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Comorbidity Burden and COVID-19 Vaccination Intention: Application of the Health Belief Model

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COMORBIDITY BURDEN AND COVID-19 VACCINATION INTENTION: APPLICATION OF THE HEALTH BELIEF MODEL

by
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ABSTRACT

MICHAEL K. RAYMOND: Comorbidity Burden and COVID-19 Vaccination Intention:
Application of the Health Belief Model
(Under the direction of Dr. Aaron Lee)

The COVID-19 pandemic impacted many aspects of American's lives causing over 79 million cases and over 950,000 deaths. Existing research shows severity of COVID-19 infection may be linked to number of underlying health conditions, known as comorbidities. The objective of this study was to determine if comorbidity burden was associated with intention to vaccinate against COVID-19. This relationship was looked at through the Health Belief Model (HBM) and its mediating variables of perceived susceptibility, perceived severity, perceived benefits, and perceived barriers. Our sample was compromised of 350 individuals recruited from an online platform who were not already vaccinated against COVID-19. Respondents completed a survey with measures of sociodemographic characteristics, mediators of the HBM, intention to vaccinate, and behavioral intention. Two parallel mediation models were examined for both low and high-risk comorbidity burden on behavioral intentions for COVID-19 vaccination via perceived severity, perceived susceptibility, perceived benefits, and perceived barriers with controls for age and smoking status, established risk factors for COVID-19. Overall, our results showed the HBM model did not mediate intentions to vaccinated as related to comorbidity burden. There was one significant indirect effect across both models for low-risk comorbidity burden via perceived barriers (*B* = 0.20, 95%CI: -0.45, -0.02), indicating individuals with greater

low-risk comorbidity burden have lower intention to be vaccinated against COVID-19. In conclusion, these results suggest that HBM may not fully account for attitudes and beliefs linking comorbidity related COIVD-19 risk and COVID vaccination intention. These findings suggest that targeted loss-framed messages focusing on patients' comorbidity burden and related COVID susceptibility and severity may have little impact on individuals' vaccination intentions. Gain framed messages emphasizing the benefits of COVID vaccination may be similarly ineffective for increase vaccination intentions.

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INTRODUCTION

In December 2019, an outbreak of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), termed COVID-19 by the World Health Organization, originated in Wuhan, China (Ciotti et al., 2020). Scientists have speculated over the origins of the COVID-19 pandemic with some members of the scientific community believing it originated in a laboratory (Ciotti et al., 2020). Genome sequencing of COVID-19 showed a very similar organization structure to beta coronavirus genomes ("Insights into the COVID-19 Pandemic," 2021). Specifically, research has shown COVID-19 to be about 96% identical to bat coronavirus, RaGT13, suggesting a bat could be the host of this virus (Ciotti et al., 2020).

The COVID-19 pandemic has had great impacts on individuals' mental health, American minority populations, and the American economy. In one study, an increased presence of anxiety and depression was found among those who had been or known someone who was quarantined as a result of COVID-19 exposure compared to those who had not experienced this (Lei et al., 2020). Minority populations in the U.S. were negatively impacted in numerous ways. In the U.S., minorities face poverty at greater rates than whites, causing them to live in areas that are more prone to the spread of COVID-19 (Tai et al., 2021). More specifically, African Americans are more likely to have more comorbidities than whites, which have been shown to lead to more severe cases of COVID-19 (Tai et al., 2021). The American economy saw a 43% decrease in the U.S. stock market over a one-month period and a 14.7 unemployment rate as the pandemic began to affect the American public (Kaye et al., 2021; Thorbecke & Link to external site, 2020).

The COVID-19 pandemic has also greatly impacted the American healthcare system. The American healthcare system and its hospitals have been estimated to face over $200 billion in revenue loss by the American Hospital Association due to the COVID-19 pandemic (Kaye et al., 2021). The federal government worked to combat these losses by providing $100 billion in relief to hospitals treating COVID-19 patients (Roy, 2020). The sudden emergence of the COVID-19 pandemic exposed an American healthcare system that lacked preparedness to handle a pandemic of this magnitude due to a lack of personal protective equipment, pharmaceutical products, and hospital equipment among others (Kaye et al., 2021; Roy, 2020). Health care providers and patients also experienced direct impacts as elective and nonemergency surgeries were paused periodically throughout the pandemic to allow more hospital beds to be used for patients with COVID-19 (Kaye et al., 2021).

Further, the impact of COVID-19 on individuals has been wide spread with over 79 million confirmed cases and over 950,000 confirmed deaths in the United States (Times, 2020). The high number of COVID-19 cases has been attributed to a special characteristic of RNA viruses: the ability to continuously mutate allowing for new variants to establish and spread among individuals (Haque & Pant, 2022). The majority of these cases have been caused by the original COVID-19 strain along with five major variants of COVID-19 – Alpha, Beta, Gamma, Delta, and Omicron – with these variants spreading globally as early as December 2021 (Haque & Pant, 2022). Each variant has had a higher transmission rate than its preceding variant, increasing COVID-19's fitness (Haque & Pant, 2022).

