OXFORD

Interacting with Computers, 2023, **00**, 1–11
https://doi.org/10.1093/iwc/iwad009
Articles

Social Media Use and COVID-19 Vaccination Intent: An Exploratory Study on the Mediating Role of Information Exposure

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Abstract

We stumble upon new and repeating information daily. As information comes from many sources, social media continues to play a predominant role in disseminating information, ultimately impacting individuals' perceptions and behaviors. A prime example of this impact was observed during the COVID-19 pandemic, in which social media use was influencing willingness to receive the COVID-19 vaccine. While studies on this relationship between social media use and vaccination intent have been widely investigated, less is known about the mechanisms that link these two variables, specifically the types of information seen on social media platforms and the effects of these different types of information. In this exploratory study, we demonstrate the mediator role of information exposure (to include both types of information and frequency) between social media use and vaccination intent. Our results show that different types of information mediate this relationship differently and demonstrate how these relationships were further moderated by the income level of the participant. We conclude with the implications of these findings and how our findings can inform the direction of future research within the field of human–computer interaction.

RESEARCH HIGHLIGHTS:

- This paper presents an exploratory study assessing how information exposure mediates the relationship between social media usage and vaccination intent. The term *information exposure* was utilized to quantify both the types of and frequency of information people engage with.
- In this exploratory study, we found that exposure to information related to vaccine efficacy and effectiveness, authorization status, and dissemination plans significantly mediated the relationship between social media usage and vaccination intent. These effects were further moderated by income.
- Our results shed light on new opportunities for future human–computer interaction research examining the influence of specific types of information received through social media rather than generalized information categories on the broad use of social media.

Keywords: information exposure, social media, vaccination intent, COVID-19, pandemic

1. Introduction

In 2019, prior to the COVID-19 pandemic, the World Health Organization categorized vaccine hesitancy as one of the top 10 threats to global health (World Health Organization, 2019). The pandemic, which has taken the lives of more than 6 million people worldwide (World Health Organization, 2022), has clearly exemplified the cost of this hesitancy, especially in the USA. In examining the trends in vaccine hesitancy during COVID-19, many researchers highlighted that the reasons for hesitancy are multi-factorial (Lazarus *et al.*, 2021) and further that there are a multitude of influential factors correlated with vaccine acceptance or uptake (Malik *et al.*, 2020), such as socioeconomic characteristics (Callaghan *et al.*, 2020, Khubchandani *et al.*, 2021) and social media usage (Jennings *et al.*, 2021, Puri *et al.*, 2020, Wilson & Wiysonge, 2020).

Following the steady increase in the utilization of social media over the past several decades (Pew Research Center, 2021), social media has become a powerful vehicle to disseminate crisis and risk information during the COVID-19 pandemic (Zhang *et al.*, 2022), even more so than in other crisis events

Received: October 27, 2021. **Revised:** January 19, 2023. **Accepted:** January 20, 2023

(Goel & Gupta, 2020). In addition to being easily accessible, social media accelerates the exchange of information, solidifying it as an important information source that millions of people rely on (Neely *et al.*, 2021), especially in times of uncertainty. For example, with regard to COVID-19 vaccine hesitancy, social media is more influential than other forms of mass media, including television, radio and websites, combined (Goldsmith *et al.*, 2022). Given the established research that recognizes the association between social media use and vaccine hesitancy, an important research question (RQ) remains unanswered:

RQ1: How does social media use influence people's intention to get vaccinated?

While a growing body of research has explored the impact that social media use has on vaccination intent (Benis *et al.*, 2021, Jennings *et al.*, 2021, Loomba *et al.*, 2021a, b), these works primarily measured *social media use* by simply asking respondents which social media platform(s) they use (Al-Hasan *et al.*, 2021) and/or how frequently they use these platforms (Xin *et al.*, 2021). Studies specifically attempted to determine the relationship between social media use and respondents' information seeking behaviors by measuring a general operationalization of information seeking, such as how frequently respondents received information regarding COVID-19 and the vaccine (Mitchell & Liedke, 2021). However, these general questions fail to explore critical concepts surrounding *how* the use of social media impacts peoples' decisions and the specific types of information shared via social media.

To address this research gap, our work focuses on identifying the potential mediating[1] role that the types and frequency of information have on influencing the relationship between social media use and vaccination intent. Specifically, we hypothesize that while there is a relationship between social media use and intent to get vaccinated, exposure to specific types of vaccine information plays a critical role in strengthening this relationship. In this work, we utilize the term *information exposure* to quantify both the types and frequency of information received.

We particularly focus on investigating five types of information that were commonly disseminated at the time of our study, which occurred in parallel with the first approvals of the COVID-19 vaccine in the USA (Karami *et al.*, 2021, Luo *et al.*, 2021, Lyu *et al.*, 2021). These five types of information are (i) vaccine efficacy and effectiveness, (ii) vaccine authorization status, (iii) vaccination dissemination plans, (iv) vaccine side effects and (v) ethical issues regarding vaccination development. Our study aims to investigate if these types of information affect individuals' attitudes toward COVID-19 vaccination by acting as a mediator in the relationship between social media use and vaccination intent. Correspondingly, this study explores the following research question:

RQ2: What information, when received frequently, mediates the relationship between social media use and vaccination intent?

To answer RQ1 and RQ2, this study utilized survey data collected from 177 individuals in the attempt to investigate the relationship between social media use and vaccination intent and to explore the mechanisms underlying the association by testing the mediating effect of information exposure related to COVID-19 vaccine and the moderating effect of income.

[1] A mediator variable, typically denoted as M, is a third variable that may exist in between a dependent and an independent variable. The existence of a mediator variable in a relationship provides more explanation on how or why the relationship occurs (see Hayes, 2017).

