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Addressing Vaccine Hesitancy Through a Trust in Science Training Intervention

Nathan Dumessa
Clemson University, ndumess@g.clemson.edu

ADDRESSING VACCINE HESITANCY THROUGH A TRUST IN SCIENCE INTERVENTION

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Nathan Dumessa
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Accepted by:
Dr. Kaileigh Byrne, Co-advisor
Dr. Leo J. Gugerty, Co-advisor
Dr. Patrick J. Rosopa
Dr. Kathleen Cartmell
Dr. Michael Shreeves

ABSTRACT

Vaccine hesitancy is an ongoing public health issue that has been underscored by the COVID-19 pandemic and has implications for future pandemics and other vaccines. This research aimed to understand and address the factors associated with hesitancy. Study 1 was a correlational study that measured several factors that could predict vaccine hesitancy among Black and White participants recruited online (n = 364). Findings suggest that trust in science was the strongest predictor of attitudes towards the vaccine's safety and effectiveness, which in turn strongly predicted vaccine hesitancy. Study 1 established the direct and indirect relationships between several predictors of vaccine hesitancy and highlighted racial differences in the model. In a follow-up project, I co-developed and delivered an educational intervention designed to improve trust in science as part of an applied project funded by the South Carolina Department of Health and Environmental Control. Study 2 tested the effectiveness of a trust in science training intervention in a randomized controlled experiment. 159 Black participants recruited online were assigned to a trust-in-science training, a COVID-19 vaccine education training, or an empty control group. Posttest measures assessed trust in science, misinformation recognition, and vaccination intention. The trust training successfully improved trust in science and misinformation recognition when compared to the empty group but did not significantly improve these measures compared to the COVID-training group. None of the training conditions significantly affected vaccination intention. Study 2 provides evidence for a successful trust-in-science training intervention that has applications for future use as an educational tool.

Keywords: vaccine hesitancy, training, trust in science, misinformation

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CHAPTER ONE

STUDY 1: FACTORS INFLUENCING VACCINATION DECISIONS

The COVID-19 pandemic has reshaped our society across several domains like education, the economy, and health care. Its impact on public health has long-term consequences by further widening health disparities in our society. Communities of color were disproportionately impacted by the virus with higher hospitalizations and death rates (CDC, 2020). During the early months of the vaccine rollouts, data from the Kaiser Family Foundation vaccine monitor in April 2021 found that communities of color showed greater hesitancy toward the vaccine. Vaccine hesitancy research can provide insights that could help address these discrepancies for current and future public health issues. In the following studies, I investigate the factors that influence people's decision to take the COVID-19 vaccine (Study 1) and then evaluate interventions designed to increase the likelihood of people taking the vaccine (Study 2). Given my interest in reducing health disparities, the interventions in Study 2 were validated only on Black people. I first discuss the literature on factors influencing vaccination behavior and describe the methods and results of a correlational study on this topic and then, based on the findings of the correlational study, propose an intervention to increase COVID-19 vaccination intentions and a study to evaluate the effectiveness of this intervention. I also discuss an applied project to increase vaccination intentions among community members in South Carolina.

The first study investigates how vaccination intentions and decisions are influenced by the perceived risks and benefits associated with the decision alternatives, by a demographic factor, race, and by long-term attitudes such as political ideology and trust in science and the medical system. The risks and benefits include beliefs about the direct consequences of vaccination—reduced risk of COVID-19 for oneself and the community and increased risk from the vaccine—as well as moral feelings regarding the vaccine—responsibility for others vs. reactance against authority. Path modeling was used to investigate the hypothesis that the immediate risks and benefits influence vaccine intention directly, while the long-term attitudes and demographic factor influence vaccine intentions indirectly. In the following sections, I first summarize important aspects of decision-making theory that guided the proposed model. Then, I describe the literature relevant to the direct and indirect influences in more detail.

Information Used to Make Decisions

Multi-attribute utility theory assumes that people make decisions after considering the probability and the utility of some of the direct consequences (outcomes) of the decision alternatives on multiple attributes (von Winterfeldt & Fischer, 1975). For example, when making decisions between two treatment options for diabetes, patients may consider the potential side effects, the efficacy of the treatments, and the duration of the treatments. In the first study, I looked at how beliefs about the seriousness of COVID-19, the effectiveness of the vaccine in protecting oneself from COVID-19 and reducing transmission to others, and the safety of the vaccine influenced vaccination intentions.

Other research on multi-attribute decision making explores ambiguity aversion when making decisions. Ambiguity aversion refers to the fear of uncertainty that may influence how people assign probabilities and utilities to decision outcomes. Research suggests that people do not take information about the probability and utility of outcomes as a given. Instead, they consider the credibility of the outcome probabilities and values (Gugerty & Link, 2020). The trustworthiness and believability of the outcome information affects its credibility, which consequently affects people's decisions. When decision makers are faced with information that varies in credibility, they tend to choose decision alternatives that have higher credibility even if it means sacrificing some utility, i.e., ambiguity aversion. Notably, throughout the COVID-19 pandemic, there has been a proliferation of low-credibility misinformation and disinformation about the COVID-19 vaccine that has been shown to decrease the likelihood of taking the vaccine (Loomba et al., 2021). I therefore measured people's ability to discriminate between true and false information about COVID-19 vaccination and evaluated whether this ability predicted vaccine intentions.

Two Approaches to Decision Making

Gathering and using information in decision-making can be studied using either an information driven or a coherence driven framework. An information driven framework assumes that people have a stable set of information stored in long term memory about the probabilities and utilities of decision outcomes that is consistent across multiple decisions. Thus, when making a decision, people would first make judgments about the outcomes based on their preexisting knowledge and then integrate the outcome information using various strategies that balance efficiency and thoroughness. Payne and Bettman (2004) describe two types of decision-making strategies for multi-attribute decisions: a reflective, effortful method and a quick heuristic method. For important health decisions, some people employ reflective strategies like weighted additive to select the preferred alternative by considering the utility of each outcome and the importance of each attribute. However, people often adjust their strategies to fit the environmental context. For example, when faced with time constraints, people may rely on heuristic approaches such as a satisficing strategy in which they look for a decision alternative that meets the minimum requirement for an outcome and select that alternative without considering all the other alternatives.

A coherence driven framework assumes that people do not have stable information stored in long-term memory about the probabilities and utilities of decision outcomes that is consistent across multiple decisions (Shreeves, 2020; Simon et al., 2004, 2008; Simon & Spiller, 2016). This approach suggests that people first make an initial choice (or leaning) among decision alternatives. This initial choice biases judgments of the probabilities and utilities of decision outcomes that are made later in the decision process so that they support the initial leaning. In the coherence framework, people construct judgments (preferences) regarding the probabilities and utilities of decision outcomes based on contextual information, including their initial leaning, instead of retrieving stable preferences from memory. This approach is considered to be a heuristic based decision-making process, because it uses fast, type-1 processing to make an initial choice and to construct preferences about outcomes. Preference constructions happen in the context of a given decisional conflict to help the decision maker reduce that conflict and are not permanent. Simon and Spiller (2016) found evidence for the elasticity of preference construction as people's preferences returned to baseline when not actively making a decision.

In support of the coherence driven framework, biases in initial choice leanings have been found to change how people value different outcomes. Simon et al. (2004) found that when given two multi-attribute decision alternatives, people modified their value and importance ratings for the outcomes of the decision to fit their initial leaning. Emotional reactions can bias our decision-making process by creating an initial leaning towards one decision alternative (Shreeves, 2020). Shreeves (2020) provided evidence for the role of affect in preference construction during health decision making. In his study, Shreeves gave participants two alternatives for health treatment and found that participants would shift their ratings of the importance of attributes and affect associated with outcomes midway through their decision to better fit their initial leaning towards a choice.

These two studies focus on single decision episodes and show how judgments concerning the outcomes of decision alternatives can be influenced by an initial leaning towards one alternative. However, the coherence approach can be extended beyond single episodes to longer periods of information seeking, information integration, and choice. It can also include other contextual factors beyond the initial leaning to include long-term attitudes and beliefs like ideology and trust in science. In this respect, the coherence-based approach to decision making seems similar to the way confirmation bias influences people to seek out and gather information that supports their initial beliefs (Nickerson, 1998). Coherence shifting and confirmation bias could explain how political biases influence vaccination decisions by pre-disposing people towards a particular choice that fits their political viewpoint. This initial leaning could then influence people to accept misinformation or low credibility information if it justifies (is coherent with) the choice favored by their political identity group. In prior research on how ideology influences causal reasoning, Kahan and Corbin (2016) found that liberals agreed much more than conservatives with the idea that human activity causes global warming even when participants holding both ideologies were high in openness to changing their beliefs based on evidence. Just as political ideology biased people's views on global warming, they could bias their beliefs about seriousness of COVID-19 and effectiveness and safety of the vaccine, all of which have been heavily politicized since the beginning of the pandemic.

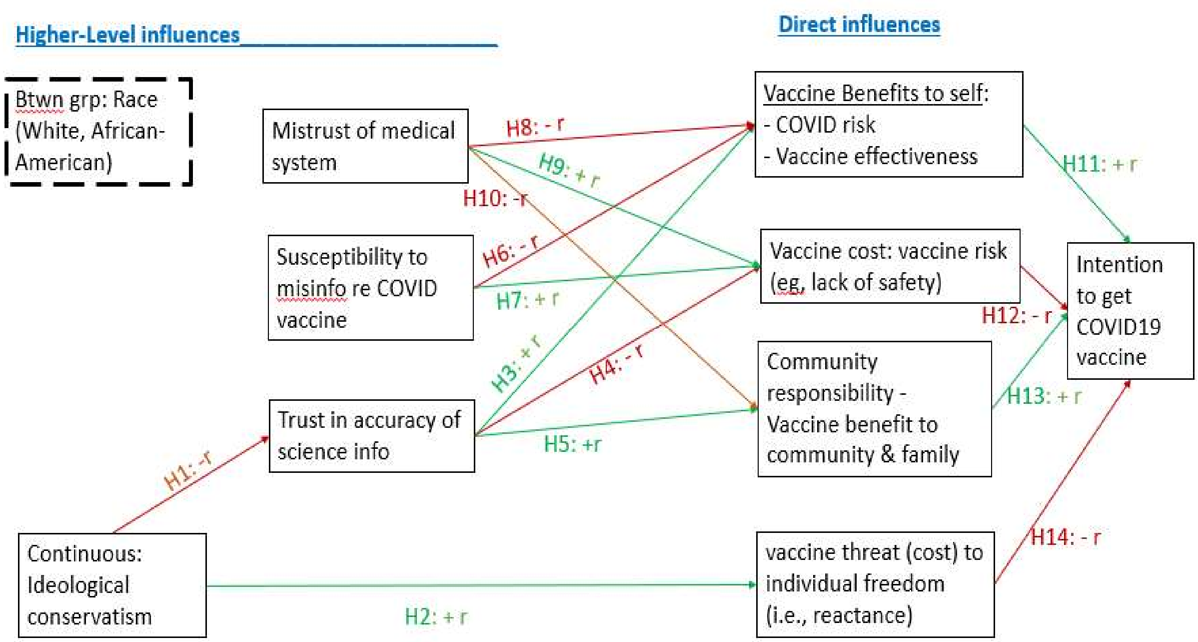
In the first study, I conducted two analyses to explore the relationships among various factors toward health behavior. The first analyses assessed how nine factors indirectly or directly influenced vaccination intention, which was operationalized as the likelihood to get the vaccine and likelihood to recommend the vaccine to others. The second analysis examined how environmental barriers to vaccination influences vaccination behavior, which was measured by whether participants have been vaccinated.

