-O_2-R model has originated in social cognition by Markus and Zajonc (1985), health communication researchers have adopted the model to explicate the complicated health-related cognitive processes (e.g., Paek, 2008; Yoo, 2013). Most recently, Yoo (2013) has tested the effects of the reality TV show *The Biggest Loser* on obesity stigma formation based on the O_1-S-O_2-R framework. In her study, she has found that exposure to *The Biggest Loser* (S) was influenced by viewers' weight concerns (O_1). The S, in turn, predicted perceived weight loss of control (O_2). Lastly, O_2 formed negative beliefs and attitudes about obese people (R). In addition, Paek (2008) has examined the relationship between exposure to anti-smoking campaigns (S) and adolescents' smoking intention (R) by applying the model. The two pre-orientations were the adolescents' internal and learned orientations (O_1) and the post-orientations were respondents' negative attitudes toward tobacco companies and peer smoking norms (O_2).

Evaluations of health information sources as a mediator

The value an individual places on certain sources for health information may shape their impacts on perceptions and behaviors (Johnson & Meishcke, 1992). It is well known that source evaluations affect people's patterns of exposure; for example, Hesse and colleagues (2005) found that people not only preferred healthcare providers and the Internet as sources of information about cancer but also sought out those sources when obtaining information. Along similar lines, the more the people trust the Internet, the more they seek AIDS-related information on the Internet (Lu, Palmgreen, Zimmerman, Lane, & Alexander, 2006).

Yet source evaluations may be indicative of more than mere exposure to those sources. The value attributed to an information source may capture the degree to which people rely on different channels more concisely than traditional measurements such as information seeking or scanning. Similarly, McLeod and colleagues have argued that *attention* must be considered alongside exposure when examining media effects (see McLeod, Shah, Hess, & Lee, 2010). We contend that the value ascribed to health information sources combines aspects of exposure and attention, since valued sources tend to be selected and attended.

Few studies, however, have specifically adopted *evaluations* of health information sources to examine perceptions or behaviors of childhood vaccinations. Instead, several studies (Jones et al., 2012; Kennedy et al., 2011; Lee & Kim, 2015; Mckeever et al., 2016; Smith et al., 2010) have examined the association between the *exposure* to health information sources and childhood vaccination behaviors or attitudes. Studies have reported that not all vaccine information sources affect childhood vaccination rates in the same way (Lee & Kim, 2015). To begin, expert sources such as a doctor or nurse are considered to be the most important sources of information on childhood vaccinations (Kennedy et al., 2011). Conversely, there is doubt surrounding the quality of mass media reports, particularly after coverage in the late 1990s and early 2000s of the now discredited link between childhood vaccines and autism (Clarke, 2008). More recent work (Clarke, Dixon, Holton, & McKeever, 2015) indicates improved media performance in terms of evidentiary balance (i.e., the preponderance of scientific evidence points to no autism-vaccine connection and scientists are presented as agreeing on this perspective). News media may have helped reshape audiences' beliefs about a scientific consensus regarding the absence of a link between autism and vaccine, and increased perceptions that vaccines are safe and effective (Clarke et al., 2015).

Recent studies have indicated negative relationships between the use of the Internet and vaccine-related beliefs (Jones et al., 2012), and vaccination behaviors (Restivo et al., 2015; Smith et al., 2010). Specifically, parents who sought vaccine information on the Internet were more likely to have lower perceptions of vaccine safety (Jones et al., 2012) and finally reach lower childhood vaccine uptake (Restivo et al., 2015; Smith et al., 2010). There appear to be two reasons for this association: (a) unlike news sources with stronger gatekeeping norms, the Internet-based vaccine information that reaches parents contains more anti-vaccine content (Kata, 2012) and (b) the anti-vaccine information spreads widely because of its frequent updating and novelty (Jones et al., 2012).