Our results suggest new opportunities for future human–computer interaction (HCI) research that examines the influence of social media on individuals' decision making. Our work contributes to the study of information-seeking behavior by discussing the importance of investigating the role of specific types of information received through online platforms (i.e. social media).

2. Related Work and Hypotheses

In this section, we present related works that informed the development of our research hypotheses.

2.1. Social media use and COVID-19 vaccination intent

Over the past decade, the ways in which social media has been utilized has continuously evolved (Treem *et al.*, 2016). In the beginning, social media was used to connect families and friends scattered around the world. Now, it has become an important platform for individuals and organizations to voice their views, communicate positions and disseminate information, regardless of factual basis or scientific research (Dubose, 2011).

In the context of vaccination, social media undoubtedly plays both critical and controversial roles. Studies in the past year alone have underlined this divergent role, especially as hesitancy toward vaccination has become a prominent issue not only in the USA (Callaghan *et al.*, 2020), but also around the world (Hamel *et al.*, 2021). For example, Wilson and Wiysonge found that beliefs about COVID-19 vaccines being unsafe were widely circulated by vaccine hesitant groups through social media platforms (Wilson & Wiysonge, 2020). Their study also highlighted a significant association between foreign dissemination and decreases in vaccination rates. Similarly, Jennings *et al.* (2021) established in their findings that frequent social media usage was a significant predictor of hesitancy to get vaccinated for COVID-19.

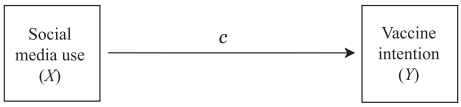
Nonetheless, despite the role that social media has in decreasing vaccination rates, it is also a beacon for promoting the positive aspects of vaccination. Concern about the decrease in vaccination rates has highlighted the need for better social media strategies to promote vaccine acceptance (Xin *et al.*, 2021). These strategies include implementing structural changes to social media networks (Plantin *et al.*, 2018), leveraging influential accounts (Dubose, 2011) and targeting parents and young adults, both synchronously and separately (Puri *et al.*, 2020). Still, there is a lack of understanding about how these strategies influence individuals to get vaccinated.

Given the current challenges present in existing work focused on social media and vaccination intent, this work extends the existing body of research by further investigating the direct association between social media usage and willingness to get vaccinated within populations that have experienced the highest rates of COVID-19 infection, hospitalization and death (see Subsection 3.1). As such, we examine the first hypothesis (H1), as depicted in Fig. 1a:

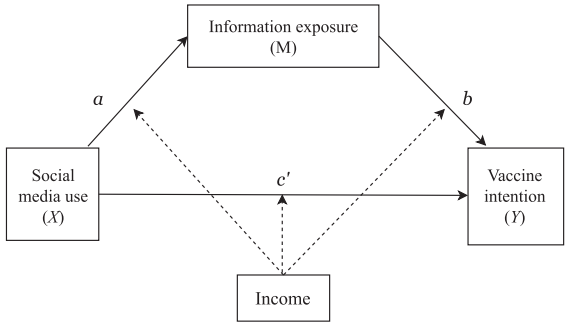
H1 Use of social media to get information related to COVID-19 vaccines directly influences vaccination intent.

2.2. The Mediating role of COVID-19 vaccine information

Various types of information regarding the COVID-19 vaccine have been widely disseminated across social media platforms, and



(a) Hypothesis H1: Direct effect of social media use, X, on vaccination intent, Y



(b) Hypotheses H2-H6: Mediating effect of information exposure, M, of social media use, X, on vaccination intent, Y with income as moderator.

FIGURE 1. Hypotheses pertaining to the influence of social media use, X, on vaccination intent, Y. *c* refers to the quantified direct effect, corresponding to H1. The hypothesized moderated mediation model (H2–H6) incorporates the indirect effect of information exposure, M, and the moderating effect of income. *c′* corresponds to the direct effect of the independent variable, X, on the dependent variable, Y, when the mediator variables are controlled for. *a* and *b* denote the specific indirect effects of the independent variable on the dependent variable via five types of information exposure mediators (not shown in the figure). The mediators are *M*1 (vaccine efficacy and effectiveness), *M*2 (vaccine authorization status), *M*3 (vaccination plans), *M*4 (vaccine side effects) and *M*5 (vaccine ethical issues). The total effect of the independent variable on the dependent variable is the sum of the direct effect and the specific indirect effects (Preacher & Hayes, 2008).

prior work has recognized the global need to address COVID-19 vaccine hesitancy (McAteer *et al.*, 2020, Schwarzinger & Luchini, 2021). Yet, it is important to differentiate the *utilization of social media* from the *reported exposure to COVID-19 vaccine information on social media*, as the latter may play a more significant role in vaccination intent. After all, social media use may not necessarily indicate exposure to COVID-19 vaccine information for all users, so deliberately exploring specific COVID-19 information exposure is critical. Therefore, our study seeks to explore how information exposure, particularly information related to COVID-19 vaccines, influences the intent to get vaccinated.

To evaluate our second research question, we selected five types of information related to the COVID-19 vaccine based on the types of information that were commonly disseminated by public health agencies, news and media outlets at the time of the study. Prior research has identified five major themes found in social media platforms during the development and deployment of the COVID-19 vaccines (Karami *et al.*, 2021, Luo *et al.*, 2021, Lyu *et al.*, 2021). Specifically, we asked participants to report their frequency of receiving information related to (i) vaccine efficacy and effectiveness, (ii) vaccine authorization status, (iii) vaccination dissemination plans, (iv) vaccine side effects and (v) vaccine ethical issues.