Analysis of Influences on Vaccination Intentions

Figure 1.1 presents the model of direct and indirect influences on vaccination intention. In the following sections I discuss the specific hypotheses in this model and review literature that supports these hypotheses.

Figure 1.1

Path Model 1 with Predicted Relationships between Variables.



Note. Relationships for the binary race variable are not shown as these were assessed using multiple-samples analysis.

Direct Influences. At the first level of the model, I discuss the factors that might directly influence vaccination intentions, which include perceptions or beliefs about the risks (seriousness) of COVID-19, the effectiveness of the vaccine in reducing those risks (for self and others), and the risk from the vaccine. Bostrom et al. (2020) suggested that moral beliefs, including feelings of responsibility for others, can also influence risk perceptions. In support of this claim, Loomba et al. (2021) found that people in the US and the UK were more likely to take the COVID-19 vaccine to protect others than themselves. Since the model's measure of beliefs about how the vaccine will protect others has a moral dimension, I refer to it as community responsibility. In contrast, a moral belief in protecting personal freedom of choice (reactance) may influence COVID-19 vaccination intentions in the opposite direction. Reactance is a negative emotional reaction to having one's individual freedom of choice threatened in a specific situation (Miron & Brehm, 2006). Soveri et al. (2020) associated higher trait reactance among parents with more negative views towards vaccinations for themselves and their children. Miron and Brehm emphasized that reactance is likely not a general trait but rather tied to threats to freedom in specific domains. In adherence to this definition, I included a measure of reactance in the face of pressure to take the COVID-19 vaccine as a direct influence on vaccination intention.

The hypothesized direct influences—COVID-19 seriousness, vaccine effectiveness, vaccine risks, community responsibility and COVID-19 reactance—collectively measure the broader construct of attitudes towards the vaccine. The individual measures of this construct focus on the perceived risks and benefits of the virus and the vaccine, which fits the information-driven decision-making framework described earlier. People can gather specific information regarding the effects of COVID-19 and effectiveness of the vaccines to help them make health decisions.

COVID-19 Risk. The risks of COVID-19, including hospitalizations and deaths, were evident since the beginning of the pandemic. The CDC has reported various demographics as high risk such as those who are older and immunocompromised. There have also been cases in which seemingly young and healthy adults have fallen seriously ill from contracting the virus. Greater perceived risk of this virus should lead people to take measures to protect themselves and others. Risk perception research on COVID-19 health behavior has shown increased adherence to mitigation measures such as mask wearing and social distancing with greater perceived risk of the virus. Thus, I hypothesize a positive correlation between perceived risk of COVID-19 and vaccination intention.

Vaccine Effectiveness. Vaccination only protects against COVID-19 to the extent that vaccines are effective. High effectiveness of the vaccine would mean reduced COVID-19 risk to oneself and to others therefore reducing fears of contracting the virus as well as reduced need for social distancing and other mitigation measures. Due to the impact of the pandemic on the economy, high effectiveness would also mean more economic opportunities and a chance to return to normalcy. Perceived effectiveness of the vaccine has been shown to be negatively correlated with vaccine hesitancy (Betsch et al., 2018). I hypothesize a positive correlation between perceived vaccine effectiveness and vaccination intention.

Community Responsibility. Freeman et al. (2020) provided evidence that perceived benefits to the community is associated with greater vaccine acceptance. Furthermore, COVID-19 mitigation measures were implemented to reduce the spread of the virus when enough people take them so that herd immunity is reached. The constructs of moral obligations and sense of collective responsibility are thus relevant as individuals may feel a sense of responsibility to do their part in fighting the pandemic. COVID-19 has been found to raise moral concerns in regards to how much one can contribute to mitigating the pandemic (Bostrom et al., 2020). It is also associated with broader worldviews as it is expected to be negatively correlated with individualism (Betsch et al., 2018). Indeed, there is some evidence from a recent study that found people with individualistic and hierarchical worldviews showed greater vaccine hesitancy (Hornsey et al., 2018). I therefore expect that greater sense of collective responsibility would be associated with greater likelihood of vaccination intention.

Vaccine Risk. Both true and false information about COVID-19 side effects can cause apprehension towards the vaccine. Roozenbeek et al., (2020) found that susceptibility to vaccine misinformation led to greater COVID-19 vaccine hesitancy, less likelihood to recommend the vaccine, and less adherence to other mitigation measures. In Model 1, greater perceived risk of the vaccine is hypothesized to be negatively correlated with vaccination intention.

COVID-19 Reactance. Differences in worldviews tend to align with political ideologies, for example, conservatism is associated with a more individualistic worldview (Piurko et al., 2011). Prior to running this study, US media outlets favorable to Republicans and then-President Trump portrayed the COVID-19 vaccine as a government infringement on individual freedom (Wise, 2021). As described earlier, I used Miron and Brehm's (2020) definition of reactance as being tied to a specific context that threatens freedom. Thus, I expect people who demonstrate greater COVID-19 reactance would have lower vaccination intention.

Higher-Level, Indirect Influences. At the higher levels of the model are factors that are hypothesized to indirectly influence vaccination intention by their influence on the direct factors that were discussed above. The higher-level factors are mainly long-term cognitive, attitudinal, and personality attributes. A study by Plohl and Musil (2021) guided my hypotheses about how higher-level factors influenced vaccination intention indirectly as mediated by perceived risks associated with COVID-19. Their study found evidence for an indirect effect of trust in science on adherence to COVID-19 mitigation measures (e.g., masks and social distancing) through the mediation of perceived seriousness of COVID-19. In their model, trust in science also served as a mediator for individual factors like political conservatism, religious orthodoxy, and conspiracy ideation. These individual factors, like political conservatism, did not show any direct effects on adherence to COVID-19 mitigation measures.

In line with their findings, the model identifies the construct of political ideology at the highest level influencing trust in science which influences the construct of protecting oneself and others (through measures of COVID-19 risk, vaccine effectiveness and safety, and community responsibility). Through these paths I predict that greater trust in science would be correlated with greater perceived risk of COVID-19, greater perceived effectiveness of the vaccine, greater community responsibility, and a lower perceived risk of the vaccine associated with greater likelihood of vaccination intention. I also hypothesize greater conservatism will be negatively correlated with trust in science as was supported by Plohl and Musil (2021).

Effects of Trust in Science. Further evidence for the role of trust in science as a predictor of using COVID-19 mitigation measures was shown among a German sample population in the early stages of the pandemic (Dohle et al., 2020). Across two studies, Dohle et al., found that trust in science was the strongest predictor for the acceptance and adoption of protective measures against COVID-19. They measured risk perceptions, trust in politics and science, and sociodemographic data such as socioeconomic status, parental status, and age. Their first exploratory study found trust in science and trust in politics to be the most important predictors of acceptance and adoption of protective measures. They conducted a follow up study a month later to assess whether their findings generalize to a later stage of the pandemic. In the second study, they found only trust in science to be the strongest predictor. Their findings emphasize the significant role that trust plays in influencing public health behavior. People are more likely to adopt and adhere to the recommendations when they come from trusted sources.

Effects of Recognition of Misinformation. Prolific misinformation campaigns have probably instilled fears among segments of the population and influenced their perceptions towards the COVID-19 vaccines. Researchers have looked at the consequences of these false claims on health behavior. Loomba et al., (2021) conducted an experiment to assess the effect of exposure to misinformation on vaccination intent. Using randomized controlled trials with UK and US participants, they found that brief exposure to misinformation, defined as false or misleading information, led to a decrease in intention to accept a COVID-19 vaccine as compared to exposure to true information. Earlier correlational research from the beginning of the pandemic found that myths about the COVID-19 vaccine like those perpetuating the idea of microchips or 5G networks exacerbating COVID-19 symptoms was associate with participants being more hesitant to get the vaccine, less likely to recommend the vaccine, and less likely to adhere to COVID-19 safety guidelines (Roozenbeek et al., 2020). To capture this construct, Roozenbeek et al. operationalized a measure for susceptibility to misinformation in which participants rated a set of false statements on a seven-point scale from (1) very unreliable to (7) very reliable. Thus, the lower the score, the less susceptible someone is to believe in misinformation.

In this study, I modify this construct to capture misinformation recognition by presenting true and false items then subtracting the average standardized score on false items from the average standardized score on true items. This way of defining susceptibility to misinformation follows Pennycook and Rand (2019). This modification is important to capture a person's accuracy in identifying true information. If we only consider believability of misinformation (ie. false items), skeptical people may perform well, not because they were able to identify the false information, but because they tend to disbelieve most of what they hear. Similarly, people who are prone to believing most of what they hear would score highly on recognizing true statements as true; but this does not necessarily indicate good ability to discriminate true from false information, which is how I define misinformation recognition. Based on the evidence discussed above, I expect greater misinformation recognition to be indirectly associated with greater vaccination intention.

Effects of Mistrust in the Medical System. Medical mistrust captures a lack of trust in the health care system. It differs from our measure of trust in science because mistrust in the medical system focuses on the intentions and beneficence of healthcare providers and other aspects of the medical care system. People who mistrust the medical system may feel like they cannot expect fair treatment from it. Researchers have shown evidence for the negative effects of medical mistrust on health behaviors. It affects people's level of satisfaction with the medical care they receive. LaVeist et al., (2000) found Black people perceived more racism and expressed greater mistrust in the medical system, which were associated with decreased satisfaction with medical care. Additionally, Thompson et al. (2004) studied Black and Hispanic urban women and found that greater medical mistrust was negatively associated with adherence to breast cancer screening practices. In general, the less trust people have in the medical system, the less likely they are to seek treatments and follow recommendations from physicians, and when they do, they are less satisfied with the care they receive. I hypothesize that greater mistrust in the medical system will be negatively correlated with perceived effectiveness and safety of the vaccine and yield lower likelihood of vaccination intention.

Effects of Conservatism. Gauchat (2012) found that historical trends showed a general decline in trust in science over several decades, from 1974 to 2010. When comparing across ideological groups, conservatives showed a steep significant decline in their trust in science (*p*

<.001) while liberals showed a small and nonsignificant decline (p =.55). In recent polls between 2019 and 2020, Pew research group also showed partisan divides in trust in scientists. Republicans showed a lower trust in scientists that has remained stable while democrats showed increasing trust (Funk et al., 2020). Conservatism has also been associated with decreased trust in science which was associated with decreased adherence to COVID-19 mitigation measures (Plohl & Musil, 2021). This empirical support for the role of politicization in trust in science leads us to hypothesize that conservatism would be negatively associated with trust in science.

Effects of Race. The hypothesis for race is not shown in Figure 1.1 because race was a binary variable that I tested using multiple samples analysis in SEM. However, I expect a between group difference in medical mistrust with Blacks showing greater mistrust. Medical research throughout United States history has not been favorable towards Blacks and other people of color. Most notably, we have heard about the Tuskegee experiment that began in the 1930s where hundreds of Black men who had contracted syphilis were left untreated to watch the progression of the disease. Consequences of racism in history has impacted health outcomes for minority groups. Research conducted by the National Medical Association in 2002 identified the persistence of health care disparities with minority groups receiving poorer quality of care (Nelson, 2002). Similarly, in a 2019 report, trends from the Agency for Healthcare Research and Quality showed that racial health disparities have persisted and some even worsened over the last two decades. They reported Blacks and Hispanics still receive worse quality care for up to 40% of their quality measures. COVID-19 is no exception to these disparities. Racial breakdowns of the COVID-19 impact showed higher rates of COVID-19 cases, hospitalizations, and deaths among Blacks, Hispanics, American Indians, and Alaska Natives (CDC, 2020). Given the historical context and ongoing inequities, it is no surprise that we see greater mistrust of the scientific community among Blacks compared to White populations in the United States.