Despite the similarity between the Internet and social media as information sources (i.e., user participation, openness, and interactivity) (Witteman & Zikmund-Fisher, 2012), this study aims to distinguish social media from the Internet because information on social media is highly embedded within interpersonal networks. Social media are defined as online services that allow users to create an individual profile through which they connect, communicate, and interact with other users and allow them to navigate through these networks of contacts (Boyd & Ellison, 2008). Though there are a number of ways to reflect the diverse range of social media platforms, such as collaborative projects (e.g., Wikipedia), content communities (e.g., YouTube), and social networking sites (e.g., Facebook) (Kaplan & Haenlein, 2010), we conceptualize social media as venues where two-way and direct communication that includes sharing of information between several parties occurs (Moorhead et al., 2013). Facebook and Twitter exemplify social media as we define them for the purpose of this study. It is important to note that communication on social media is different from interpersonal communication, which, in this study, is defined as one-on-one communication, primarily with authoritative healthcare professionals such as doctors or nurses. It is widely known that social media enable either anonymity or personal connection, as preferred for particular interactions, and encourage a sense of connectedness among individuals (Korda & Itani, 2013). Previous studies examining social media as a tool for health-related information have shown that people interact with their friends, family, and others on health issues using social media (Moorhead et al., 2013). Social media also blend information, speculation, and opinions regarding vaccinations, with previous studies finding the prevalence of concerns, fears, and misinformation about vaccines in social media posts (Kata, 2012; Witteman & Zikmund-Fisher, 2012). Moreover, those who were exposed to negative opinions on social media were more likely to subsequently post negative statements (Dunn et al., 2015). Due to its interactive and user-generated characteristics, social media can exacerbate tensions related to controversial topics such as childhood vaccinations (Mckeever et al., 2016; Shoup et al., 2015). Misinformation can be reinforced on social media, since people are more likely to connect and collaborate with like-minded users (Shoup et al., 2015).

Given that social media platforms are among the top resources used by parents in the vaccination decision-making processes (Mckeever et al., 2016), this study includes social media as health information sources. By focusing on the value respondents place on various health information sources, not specific information seeking or scanning, we can compare across sources such as magazines, newspapers, television, interpersonal communication, the Internet, and social media. We can then explore the way each health information source is associated with parental perceptions of vaccination benefits as well as the maintenance of vaccination schedules.

Research Question 1: When accounting for demographic characteristics (O_1), how are evaluations of health information sources (magazines, newspapers, television, interpersonal communication, the Internet, and social media) (S) related to parental perceptions on childhood vaccination benefits (O_2)?

Research Question 2: When accounting for demographic characteristics (O_1), how are evaluations of health information sources (magazines, newspapers, television, interpersonal communication, the Internet, and social media) (S) related to the maintenance of vaccination schedules (R)?

Given that we are accounting for demographic characteristics, we also consider the associations between these pre-orientations (O_1), and the evaluations of health information sources (O_2) and the maintenance of vaccination schedules (R).

Research Question 3: How are demographic characteristics (O_1) related to parental perceptions of childhood vaccination benefits (O_2)?

Research Question 4: How are demographic characteristics (O_1) related to the maintenance of vaccination schedules (R)?

Despite an abundance of scientific reviews rejecting a causal association between childhood vaccination and autism spectrum disorder advanced in the retracted (The Editors of The Lancet, 2010) 1998 *Lancet* publication by Wakefield and associates, concerns about a possible link have persisted among parents (Young et al., 2015), sparking several measles outbreaks (Mckeever et al., 2016). Although parents have reported a variety of different vaccine-related concerns such as painfulness of vaccines for their children (Kennedy et al., 2011), concerns that vaccines may cause learning disabilities such as autism remain highly reported as barriers preventing parents from vaccinating their children (Brown et al., 2010; Young et al., 2015).

The tendency to forego vaccination is a prominent issue among parents of children diagnosed with autism. Young and colleagues (2015) have examined attitudes toward childhood vaccination among parents of children diagnosed with autism; they found that 56% of respondents believed that vaccination contributed to their child's autism, and 16% would discourage others from vaccinating their children. Similarly, Mercer, Creighton, Holden, and Lewis (2006) have examined parents involved with autism organizations in the United States and Canada and found 40% of respondents believed the most significant factor involved in their child's autism was vaccines. Given this pattern, this study also examines that whether the relationships between evaluations of information sources and vaccination perceptions and behaviors differ among parents of children diagnosed with autism as compared to parents of children without autism.