Similar to other studies that explore the underlying mechanisms in relationships between independent and dependent variables (Dambacher *et al.*, 2021, Liu & Liu, 2020, Reno *et al.*, 2021), our work utilizes mediation analysis (Hayes, 2017) to explore if the relationship between social media and vaccination intent can be further explained by the information an individual receives. Correspondingly, we test the following five hypotheses (H2–H6), which focus on the mediating roles of these types of information. A visual description of the hypotheses is also provided in Fig. 1b.

- H2 Exposure to information related to *vaccine efficacy and effectiveness* mediates the relationship between social media usage and vaccination intent.
- H3 Exposure to information related to *vaccine authorization* mediates the relationship between social media usage and vaccination intent.
- H4 Exposure to information related to *vaccination plans* mediates the relationship between social media usage and vaccination intent.
- H5 Exposure to information related to *vaccine side effects* mediates the relationship between social media usage and vaccination intent.
- H6 Exposure to information related to *vaccine ethical issues* mediates the relationship between social media usage and vaccination intent.

2.3. The moderating role of income

In addition to information exposure, socio-demographic factors (e.g. income, education level and age) are also associated with vaccine hesitancy (Browne *et al.*, 2015, Moran *et al.*, 2016, Truong *et al.*, 2022). For example, a report by the Centers for Disease Control and Prevention found that adults with at least some college education indicated a greater willingness to get vaccinated (Santibanez, 2021). As for age, prior work suggests that older adults are more likely to get vaccinated than younger generations (Truong *et al.*, 2022), potentially due to increased vulnerability to the effects of COVID-19 (Centers for Disease Control and Prevention, 2021, Truong *et al.*, 2022).

In this work, we strategically focus on income as a moderator,[2] due to several reasons. First, our sample size limits the ability to stratify on age. Second, among our participants, education was correlated with income. Therefore, findings pertaining to the role of income reflect similar findings regarding the role of education. Third, socioeconomic status (SES) is a 'fundamental cause' of health inequity generally (Phelan *et al.*, 2004) and COVID-19 inequities specifically. As income is one of the most widely used proxies for SES (Chokshi, 2018); therefore, it is beneficial to use income as compared with employment or education, given employment and education can obscure underlying disparities (e.g. racial differences in payments for individuals with similar occupations or education level). Moreover, ongoing work regarding concerns about vaccine access and intent has been focused on low-income groups (Hamel *et al.*, 2021) since low-income groups may less likely to be willing to get vaccinated as they are concerned about having to take time off from work, as well as about difficulty to travel to a vaccination site (Hamel *et al.*, 2021).

[2] A moderating variable that affects the strength and direction of a relationship between independent and dependent variables (Miles *et al.*, 2015). Different from a mediating variable which explains the relationship between two variables, a moderator variable influences the relationship by identifying conditions in which the relationship holds. Such influence is similar to a two-way interaction effect (Miles *et al.*, 2015). To fully understand the relationships between variables, a combination of both moderation and mediation analysis may be necessary, commonly referred to as 'moderated mediation'. In moderated mediation, a moderator is added to a mediation model, where the moderator can occur in any paths on the mediation model (Preacher *et al.*, 2007).

Other than vaccination intent, income has also been associated with social media usage, shedding light on digital inequity and inequality in accessing reliable information. Specifically, studies have found that lower-income families are more likely to engage with social media sites, as compared with those with a higher income (Micheli, 2016).

In essence, since income can play moderating role in any of the relationships tested in the mediation model, we proposed a moderated mediation analysis (Hayes, 2017, James & Brett, 1984) and tested income effects on either between social media use and the mediator, mediator and vaccine intent, or between social media use and vaccine intent. Figure 1b shows the potential moderating role of income in our study.

3. Methods

3.1. Data

To explore the relationships between vaccine intent and social media usage for gathering specific types of information, we employ a survey instrument, where data are collected through a series of questions. Responses were then coded in a numerical format for purposes of statistical analysis (Shoemaker & McCombs, 2003). Specifically, we surveyed 177 adults aged 18 years and above with low or moderate household incomes (2019 household income of less than $100,000). To ensure diversity in the population, participants were from both urban and suburban locations within Georgia and Massachusetts in the USA. The small sample size is consistent with those used in other exploratory studies focused on preliminary investigations of new theories (González-González & Jiménez-Zarco, 2015, with $n = 27$, Vaterlaus *et al.*, 2016, with $n = 34$ and Warner-Søderholm *et al.*, 2018 with $n = 214$).

Participants were recruited for the study by the online research panel service, Qualtrics (2021). Each respondent provided explicit consent to participate in the survey and was required to complete at least 98% of the questions in each survey. Respondents who completed their survey were compensated by Qualtrics directly. The data were collected between December 15 and 21, 2020, 1 week after the first COVID-19 vaccine was authorized for emergency use in the USA (US Food and Drug Administration, 2021)[3].

In the demographic questions, survey respondents were asked to provide information about their age range, education and household income. Specifically, respondents were given options to select the age group they belong to. The options were 18–24, 25–34, 35–44, 45–54, 55–64, 65+ years. To ensure a similar number of participants in each age group for the analysis, the final age groups used in the study were (i) 18–34, (ii) 35–44 and (iii) 45+ years. The options for selecting their highest education level included: Less than High School, High School Diploma or Equivalent, Associate's Degree, Bachelor's Degree, Master's Degree, Doctorate Degree and Professional Degree. Similar to the aggregation of age groups for the analysis, since some categories had few participants, we categorized respondents' education into two categories for the analysis: (i) no bachelor's degree and (ii) at least a Bachelor's degree. Respondents also provided their 2019 household income by selecting the appropriate income bracket based on the 2020 US Federal Poverty Level (FPL) Guidelines (US Department of Health & Human Services, 2020). Options provided include less than $23 607, $23 607 - $31 894, $31 895 - $40 182, $40 183 - $48 470, $48 471 - $56 758, $56 579 - $65 046, $65 047 - $73 334, $73 335 - $81 622, $81 623 - $89 999 and $90 000 - $99 999. For the analysis, these groups were aggregated into two categories: (i) low-income and (ii) middle-income. These categorizations account for both income and household size (see Subsubsection 3.2.4).