Analysis of Influences on Vaccination Behavior

Marginalized communities often experience physical and structural barriers to access such as lack of resources, access to primary care, and lack of insurance that can play a role in their health outcomes (Watson, 2014; Douthit et al., 2015). My second model captures the relationship between barriers and vaccination behavior. Barriers may impact vaccination behavior directly by limiting the ease and accessibility of getting the vaccine. For some segments of the population, such as rural residents and those with lower socioeconomic status, vaccine distribution can be a hurdle. Lack of reliable transportation can make it difficult to reach distribution sites. For the vaccines, like Pfizer and Moderna, that require two shots, it can be inconvenient for people to take off two or more days to complete their vaccinations and deal with any side effects. Research has found that convenience is one of the key determinants in vaccination decisions (Betsch et al., 2018). Poor accessibility whether through physical or structural barriers, can deter people from getting vaccinated. In my second (much simpler) model, I hypothesize that people who have greater perceived barriers to vaccination are more likely to not be vaccinated than those who have lower perceived barriers.

Study 1 was a correlational study that investigated the influences on vaccination intention shown in the model in Figure 1.1 and the second model on vaccination behavior. This study used ten predictor variables and two outcome variables, COVID-19 vaccination intention (continuous) and whether participants have taken the COVID-19 vaccine (binary).

Methods

Participants

Kline (2015) suggests that 20 participants per estimated free parameter in a model is an acceptable sample size for SEM models and 10 participants per estimated free parameter is the minimum sample size. Because there are 14 direct path coefficients in the model in Figure 1.1 and 3 exogenous variables (which yields 6 more parameters to be estimated), there are 20 free parameters in our model. This yields a sample size range of 200 to 400. Furthermore, Kline suggests that 200 participants per group yield adequate power for testing between-group hypotheses using multiple-samples analysis in SEM. The sample size and racial breakdowns are in close proximity to these estimates.

I recruited participants so that Black and White people were about equally represented in the sample. I also attempted to get as close as possible to equal numbers of liberal and conservative participants within each racial group. Participants were recruited online through Cloud Research, which uses Amazon Mechanical Turk (N = 364). The platform provides participant screening criteria including race and political ideology. These screening capabilities also allowed me to compensate for the known liberal bias among Mechanical Turk workers (Levay et al., 2016). I used data from the American National Election Survey 2020 concerning the percentage of liberal, moderate, and conservative respondents of different racial groups among a large sample (>5500) that was representative of eligible voters for the 2020 US election. These data showed that Black people are much more liberal and less conservative than Whites. The final sample included 181 White participants with 79 liberals, 36 moderates, and 66 conservatives and183 Black participants, with 97 liberals, 42 moderates, and 44 conservatives. The pattern of liberals greatly outnumbering conservatives was less pronounced in our sample than in the American National Election Survey data. There were 180 females, 181 males, 2 nonbinary, and 1 that did not disclose gender. All participants were adult United States residents ranging in age from 18 to 74 years old (M = 40.39, SD = 12.79).

To improve data quality and reduce likelihood of bots, all participants were required to have at least 95% of their previous Amazon Turk assignments approved and to have a minimum of 50 accepted assignments. In addition, participants were blocked from participation based on data quality features provided by the recruitment platform (i.e., suspicious/duplicate/non-US IP addresses and presence on a Universal Ban List). Participants were compensated at a rate of $8.00 per hour. The study took approximately 30 minutes.

Materials and Tasks

In the following sections, I describe the measures for each variable. The survey was conducted online through Qualtrics program. The complete measures of each construct below are included in Appendix A.

Trust in Science. Trust in science (Continuous, 1 to 5) measures trust in the accuracy, veracity, and lack of bias of the information provided by scientists. This scale was developed based on Nadelson et al.'s Trust in Science and Scientists scale (2014) and contains 13 items with a 5-point response scale from strongly disagree to strongly agree. An example item is: "Scientists ignore evidence that contradicts their work." A score of 1 reflects lowest trust in science and a score of 5 reflects maximum trust in science information. Their scale shows high reliability with Cronbach's alpha of $\alpha = 0.86$. The Trust in Science and Scientists scale has been shown to predict COVID risk perceptions and adherence to mitigation measures (Plohl & Musil, 2021).

Recognition of COVID-19 Misinformation. This scale (Continuous, 1 to 4) measures accuracy in identification of true and false statements regarding COVID and the COVID vaccine. The scale consisted of 8 false statements and 4 true statements, each containing a single factual claim. I wanted this measure to assess people's ability to judge the credibility of information content without using other credibility cues. Therefore, the source of the factual claims excluded. An example a false statement is: "June 8, 2021. Receiving COVID vaccines causes your body to become magnetized." The response scale was definitely false, false, true, or definitely true. False statements were drawn from CDC websites that listed common myths and true statements were drawn from news headlines. All items were pilot tested on a sample of 60 participants and some items were removed based on poor item-total correlations.

Mistrust in Medical System. Mistrust in medical system (continuous, 1 to 5) measures beneficence, interest, and motivation of the health care system in the United States. This scale was developed from the Health Care System Distrust Scale (Shea et al., 2008) and the Group-Based Medical Mistrust Scale (Thompson et al., 2004). This scale contains 13 items with a 5-point response scale from strongly disagree to strongly agree. An example item is: "The Health Care System covers up its mistakes." A score of 1 reflects lowest mistrust in the health care system information and a score of 5 reflects greatest mistrust in the health care system. The Health Care System Distrust Scale has a Cronbach's alpha of $\alpha = 0.83$ and has been shown to predict lower self-reported health (Armstrong et al., 2006). The Group-Based Medical Mistrust Scale has a Cronbach's alpha of $\alpha = 0.87$ and has been shown to predict health care avoidance and reduced health care satisfaction (Shelton et al., 2010).

Vaccine Benefits to Self. Vaccine benefits to self (continuous, 1-5) measures perceived benefits of taking the vaccine as well as perceived risks of the COVID virus. This scale consists of 5 items with 5-point rating scales. This scale is partly based on Bostrom et al. (2020). An example item is: "COVID-19 vaccines reduce the spread of the COVID-19 virus." A score of 1 reflects lowest perceived benefits to self while a score of 5 reflects highest perceived benefits to self.

Vaccine Risk. Vaccine risk (continuous, 1-5) measures perceived risks of taking the vaccine. This scale consists of 4 items with 5-point rating scales. An example item is: "The COVID-19 vaccines can cause dangerous side effects." A score of 1 reflects lowest perceived risks to self while a score of 5 reflects highest perceived risks to self.

Community Responsibility. Community responsibility (continuous, 1-5) measures the perceived impacts of the COVID vaccine and the virus on the broader community, including family members. The scale consists of 4 items with 5-point rating scales. An example item is: "How much responsibility do you feel to help reduce the effects of COVID-19 on others by your actions?" A score of 1 reflects lowest perceived community responsibility while a score of 5 reflects the highest perceived community responsibility.

COVID-Related Reactance. COVID-related reactance (continuous, 1-5) was measured in the context of COVID-19. This scale was adapted from Conway et al. (2020). It consists of 4 items with a 5-point response scale from strongly disagree to strongly agree. An example item is: "I am upset at the thought that the government or businesses would force people to wear masks against their will." A score of 1 reflects lowest reactance and a score of 5 reflects maximum reactance.

Barriers. This measure (Continuous, 1-5) assessed perceived structural and physical barriers to accessing the COVID vaccine. This scale was taken from Baack et al. (2021) and consists of 5 items with 5-point rating scales. An example item is: "It is difficult to find or make an appointment for the COVID-19 vaccine." A score of 1 reflects least perceived barriers to self while a score of 5 reflects highest perceived barriers to access.

Political Ideology. Political ideology was captured using two items regarding political viewpoint and party affiliation taken from Gugerty, Shreeves & Dumessa (2021), as shown here. *Viewpoint*: Which of these options comes closest to your political views? Responses: Very Liberal, Liberal, Moderate, Conservative, Very Conservative. *Party*: Which of these options is closest to the political party you identify with? Responses: Strong Democrat, Democrat, Independent Lean Democrat, Independent, Independent Lean Republican, Republican, Strong Republican.

Demographic Variables. Age, gender, education, and race were measured. Education was measured as the highest level attained using a 6-point scale ranging from (1) high school to (6) Ph.D, law, or medical degree. Race was measured using a 7-item scale consisting of the five categories in the 2020 US Census race question in addition to two categories from the Census ethnicity question, "other" and "Hispanic, Latino."

Vaccination Behavior. This scale consisted of a single item (categorical, yes/no) measuring whether participants have received their vaccination (either fully vaccinated or at least one dose of a two-dose vaccine).

Vaccination Intention. Vaccination intention was measured using two items: *Willingness to Vaccinate* (continuous, 1 – 7) was assessed by the question "When you decided to get the COVID-19 vaccination, how willing were you to receive the vaccine?" if participants answered Yes to the vaccination behavior question and by the question "If one of the COVID-19 vaccines were available for you to take today, how willing would you be to take it?" if they answered No. These questions used a 7-point scale ranging from extremely unwilling to extremely willing. *Likelihood of Recommending Vaccination* (continuous, 1-7) measured likelihood to recommend the COVID vaccine to friends and family, using a 7-point scale ranging from extremely unlikely to extremely likely. The willingness and likelihood of recommendation items were averaged to create the vaccination intention score. A score of 1 reflects the weakest intention while a score of 7 reflects the strongest intention.

Procedure

Measures were presented to participants in the following order: 1. vaccination intent; 2. vaccine benefits to self, vaccine risk, community responsibility, and COVID-19-related reactance in random order; 3. trust in science, medical system mistrust, and misinformation recognition in random order; 4. barriers to vaccination; 5. political ideology, race, and other demographic variables. The order of the items within each measure was randomized.

Results and Discussion

Data collection for Study 1 was completed in September 2021. The study design, hypotheses, and data analysis plan were pre-registered before data collection at OSF (see osf.io/ug8hw) and none of these were changed in writing this paper.

The results pertaining to the model of predictors of vaccination intention (Figure 1.1) are presented first. Table 1.1 presents the means for all the participants on demographic variables and Table 1.2 presents the descriptive statistics for all the participants on all predictor variables in the model. The vaccine benefits variable captured measured perceptions regarding the seriousness of COVID-19 and the effectiveness of the COVID-19 vaccine. I split the variable into COVID-19 seriousness and vaccine effectiveness for analysis so I could delineate between these separate constructs. The attitudes towards the vaccine variable will be discussed later.

Table 1.1
Descriptive Statistics for Study 1 Demographics Variables

Variables	Mean or N	SD
Age, mean	40.39	12.79
Gender, N		
Female	180	
Male	181	
Other	3	
Race, N		
Black	183	
White	181	
Highest education attained, N		
Some high school or less	1	
High school degree	109	
Degree from 2-year college	52	
Degree from 4-year college	153	
Master's degree (2 years)	44	
PhD, law, or medical degree	5	

All the variables in the model showed excellent reliability with Cronbach's alpha ranging from $\alpha = .80$ for misinformation recognition to $\alpha = .95$ for trust in science. Table 1.2 shows Cronbach's alpha for each scale. We assessed the distribution of our variables and checked for any outliers. Some of the variables showed moderate non-normality due to skew. Therefore, I used robust estimation methods in path modeling.