To determine current COVID-19 infection, individuals must take a polymerase chain reaction test or an antigen test (Commissioner, 2022). Individuals whose test comes back positive for COVID-19 may experience a variety of common symptoms which include fever, cough, fatigue, dyspnea, and sputum production (Alimohamadi et al., 2020). Less frequent symptoms include, but are not limited to, chest tightness, diarrhea, headaches, myalgia, shortness of breath, and sore throat (Alimohamadi et al., 2020).

Severity of COVID-19 symptoms can be linked to underlying health conditions, known as comorbidities (Sanyaolu et al., 2020). One prior study found that 72% of COVID-19 patients with comorbidities required admittance into the intensive care unit (ICU) while only 37% COVID-19 patients with zero comorbidities required admittance into the ICU (D. Wang et al., 2020). Across seven studies, data showed that COVID-19 patients with diabetes were associated with a 14 to 32% chance of having a severe COVID-19 infection (Singh et al., 2020). A meta-analysis of various studies indicated that diabetes, COPD, hypertension, cardiovascular disease, and cerebrovascular disease all increased the risk of COVID-19 severity (B. Wang et al., 2020). A study on neurological comorbidities and the severity of COVID-19 infection found an increased risk of COVID-19 severity among all types of neurological conditions (Alberto et al., 2021).

As of August 2020, the Centers for Disease Control and Prevention (CDC) released a list of comorbidities that can lead to a high-risk of severity for infection from COVID-19 (i.e. cancer; chronic kidney disease; chronic obstructive pulmonary disease (COPD); immunocompromised state from solid organ transplant; obesity; serious heart conditions (heart failure, coronary artery disease, or cardiomyopathy); sickle cell disease; and type 2 diabetes) (CDC, 2020a). Similarly, the CDC has released a list of comorbidities associated with a low-risk of severity for infection from COVID-19 (i.e. asthma (moderate-to-severe); cerebrovascular disease; cystic fibrosis; hypertension or high blood pressure; immunocompromised state from blood or bone marrow transplant, immune deficiencies, HIV, use of corticosteroids, or use of other immune weakening medicines; neurological conditions; liver disease; pregnancy; pulmonary fibrosis; smoking; thalassemia; type 1 diabetes mellitus) (CDC, 2020a). Individuals with varying levels of high and low-risk comorbidity burden may have greater perceptions of COVID-19 related threat and therefore, may more be more likely to engage in protective behaviors to mitigate risk of COVID-19 infection (e.g., mask wearing, social distancing, vaccination).

Governments have forced individuals to limit social interaction, regardless of comorbidity burden, to minimize the spread of COVID-19 as it is mainly spread through respiratory saliva droplets or nose discharge (Govindasami, 2020). Implementation of this has been seen in forced shutdowns of businesses within the United States (Govindasami, 2020). By April 2020, there were mandatory lockdowns in over 42 states in the U.S. (Ngonghala et al., 2020). Social distancing in public and quarantining in one's home after a positive test or potential exposure were also encouraged to reduce the continual spread of COVID-19 (Govindasami, 2020). Throughout the pandemic, the use of face masks has been either enforced or encouraged by various state and local governments (Ngonghala et al., 2020).

While prevention measures such as social distancing and mask wearing are helpful, they do not provide the public with the same immunity to COVID-19 as seen with a vaccine (Mangalakumari et al., 2020). Public vaccination is considered the most effective way to end the COVID-19 pandemic (Rashedi et al., 2021). This view led to unprecedented efforts towards researching and developing an effective and safe vaccine, resulting in over 160 vaccine candidates with December 2020 marking distribution of the first dose (Mangalakumari et al., 2020; Rashedi et al., 2021; Tung et al., 2020). Of these vaccine candidates, three are currently administered throughout the United States: Pfizer/BioNTech (Pfizer), Moderna, and Johnson &

Johnson/Janssen (Johnson & Johnson) (CDC, 2022a). The Pfizer and Moderna vaccines are both modified mRNA vaccines that have received FDA approval (CDC, 2022b, 2022c; Rashedi et al., 2021). The Johnson & Johnson vaccine is a recombinant adenovirus vector vaccine that has received FDA Emergency Use Authorization (EUA) (*Johnson & Johnson COVID-19 Vaccine Authorized by U.S. FDA For Emergency Use | Johnson & Johnson*, 2021; Rashedi et al., 2021). To receive FDA approval or EUA, each vaccine was required to go through many rounds of clinical trials. The Pfizer, Modern, and Johnson & Johnson vaccines were shown to be 95%, 94.1%, and 66.3% effective, respectively, at preventing COVID-19 infection in clinical trials of people who had received all doses of the vaccine and had no previous COVID-19 infection (CDC, 2022b, 2022c, 2022d).