[3] This work has been approved by our university's institutional review board.

3.2. Measures

We collected and analyzed participants' responses about demographics, social media usage, frequency of receiving the five types of vaccine information and their intent to get vaccinated. The full list of questions can be found in Appendix 1.

3.2.1. *Social media use*

To investigate social media usage, we asked participants to select 'Yes' or 'No' for the following statement: 'I did not use social media to get coronavirus information.' (Mitchell & Liedke, 2021).

3.2.2. *Information exposure*

Exposure to COVID-19 vaccine information was measured with a series of questions. Specifically, respondents were asked, 'In the past 7 days, about how often did you get the following [type of information] about the coronavirus vaccine?' The types of information included (i) vaccine efficacy and effectiveness, (ii) vaccine authorization, (iii) vaccination plans, (iv) vaccine side effects and (v) vaccine ethical issues. Participants were asked to report the frequency of receiving each type of information using the following scale: 1 = 'Never', 2 = 'Rarely (once a week)', 3 = 'Sometimes (two to three times a week)', 4 = 'Often (four to six times a week)' and 5 = 'Everyday' (Zhang *et al.*, 2022).

3.2.3. *Vaccination intent*

Intent to get vaccinated was measured with the following question: 'Considering the coronavirus information you received in the past 7 days, which statement best describes how you feel about the coronavirus vaccine?' The options provided to the participants were as follows. (i) 'I will definitely not get it.' (ii) 'I will probably not get it.' (iii) 'Not sure/Don't know.' (iv) 'I will probably get it.' (v) 'I will definitely get it.' The responses were dichotomized into two categories: 0 = 'Hesitant' for the responses 'I will definitely not get it,' 'I will probably not get it,' and 'Not sure/Don't know' and 1 = 'Accept' for the responses 'I will probably get it' and 'I will definitely get it' (Funk & Alec, 2020).

3.2.4. *Moderator*

Income was examined as the moderator in the moderated mediation model with 0 = low-income and 1 = middle-income. The classification of low- and middle-income groups is derived from the income bracket and household size denoted by each participant, following the 2020 FPL (US Department of Health & Human Services, 2020). Specifically, we classified participants as low-income if their adjusted household income was less than or equal to 185% of the FPL following the eligibility guidelines for federal aid programs (US Food and Nutrition Service, 2020).

3.2.5. *Control variables*

Control variables included respondents' sociodemographic characteristics, such as age (1 = 18–34, 2 = 35–44, 3 = 45+) and education (0 = less than a Bachelor's degree, 1 = at least a Bachelor's degree).

TABLE 1. Sample characteristics.

Characteristics	Overall $N = 177$	Low-income $N = 80$	Middle-income $N = 97$	*p*-value
Age, *N*(%)				
18–34	79 (44%)	40 (50%)	39 (40%)	0.1
35–44	51 (29%)	17 (21%)	34 (35%)	
45+	47 (27%)	23 (29%)	24 (25%)	
Education, *N*(%)				
Less than a Bachelor's degree	114 (64%)	63 (79%)	51 (53%)	<0.001
At least a Bachelor's degree	63 (36%)	17 (21%)	46 (47%)	
Use of social media to get COVID-19 information, *N*(%)	114 (64%)	53 (66%)	61 (63%)	0.64
COVID-19 vaccine information exposure, *M*(*SD*)				
Vaccine efficacy and effectiveness	3.4 (1.3)	3.4 (1.3)	3.5 (1.3)	0.42
Vaccine authorization	3.2 (1.4)	3.0 (1.4)	3.4 (1.3)	0.32
Vaccination plans	3.4 (1.3)	3.4 (1.4)	3.4 (1.2)	0.65
Vaccine side effects	2.6 (1.2)	2.5 (1.3)	2.7 (1.2)	0.22
Vaccine ethical issues	2.2 (1.3)	2.2 (1.4)	2.2 (1.2)	0.97
COVID-19 vaccine intent, *N*(%)	93 (53%)	34 (42%)	59 (61%)	0.015

Analyses of differences between low-income and middle-income groups was performed with *t*-tests for continuous variables and Fisher's exact test for categorical variables.
Income group is categorized based on the 2020 FPL (185%) adjusted for household size (US Department of Health & Human Services, 2020).
Vaccine intent pertains to the percentages of respondents who responded they 'will probably' or 'will definitely' get the vaccine.
Notation: *N* denotes count. % denotes percentage. *M* denotes mean. *SD* denotes the standard deviation.
All results are from the survey conducted between December 15 and 21, 2020.

3.3. Analysis

Descriptive statistics for all variables were calculated, including absolute frequencies, relative frequencies, means and standard deviations. Differences between income groups were analyzed using *t*-tests for independent samples and the associations between information exposure and vaccination intent were assessed with Pearson's correlations. Finally, we conducted a simple mediation analysis (Hayes, 2017) and tested for multiple paths where a moderation effect may occur. To assess for inferential statistics and the 95% confidence interval (CI) for the indirect effect, we used bootstrapping with 10 000 iterations (Rosenfeld *et al.*, 2017).

Statistical significance was determined with alpha ≤ 0.05. Analyses were conducted using R version 4.0.2 with *lavaan* package (Rosseel, 2020).