Path Modeling

Original Model – 9 predictors. I initially used path modeling to test the hypothesized model (9 total predictors) without including race in the model. This was done using the lavaan procedure in R. This model showed a poor fit, $X^2(28) = 1081.98$, $p = .00$, CFI = .60, RMSEA = .32. In support of the hypothesis, reactance showed a strong positive relationship with conservatism, $\beta = .61$, $p < .01$. Contrary to the hypotheses, the standardized path coefficients from COVID seriousness (.05) and reactance (.04) to the outcome variable, vaccination intention, were low and not significant. In respecifying the model, I therefore dropped these two predictors.

Table 1.2
Means and Standard Deviations for Model Variables

Variable	Mean	SD	Cronbach's alpha
Vaccination intent (1 very unlikely to 7 very likely)	5.13	2.11	.90
Vaccine benefits	3.63	.96	.85
Vaccine effectiveness	3.69	1.07	.86
COVID-19 seriousness	3.59	1.10	.85
Vaccine risks	2.86	1.24	.91
Community responsibility	3.87	1.00	.82
COVID-19 reactance	2.98	1.36	.90
Attitudes towards the vaccine (composite: vaccine effectiveness, vaccine risk, and community responsibility)	0.00	0.92	
Medical mistrust	2.69	1.00	.94
Trust in science	3.76	0.95	.95
Misinformation recognition	0.00	1.44	.80
Ideology (1 liberal to 7 conservative)	3.68	1.85	

Note. Attitudes toward the vaccine and Misinformation recognition variables use standardized scores. All other variables unless stated otherwise are on a 1 to 5 scale with 5 representing the highest degree of the construct.

Reduced Models. The reduced model, with 7 predictors, Model 2, still had a very poor fit, $X^2(16) = 541.88$, $p = .00$, CFI = .67, RMSEA = .33. This fit was likely due at least partly to multicollinearity among some of the predictor variables. Table 1.3 shows the intercorrelation matrix for all the predictor variables. The direct influences that capture attitudes towards the vaccine (efficacy, risk, and community responsibility) showed high intercorrelations $r > .7$. Items in the scales measuring direct influences on vaccination intention were adapted from Freeman et al. (2020). In their analyses, they found similar high intercorrelations among their predictor variables which were then merged to form a composite construct of beliefs about the vaccine. Thus, I merged the direct influences into a composite measure of attitudes toward the vaccine. Vaccine safety was reversed so a higher value would represent a positive attitude toward the vaccine. Then vaccine efficacy, vaccine risk, and community responsibility were standardized and averaged to form a variable called attitude toward the vaccine.

Table 1.3

Intercorrelation Matrix for 9 Predictors and Vaccination Intention

Variables	1	2	3	4	5	6	7	8	9
1. Conservatism	-								
2. Misinformation recognition	-.34*	-							
3. Mistrust in medical system	.18*	-.42*	-						
4. Trust in science	-.47*	.55*	-.60*	-					
5. Community responsibility	-.49*	.50*	-.38*	.66*	-				
6. Vaccine efficacy	-.37*	.37*	-.35*	.60*	**.82***	-			
7. Vaccine risks	.40*	-.50*	.54*	-.68*	**-.72***	**-.75***	-		
8. COVID serious	-.28*	.19*	.01	.33*	.62*	.53*	-.32*	-	
9. Reactance	.66*	-.52*	.37*	-.66*	**-.73***	-.59*	.67*	-.49*	-
10. Vaccination intention	-.35*	.39*	-.36*	.55*	.79*	.83*	-.75*	.50*	-.60*

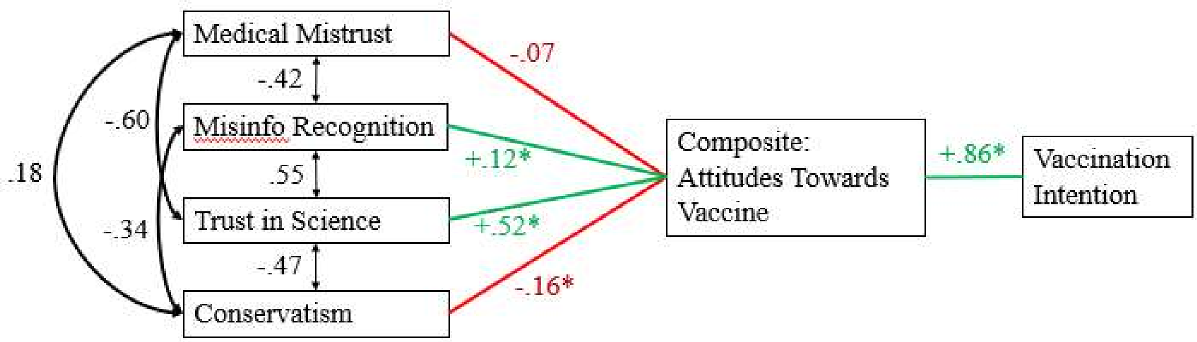
Note. * signifies p < .001

The further reduced model, model 3, with 5 predictors, still fit poorly, $X^2(6) = 188.97$, $p = .00$, CFI = .83. RMSEA = .30. I conducted a form of local fit testing called conditional independence analysis (Kline, 2015, p 240) to identify the source of the poor fit for this model. This analysis looks for violations of the assumption that causal variables in the model that can be d-separated should be independent when conditioned on their parent causes, as these may indicate an incorrectly specified model. AMOS SEM software was used to calculate the partial correlations to test the conditional independence assumptions. The analysis revealed high partial correlations (much greater than the .10 cutoff recommended by Kline) among conservatism, trust in science, misinformation recognition, and medical mistrust. This finding suggested that the causal structure hypothesized for these variables—with trust in science, medical mistrust and misinformation recognition directly influencing vaccine attitudes and conservatism directly influencing trust in science—was mis-specified. Therefore, I re-specified the model by putting conservatism at the same level as trust in science, misinformation recognition, and medical mistrust (See Figure 1.2).

Final Causal Structure. This re-specified model, Model 4, showed good fit, $X^2(4) = 9.44$, $p = .051$, CFI = .96, RMSEA = .062. Next, I tested the assumption that the higher-level variables (the three trust-related variables and conservatism) had only indirect effects on vaccination intention through the mediating factor of lower-level variables like attitudes towards the vaccine. When direct effects from the higher-level variables to vaccination intention were added to the model in Figure 1.2, these direct relationships were not significant (Medical mistrust, $\beta = .01$, $p = .76$, misinformation recognition, $\beta = -.02$, $p = 58$, trust in science, $\beta = -.08$, $p = .06$, conservatism, $\beta = .04$, $p = .25$) and model fit showed a just-identified model: CFI = 1.00, RMSEA = .00. This supported the hypothesis that attitudes towards the vaccine—based on perceptions of vaccine effectiveness and risk and feelings of community responsibility—mediated the influence of higher-level variables including ideology and trust on vaccination intention. Therefore, the final included only the indirect, mediated relationship as shown in Figure 1.2.

Figure 1.2

Model 4 with Final Causal Structure



Findings Concerning the Entire Sample

Higher-level indirect influences. The following hypotheses are regarding the higher-level indirect influences in the model:

H1: Ideological conservatism will be negatively correlated with trust in science.

H2: Ideological conservatism will be positively correlated with COVID-related reactance.

Both hypotheses regarding conservatism were supported. Ideological conservatism had a significant negative correlation with trust in science, $r = -.47$, $p < .001$, and a significant positive correlation with COVID-related reactance $r = .66$, $p < .001$. Greater conservatism was associated with lower trust in science and higher COVID-related reactance. However, reactance was dropped from the final causal structure thus removing the path between conservatism and reactance. This aligns with much of what we see in the politicization of the pandemic as the conservative ideology promotes individual freedom when it comes to getting the COVID vaccine. The strong relationship between ideology and reactance provides evidence for the criterion-related validity of our reactance measure. Given this evidence, the unexpected negligible relationship between reactance and vaccination intention is noteworthy, as it suggests that conservatives' strong sentiments against COVID-19 mitigation measures did not influence their behavioral intention regarding vaccination.

H3 – H5: Trust in science will be positively correlated with perceived benefits of the vaccine to self (H3) and with community responsibility (H4). Trust in science will be negatively correlated with perceived risks of the vaccine (H5).

Trust in science was hypothesized to positively correlate with perceived vaccine benefits to self and community responsibility and negatively correlate with perceived vaccine risks. Because of multicollinearity among the direct influences on vaccination intention, I could not test the original hypotheses that greater trust would be associated with higher perceived vaccine effectiveness and community responsibility and with lower perceived vaccine risk. However, trust in science was positively correlated with the composite attitudes towards the vaccine variable based on these three measures (after reversing vaccine risk). This is consistent with findings from Plohl and Musil (2021) that showed a positive correlation between trust in science and perceptions of COVID-19 risk and Dohle et al. (2020) that found higher trust in science associated with more acceptance of protective measures during the pandemic.

H6 and H7: Misinformation recognition will be positively correlated with perceived benefits of the vaccine to self (H6) and negatively correlated with the risks of the vaccine (H7).

Given the composite measure of attitudes towards the vaccine, misinformation recognition was expected to be positively correlated with attitudes toward the vaccine. This hypothesis was supported as better misinformation recognition predicted more positive attitudes towards the vaccine. It is consistent with recent studies that found greater susceptibility to misinformation to be associated with lower vaccination intention (Loomba et al., 2020, Roozenbeek et al., 2021).

H8 – H10: Mistrust in the medical system will be negatively correlated with perceived benefits of the vaccine to self (H8) and with community responsibility (H9) and positively correlated with perceived risk of the vaccine (H10).

These hypotheses were not supported. Figure 1.2 shows a very small and nonsignificant negative relationship between medical mistrust and attitudes towards the vaccine. This is interesting given the high correlation between medical mistrust with trust in science. As these variables capture related constructs of trust, and thus I expected them to show similar relationships with attitudes toward the vaccine. One possible explanation for this finding is that mistrust may be a long-standing attitude towards the medical system that is more stable and thus may not have as much influence as other factors that are more directly related to the COVID-19 vaccine.

Direct influences. The following hypotheses were made regarding the direct influences on vaccination intention:

H11: Perceived benefits of the vaccine to self will be positively correlated with vaccination intention.

H12: Perceived risks of the vaccine will be negatively correlated with vaccination intention.

H13: Community responsibility will be positively correlated with vaccination intention.

H14: COVID-related reactance will be negatively correlated with vaccination intention.

Three of the hypotheses about the direct influences on vaccination intention were supported. Vaccination intention was hypothesized to increase as perceived vaccine effectiveness and community responsibility increased, and as perceived vaccine risk decreased. Since vaccine risk was reversed before forming a composite predictor from these three variables, the composite was expected to correlate positively with vaccine intention. Figure 1.2 shows a strong positive coefficient, supporting these hypotheses. However, the hypotheses that perceived COVID seriousness and COVID-related reactance would predict vaccination intention were not supported, as these variables had low correlations with vaccination intention and were dropped from the final model.