Research Question 5: Do parents who have at least one child diagnosed with autism (O_1) condition the relationship of evaluations of health information sources (S) on parental perceptions of vaccination benefits (O_2) and the maintenance of vaccination schedules (R)?

Methods

Data

This study analyzed the Multimedia Audience Research Systems (MARS) data that were collected from January 2013 to April 2013 by Kantar Media. The MARS 2013 is a nation-wide study combining the national sample and the list-enhanced oversample. The national sample defined the universe as adults who reside in the 50 U.S. states, excluding people in special living conditions (e.g., dormitories and nursing homes). The national sample of 26,800 individuals was obtained through a systematic random sampling procedure from KBM's AmeriLink database of 242 million consumers in the United States The list-enhanced sample was included in the MARS 2013 to collect more information about people with various ailments. Combining the national sample and the list-enhanced oversample, the MARS 2013 selected 48,666 potential participants with an expected response rate of 50% and sent questionnaire packets to them. A total of 19,420 participants completed and returned the questionnaire packets with a response rate of 42.8%. The focus of this study was restricted to parents by asking respondents if they are parents of any children under the age of 18. A total of 4,174 parent respondents were included in the final sample. Among them, 138 respondents were parents of at least one child diagnosed with autism.

Measures

Four sets of variables were measured: Pre-orientations (O_1) – demographic variables that comprise parent's age, gender, race, education, household income, whether they have child(ren) diagnosed with autism and their child's age; Stimuli (S) – evaluations of a range of health information sources; Post-orientations (O_2) – parental perceptions of vaccination benefits, and Response (R) – maintenance of vaccination schedules. Exploratory factor analysis and Cronbach's alpha (α) were used to assess the internal consistency of variables measured with multiple items.

For *maintenance of vaccination schedules* measure, respondents were asked a single-item question with a 5-point scale (1 = disagree a lot to 5 = agree a lot): "I always make sure my child's vaccinations are up-to-date."

Perceptions of vaccination benefits were also measured with a single-item question with a 5-point scale (1 = disagree a lot to 5 = agree a lot): "The benefit of having my children immunized far outweighs the risks."

Evaluations of health information sources were measured with the following questions with a 4-point scale (1 = very much to 4 = not at all): Please indicate how much you value each of the following sources for healthcare information. Items were reversed to make higher numbers indicate greater value placed on the information source. Exploratory factor analysis (EFA) shows six factors. Magazines consist of three items: magazine advertisements, magazine articles, and magazines in doctors' offices (α = .89). Newspapers consist of two items: newspaper articles and newsletters (α = .83). Television consists of two items: TV programs or reports, and TV program in doctors' office (α = .96). The Internet consists of four items: search engines, general websites (e.g., cnn.com), drug company websites (e.g., advil.com), and other health websites (e.g., WebMD.com) (α = .89). Interpersonal communication consists of four items: doctors, nurses/physician assistants, pharmacists, and friends (α = .82). Social media consist of two items: social networking sites (SNS) and online blogs/vlogs (α = .76).

Six *demographic variables* were measured including the responding parent's age and the age of their child, their gender, their race, their household income, and their educational attainment. While the parents' age was assessed using 13 increasing age-ranges, it is condensed into four categories for parsimony (18–29, 30–44, 45–59, and 60 or more). The child's age was measured by indicating the age range of each child and collapsed into four categories (under 24 months, 2–5 years, 6–11 years, and 12–17 years); in households with multiple children, the age of the youngest child was used. Gender was recoded as binary with 1 being male and 2 being female. Race was asked as a categorical variable and multiple responses allowed: "White," "Black or African American," "American Indian or Alaska Native," "Asian or Pacific Islander," or "Some other race," and ethnicity was also asked as a binary with 1 being Spanish/Hispanic/Latino and 0 being others. Under the race/ethnicity variable, two variables (1 being Black and 0 being others; 1 being Hispanic and 0 being others) were created as binary. In terms of education, less than high school was recoded 1, high school graduate was recoded 2, some college was recoded 3, and college graduate or more was recoded 4. While household income variable was assessed using 10 declining income ranges, it was collapsed into 3 categories (less than \$20,000, \$20,000–\$ 49,999, and \$50,000 or more), indicating that higher score means a higher household income.