4. Results

4.1. Sample characteristics

Table 1 details the participants' characteristics. The characteristics are presented as counts and percentages for categorical variables and mean ± standard deviation for continuous variables. A total of 45.2% of our participants were classified as being low-income and the remainder as being middle-income (see Subsection 3.1 for income classification). The majority of our study population did not have a Bachelor's degree (64.4%) and were between 18 and 34 years old (44.6%).

Almost two-thirds of our respondents (64%) used social media to obtain COVID-19 vaccine information. Three of the types of COVID-19 vaccine information were received more frequently than the other two. These three types of information include vaccine efficacy and effectiveness (3.4 ± 1.3), vaccine authorization status (3.2 ± 1.4) and vaccination plans (3.4 ± 1.3). In total, 53% of all respondents reported intent to get vaccinated, whereas less than half (42%) of respondents from the low-income group reported similar intent.

The comparison between low- and middle-income groups was performed using Welch's t-test for continuous variables and Fisher's exact test for categorical variables. The results show that there was not a significant difference between low-income and middle-income groups in terms of exposure to COVID-19 vaccine information. Nonetheless, there were significant differences in vaccine intent between these two income groups, with more respondents from the middle-income group reporting vaccination intent than respondents from the low-income group (61% vs. 42%, $P = 0.015$).

4.2. Main association analysis

H1 posited that social media use would be associated with vaccination intent. Yet, our results suggested that this relationship is not significant (*Est.* = –0.12, *SE* = 0.20, *P* = 0.25, 95% CI = [–0.24, 0.06]) in our data. Therefore, 2.1 is not supported. While there is no significant direct effect (see Fig. 1) in our main association analysis, according to Hayes (2017), examining individual direct paths separately does not explain the mediation as a whole. Since the individual direct paths are components of the indirect paths, examining the indirect paths (*a* and *b* in Fig. 1b) is a more accurate and precise way to explain the relationships in a mediation model. We present the analysis results for direct and indirect effects, consisting of five models, each pertaining to a type of information exposure, in Table 2. For each model, we report the standardized coefficient, standard error, CI and p-value for each of the paths illustrated in Fig. 1.

4.3. Testing for mediation effect

H2 posited that receiving information about vaccine efficacy and effectiveness would mediate the relationship between social media use and vaccination intent. Our results suggest a significant mediation effect (*Mediation index* = 0.066, *SE* = 0.029, *P* = 0.021, 95% CI = [0.021, 0.136]), as shown in Table 2. Similarly, we found that both information about vaccine authorization status (H3) and vaccination plans (H4) also significantly mediated the relationship with *P*=0.008 (95% CI = [0.034, 0.163]) and *P*=0.030 (95% CI = [0.017, 0.125]), respectively. Thus, H2–H4 are supported. An example of significant indirect paths, integrating the results from Table 2, is shown in Fig. 2.

TABLE 2. Mediation analyses with information exposure as mediators.

	β	SE	95% CI	p
Model 1: Vaccine efficacy & effectiveness as mediator				
Social media → efficacy & effectiveness	0.619	0.207	[0.199, 1.018]	0.003
Efficacy & effectiveness → vaccine intent	0.107	0.028	[0.049, 0.158]	<0.001
Social media → vaccine intent	–0.088	0.077	[–0.240, 0.063]	0.252
Social media → efficacy & effectiveness → vaccine intent	0.066	0.029	[0.021, 0.136]	0.021
Model 2: Vaccine authorization status as mediator				
Social media → authorization	0.842	0.215	[0.408, 1.255]	<0.001
Authorization → vaccine intent	0.100	0.026	[0.048, 0.150]	<0.001
Social media → vaccine intent	–0.107	0.079	[–0.260, 0.053]	0.177
Social media → authorization → vaccine intent	0.084	0.032	[0.034, 0.163]	0.008
Model 3: Vaccination plans as mediator				
Social media → vaccination plans	0.653	0.202	[0.247, 1.036]	<0.001
Vaccination plans → vaccine intent	0.090	0.029	[0.032, 0.145]	0.002
Social media → vaccine intent	–0.077	0.079	[–0.233, 0.079]	0.333
Social media → vaccination plans → vaccine intent	0.059	0.027	[0.017, 0.125]	0.030
Model 4: Vaccine side effects as mediator				
Social media → side effects	0.301	0.193	[–0.085, 0.676]	0.118
Side effects → vaccine intent	0.088	0.029	[0.029, 0.144]	0.002
Social media → vaccine intent	–0.049	0.077	[–0.197, 0.103]	0.525
Social media → side effects → vaccine intent	0.027	0.020	[–0.004, 0.080]	0.194
Model 5: Vaccine ethical issues as mediator				
Social media → ethical issues	0.226	0.206	[–0.188, 0.620]	0.273
Ethical issues → vaccine intent	0.045	0.030	[–0.015, 0.104]	0.140
Social media → vaccine intent	–0.032	0.078	[–0.185, 0.122]	0.680
Social media → ethical issues → vaccine intent	0.010	0.013	[–0.005, 0.051]	0.437

Note. β is a standardized coefficient. *SE* is standard error. p less than 0.05 or no zero in bootstrap CI is considered statistically significant. Standardized and 95% CI of path coefficients were estimated with 10,000 bootstraps.

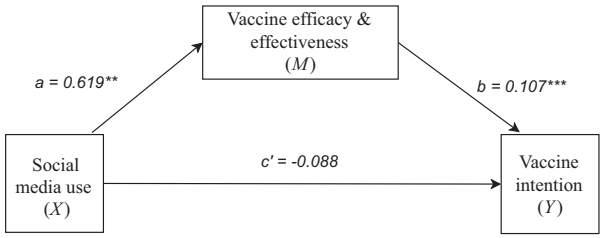


FIGURE 2. Example of all paths involved in mediation analysis using 'Vaccine efficacy & effectiveness' as mediator.