Exogenous variables. Among the exogenous variables, trust in science, medical mistrust, and misinformation recognition showed moderate to high intercorrelations. This reflects the overarching construct of trust that is captured in each of the three variables. Medical mistrust and trust in science directly assess trust in different contexts, in the health care system and in the scientific process, respectively. Trust is also inherently involved in identifying true and false statements because people are making judgments about the credibility of the information, which requires judging the trustworthiness of information sources. It makes sense that trust in science would be positively correlated with misinformation recognition as the information being assessed is scientific information regarding COVID-19. Conservatism shows a moderate correlation with trust in science and low correlations with medical mistrust and misinformation recognition. These correlations may again be attributed to the political discourse surrounding COVID-19 and is supported by previous findings that link greater conservatism with lower trust in science (Gauchat, 2012, Funk, 2020, Plohl & Musil, 2021).

Summary. One of the main contributions of Study 1 to the literature is the evidence for a hierarchical model that represents the relationships between the direct and indirect factors associated with vaccine hesitancy. Several studies have looked at these factors separately, but few have tried to model the relationships among these factors. The model in this study found that among the higher-level factors, conservatism, trust in science, and misinformation recognition only predict vaccine hesitancy through the mediating effects of attitudes toward the vaccine. Medical mistrust was not a significant predictor in the model; however, a previous study shows greater medical mistrust is associated with vaccine hesitancy (Charura et al., 2022). The direct influences were strong predictors of vaccine hesitancy which is consistent with much of the literature that has established the direct association between perceptions of risk, safety, and benefits and vaccine hesitancy (Betsch et al., 2018, MacDonald, 2015).

Mean Racial Differences for Demographic Variables

Among White participants (N=181), there were 86 females (47.5%), 94 males (51.9%), and 1 participant chose not to disclose their gender. For Black participants (N = 183), there were 94 females (51.3%), 87 males (47.5%), and 2 participants reported as other. As Table 1.4 shows, Black participants were significantly younger than White participants. There were no significant differences in gender ratio between Black and White participants. However, there was a significantly higher education level among Black than White participants, $U = 14404.5$, $p = .02$. These age and education data reflect the younger and more educated participant pools in online recruitment platforms such as Mechanical Turk (Huff and Tingley, 2015). Table 1.4 presents the means for the Black and White participants on demographic variables and Table 1.5 presents the means for Black and White participants on all predictor variables in the model shown in Figure 1.1.

Table 1.4
Racial Differences in Demographic Variables

Variable	Mean (*SD*) or N		*Test Statistic*	*p*	*Effect Size*
	White	Black			
Age, mean	43.12 (13.14)	37.70 (11.87)	$t = 4.12$	<.001	*d* (0.43)
Gender, N (female, male, other)	86, 94, 1	94, 87, 2	$X^2(3) = 3.62$	.306	
Highest education attained, N			$U = 14404.5$	.023	*r* (-.12)
Some high school or less	1	0			
High school degree	56	53			
Degree from 2-year college	31	21			
Degree from 4-year college	81	72			
Master's degree (2 years)	8	36			
PhD, law, or medical degree	4	1			

Mean Racial Differences for Variables in the Model

The first hypothesis regarding differences between racial subgroups was that Black participants would show greater mistrust of the medical system than White participants. This hypothesis was supported. Table 1.5 shows that Black participants had significantly more medical mistrust, less trust in science and lower misinformation recognition than White participants. These last two findings were not hypothesized. Effect sizes (Cohen's *d*) ranged from small (0.34 for trust in science) to extremely large (1.35 for medical mistrust). Since a key characteristic of recognizing misinformation is the ability to judge which information sources are trustworthy or credible and which are not, these findings suggest that compared to White people, Black people trust the medical system and science less and trust non-credible information sources more.

The second hypothesis regarding racial subgroups was that White participants would have greater ideological conservatism than Black participants. This hypothesis was not supported. Though White participants had slightly higher conservatism ($M = 3.85$, $SD = 1.92$) than Black participants ($M = 3.55$, $SD = 1.77$), the difference was not significant.

Table 1.5

Racial Differences in Model Variables

Variable	Mean (*SD*)		*t*	*p*	*d*
	White	Black			
Vaccination intent (1 to 7 very likely)	5.14 (2.22)	5.11 (2.01)	0.13	.90	0.01
Vaccine benefits	3.45 (1.08)	3.81 (.78)	-3.63	<.001	-0.38
Vaccine effectiveness	3.67 (1.16)	3.70 (.98)	-0.20	.84	-0.02
COVID-19 seriousness	3.30 (1.22)	3.88 (.88)	-5.22	<.001	-0.55
Vaccine risks	2.66 (1.36)	3.06 (1.07)	-3.15	.002	-0.33
Community responsibility	3.83 (1.12)	3.91 (.86)	-0.79	.43	-0.08
COVID-19 reactance	2.96 (1.51)	3.00 (1.21)	-0.31	.76	-0.03
Attitudes toward the vaccine (vaccine effectiveness, vaccine risk, and community responsibility)	0.04 (1.04)	-0.04 (.78)	0.77	.44	0.08
Medical mistrust	2.12 (.82)	3.23 (.85)	-12.89	<.001	-1.35
Trust in science	3.92 (1.05)	3.60 (.80)	3.26	<.001	0.34
Misinformation recognition	0.34 (1.41)	-0.34 (1.39)	4.63	<.001	0.49
Ideology (1 liberal to 7 conservative)	3.82 (1.92)	3.55 (1.77)	1.41	.16	0.15

The only other significant racial differences were in vaccine benefits, which was due to lower belief in COVID seriousness among Black participants. However, COVID seriousness was not retained in the final model. Racial differences in all other variables in this model were non-significant and of negligible size. It is important to note that despite the lower scores on the three trust variables among Black participants, Black participants were approximately equal to White participants in vaccination intent and attitudes towards the vaccine.

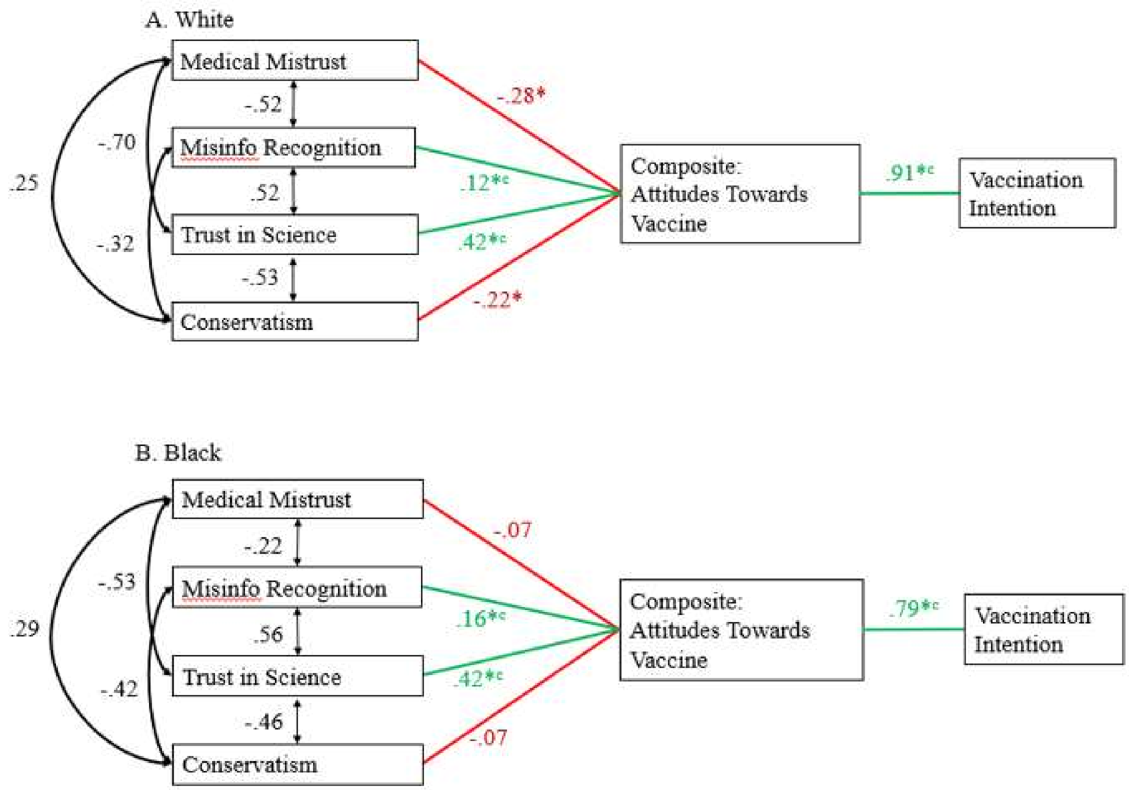
Influences of Race

Between-group differences in the model in Figure 1.2 were assessed using race as a categorical variable by using multiple-samples analysis for path modeling. In an initial model, there were no constraints on any model parameters (path coefficients, covariances between exogenous variances, intercepts). Although this model fit well, $X^2(8) = 14.64$, $p = .07$, CFI = .96, RMSEA .068, it is un-parsimonious to have models where all parameters are different for each race. The more parsimonious model with all path coefficients constrained to be equal for both races was evaluated, $X^2(13) = 40.63$, $p = .00$, CFI = .98, RMSEA .108; but this model appreciably decreased in fit, ΔX^2 (5) = 25.99, $p < .001$, ΔCFI = .03, ΔRMSEA = .04. In the completely unconstrained model, some of the unstandardized path coefficients were similar between the two races, while others (namely the paths from medical mistrust and conservatism to vaccine attitudes) differed widely.

In the final model, these two unstandardized coefficients were allowed to vary freely between the groups while all other unstandardized coefficients were constrained to be equal. This improved the fit to $X^2(11) = 17.42$, $p = .10$, CFI = .995, RMSEA = .057. This improvement in fit provides evidence that the path coefficients from medical mistrust and conservatism to vaccine attitudes differed between the races. These differences were un-hypothesized. The standardized parameter values for the multiple-samples model for Black and White participants are shown in Figure 1.3. All the high-level factors were significant predictors of attitudes towards vaccine for White participants, but only truth discernment and trust in science were significant for Black participants. Vaccine attitudes was a strong predictor of vaccination intention for both groups.

Figure 1.3

Path Analysis of Final Causal Structure for White (panel A) and Black (panel B) Participants with Standardized Coefficients.



Note. *indicates significance, $p < .05$; [c]indicates that the unstandardized coefficient was constrained to be equal for both races.

Findings Concerning Racial Subgroups

As hypothesized, Black participants showed much greater mistrust in the medical system than White participants ($d = 1.35$). Interestingly, post hoc analysis also found Black participants showed lower trust in science and lower misinformation recognition. These racial differences are consistent with previous findings in the literature (LaVeist et al., 2000, Strully et al., 2021, Nan et al., 2022). Despite these differences, between group differences in vaccination intention or attitudes towards the vaccine were of negligible size and not significant. For Black and White participants, attitudes toward the vaccine were a very strong predictor of vaccination intention.

As expected, more positive attitudes towards the vaccine are associated with higher likelihood to get vaccinated.

Higher-level predictors showed an interesting trend. For White participants, trust in science, medical mistrust, conservatism, and misinformation recognition strongly predicted people's attitudes toward the vaccine in that order. Meanwhile, for Black participants, only trust in science and misinformation recognition significantly predicted attitudes toward the vaccine. This is surprising because I expected medical mistrust to play a bigger role in shaping attitudes towards the vaccine for both groups, but especially for Black participants given the greater level of mistrust and historical context.