Parents of children diagnosed with or without autism were measured with a single item, "indicate whether autism currently

Table 1. Demographic characteristics of parents of children diagnosed with and without autism (*N*, %).

Variable Items	Pooled Sample (*N* = 4,174)	Parents of Children without Autism (*N* = 4,036)	Parents of Children with Autism (*N* = 138)	Independent sample *t*-test
	N (%)	*N* (%)	*N* (%)	*p*
Parents' age				.08
18–29	570 (13.7)	553 (13.7)	17 (12.3)	
30–44	2292 (54.9)	2204 (54.6)	88 (63.8)	
45–59	1169 (28.0)	1137 (28.2)	32 (23.2)	
60+	143 (3.4)	142 (3.5)	1 (.7)	
Children's age				.15
0–24 months	707 (16.9)	693 (18.4)	14 (10.4)	
2–5 years	1007 (24.1)	972 (25.8)	35 (25.9)	
6–12 years	1056 (25.3)	1004 (26.6)	52 (38.5)	
13–17 years	1136 (27.2)	1102 (29.2)	34 (25.2)	
Gender				.28
Male	1223 (29.3)	1188 (29.4)	35 (25.4)	
Female	2951 (70.7)	2848 (70.6)	103 (74.6)	
Race/ethnicity				
White	3469 (83.1)	3357 (83.2)	112 (81.2)	.53
Black	440 (10.5)	427 (10.6)	13 (9.4)	.66
Hispanic	302 (7.2)	283 (7.0)	19 (13.8)	.02*
Education				.09
Less than high school	191 (4.6)	178 (4.4)	13 (9.4)	
High school graduate	917 (22.0)	884 (21.9)	33 (23.9)	
Some college	1269 (30.4)	1233 (30.6)	36 (26.1)	
College graduate +	1797 (43.1)	1741 (43.1)	56 (40.6)	
Income				.00***
Less than $ 20,000	583 (14.0)	554 (13.7)	29 (21.7)	
$ 20,000–$ 49,999	1228 (29.4)	1175 (29.1)	53 (38.4)	
$ 50,000 +	2363 (56.6)	2307 (57.2)	56 (40.6)	

Note. Parents' age, children's age, education, and income were originally measured with more specified categories (i.e., parents' age with 13 ordinal scales (18–20, 21–24, 25–29, … 75+); children's age with five ordinal scales (0–12 months, 12–24 months, 2–5 years, 6–12 years, and 13–17 years); education with five ordinal scales (less than high school, high school graduate, some college, college graduate, and post-graduate); income with 10 ordinal scales (less than $20,000, $20,000–$29,999, … $250,000+)). In addition to the current analyses (see Table 3 and Figure 1), the same models with original demographic variables were analyzed, and we confirmed that the results hold. The demographic variables with fewer categories were used throughout the analyses for parsimony.
*$p < .05$, **$p < .01$, ***$p < .001$.

exists in your child(ren)" and recoded as binary. Descriptive characteristics of the variables within the pooled sample, and distinguishing parents of children diagnosed with and without autism, are reported in Tables 1 and 2.

Analytic strategy

Before fitting a structural equation model, independent sample *t*-tests for all variables were performed between parents of children diagnosed with and without autism. These tests indicated that parents of children diagnosed with autism have significantly lower household income ($t = -3.6$, $p < .001$), lower levels of perceptions of vaccination benefits ($t = -2.8$, $p < .01$), and are more likely to be Hispanic ($t = 2.2$, $p < .05$), as shown Table 1. These significant differences between parents of children diagnosed with and without autism support our rationale for treating this variable as a pre-orientation.