Both information about vaccine side effects (95% CI = [–0.004, 0.080]) and vaccine ethical issues (95% CI = [–0.005, 0.051]) did not show any significant mediation effects. Thus, H5 and H6 are not supported. In the next section, we test for moderated mediation for the three significant mediators (H2, H3, H4), with income as the moderator.

4.4. Testing for moderated mediation

Extending on the findings from the mediation model, we also tested for moderated mediation of the effect of social media and information exposure on vaccination intent by income group. We limit the analysis to the three types of information exposure that were found to be significant mediators in Subsection 4.3.

For each of the three information exposure, a test for moderated mediation was completed using two models. The first assessed the relationship between the independent variables and the dependent variable defined by the type of information exposure. The second model incorporates information exposure and an independent variable and tests for correlation with the dependent variable of vaccination intent. The results are presented in Tables 3– 5. While the interaction between social media use and income had a significant predictive effect on vaccination intent (as demonstrated by statistically significant t-scores), the interaction between information exposure and income did not show any significant predictive effect in two out of three types of information tested. This suggests that the effect of information related to vaccine efficacy and effectiveness, and vaccine authorization status on vaccination intent does not vary by income but varies when information related to vaccination plans is the independent variable.

To further examine the moderating effects of income, we examined the simple effects of social media use and vaccination intent, at the two levels of income. Simple slope tests of social media use showed a significant result for the middle-income group ($\beta = 0.13$, $SE = 0.10$, 95%$CI = [0.08, 0.33]$), but not for the low-income group ($\beta = -0.19$, $SE = 0.12$, 95%$CI = [-0.43, 0.03]$). Nonetheless, when tested for the difference of simple slopes (i.e. test of interaction), our results showed that there exists a significant difference between the low-income and middle-income groups in terms of the relationship between social media use and vaccination intent ($\beta = -0.325$, $SE = 0.155$, $P < 0.05$). Specifically, the association between social media use and vaccination intent was significantly stronger for individuals in low-income groups than for individuals in middle-income groups (see Fig. 3).

Moreover, we further examined whether the moderated direct and indirect effects of social media use on vaccination intent were statistically significant. First, the moderated direct effect (c' showed that the association between social media use and vaccination intent was stronger for individuals in low-income groups (see Table 6 and note the opposite direction of the effects). Second, while there are no significant differences between incomes on the indirect effect, $a \times b$, the bootstrapping results indicated that the indirect effect of social media use and vaccination intent via information exposure was in fact significantly moderated by

TABLE 3. Testing the moderated mediation with vaccine efficacy & effectiveness as information exposure

Predictors (IV)	Model 1 (DV: IE)			Model 2 (DV: VI)		
	β	SE	t	β	SE	t
Age	0.31	0.39	0.78	–0.07	0.046	–1.48
Education	0.19	0.21	0.89	0.09	0.08	1.10
Social media use	0.43	0.29	1.46	–0.26	0.11	–2.27*
Income (middle)	–0.09	0.32	–0.29	–0.05	0.21	–0.24
Social media use x income	0.31	0.39	0.78	0.29	0.16	1.87
IE (efficacy)				–0.05	0.21	–0.24
IE (efficacy) x income				0.29	0.16	1.87
R^2		0.10			0.14	
F		3.90***			3.87***	

Note. Indirect effects are estimated with $a \times b$ and are significant at $p \leq .05$ (see Table 2). β denotes a standardized coefficient. SE denotes the standard error. IV denotes the independent variable. DV denotes the dependent variable. IE denotes information exposure. VI denotes vaccination intent. *:$P < 0.05$, **:$P < 0.01$, ***:$P < 0.001$.

TABLE 4. Testing the moderated mediation with vaccine authorization status as information exposure.

Predictors (IV)	Model 1 (DV: IE)			Model 2 (DV: VI)		
	β	SE	t	β	SE	t
Age	0.23	0.12	1.88	–0.06	0.05	–1.304
Education	0.12	0.23	0.54	0.10	0.08	1.20
Social media use	1.75	0.47	3.75**	–0.32	0.12	–2.67**
Income (middle)	0.60	0.34	1.78	–0.11	0.19	–0.59
Social media use x income	–0.37	0.42	–0.87	0.36	0.15	2.27*
IE (authorization)				0.10	0.04	2.51*
IE (authorization) x income				–0.00	0.05	–0.02
R^2		0.10			0.14	
F		4.93***			3.94***	

Note. β denotes a standardized coefficient. SE denotes the standard error. IV denotes the independent variable. DV denotes the dependent variable. IE denotes information exposure. VI denotes vaccination intent. *:$P < 0.05$, **:$P < 0.01$, ***:$P < 0.001$.

TABLE 5. Testing the moderated mediation with vaccination plans as information exposure.

Predictors (IV)	Model 1 (DV: IE)			Model 2 (DV: VI)		
	β	SE	t	β	SE	t
Age	0.34	0.12	2.93**	–0.06	0.05	–1.39*
Education	0.09	0.21	0.42	0.09	0.08	1.20
Social media use	0.83	0.29	2.87**	–0.28	0.12	–2.36*
Income (middle)	0.27	0.31	0.88	–0.15	0.21	–0.72
Social media use x income	–0.33	0.39	–0.85	0.33	0.16	2.11*
IE (Plans)				0.09	0.04	1.96*
IE (Plans) x income				0.33	0.16	2.11*
R^2		0.11			0.12	
F		4.17***			3.51***	

Note. β denotes a standardized coefficient. SE denotes the standard error. IV denotes the independent variable. DV denotes the dependent variable. IE denotes information exposure. VI denotes vaccination intent. *:$P < 0.05$, **:$P < 0.01$, ***:$P < 0.001$.

income, since zero is not contained between lower and upper *CI* (see Table 7).