Another interesting finding is that conservatism negatively predicted attitudes towards the vaccine for White participants but not for Black participants. The politicization of the pandemic had engendered polarizing viewpoints on individual freedom between liberals and conservatives. Thus, I expected people with more conservative ideologies would have less favorable attitudes towards the vaccine which would align with what we see in the media. However, for Black participants, the lack of influence of conservatism on attitudes could potentially be explained by the intersectionality of their identities. Generally, Black people in the United States tend to align with the democratic party and liberal ideologies. Conservative ideologies may not have a strong influence on their in-group association and may therefore not have a strong influence on their beliefs toward the vaccine.

Summary. Another contribution of this study to the literature is the evidence of how the hierarchical model differs between Black and White participants. In trying to understand the complex relationships among the many factors associated with vaccine hesitancy, it is useful to consider racial differences that may affect how the factors interact. The findings suggest that these predictors may not affect everyone equally. For White participants, all four of the higher-level factors significantly predicted attitudes toward the vaccine. However, only trust in science and misinformation recognition significantly predicted attitudes toward the vaccine among Black participants. The value of comparing racial differences using this model is to highlight the key relevant factors for each demographic.

Findings Concerning Barriers and Vaccination Rates

A separate model assessed the relationship between perceived physical and structural barriers and vaccination behavior. I expected that greater perceived barriers would predict lower vaccination rates. This hypothesis was not supported. A logistic regression analysis showed that barriers did not significantly predict vaccination rates ($B = .041$, $p = .74$).

For racial subgroups, 70.1% of White participants and 69.9% of Black participants reported that they were already vaccinated at the time of the study. There was no significant difference in vaccination rates between the two groups, $X^2(1) = 0.16$, $p < .69$. I hypothesized that Black participants would have greater perceived barriers than White participants which may deter them from getting vaccinated. The data showed an extremely positive skew with a median score of 1 on a 1-5 scale. A score of 1 represents the least perceived barriers. Therefore, I tested this hypothesis by splitting the barriers data into a binary (no perceived barriers vs. some perceived barriers) and conducting a chi-square test. The results showed a significant group difference $X^2(1) = 14.34$, $p < .001$ with 56.8% of Black participants and only 37% of White participants reporting some perceived barriers. This finding supports the hypothesis which is consistent with research that shows marginalized communities tend to experience more physical and structural barriers that limit their access to quality health resources (Douthit et al., 2015; Watson, 2014).

One possible explanation for the extremely skewed distribution of perceived barriers is the nationwide vaccination campaign that pushed to provide access to vaccinations. Several venues and clinics were transformed into vaccination sites to make it easier for people to get vaccinated. These efforts along with pressures from public and private institutions likely contributed to the high vaccination rates and overall low perceived barriers found in this study. Additionally, the vaccination campaign was largely facilitated by online tools to help find and schedule vaccinations. Given that this was an online study, the participants we recruited have access to the internet which makes access to vaccinations a little easier.

Implications for Intervention

Findings from the first study yield useful insights for developing an intervention. The findings suggest that a focus on addressing trust in science and misinformation recognition could improve the public's attitudes towards the COVID-19 vaccine and consequently increase vaccination intentions. In the fall of 2021, I joined a six-month grant-funded project known as COVID H.O.P.E. (Health Outcomes in Pursuit of Equity) and had the opportunity to apply these lessons learned from Study 1 to a community-based intervention to increase vaccination acceptance. This project, described in more detail below, implemented the findings to include trust-specific training as part of COVID-19 educational sessions administered to church networks throughout South Carolina. In a follow-up experimental study, I design an intervention that focuses on improving trust in science by providing education and transparency into the scientific process to highlight its integrity and credibility.

CHAPTER TWO

PROJECT COVID H.O.P.E.

Project COVID H.O.P.E. was formed as an outreach effort to improve vaccination acceptance in South Carolina. In November 2021, Clemson Rural Health at Clemson University received a grant from the South Carolina Department of Health and Environmental Control to increase vaccine knowledge and improve perceptions towards getting the vaccine among faith-based, predominantly Black communities in South Carolina. Clemson Rural Health partnered with three local church networks: Rocky River Baptist Association, SC Witness Project, and Imani Group. These networks were led by Sister Marian Robinson, Pastor Jacqueline Talley, and Reverend Brendolyn Jenkins Boseman, respectively. The three networks represented the Upstate, Pee Dee, Midlands, and Low Country regions of South Carolina, thus covering the entire state. The leaders regularly worked within their regions on various health related campaigns to improve the welfare of their communities. They partnered with Clemson University for this project to tackle the challenges of the pandemic that disproportionately affected their rural communities. The project team consisted of Clemson University faculty members across multiple disciplines along with the church network leaders. The team brought together experts in psychology, communication, public health, community engagement, and nurse practitioners.

Methods

The project implemented an educational intervention using a train-the-trainer approach. Using existing network structures, the Clemson team conducted training sessions to educate and inform network leaders and their team of community members who would serve as vaccine champions for their community. The role of vaccine champions was to use the training we provided along with additional resources shared with them to conduct culturally competent educational training sessions for their communities. The main benefit of the train-the-trainer approach is that training was delivered to community members by people from their local communities, who may be more trusted than an outside expert.

A smaller team within the COVID H.O.P.E. project made up of Clemson faculty and graduate students, Dr. Kathleen Cartmell, Dr. Leo Gugerty, Bonnie Treado, Dela Sirizi, and Nathan Dumessa, was responsible for developing the materials used for the educational intervention. The team developed training slides by adapting a vaccine champion training presentation that was developed by the San Francisco Department of Public Health (2021). The adapted training covered topics such as vaccine regulatory process, vaccine safety and effectiveness, and communication strategies. Train-the-trainer sessions lasted about 6 hours.

Among the topics covered, Dr. Leo Gugerty and I developed a section in the training that was specifically focused on improving trust in science and the medical system. We based some of the topics in this section around the items in the trust in science scale used in Study 1. The items in the scale were largely centered around honesty and bias in scientific work. It included items like, “We cannot trust scientists because they are biased in their perspectives,” and “Scientists intentionally keep their work secret.” Thus, in developing our slides, we aimed to highlight characteristics of the scientific process to demonstrate honesty and lack of bias.

Figure 2.1

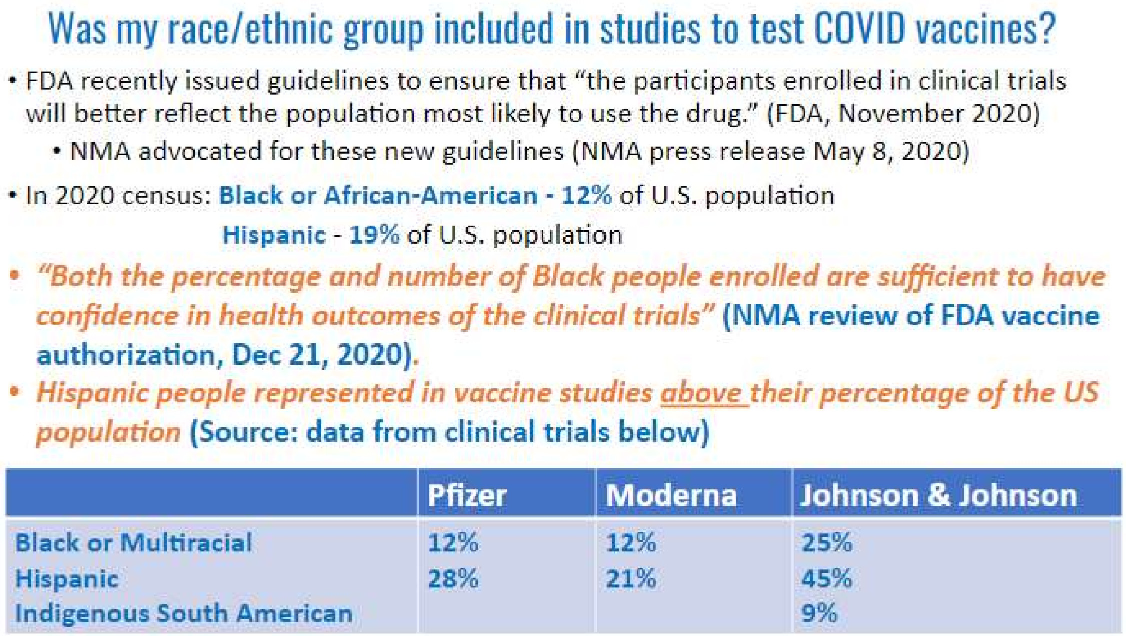
Example Training Slide: Timeline of Vaccine Safety and Effectiveness Testing

The slide in Figure 2.1 demonstrates the timeline for emergency use and full approval of the vaccines along with ongoing safety monitoring. It highlights key facts like the number of volunteers that participated in the clinical trials and the number of people that are fully vaccinated to provide evidence supporting the safety and effectiveness of the vaccines. It also highlights the safety assessments done between emergency use authorization and full FDA approval of the vaccines to express the rigor involved in ensuring safety.

The slide in Figure 2.2 addresses the concern of representation in clinical trials. We present the policy changes that the FDA implemented to ensure representative sampling in clinical trials. We compare the racial breakdown in the vaccine trials to the racial breakdown in the United States based on 2020 census data to demonstrate the representativeness of the samples used to test the vaccines.

Figure 2.2

Example Training Slide: Representation in Clinical Trials



In addition to the training slides, we developed pre and post test questions for the vaccine champion training to assess vaccination intention, knowledge gain regarding COVID-19, perceptions towards the vaccine, and trust in science and medical system. Knowledge gain questions included a total of 25 true or false items regarding the virus and the vaccine. For example, "COVID-19 booster doses are needed because the virus changes over time." Perceptions towards the vaccine and trust measures were presented in the same section with a total of 21 items rated using a 7-point Likert scale (strongly disagree (1) – strongly agree (7)). The items included, "COVID-19 vaccines can stop serious infectious diseases" and "We should trust that scientists are being honest with their work." The pre and post test questions also included demographic measures and feedback questions to assess trainer readiness and ways to improve the program.

Procedure

The training took approximately six hours to complete. The training slides were administered by members of the COVID HOPE research team to 3 to 15 trainers for each of the three church networks. The church networks decided if they wanted to complete the training in one 6-hour session or two 3-hour sessions. Given the transportation barriers and general concerns for maintaining safe COVID practices, we conducted all our training sessions virtually via Zoom. Participants completed pre and posttest surveys online through REDCap.

Takeaways

The primary goal of the project was to educate and address concerns of the communities about vaccination in order to appease vaccine hesitancy and increase acceptance. Interviews with community leaders at the beginning of the project unveiled that community members may be deterred by mistrust of science and experimental research methods. Thus, we took a culturally sensitive approach to center the project around the needs of the communities. One of the takeaways was understanding the complexities of implementing a methodological approach in this context. Part of the mistrust from the community members was due to feelings of being experimented on like guinea pigs. Additionally, most of the community educational sessions occurred during church services. These factors limited the administration of the surveys, making it difficult to conduct within-subjects pre and posttest assessments. Additionally, not everyone who took a pretest survey completed a posttest survey. The project allowed for a formative evaluation of trust related training material through feedback from the network leaders and vaccine champions. Working with the community leaders and members was insightful in understanding the types of concerns that people had regarding vaccines and scientific research.