Next, structural equation modeling (SEM) was performed to test our research questions. The lavaan in R program was employed with maximum likelihood estimates. First, the model ($N = 4174$) shows a good fit, χ^2 (219) = 3153.86, $p = .000$, root mean square error of approximation (RMSEA) = .05, Tucker-Lewis Index = .90, comparative fit index = .93. Among the full sample of 4,174, there were 559 missing responses for the O_2 (perceptions of vaccination benefits) and 538 missing responses for the R (maintenance of vaccination schedules). In order to address the missing data issue, we used full information maximum likelihood (FIML) by imputing data rather than losing approximately 15% of the sample. We also used maximum likelihood estimator (MLR) to address non-normality problem. Thus, the final study sample was still 4,174 (parents of children diagnosed with autism: 138, parents of children diagnosed without autism: 4036). Given that we had a large number of paths between variables, only significant paths between O_1 and O_2, O_1 and R, S and O_2, S and R, and O_2 and R were shown in Figure 1 to address the research questions.

Finally, hierarchical regression analyses were performed as a supplement with SPSS 21 to test whether an autism diagnosis conditioned the relationship between evaluations of health information sources on the two outcomes (Research Question 5).[3] For these models, perceptions of vaccination benefits and maintenance of vaccination schedules were entered as two dependent variables; pre-orientations (demographic characteristics and whether parents have children diagnosed with autism) were entered in Step 1; evaluations of health information sources (magazines, newspapers, television, interpersonal

[3]Although we planned to conduct SEM with two different groups (parents of children diagnosed with autism and those without), due to the relatively small sample size for the group of parents of children diagnosed with autism ($N = 138$), we examined interaction effects using hierarchical regression analysis. Since we addressed missing data and non-normality issue with the SEM, and this model addressed our research questions more precisely, we interpreted the main effects using the SEM.

Table 2. Descriptive characteristics of evaluations of information sources, perceptions of vaccination benefits, and maintenance of vaccination schedules (*M, SD*).

	Pooled Sample (*N* = 4,174)		Parents of Children without Autism (*N* = 4,036)		Parents of Children with Autism (*N* = 138)		Independent sample *t*-test
Variable Items	*M*	*SD*	*M*	*SD*	*M*	*SD*	*p*
Evaluations of information sources (range1–4)							
Magazine	1.86	0.84	1.86	0.84	1.91	0.88	.73
Newspaper	1.73	0.81	1.73	0.81	1.77	0.81	.58
Interpersonal	2.76	0.92	2.76	0.92	2.69	0.96	.38
Television	1.70	0.90	1.70	0.89	1.78	0.92	.28
Internet	1.85	0.84	1.85	0.84	1.82	0.84	.73
Social Media	1.58	0.73	1.58	0.73	1.61	0.69	.66
Perceptions of vaccination benefits (range 1–5)	4.28	1.02	4.29	1.01	3.98	1.19	.00**
Maintenance of vaccination schedules (range 1–5)	4.61	0.81	4.61	0.80	4.50	1.00	.23

*$p < .05$, **$p < .01$, ***$p < .001$

Table 3. Hierarchical regression analyses presenting interaction effects of parents of children diagnosed with autism and evaluations of health information sources.

	Parental Perceptions of Vaccination Benefits		Maintenance of Vaccination Schedules	
Variable Items	β	*p*	*B*	*p*
Pre-orientations				
Parents' age	.052	.009*	.021	.295
Children's age	−.011	.571	−.004	.829
Gender	.074	.000***	.054	.002**
Race/ethnicity				
Black	.010	.543	.053	.002**
Hispanic	.048	.004**	.039	.019*
Income	.044	.018*	.006	.742
Education	.076	.000***	.013	.486
Autism	.009	.874	−.052	.351
Stimuli				
Magazine	.060	.030*	.073	.008**
Newspaper	.019	.488	−.022	.412
Television	−.004	.868	.046	.065
Interpersonal	.104	.000***	.078	.000***
Internet	.009	.874	−.004	.893
Social Media	−.089	.000***	−.074	.003**
Stimuli Interactions				
Magazine × Parents of children with autism	.021	.720	.050	.395
Newspaper × Parents of children with autism	−.107	.074	.067	.262
Television × Parents of children with autism	−.056	.224	.025	.588
Interpersonal × Parents of children with autism	−.023	.694	−.070	.238
Internet × Parents of children with autism	.058	.376	−.018	.766
Social Media × Parents of children with autism	.042	.485	−.018	.765
N	3537		3555	
Total R^2	.040*		.025*	

Note. All the coefficients are standardized.
*$p < .05$, **$p < .01$, ***$p < .001$.

communication, the Internet, and social media) were entered in Step 2; and the interaction terms were entered in Step 3.