5. Discussion

In our survey, almost two-thirds (64%) of our participants reported using social media to get COVID-19 information, confirming the predominant role this platform had in disseminating information. Further, with the fast spread of information on social media, it is plausible that individuals will be incidentally exposed to misinformation and conspiracy theories related to COVID-19 as part of this exposure. Although extensive studies have examined the effects of social media use on vaccination intent (Al-Hasan *et al.*, 2021, Mitchell & Liedke, 2021, Xin *et al.*, 2021), considerations regarding the link between this relationship still require further investigation.

Unlike previous studies (Jennings *et al.*, 2021, Xin *et al.*, 2021), which found a significant direct association between social media use and vaccination intent, our findings suggested that this relationship was significantly strengthened, not with general vaccine information, but with the exposure of three specific types of vaccine information (vaccine efficacy and effectiveness, vaccine authorization status, vaccination plans). These results highlight the importance of incorporating precise and specific measures of information consumption in future studies within the HCI field. This is in line with another study that found that Facebook users

TABLE 6. Analysis of effects of income group as moderator.

Mediator/Moderator	*a*	*b*	*c′*	*ab*
Model 6: Vaccine efficacy and effectiveness				
Low-income	0.257	0.095*	–0.257*	0.024
Middle-income	0.820**	0.104*	0.056	0.085*
Differences	1.6	0.026	3.8*	1.2
Model 7: vaccine authorization status				
Low-income	0.840*	0.077*	–0.297*	0.065
Middle-income	0.684**	0.104**	0.070	0.071*
Differences	0.13	0.26	5.3**	0.013
Model 8: vaccination plans				
Low-income	0.639*	0.067	–0.269	0.043
Middle-income	0.513	0.117***	0.081	0.060
Differences	0.098	0.78	4.6**	0.11

Tests for differences for the indirect effect (see Figure 1) were computed using Wald Tests and based on bias-corrected CIs derived from bootstrap estimates.
Note. *$P \leq 0.05$, **$P \leq 0.01$, ***$P \leq 0.001$.

TABLE 7. Bootstrap moderated mediation effect.

	β	SE	LLCI	ULCI
Social media → vaccine efficacy and effectiveness → vaccine intent	0.061	0.028	0.013	0.124
Social media → vaccine authorization plans → vaccine intent	0.067	0.029	0.020	0.131
Social media → vaccination status → vaccine intent	0.053	0.082	0.010	0.114

Note. β denotes a standardized coefficient for indirect effect. *SE* denotes the standard error. *LLCI* and *ULCI* denote the lower and upper limits of the CI, respectively. The effect is considered statistically significant if zero does not fall between *LLCI* and *ULCI*. SE, *LLCI* and *ULCI* are estimated with 10 000 bootstraps.

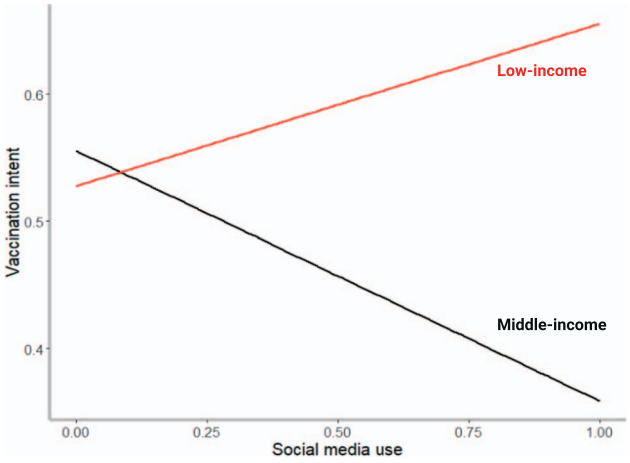


FIGURE 3. Two-way interaction between social media use and income on vaccination intent. While simple slope test is only significant for middle-income, differences in simple slope test (i.e. test of interaction) show that the association between social media use and vaccination intent was significantly stronger in low-income than in middle-income.

were more likely to have anti-vaccine opinions than Fox News viewers but concluded that further research is needed to figure out what content people are consuming on these platforms and how it affects their behavior (Lazer *et al.*, 2021). Our analysis of the mediation relationships between types of information exposure and vaccination intent exemplifies a strategy for addressing this research need.

Further, we highlight the importance of simultaneously examining the moderating effects of features such as socio-demographics, as future research should account for the potential inequalities in technology use and health across demographics (Shoff & Yang, 2012). For example, our results show how the association between social media use and vaccination intent was significantly stronger in low-income participants than in middle-income. This finding suggests that social media plays a more influential role in making decisions for low-income populations than for middle-income adults, which corresponds to the findings reported by Micheli (2016) and is further confirmed by Albashrawi *et al.* (2022). Such influence may arise from the fact that populations with low-income are more likely to use social media than those who have higher income (Albashrawi *et al.*, 2022).

Despite the importance of examining the type of information seen on social media, there are significant methodological challenges related to this type of data collection. One such challenge is the need for obtaining permission from social media users to access the information they see online to understand individual information flow (e.g. on Facebook) (Zhang *et al.*, 2022). Even with the user's expressed permission, it is important for researchers to determine the proper balance between the level of granularity measured in the user's social media content and their privacy. Correspondingly, repeated interviews (Merton & Merton, 1968) or diary studies with social media users may be useful in tracking information consumption over social media, as well as gathering a more in-depth understanding of how various information types impact vaccination intent or other health-related decisions.