CHAPTER THREE

STUDY 2: TRUST IN SCIENCE TRAINING INTERVENTION

Following the implementation project with COVID HOPE, Study 2 was designed to assess the effectiveness of a trust specific training intervention among Black participants using a controlled experiment. More specifically, the goal of this experiment was to assess how well a training intervention improves trust in science and scientific information and vaccination intentions. Based on the findings from Study 1, I developed an intervention focused on trust due to its role in health behavior and decisions. In a randomized controlled trial, a sample of Black participants recruited online were assessed using the trust in science scale from Study 1, a misinformation recognition questionnaire similar to the one in Study 1, and vaccination intention questions regarding current and future vaccines.

Model of Health Behavior

Study 1 demonstrated that trust in science and the ability to recognize misinformation were both positively related to the outcome measure of vaccination intentions as mediated by attitudes towards the vaccine. Of the three higher-level predictors, trust in science most strongly predicted positive attitudes towards the vaccine, which very strongly predicted increased vaccination intention. The role of attitudes in predicting behavioral intentions is well supported by theoretical models of health behavior such as the theory of planned behaviors (Carter et al., 2006).The theory identifies attitudes as one of the key factors, along with social norms and behavioral control, that shape behavioral intentions, which then predict actual behaviors. Study 1 identified what types of attitudes play a role in the specific context of COVID-19 vaccination; namely perceptions of safety, effectiveness, and community responsibility. Additionally, Study 1 provided an understanding of the most relevant factor, trust in science, that is positively associated with attitudes towards the COVID-19 vaccine. I, therefore, focused the intervention in Study 2 on training that aims to improve trust in science and scientific information.

Previous research on educational interventions targeting health knowledge with the goal of changing intentions and behavior has found little success and sometimes a backfire effect in which people who disbelieve consensus scientific knowledge express even stronger beliefs after the intervention (Trevors et al., 2016). For example, Nyhan and Reifler (2015) conducted an intervention study to increase vaccination intention for the flu vaccine. In one treatment condition, they used corrective information from the CDC website to address myths about the flu vaccine. They found that although this intervention reduced misperceptions about the flu vaccine, it also greatly reduced vaccination intention among participants with high concerns about the flu. Their results suggest that corrective knowledge may not be an effective or appropriate means of intervention especially when people have strongly held beliefs against the issue. A similar backfire effect was found with intentions to get the MMR vaccine (Nyhan et al., 2014).

The limitation of educational interventions is that they focus on correcting inaccurate knowledge and beliefs. Unfortunately, people do not like being challenged about their strongly held beliefs. Studies have provided evidence for belief bias, which is sometimes referred to as myside bias, whereby people judge arguments more harshly when they go against their beliefs (Stanovich et al., 2013). In Gugerty et al. (2021), participants made judgments about the causal strength of COVID-19 mitigation measures by presenting hypothetical scenarios showing cities with varying levels of COVID cases and mitigation measures. Regardless of political ideologies, both liberal and conservative participants who expressed prior beliefs that were supportive of mitigation measures overestimated the causal strength of COVID-19 mitigation measures while judging the scenarios, while participants whose prior beliefs opposed mitigation measures underestimated the strength of mitigation measures. In other words, prior beliefs biased interpretation of the evidence during the causal reasoning task.

Other research has attributed this resistance to corrective information in part due to motivated reasoning in which people seek out information in support of their beliefs while ignoring evidence against their belief (Kunda, 1990; Nyhan & Reifler, 2010; Trevors et al., 2016). This resistance is most common among those who are very actively engaged with the issue. Trevors et al. (2016) discuss the perceived threat of corrective information to one's self-concept which is tied to the strongly held beliefs of one's in-group identity often in context of sociopolitical issues. This research suggests that belief bias and motivated reasoning functions to protect some strongly-held beliefs from change in the face of contradictory evidence. Therefore, when it comes to interventions and public messaging strategies, it is best to avoid trying to correct people's strongly held beliefs and knowledge. In this experiment we avoid that approach because of the politicization of the COVID-19 pandemic. Instead, the focus of our training is to improve trust by demonstrating characteristics of the scientific process that highlight its credibility.

Understanding Trust

Trust is a social and interpersonal construct that is nuanced and complicated. This study focuses on one aspect of this construct—trust in science, scientists and scientific information. In this context, we care how much trust people have in scientific information such as recommendations about COVID-19 and the scientists who make these recommendations. Researchers have been studying the role of trust in how we perceive information. When considering whether to believe a factual claim about the world as true, people take into account the credibility of the information and its source. Gugerty & Link (2020) reviewed the voluminous literature on how people judge credibility of factual claims. This research suggests that a source is judged to be credible to the extent that it is perceived to be accurate in making factual claims, honest, and lacking bias. Credibility researchers have used the construct of trustworthiness to describe a source that is honest and unbiased (Hovland et al., 1953). Importantly, belief in a factual claim depends on more than obtaining credible information from a single source. A critical cue to credibility is the amount of corroborating information from independent sources, with multiple pieces of converging evidence increasing the perceived credibility of the claim (Corner & Hahn, 2009; Metzger et al., 2010).Researchers suggest that when judging credibility of information, people often lack knowledge of the topic, so they rely on external cues that signal the credibility of a source (Metzger et al., 2010). People use external cues like reputation and expertise to judge how accurate a source is in making factual claims. Expertise is indicated by cues like credentials. A source's reputation is based on what others say about it and personal experience with it. The more reliable a source is in providing accurate information through a series of interactions, the stronger the reputation (Corner & Hahn, 2009; Yaniv & Kleinberger, 2000). As Yaniv and Kleinberger (2000) discussed, negative experiences yield greater loss in trust than positive experiences yield a gain in trust. People also use beliefs about the honesty and bias of sources in judging source credibility. Wallace et al., (2020) found that perceived dishonesty was linked to lower perceived trustworthiness while perceived bias was linked to lower perceived credibility of a source.

Developing the Trust Intervention

The content of the intervention centers around four aspects of scientific methods that increase the credibility of scientific research findings: accuracy, honesty, lack of bias and corroboration of evidence. Each of these was identified as important to people trusting and believing in information in the previous review of the credibility literature. Nadelson et al. (2014) discussed key principles of trust including credibility and trustworthiness that shaped the development of their trust in science scale used in Study 1. I assessed the individual items of their trust in science scale and found themes of honesty, bias, and accuracy. For example, “We cannot trust scientists because they are biased in their perspectives” addresses bias in the work of scientists. These constructs map directly to some of the characteristics identified in the literature review of credibility cues.

The first scientific method discussed in the training is representative (or stratified) sampling. This highlights accuracy in scientific work by defining the value of having a sample that is representative of the target demographic. Findings cannot accurately describe a population unless it is adequately represented in the sample.

The second method is randomized controlled trials, which reduce bias by eliminating sampling biases such as self-selection. This method also increases accuracy by demonstrating clearer evidence for cause and effect. Having a control condition and random assignment coupled with double-blind procedures allows researchers to attribute their results more confidently to the treatment/intervention and reduces the likelihood of researchers imputing causation based on spurious correlations.

The third method, peer review, reduces researcher bias and helps ensure accuracy and honesty of work by having independent reviewers check the research. Finally, the fourth method of requiring converging evidence further increases accuracy and reduces bias by aggregating research findings from independent researchers.

The training was designed to cover each of these key methods in detail by using real world research studies as examples. It also included practice testing and self-explanation with comprehension questions throughout the training, as research has shown that these practices improve learning (Dunlosky et al., 2013). The training was pilot tested iteratively and modified until participants completed the module in less than an hour on average and scored well on the comprehension questions.

Control Conditions

In the COVID training condition, participants received training on the direct influences of vaccination intention that were described in the causal model in Study 1. This training mimicked the standard approach of educating people about the vaccine by providing accurate information regarding the safety and effectiveness of COVID-19 vaccines. It allows us to assess the effectiveness of providing factual information about the vaccine. Based on the literature reviewed above, participants may show belief bias and motivated reasoning to discount the information presented if it does not align with their prior beliefs about the vaccine. Therefore, I predict that this intervention will not be effective at changing participants' beliefs about the vaccine or their vaccination intentions.

In the empty control condition, participants received did not receive any training. Instead, they only completed the posttest scales.

Hypotheses

Based on literature reviewed above, I hypothesized that the participants who received the training intervention focused on trust would increase their trust in science more than those in either of the control conditions. In addition, I hypothesized that participants who received the training on trust in science would show a higher vaccination intention than participants in either of the control conditions on a post-intervention test. This is supported by the findings in Study 1 in which trust in science strongly predicted attitudes towards the vaccine which even more strongly predicted vaccination intention. In contrast, the literature on myside bias and motivated reasoning suggests that factual education is often ineffective at changing health beliefs and influencing health behavior.

I also hypothesized that participants who received the trust in science training would show the best posttest performance across the three groups in recognizing misinformation about scientific topics commonly seen in the news. This is because recognizing misinformation on topics where the reader lacks expertise depends on making good judgments about source credibility and the trust-in-science training highlights the methods by which scientists credibly evaluate factual claims.

Regarding participants in the COVID training condition, the literature reviewed above suggests that if participants hold strong views about COVID-19 and the vaccines, then the vaccine-education training may not be effective. They may show belief bias and motivated reasoning to discount the evidence presented in the vaccine-education training. Thus, it may not affect their vaccine intentions. However, if participants do not feel very strongly about the COVID-19 and the vaccines, their vaccine intentions could be influenced by the vaccine-education training. As Study 1 found, attitudes towards the vaccine very strongly predicted vaccination intentions. So, if enough participants in the vaccine-education condition are indifferent about the vaccines, their vaccine intentions might be swayed more positively compared to participants in the control group who do not receive any information about the vaccine at all.

Methods

Participants

I conducted a GPower analysis for an ANCOVA: Fixed effects, main effects and interactions with alpha = .05, power = .80, numerator df = 2, groups = 3, and 1 covariate. Though there are very limited studies on similar interventions, other intervention studies on related constructs like misinformation recognition have found medium effect sizes (Basol et al., 2021). Thus, a medium effect size, Cohen's $d = 0.5$, was used for the analysis. This yielded a total sample size of 158 participants, or 53 per group. In order to test the trust-in-science intervention, people who show high trust in science on a pretest were excluded from participation, as they cannot be used to test the hypothesis. Unfortunately, Study 1 showed that many participants had high trust in science with an average score of 3.6 (on a 1 low to 5 high scale) among Black participants. I planned to exclude participants with pretest trust scores above 3.5 in Study 2 to allow room for trust to improve while leaving enough participants to test the hypothesis. Only 41% of Study 1 participants scored below 3.5 on the trust in science scale. Therefore, I oversampled by 59% to meet the sample size goals for Study 2 training.

The distribution of pretest trust in science scores for all pretest participants in Study 2 showed high negative skewness and had a mean of 3.78 (see Figure F.1 in Appendix F). Based on this distribution, I adjusted the planned exclusion cutoff slightly from 3.5 to 3.54. Thus, only participants with Study 2 pretest trust scores less than 3.54 were invited to be in the posttest.

Participants were recruited in two waves of data collection through Prolific. In the first wave, among 390 Black participants who completed the pretest, 35.1% ($n = 137$) scored at or below 3.54 on the trust in science scale and were invited to complete the intervention. In the second wave, 260 completed the pretest, with 38.1% ($n = 99$) scoring at or below 3.54. In total, 650 participants completed the pretest, 236 participants were invited back for the intervention sessions, and 159 completed these sessions. Demographic information for participants is presented in the Results section.

Design

The study was distributed online as a multipart study to first capture performance on the pretest. After a two-week delay, the intervention and posttest were administered to participants who were eligible to participate. Additionally, the pretest included one filler survey that was unrelated to trust in science or COVID-19 so that participants do not figure out the purpose of the study. Study 2 has one between-subjects factor, type of training, with three groups: trust in science, vaccine education, and irrelevant training and one within-subjects factor, pretest vs. intervention.