Despite the vaccine being free to U.S. residents, widely availability, and effective, COVID-19 vaccine rates in the U.S. have remained relatively low. For example, only 76.6% of the United States population received at least one dose with only 65.1% of the U.S. adults are fully vaccinated as of March 8, 2022 (*U.S. COVID-19 Vaccine Tracker*, 2022). The number of fully vaccinated adults are well below the World Health Organization's goal to achieve a 70% vaccination rate among U.S. adults by 2022 (Carbajal, 2022). Unfortunately, vaccines for highly contagious respiratory viruses are more effective at slowing the spread of viral transmission among individuals when vaccination rates are high at the population level. Together, these findings underscore the difficulty of the public health issue facing policymakers and healthcare providers in the United States.

There are many possibilities one could speculate caused the low rate of vaccine acceptance among U.S. residents, and many studies have sought to link potential causes for low rate of acceptance. Among these possibilities are conspiracy theories that have circulated through social media regarding COVID-19 and its vaccines, claiming the virus is a bio-warfare weapon and the vaccine is a host for insertion of a trackable microchip, although these theories all have been refuted (Ullah et al., 2021). Studies have also shown an association between hesitancy to receive a COVID-19 vaccine and concern for vaccine safety and efficacy (Ullah et al., 2021).

This study used the Health Belief Model (HBM) to elucidate mechanisms linking objective medical risk (i.e., comorbidity burden) and intentions to be vaccinated for COVID-19 among U.S. adults during the initial roll out and distribution of COVID vaccine. The HBM, which was developed in the 1950s to predict individual’s behavior based on their unique characteristics and beliefs about cost, benefits, and potential barriers to health behaviors (Glanz et al., 2008). Specifically, the HBM predicts that individual risk factors (i.e., modifying factors factor) impact intentions to engage in specific health behaviors via four distinct types of beliefs about the target health behavior: perceived susceptibility to a health problem, perceived severity of the health problem, perceived benefits from engaging in a related health behavior, and perceived barriers to engaging in a related health behavior (Figure 1). Perceived susceptibility is a person’s perception of their risk to contract a disease (LaMorte, 2019). Perceived severity refers to a person’s perception of how a disease, if contracted, would affect their health and social functioning (Glanz et al., 2008). Perceived benefits reflect a person’s beliefs regarding how helpful the recommended behavior will be to them (Glanz et al., 2008). Perceived barriers refer to a person’s beliefs regarding how difficult the recommended health behavior will be to achieve (LaMorte, 2019). A review of HBM studies from 1974-1984 determined perceived susceptibility, perceived benefits, and perceived barriers to be effective predictor of intended behavior, consistently, with perceived severity showing significance in only one-third of the studies analyzed (Janz & Becker, 1984). Yet, no studies to date have used the HBM as framework to better understand and identify mechanisms linking high and low-risk comorbidity burden to intentions to receive COVID-19 vaccination decisions to engage in these types of protective behaviors. Such research is critical to develop evidence-based approaches to improve vaccine adoption among U.S. adults.

The purpose of this study was to use the HBM as a framework for predicting individuals' intention to be vaccinated against COVID-19. Specifically, we examined the mediating role of perceived severity, perceived susceptibility, perceived benefits, and perceived barriers on the relationship of high and low-risk comorbidity burden with behavioral intentions for COVID-19 vaccination among U.S. adults during the early stages of COVID-19 vaccine distribution, adjusting for important and established patient risk factors (i.e., age and current smoking status) (Biswas et al., 2021; Patanavanich & Glantz, 2020). Consistent with the HBM, we hypothesized that perceived severity, perceived susceptibility, perceived benefits, and perceived barriers will mediate the total, direct, and indirect effects of high or low-risk comorbidity burden on intention to receive a COVID-19 vaccine.

METHODS

Participants

The sample was compromised from 363 individuals from across the United States of America. Respondents were recruited from Amazon.com's Mechanical Turk (MTurk) platform from February to April of 2021. To be eligible, respondents had to be 18 years of age or older, located in the United States, and not vaccinated against COVID-19. Respondents received $0.05 for completing the screener. 698 respondents initiated the screener to determine study eligibility. All of the individuals who initiated the screener were located in the United States. Of those who initiated the screener, 697 (99.9%) indicated that they were 18 years of age or older. All of these respondents provided informed consent to participate in this screener. 112 (16.1%) individuals reported that they had received a COVID-19 vaccine and therefore, were not eligible to participate in the study. Quota samples were used for age, race, and ethnicity to match the characteristics of our sample to those of the general U.S. population of adults (*U.S. Census Bureau QuickFacts*, 2020). 211 individuals (30.3%) were excluded due to full quotas. Of the remaining eligible participants, 367 (98.1%) agreed to participate in the study. Of those agreed to participate, 363 (99.7%) passed both attention checks. 13 (3.6%) did not complete all study measures and were excluded from subsequent analyses. Therefore, the final sample was comprised of 350 U.S. adults who had not previously been vaccinated for COVID-19. All participants who successfully completed the survey received an additional $1.00 bonus.