Although information related to vaccine side effects and ethical issues did not significantly mediate the relationship between social media usage and vaccination intent, these findings are enlightening, as it implies two directions that future work can address, the roles of information avoidance and personalized information ecology. First, with the focus on what information was received, we did not capture whether or not, and to what extent, participants actively avoided particular types of information. This phenomena is commonly referred to as 'information avoidance' (Golman *et al.*, 2017), or a delay in the acquisition of available, but potentially unwanted, information (Golman *et al.*, 2017). As research has continually shown the inherent biases that social media platforms establish within users (Messing & Westwood, 2014), understanding this information avoidance tendency

on social media platforms will support the opportunity for future work to identify potential ways in which biases and polarization can be mitigated online. Second, the roles of information exposure examined in our study are based on the notion that social media is providing sufficiently *equal* amounts of available information to its users. While this may be true, personalized algorithms created by social media platforms dictate the amount and types of information received by users (Seargeant & Tagg, 2019), thus varying the receipt of information among individual users online. Therefore, future research should consider how this personalized information ecology, seen on many social media platforms, complicates the relationship between social media use, information exposure and vaccination intent.

More fundamentally, as we measured the frequency of receiving types of information, we found that information regarding vaccine side effects and ethical issues was received the least compared to other types of information. It is unknown whether the information was received the least because it was not actively shared on social media or simply because the strategies for promoting vaccine acceptance over social media had not come to fruition. Thus, further research that incorporates an analysis of how different sets of strategies utilized by social media platforms (i.e. connecting users to credible information through banners and notices on feeds/posts related to COVID-19 (Facebook, 2020)) or public health agencies (i.e. leveraging celebrities and influencers to promote vaccination (Heilweil, 2020)) influence vaccination intent—both toward getting vaccinated or refusing vaccination. Such research may be an interesting extension of our study.

6. Conclusions, Limitations and Future Research

As with all research, our exploratory study comes with a few caveats. First, the inclusion criteria used in our study (living in Massachusetts or Georgia and 2019 household income of less than $100 000) may skew our results. Focusing on these two regions enabled us to explore the effect of social media on vaccination intent, which may be impacted by where one has lived amidst the pandemic (Zhang *et al.*, 2022). Specifically, states within the USA differed in their COVID-19 policies and mitigation approaches (National Governors Association, 2021) and incidence patterns (Johns Hopkins University, 2021). These contextual factors may have a significant impact on pandemic attitudes such as vaccination intent, which drove our decision to focus on respondents living in two specific states. Furthermore, we chose our participant income threshold to narrow our focus to low- and middle-socioeconomic populations and investigate the influence of social media usage on vaccine decisions between these two income levels. Nonetheless, our small sample size ($n = 177$) limits the statistical power for detecting a significant association between variables, specifically as we seek to identify the differences in vaccination intent among different demographic groups, as found in other studies (Callaghan *et al.*, 2020, Khubchandani *et al.*, 2021, Lazarus *et al.*, 2021). Our sample size, when stratified across groups such as income, age and education, limits our ability to test how these features may significantly moderate the relationship between social media, vaccine intent and information exposure.

Second, our participants were recruited through the Qualtrics online research panel service (Qualtrics, 2021). We chose Qualtrics due to its ability to build surveys, distribute surveys and analyze responses from a single online platform. Moreover, online panels such as Qualtrics have been found to provide data that approximates the results produced by more conventional modes of survey data collection (Kees *et al.*, 2017, Porter *et al.*, 2019). Such online panels can also help support the recruitment of hard-to-reach populations (Mayer, 2021), such as those focused on in our inclusion criteria. All of these affordances led us to use Qualtrics for recruitment. Still, the timing of our data collection, which aligned with the first vaccine approval, may have skewed our results. For example, the type of information disseminated in the months after our study was completed may be different from the information highlighted in our study, such that information regarding vaccination plans and approval may be less significant given the increase in the number of individuals who were vaccinated. However, it is important to note that all information and knowledge are situated (Haraway, 1988, Suchman, 1987), meaning that information and knowledge are shaped by the context in which they are produced. This phenomena is particularly apparent amidst the COVID-19 pandemic, in which high levels of uncertainty and dynamic changes have shaped what and how information has been shared. As such, any research studying information practices amidst the pandemic—and the impact of these practices—will necessarily need to be contextually specific, to understand the particular patterns and implications of information consumption during distinct phases of this ever-evolving public health crisis.

Finally, we acknowledge the limitations on the use of binary survey questions concerning social media usage. Specifically, our question only focuses on whether or not participants use social media to get coronavirus information. Our survey lacks the understanding of which social media platform our participants use to get the information, as well as how often they use the platform. Future extensions of this work should include questions regarding the frequency of using different social media platforms, as well as the activity performed on these platforms. Questions such as 'How often do you post or repost on social media (or a particular platform)?' may provide a new perspective into the correlation of frequency and level of engagement, as well as the correlation between frequency and effect, given the differences in the characteristics of passive and active social media users (Gerson *et al.*, 2017). Additionally, it can explore the differences in the effects of the use of different social media platforms.

Despite these limitations, through a moderated mediation model, this study contributes to the literature on social media use and its effects by articulating its association with the consumption of different types of information. The term *information exposure* was utilized to characterize the types and frequency of the information. By taking into consideration the influence of income levels, this study further examines inequalities in the digital age, not only from the perspective of owning or using smart devices (Suhaimi *et al.*, 2022) but also from the perspective of how online information affects decision making. Such differences among groups, including those defined by income levels, should continue to be highlighted and examined in future HCI research that focused on the relationships between information, social media and decision-making.

Acknowledgments

This research was funded through an unrestricted gift from Google and Northeastern University. We thank our anonymous reviewers for their insightful comments and our participants for their support in our research.

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