Results

Evaluations of health information sources

Beginning with Research Questions 1 and 2, we examined the associations between evaluations of health information sources and parental perceptions of vaccination benefits (RQ1) and maintenance of vaccination schedules (RQ2) by interpreting the paths both from S to O_2 and S to R, respectively, in our SEM. The results of our analysis demonstrated that the two outcomes were significantly predicted by the value assigned to several information sources, as summarized in Figure 1. The values placed on magazines ($\beta = .11$, $p < .05$) and interpersonal communication ($\beta = .14$, $p < .001$) as health information sources were positively associated with parental perceptions of vaccination benefits, whereas the value placed on social media as sources of health information was negatively associated with perceptions of vaccination benefits ($\beta = -.27$, $p < .01$). In addition, only the value placed on television as a health information source was positively related to the maintenance of vaccination schedules ($\beta = .05$, $p < .01$). In turn, parental perceptions of vaccination benefits were strongly associated with the maintenance of vaccination schedules ($\beta = .47$, $p < .001$).

Demographic variables and parents of children diagnosed with autism

Considering Research Questions 3 and 4, we also examined the influence of demographic characteristics on parental perceptions of vaccination benefits (RQ3), and maintenance of vaccination schedules (RQ4). Female ($\beta = .17$, $p < .001$), Hispanics ($\beta = .08$, $p < .05$), older ($\beta = .08$, $p < .01$), more educated respondents ($\beta = .07$, $p < .01$), and parents of children *without* autism ($\beta = -.27$, $p < .05$) tended to perceive the benefits, while Black respondents ($\beta = .12$, $p < .001$) and those with less

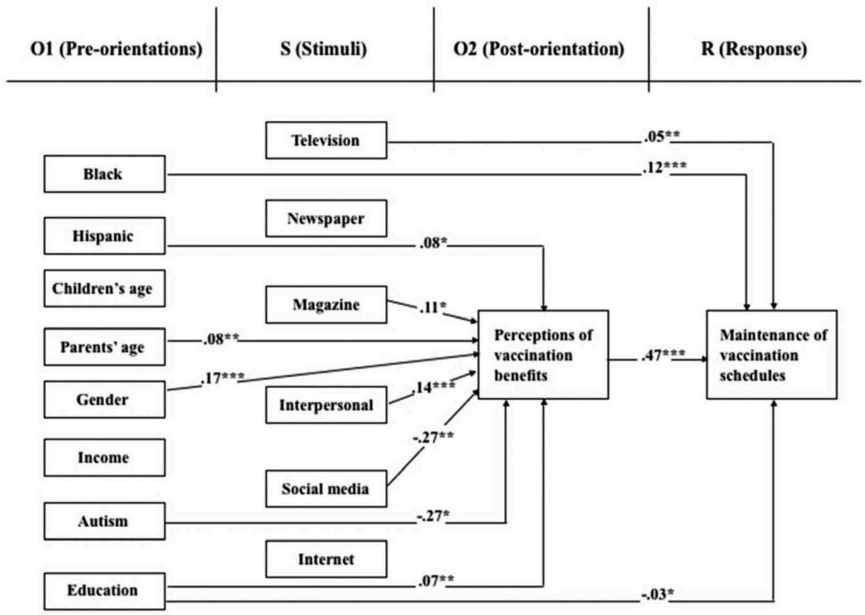

Figure 1. Structural equation model of the maintenance of childhood vaccination schedules (N = 4,174).
Note. All the coefficients are standardized. This figure only shows the significant paths addressing research questions for visual clarity.
$^*p < .05$, $^{**}p < .01$, $^{***}p < .001$.

education (β = -.03, p < .05) were more likely to maintain vaccination schedules for their children. Notably, many of these effects size were quite small relative to the associations observed for health information sources, especially the comparatively large role of social media.