Measures

Sociodemographics. Participants were surveyed on a variety of sociodemographic measures. Participants responded to a series of multiple-choice questions related to their background information (i.e., sex, race, ethnicity, level of education, income range, employment status). Participants also provided their age and their height and weight, which was used to determine each participant's body mass index (BMI). Female participants indicated whether they were currently pregnant. We asked participants questions about their current healthcare status (i.e., whether they have health insurance or a primary care provider). Participants who signified if they had previously tested positive for COVID-19, signifying the month and date if answering "yes". We asked each participant to self-determine if they were in a high priority group for vaccination. A qualitative reasoning was provided if an individual answered "yes".

Comorbidity burden. The CDC released a list of comorbidities related to COVID-19, detailing whether individuals with these conditions were at a high-risk or low-risk to have greater medical complications from COVID-19 if contracted (CDC, 2020a). For each comorbidity, participants were asked to indicate whether they had been diagnosed. Using the CDC's grouping of comorbidities, participants' responses were summed to generate a total score reflecting total high-risk and total low-risk comorbidity burden.

Health Belief Model Variables. We adapted a portion of our survey from a study on the swine flu pandemic which used mediators of the HBM (Myers & Goodwin, 2011). These 16 items measured five different variables including the four mediators of the health belief model. The four mediators of the health belief model are perceived susceptibility (*e.g., "My chance of getting COVID-19 in the next few months is great."*), perceived severity (*e.g., "I will be very sick if I get COVID-19."*), perceived barriers (*e.g., "I am scared of needles."*), and perceived benefits (*e.g., "Vaccination decreases my chance of getting COVID-19 or its complications."*). The fifth variable measured was past and future related behaviors (*e.g., "Last year did you have a vaccination for the ordinary seasonal flu").* Each question was measured on a 7-point Likert scale ranging from 1 ("*strongly agree*") to 7 ("*strongly disagree*"). The perceived susceptibility and perceived severity scales have demonstrated good reliability in prior studies (α = .75-.76) and in this study sample (α = .78-.79) (Myers & Goodwin, 2011). The perceived benefits scale demonstrated good reliability in the sample (α = .80). Reliability for the perceived barriers (α = .45) scale was low. All items were recoded, so a greater score equaled greater intention to be vaccinated.

Intention to be Vaccinated. We adapted a measure of behavioral intentions from a survey for H1N1 flu vaccination (Agarwal, 2014). These 3 items measured behavioral intention (*e.g., "I intend to get a COVID-19 vaccine once available to me."*). Each question was measured on a 7-point Likert scale ranging from 1 ("*strongly agree*") to 7 ("*strongly disagree*"). In previous studies, behavioral intentions have demonstrated good reliability (α = .90) (Agarwal, 2014). The behavioral intention scale demonstrated excellent reliability in this study (α = .99). All items were recoded, so a greater score equaled greater intention to be vaccinated.

Intention Not to be Vaccinated. Individuals who indicated they were unlikely to receive a COVID-19 vaccine were asked to provide a reasoning why. Participants' qualitative responses were reviewed to identify themes and then, subsequently organized into 6 different categories (i.e., lack of efficacy, lack of safety, government mistrust, unnecessary, previous vaccination issue, other).

Data Analysis

Descriptive statistics were used to characterize the sample. Consistent with the HBM, we tested two parallel mediation models examining the comorbidity burden (high and low-risk burden) on behavioral intentions for COVID-19 vaccination via perceived severity, perceived susceptibility, perceived benefits, and perceived barriers. Specifically, we examined 1) the total effect of high and low-risk comorbidity burden on intention to receive a COVID-19 vaccine, 2) the direct effect of high and low-risk comorbidity burden on intention to receive a COVID-19 vaccine, and 3) the indirect effect of high or low-risk comorbidity burden on intention to receive a COVID-19 vaccine via each putative mediator (i.e., perceived severity, perceived susceptibility, perceived benefits, and perceived barriers). All mediation models controlled for age and smoking status which are established risk factors for negative COVID-19 related outcomes (Biswas et al., 2021; Patanavanich & Glantz, 2020). Tests of all indirect effects were performed using bias accelerated and corrected bootstrapped standard error with 5000 resamples. All inferential statistical tests were two-tailed with alpha = .05. SPSS was the statistical analysis software used for all quantitative analyses.

RESULTS

Sample

The sample was predominantly white (80%) and non-Hispanic (93%), and approximately half male with an average age of 40 years. Over half of the sample obtained a 4-year college degree or higher (55%) and had an annual household income of over $50,000 per year (53%). Nearly three-fourths (74%) of our sample were currently employed. Most of the sample had a primary care provider (69%) and had health insurance (81%). The sample had an average BMI of 27 which is consistent with an individual who is overweight (CDC, 2020b). Less than one-fourth (15%) of the sample were current smokers.

Low-Risk Comorbidity Burden

Results of the mediation model examining the total, direct, and indirect effects of low-risk comorbidity burden and behavioral intentions to receive a COVID-19 vaccine via perceived severity, perceived susceptibility, perceived benefits, and perceived barriers are depicted in Table 2. The total effect of low-risk comorbidity burden on behavioral intentions for vaccination was not significant (p = .877). Greater low-risk comorbidity burden was significantly associated with greater perceived severity (p = .021), perceived susceptibility (p = .018), perceived barriers (p = .032). Greater perceived benefits were associated with greater intention to be vaccinated (p < .001). Greater perceived barriers were associated with lower intention to be vaccinated (p < .001). Perceived susceptibility (p = .105) and perceived severity (p = .377) were not significantly associated with intention to vaccinate. There was a significant indirect effect of greater low-risk comorbidity burden on greater intention to be vaccinated via lower perceived barriers (p < .05).

No other indirect effects were significant ($p > .05$). The direct effect of low-risk comorbidity burden on intention to be vaccinated was not significant ($p = .265$).

High-Risk Comorbidity Burden

Results of the mediation model examining the total, direct, and indirect effects of high-risk comorbidity burden and behavioral intentions to receive a COVID-19 vaccine via perceived severity, perceived susceptibility, perceived benefits, and perceived barriers are depicted in Table 3. The total effect of high-risk comorbidity burden on behavioral intentions for vaccination was not significant ($p = .143$). Greater high-risk comorbidity burden was significantly associated with greater perceived severity ($p < .001$) and perceived susceptibility ($p < .001$). Greater perceived benefits were associated with greater intention to be vaccinated ($p < .001$). Greater perceived barriers were associated with lower intention to be vaccinated ($p < .001$). Perceived susceptibility ($p = .071$) and perceived severity ($p = .569$) were not significantly associated with intention to vaccinate. No indirect effects were significant ($p > .05$). The direct effect of high-risk comorbidity burden on intention to be vaccinated was not significant ($p = .263$).

Intention Not to Vaccinate

Results of individuals' intentions not to be vaccinated were most frequently due to a concern for lack of safety (*e.g., "I need more information about long term side effects."*). The second most frequent reason was due to a lack of necessity (*e.g., "I don't see the need."*). Lack of efficacy (*e.g., "I do not think it is as effective as people say it is."*), other (*e.g., "I prefer wholistic measures to keep myself healthy. I [do not] care to inject myself with something and potentially [experience] side effects."*), government mistrust (*e.g., "I do not trust the government and big pharma to have my best interest at heart..."*), and previous vaccination issue (*e.g., "I* *had a bad reaction to a vaccine when I was a child.''*) were each less than 10% of reasons for intention not to be vaccinated.

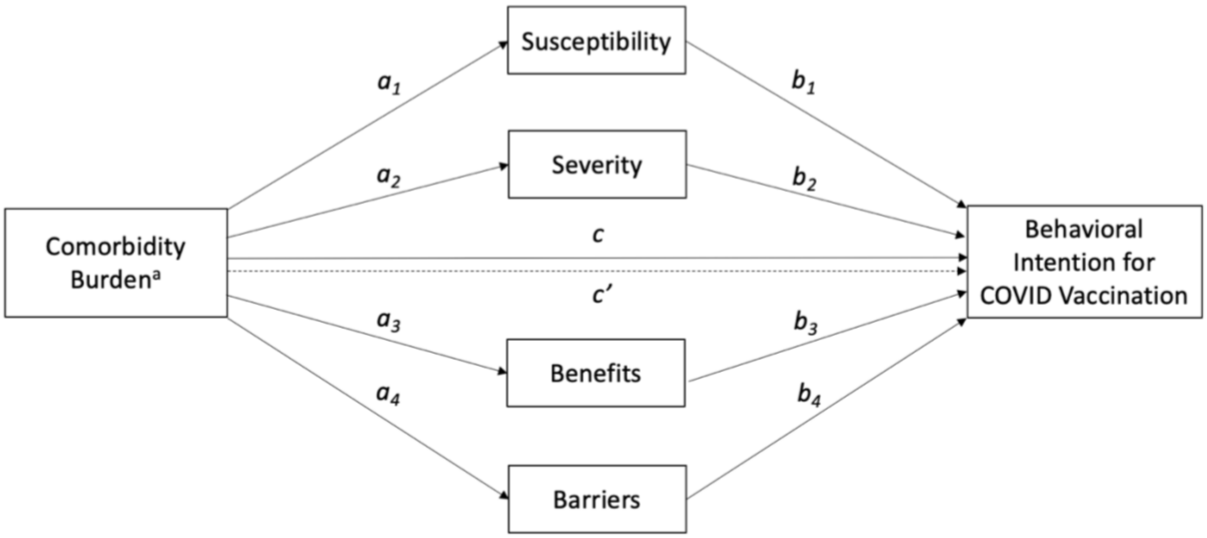

Figure 1. Parallel mediation model examining the total, direct, and indirect effect of comorbidity risk and behavioral intention for COVID vaccination, controlling for age and smoking status.
[a]Total of either low-risk comorbidities or high-risk comorbidities.