Finally turning to Research Question 5, we considered whether the relationship of evaluations of health information sources (S) on parental perceptions of vaccination benefits (O_2) and the maintenance vaccination schedules (R) differs among parents who have children diagnosed with autism. To do so, we tested hierarchical regression models including interaction terms between information sources and autism diagnosis. None of the interaction terms achieved significance, as presented in Table 3. The relationships observed in SEM did not appear to be isolated to a particular subset of parents.

Discussion

This study investigated the associations between evaluations of health information sources, parental perceptions of vaccination benefits, and maintenance of vaccination schedules. We found that traditional information sources, such as magazines and television, and authoritative sources, such as interpersonal communication with doctors, nurses, pharmacists, and friends, yielded significant positive associations with parental perceptions of childhood vaccination benefits and the maintenance of vaccination schedules. On the other hand, the value placed on social media, less vetted and authoritative sources, yielded significant negative associations with parental perceptions of vaccination benefits, indirectly influencing vaccination behaviors.

These results confirm the findings of past studies and provide novel insights. Given that previous studies have found that healthcare providers were among the least fear-inducing information sources (Young et al., 2015) and that trust in healthcare providers was associated with a reduction on vaccine safety concerns (Moran et al., 2016), the positive association between interpersonal communication, which is conceptualized as one-on-one communication primarily with authoritative healthcare professionals, and maintenance of vaccine schedules is consistent with past works.

The negative association between evaluations of social media and vaccination perceptions supports the view that social media feature a prevalence of concerns, fears, and misinformation about vaccines (Kata, 2012; Witteman & Zikmund-Fisher, 2012). However, our results run counter to previous findings suggesting the negative association between Internet use as a health information resource and vaccination behaviors (Jones et al., 2012; Restivo et al., 2015) or perceptions of vaccine safety (Smith et al., 2010). Given that we found the negative association of vaccination perceptions only with social media, and not the Internet, we speculate that interpersonal interactions on social media may lead to lower perceptions of vaccination benefits. This speculation is supported by the fact that, in this study, we focus on the personal dialogic nature of social media platforms such as Facebook and Twitter.

Contrary to previous studies claiming negative associations between mass media use and intentions of childhood vaccination (e.g., Lee & Kim, 2015), we found strong positive associations between the value placed on magazines and television and perceptions of vaccination benefits. It may reflect the changing values within mass media regarding reporting on vaccines. Mass media reports in the 1990s touted allegations of a possible link between MMR vaccine and autism, supporting the anti-vaccination movement (Ledford, Willett, & Kreps, 2012). In recent years, Holton and colleagues (2012) have shown that blame attribution for an autism-vaccine link in media coverage has changed over time. Given this shift, we interpret this positive relationship between more established mass media outlets and vaccine perception as a reflection of current coverage, which is evidently more accurate (Clarke et al., 2015).

Shifting to whether parents of children diagnosed with autism perceived fewer benefits of vaccination, our data indicate much. However, there were no associations with the evaluations of health information sources. Our regression analyses examined any possible interaction effects between autism diagnosis and evaluations of health information sources on perceptions and behaviors. No interaction effects were observed. In sum, these results led us to conclude that parental perceptions and behaviors associated with information sources are not restricted to parents of children diagnosed or not diagnosed with autism.

Notably, for the purposes of this study, we defined childhood vaccination in a holistic manner. Despite the differences between a variety of vaccines in terms of their perceived consequences, uptake rate, and media coverage, we aimed to investigate the overall perceptions of childhood vaccination. According to the CDC Advisory Committee on Immunization Practices, a recommended immunization schedule for children includes four doses of diphtheria, tetanus, and acellular pertussis vaccine (DTaP), three doses of inactivated poliovirus vaccine (IPV), one dose of MMR, three doses of hepatitis B, three or four doses of Haemophilus influenzae type b (HIB), four doses of pneumococcal conjugate, and one dose of varicella (VAR) vaccine by age 18 months. In addition, one booster dose of DTaP, IPV, MMR, and VAR is required to be injected between 4 and 6 years of age. Also, one dose each of Meningococcal vaccine for both at age 11–12 years and at 16 years is required (Seither et al., 2016).[4] Given that vaccine schedules require immunizations at various time points, we controlled for child's age along with parent's age. The fact that the observed relationships between evaluations of health information sources and vaccination perceptions and behaviors existed after controlling for child's age suggests that these findings are not simply a function of the different types of childhood vaccinations or childhood vaccination schedules.