Table 1. Sociodemographic characteristics of study sample.

Variable	*n* (%) or Mean (*SD*)
Age	40.4 ± 12.2
Female	46.1
Race	
White	79.9
Black or African American	4.7
Asian	8.5
American Indian or Alaska Native	1.1
Other	2.2
Multiracial	3.6
Ethnicity (Latino)	6.6
BMI	27.1 ± 6.4
Education	
< High school	0.8
High school	12.9
Some college	31.7
4-year college graduate	41.6
≥ 4-year college graduate	12.9
Income	
< 15,000	9.9
15,000 to 30,000	14.9
30,000 to 50,000	21.8
50,000 to 75,000	24.9
≥ 75,000	28.5
Employment	
Employed	73.5
Unemployed due to COVID-19	6.6
Unemployed but not retired	15.7
Retired	4.1
Current smoker	14.6
Health insurance	81.2
Primary care provider	69.1

Table 2. Results of parallel mediation model testing the total, direct, and indirect effects of low-risk comorbidity burden on vaccination intentions.

			95% CI	
	B	SE	LLCI	ULCI
Total effect (*c*)	-.09	.55	-1.17	1.00
a_1	.88	.37	.15	1.61
a_2	.90	.39	.14	1.67
a_3	-.40	.39	-1.17	.38
a_4	.78	.36	.07	1.50
b_1	.10	.06	-.02	. 23
b_2	.05	.06	-.07	. 18
b_3	.97	.06	.86	1.08
b_4	-.25	.05	-.35	-.15
Direct effect (*c*')	.36	.32	-.27	.99
Indirect effects				
a_1*b_1	.09	.07	-.03	.26
a_2*b_2	.05	.07	-.07	.21
a_3*b_3	-.39	.41	-1.17	.41
a_4*b_4	-.20	.11	-.45	-.02

Note: Bootstrapped estimates are provided for the standard error and 95% confidence intervals for indirect effect

Table 3. Results of parallel mediation model testing the total, direct, and indirect effects of high-risk comorbidity burden on vaccination intentions.

			95% CI	
	B	SE	LLCI	ULCI
Total effect (c)	.88	.60	-.30	2.05
a_1	1.39	.40	.61	2.18
a_2	1.71	.42	.89	2.53
a_3	.33	.43	-.51	1.17
a_4	.27	.39	-.50	1.05
b_1	.12	.06	-.01	.24
b_2	.04	.06	-.09	.16
b_3	.98	.06	.87	1.09
b_4	-.24	.05	-.34	-.14
Direct effect (c’)	.39	.35	-.30	1.08
Indirect effects				
a_1*b_1	.16	.12	-.03	.42
a_2*b_2	.06	.12	-.18	.30
a_3*b_3	.33	.43	-.55	1.16
a_4*b_4	-.07	.09	-.25	.10

Note: Bootstrapped estimates are provided for the standard error and 95% confidence intervals for indirect effect

Table 4. Results of qualitative analysis of individuals' reasonings for intentions not to be vaccinated.

Reason	Percentage
Lack of Efficacy	.10
Lack of Safety	.46
Government Mistrust	.07
Unnecessary	.23
Previous Vaccination Issue	.04
Other	.09

DISCUSSION

This study used the Health Belief Model (HBM) as a framework for examining attitudes and beliefs linking comorbidity burden to intentions to be vaccinated against COVID-19 following the initial COVID-19 vaccine distribution in February of 2021. Specifically, we examined and tested the total and direct effects of high and low-risk comorbidity burden with intentions for COIVD-19 vaccination, as well as the indirect effects comorbidity burden on vaccination intentions via perceived severity, perceived susceptibility, perceived benefits, and perceived barriers. As the COVID-19 pandemic continues to develop, it is important for healthcare professionals and policymakers to understand possible motivations and deterrents to vaccination. This study is novel in its efforts to use the HBM to predict behavioral intentions for vaccination associated with comorbidity risk. Overall, we did not find evidence of the mediating role of the HBM variable on the link between comorbidity burden and vaccine intentions. Our results suggest that the HBM may not to fully explain vaccination intentions among U.S. adults. The results of this study yield information that may be useful to determining how we develop vaccine campaigns in the future by looking at individuals' beliefs.