Limitations and future directions

Despite several implications of this study, methodological limitations temper the conclusions of this study. First, since this study uses a cross-sectional survey, there may be a concern related to a causal direction. Particularly, critics may take issue with the assumed causal relationships between S (evaluations of health information sources) and O_2 (parental perceptions of vaccination benefits). Longitudinal data should verify the causal relationship more carefully in future studies.

Second, despite our goal to examine parental perceptions and behaviors for a range of vaccinations, the validity and reliability of our findings can be questioned because we did not measure each vaccine uptake (e.g., TDap, MMR, or HPV). Also, maintenance of vaccination schedules was measured with a self-reported question, rather than relying on actual medical records. Similarly, the measurement of evaluations of health information sources may also have limitations, due to its failure to account for actual exposure and attention.

Lastly, our findings regarding social media are restricted to the scope of SNS and blogs, given the measurement available from this survey. It should also be noted that not all social media communication is as personal and dialogic as what occurs on platforms such as Facebook and Twitter. We recommend that future studies distinguish an array of social media sites where vaccination information may be encountered by parents, potentially examining social media sites by specific typology (e.g., collaborative projects, content communities, and social networking sites). Although studies indicating the prevalence of fear and misinformation about vaccines on social media have been conducted (Kata, 2012; Witteman & Zikmund-Fisher, 2012), it remains unclear exactly what information on social media leads to lower perceptions regarding vaccination benefits. Prospective studies should examine what information or communication on social media contributes to these lower perceptions. Many of these issues are a function of secondary analysis of an existing dataset.

Despite these limitations, the examination of the mechanisms through which parents form perceptions of vaccination benefits and decisions to maintain vaccination schedules for their children reveals important differences between various health information sources. A theoretical contribution of this study lies in the light it sheds on the role of health information sources on the maintenance of childhood vaccination schedules, applying the O_1-S-O_2-R model. Because few people clearly understand the intricacies of health interventions' benefits and risks, the public turns to media to help them make many important health decisions. Therefore, we use the O_1-S-O_2-R model as an integrative theoretical framework, representing parents' behavioral outcomes as resulting from the cognitive processes caused by their evaluations of health information sources regarding childhood vaccination. Future studies can apply the O_1-S-O_2-R model to better understand the media's roles in public health decision-making or perceptions in health contexts other than vaccination.

Furthermore, we examined the effects of various media, including the Internet and social media simultaneously, on perceptions and behaviors. Our results indicated strong negative associations between social media and perceptions of vaccination benefits; these findings contrast with findings of previous studies negatively linking the Internet use to vaccination perceptions (Jones et al., 2012) or behaviors (Restivo et al., 2015; Smith et al., 2010). This may be attributed to the constantly changing nature of

[4]All the 50 states and the District of Columbia required 2 doses of a measles-containing vaccine, with MMR as the only measles-containing vaccine available in the United States. For local DTaP vaccine requirements, Nebraska required 3 doses, 4 states (Illinois, Pennsylvania, Virginia, and Wisconsin) required 4 doses, Pennsylvania did not require pertussis, and all other states required 5 doses unless the fourth dose was administered on or after the fourth birthday. Kentucky required 5 doses of DTaP by age 5, but reported 4-dose coverage for kindergartners. For varicella vaccine, eight states required 1 dose and 42 states and DC required 2 doses. Alabama, Florida, Georgia, Iowa, Mississippi, New Hampshire, and New Jersey considered kindergartners up-to-date only if they had received all doses of all vaccines required for school entry (Seither et al., 2016).

both social media and the Internet's roles in influencing vaccination outcomes. Thus, we suggest that future researchers develop a more detailed typology of health information sources, with a particular focus on both social media and the Internet to understand the underlying dynamics influencing vaccination decisions.

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