Our results for low-risk and high-risk comorbidities yielded similar results. The total effects of comorbidity burden on behavioral intentions for COVID-19 vaccination were not significant, indicating that burden of COVID-19 related medical conditions is not associated with greater vaccination intention. Our study also resulted in no significant direct effects of comorbidity burden on COVID-19 vaccination intentions. Only one significant indirect effect emerged in the high and low-risk comorbidity burden models. Specially, there was a significant indirect effect of greater low-risk comorbidity burden on greater vaccination intentions via lower perceived barriers to vaccination. However, the parallel indirect effect was not significant in the high-risk comorbidity burden model. Contrary to prediction, neither perceived severity, perceived susceptibility, nor perceived benefits mediated the relationship between high or low-risk comorbidity burden with vaccination intentions. Only greater perceived benefits and lower perceived barriers were associated with greater intention to be vaccinated for both comorbidity burdens.

High and low-risk comorbidity burden predicted greater perceived susceptibility, but perceived susceptibility was not associated with intention to vaccinate. Similarly, high and low-risk comorbidity burden was significantly associated with greater perceived severity of COVID-19 infection, but greater perceived severity did not translate to increased intention to vaccinate. These results suggest that individuals with greater COVID-19 related risk due to preexisting medical conditions accurately perceive themselves as more susceptible to COVID-19 and more likely to experience severe symptoms of COVID-19. However, increased perceptions of COIVD-19 related threat do not appear to influence their intention to get vaccinate against COVID-19.

High and low-risk comorbidity burden was not related to perceived benefits associated with COVID-19 vaccination. However, greater perceived benefits of vaccination were associated with greater intention to vaccinate. High-risk comorbidity burden was not associated with perceived barriers to vaccination. However, there was a significant association between greater low-risk comorbidity burden and greater perceived barriers to vaccination. In turn, greater barriers to vaccination were significantly associated with lower vaccination intentions.

We found a significant indirect effect of low-risk comorbidity burden on vaccination intentions via perceived barrier to vaccination. Specifically, greater low-risk comorbidity burden was associated with lower vaccination intentions through greater perceived barriers to vaccination. This result indicates that individuals with more low-risk comorbidities are less likely to purse COVID-19 vaccination because they perceive more barriers to COVID-19 vaccination. It is possible that adults with more low-risk comorbidities may face challenges to getting vaccinated against COVID-19 and thus, maybe are less likely to purse vaccination. Consequently, efforts to increase access to COVID-19 vaccines and/or messaging to decrease perceived barriers to getting vaccinated against COVID-19 may be effective in increasing vaccine intentions among adults with a high level of low-risk comorbidity burden.

Our results are similar to a Malaysian study which also found lower perceived barriers and greater perceived benefits were associated with greater intention to vaccinate (Wong et al., 2020). However, based on our findings, the mediators of the HBM were not reliable mediators of the relationship between high and low-risk comorbidity burden and intentions to receive a COVID-19 vaccination among U.S. adults. In contrast to this study's findings, other studies have found that HBM variables including perceived susceptibility, perceived severity, perceived benefits, and perceived barriers to mediate the relationship between other potentially important modifying variables (i.e., gender, number of prescription medications, age group, education, and household income) and vaccination intention among U.S. adults (Mercadante & Law, 2021; Zampetakis & Melas, 2021). Moreover, pre-pandemic studies of U.S. adults validated the HBM for influenza vaccination (Cheney & John, 2013; Corace et al., 2016). Together, these findings suggest that other attitudes and beliefs specific to COVID-19 vaccination, not measured or examined in this study, may explain COVID-19 vaccination intentions among our study sample.

It is possible that behavioral intentions to be vaccinated against COVID-19 may be associated with other non-health related beliefs. For example, some evidence suggests that pollical beliefs and affiliation are strong predictors of COVID-19 related vaccine intentions. A recent study suggested that COVID-19 vaccination intention may be related to political beliefs and party affiliation (Sharma et al., 2021). For example, Sharma, et al., 2021 found a lower acceptance rate of COVID-19 vaccines among college students who identified as Republicans. The results of Sharma, et al., 2021 are congruent with other studies which found greater vaccine hesitancy among Republicans (El-Mohandes et al., 2021; Muñana et al., 2020).

Further, it is possible that other individual characteristics may directly impact vaccine intentions. For example, intentions to vaccinate against COVID-19 may be explained by sociodemographic characteristics. One recent study among healthcare workers found an increased intention to receive a COVID-19 vaccine with increasing age, income, and education levels (Shekhar et al., 2021). The results of Shekhar et al., 2021 were similar to another study which found lower vaccine hesitancy among individuals with more education (Liu & Li, 2021). Other studies have found black adults are less likely be vaccinated against COVID-19 when compared to white adults (Liu & Li, 2021; Muñana et al., 2020). Finally, a large body of research suggest that previous behaviors (i.e., influenza vaccination) are a particularly strong predictor of individuals intentions to be vaccinated against COVID-19 (Latkin et al., 2021; Q. Wang et al., 2021).

Findings from the present study suggest that HBM may not fully account for attitudes and beliefs linking objective COIVD-19 related risk (e.g., high and low-risk comorbidity burden) with vaccination intentions. Further, null results of this study still have several important implications for healthcare providers and policymakers. First, the present findings suggest that it may be helpful to reconsider how healthcare providers develop and deliver persuasive messages to increase patients' vaccine adoption. For example, the present results suggest patients with greater comorbidity burden may already perceive themselves as more susceptible to COVID-19 with more severe outcomes if infected. However, our results suggest that patients' perceived susceptibility and severity related to COVID-19 are not related to their intentions to be vaccinated. Consequently, messaging to enhance patients' perceptions of their own susceptibility and severity are unlikely to be effective for increasing intentions for COVID-19 vaccination. That is, increased perceived threat associated with COVID-19 does not appear to serve as a great enough motivator to increase intention to receive a COVID-19 vaccine. It is critical healthcare workers are thorough in their explanations of possible health related outcomes if certain actions are not taken to encourage positive health related behaviors.

Secondly, healthcare providers and government officials must be more thorough in their vaccination campaigns to demonstrate need, safety, and efficacy. Participants in this study endorsed a lack of need, safety, and efficacy as reasons for not intending to receive a COVID-19 vaccine. In another study, individuals who lacked health literacy, education, trust in government, and income were associated with a greater hesitancy towards being vaccinated against COVID-19 (Ullah et al., 2021). Marketing campaigns must work to meet individuals where they are through related personas and trusted figures who can convey information specific to a demographic or about a social norm (Evans & French, 2021). One study found messaging which highlighted the efficacy of COVID-19 vaccines relative to influenza vaccines caused a significant increase in COVID-19 vaccination intentions (Davis et al., 2021). These results suggest that the way in which information is framed regarding vaccination can affect rates of vaccine acceptance. After the pandemic ends, it may be useful to review messaging strategies for healthcare campaigns to reevaluate how to connect with the U.S. population and how to educate them on current public health matters, leaving them motivated to take actions to end it.

Lastly, it is important healthcare providers understand the role they can play in influencing their patient's behaviors towards increased health benefits for the patient. One study found only 50% of college students in the study's sample were encouraged to receive a COVID-19 vaccine by their healthcare provider (Sharma et al., 2021). A study conducted regarding H1N1 vaccination found a positive doctor-patient relationship is associated with increased likelihood for patients to talk about vaccinations with their doctor and to follow their doctor's recommendations towards vaccination (Borah & Hwang, 2021). Another study found a 32% increase in HPV vaccination rates in adolescent males who received a recommendation from their provider (Lu et al., 2019). Therefore, doctors must work to establish trust with their patients to create an environment of willingness to discuss potential health related behaviors and to then act on those behaviors that lead to their patients' most favorable health related outcomes.

Our findings are qualified by several notable limitations. First, all participants were recruited from MTurk and thus, needed access to the internet on an electronic device to be able to participate in the survey. Second, the recruitment, screening, and enrollment procedures used in this study may have introduced a selection bias. The study sample had demographic characteristics similar to the U.S. population. However, this was not a probability sample of the U.S. population. Consequently, the study sample is not representative of the U.S. population and thus, our results may not generalize to all U.S. adults. Third, our study is also limited as our sample's beliefs and intentions may have changed since time of data collection as information relating to the COVID-19 pandemic, vaccine safety, and vaccine efficacy were continually studied and made available to the public. Fourth, our ability to draw casual inferences was limited by the cross-sectional nature of our study. Fifth, we measured behavioral intentions for COVID-19 vaccination rather than actual vaccination behavior. A longitudinal study of Chinese adults showed an 18.2% difference between individuals who indicated they intended to get a COVID-19 vaccination compared to those who received a COVID-19 vaccine (J. Wang et al., 2022). Thus, it is possible that respondents' reported intentions may significantly overestimate actual rates of COVID-19 vaccination. However, we do not know the actual rate of vaccination among the study sample. Sixth, the perceived barriers scale demonstrated low internal consistency and may not provide a reliable measure of respondents perceived barriers to COVID-19 vaccination.

The HBM was the only model used in this study which limited our capacity to determine which actions could be taken to induce change based on our findings (LaMorte, 2019). Our results suggest that the HBM has limited utility for explaining U.S. adults' decisions to receive the COVID-19 vaccination with comorbidity burden as the modifying factor during the initial phase of the vaccine distribution. The HBM is limited in its ability to only measure intentions for behaviors using health related mediators (LaMorte, 2019). A review of the HBM determined severity to not be a good measure of intended behavior when individuals are asymptomatic, a possibility of COVID-19 infection (Janz & Becker, 1984). The HBM is also limiting as researchers still do not entirely understand how the model's mediators relate to one another (Glanz et al., 2015).

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