Materials and Tasks

One of the main goals of any training is to maximize learning and retention of the material. Dunlosky et al. (2013) identified the strengths and weaknesses of various learning techniques. Among those, practice testing, elaborative interrogation, and self-explanation were some of the most useful techniques to improve learning and retention. I apply these techniques in the training by providing practice questions interspersed throughout the instructional sections. These were multiple-choice and open-ended elaborative questions that encouraged participants to generate self-explanations for their answers. The appendix contains the full training modules for each type of intervention.

Trust in Science Training. This training was developed on Microsoft PowerPoint and integrated into Qualtrics survey format. The training began with a background section that introduced the scientific process. This section discussed possible problems with conducting research (e.g., the difficulty of determining causality) and how specific scientific methods address these problems. Participants were trained on the four key scientific methods described earlier that scientists use to avoid biases and conduct accurate research: representative sampling, randomized controlled trials, peer review, and converging evidence.

The next section of the training used part task training to break down each of the four methods and explain the purpose behind them. For each of the methods, participants went through an example scenario that demonstrated the method applied in an example research study. Finally, participants completed practice questions in multiple choice and open-ended, elaborative format. Table 3.1 shows a pair of comprehension questions from the peer review section. After participants responded to these questions, they received feedback with the correct answers and explanations.

Following the part task training section, participants went through a few whole task scenarios that incorporated some or all of the four key methods. These scenarios were similar to short news stories. Participants parsed through the information to identify good scientific practices that demonstrated the key methods discussed in the training.

Table 3.1

Example Comprehension Questions from the Peer Review Section of Trust Intervention

Imagine that you read about a scientific study in your local newspaper. Which of the following news stories about the study would give you the most trust that the study was accurate and unbiased?

- The news article mentions that the study was done by scientists at a large university in your state. It also says that the study has not yet been peer-reviewed.
- The news article does not mention who did the study. It says that the study has not yet been peer-reviewed.
- The news article mentions that the study was done by scientists at a large university in your state. It also says that the study has been published in a prestigious scientific journal.

Explain why you choose that answer: ________________________(open ended)

The training concluded with a review section that includes high-level abstract concepts that participants should take away from the training. These questions targeted abstract concepts that required a generalization of the specific training they received. For example, “how do scientists reduce bias in research?” In this case, the question could be answered by explaining the value of peer reviews and converging evidence as a form of checks and balances or representative sampling and randomized control trials that provided strong evidence for cause and effect. It took approximately one hour to complete the training module.

COVID Training. The content for this training was adapted from CDC.gov to provide the most current and accurate information regarding COVID-19. The training began with an overview of the key facts about COVID-19 vaccines. Then, it provided detailed information on the following topics: how the vaccine works, the development of the vaccine, vaccine safety and effectiveness, and community immunity. Throughout the different sections, participants completed comprehension questions and received feedback along the way. Next, the training discussed common COVID-19 misconceptions. Finally, a conclusion section summarized the key takeaways from the training. It took approximately 35 minutes to complete this module.

Empty Control. Participants in this condition did not receive any training intervention. Instead, they only completed the posttest survey items.

Measures. Participants completed a pretest which included the trust in science scale used in Study 1 and an additional filler survey on interest in art and literature. In the posttest, participants completed the same trust in science scale, a scientific reasoning scale, a measure of misinformation recognition similar to Study 1, and vaccination intention questions for current and future vaccines.

Trust in Science Scale. (Continuous, 1 to 5) This is the same scale that was used in Study 1 ($\alpha = .90$).

Misinformation Recognition Survey. (Continuous, 1 to 4) This scale measures accuracy in identification of true and false statements made on social media regarding various health information (statins, cancer, and HPV). It was adapted from Scherer et al. (2021). The scale consists of 7 false items and 5 true items and has good reliability, Cronbach's alpha of $\alpha = .83$. For each statement, participants respond on a 4-point scale consisting of definitely true, probably true, probably false, and definitely false.

The scale items were similar to Study 1, except source information was included for each statement. The items in Study 1 did not include any information about the source of the true and false statements. Source information provides critical cues that can be used to determine the credibility of the source and therefore of the message itself. For Study 1, I wanted the misinformation recognition measure to assess how well people had applied credibility assessment skills to evaluate COVID-related information prior to participating in the study. Source credibility cues are an integral part of the methods being taught in the trust training. However, learning about the methods by which scientists reach credible conclusions in Study 2 would not help participants re-assess the validity of their prior knowledge about COVID-19. My hypothesis that trust-in-science training improves misinformation recognition only makes sense if source credibility cues are included for true and false statements. Other researchers have included source cues when measuring misinformation recognition (Pennycook et al., 2020; Pennycook & Rand, 2019).

Scientific Reasoning Scale. (True or False) This scale measures scientific knowledge/reasoning on various concepts related to scientific research (such as peer review, random assignment, etc). This scale was adapted and from the Scientific Reasoning Scale (Drummond & Fischhoff, 2017) and modified for this study. In the modified version, there were nine items presented to participants and only six items were scored for scientific reasoning because they were directly relevant to the topics covered in the trust training intervention. An example item is "A team of researchers wants to test an anti-acne cream on teenagers with acne to see if it works. True or False? To see if the cream works, the researchers should give it to all the teenagers in the study." The three filler items were included to disguise the intent of the measure.

Vaccination Intention. This scale is a modified version of the scale used in Study 1. Three items were used to measure vaccination intention in Study 2 ($\alpha = .86$).

1. Willingness to vaccinate (continuous, 1 – 7) was assessed by the question "When you decided to get the COVID-19 vaccination, how willing were you to receive the vaccine?" if participants have already received one or two doses of the vaccine and by the question "If one of the COVID-19 vaccines were available for you to take today, how willing would you be to take it?" if participants had not received any doses. Both questions use the same seven-point response scale ranging from extremely unwilling to extremely willing. A score 7 reflects the most willingness to get the vaccine.
2. Likelihood of recommending vaccination (continuous, 1-7) measured likelihood to recommend the COVID vaccine to friends and family using a 7-point scale ranging from extremely unlikely to extremely likely. A score of 7 reflects the most likelihood to recommend the vaccine.
3. Future vaccination intention (continuous, 1-7) measured willingness to vaccinate in a similar, but hypothetical future scenario in which a vaccine could be needed to

mitigate a pandemic. This was assessed by the question "Imagine in 5 years, the United States experiences another dangerous pandemic with a new virus (NOT the Coronavirus). If scientists developed a new vaccine that is safe and effective to protect against the new virus, how willing would you be to take the new vaccine?" A score of 7 reflects the most willingness to get the vaccine.

Procedure

Participants first completed a pretest survey which includes demographic questions, trust in science scale and one additional filler survey. After a two-week delay period, eligible participants were randomly assigned to one of the three training conditions and completed the training module. The duration for each training condition ranged from 20 minutes to 80 minutes. Immediately after their assigned training condition, participants completed a posttest survey which included trust in science scale, misinformation recognition questions, scientific reasoning scale, and vaccination intention questions. Note, the empty control group did not have a training intervention, so they only completed the posttest surveys during their session.

Results

Data collection for Study 2 began on February 6, 2023, and ended on March 9, 2023. A total of 650 Black participants completed the pretest, and after the trust-in-science screening process, 159 total participants completed the intervention session with 53 participants assigned to each condition.

Table 3.2 shows the data for the demographic variables. Table 3.3 shows the means for the demographic variables and pretest trust in science score across the three training conditions. There were no significant differences between the conditions on any of these variables. The three conditions were balanced across all demographic factors. Since the trust in science variable had high negative skew, an inverse transformation was used to achieve normality. The significance test was done on the transformed variable, but Table 3.3 shows the median of the untransformed variable for clarity.

Table 3.2
Descriptive Statistics for Study 2 Demographic Variables

Variables	Mean or N	SD
Gender, N		
Female	83	
Male	74	
Other	2	
Highest education attained, N		
Some high school or less	0	
High school degree	56	
Degree from 2-year college	22	
Degree from 4-year college	56	
Master's degree (2 years)	23	
PhD, law, or medical degree	2	
Age, mean	38.44	12.99
Ideology (1 liberal, 7 conservative)	3.34	1.28

Table 3.3
Demographic Variables and Covariate Compared Across Conditions

	EMPTY		COVID		TRUST			
Variables	Mean/N	SD	Mean/N	SD	Mean/N	SD	*F* or χ^2	*p*
Gender, N							2.22	.70
Female	25		28		30			
Male	28		24		22			
Other	0		1		1			
Age mean	40.87	13.44	36.74	11.70	37.72	13.62	1.47	.23
Education mean (1-6)	3.45	0.97	3.43	1.19	3.09	1.23	1.68	.19
Ideology mean (1-7)	3.35	1.26	3.29	1.19	3.53	1.40	0.49	.62
Trust in Science median 1-5	3.00	0.49	3.15	0.40	3.00	0.58	1.45	.24

Performance During Trust Training

During the trust training, participants completed ten review questions distributed across the different topics covered in the module. Participants' scores ranged from 72% to 98%. After each question, participants received feedback with the correct answer and if they chose the wrong answer, the feedback included an explanation for why that choice was incorrect. These scores reflect a higher than chance performance and suggest that participants were paying attention and learning the material.

Performance During COVID Training

During the COVID training, participants completed four review questions distributed across the module. Participants' scores ranged from 68% to 92%. Similar to the trust training, participants received feedback after each question with the correct answer and an explanation if they chose the wrong answer. Similarly, these scores reflect higher than chance performance and suggest good engagement with the training material.

Scientific Knowledge and Reasoning

The posttest included a scientific knowledge and reasoning scale as a manipulation check to see how well participants learned from the training. Six items on this nine-item scale directly measured knowledge of concepts taught in the trust training. Performance on these six items was used to measure scientific knowledge and reasoning. I predicted that participants in the trust training group would perform better than the COVID training and empty control group on this scale and that the COVID training and empty control group would perform similarly. Results from a one-way ANOVA supported this hypothesis, $F(2, 156) = 7.79$, $p < .001$. Participants in the trust training group had the highest mean ($M = 0.67$) and performed significantly better than the empty control group ($M = 0.51$), $p < .001$, Cohen's $d = 0.68$, and the COVID training group

(M = 0.56), p = .02, Cohen's d = 0.47. The COVID training and empty control group performed similarly and had no significant difference, p = .49, Cohen's d = 0.24. This suggests that the trust training was successful in conveying the key concepts it was designed to teach.

Trust in Science

The first hypothesis predicted that participants who receive the trust training would show greater improvement in their trust in science posttest score than participants in the COVID training and empty control groups. One possible approach to test this hypothesis is a mixed model analysis with trust in science pretest and posttest scores as repeated measures and training condition as a between-subjects factor. However, when comparing gains in performance due to intervention, the literature suggests a better approach would be using analysis of covariance for more power (Cronbach & Furby, 1970). Since participants were stratified and randomly assigned into the training conditions, an analysis of covariance is a suitable approach. An ANCOVA was used to test these group differences, with trust in science pretest scores as the covariate. The pretest score was transformed using the inverse transform to normalize the data. The transformed score had a significant positive correlation with posttest trust in science score, $r = .50$, $p < .001$. This correlation represents a large effects size (Cohen, 1992).

Results from the ANCOVA showed a significant main effect of the training condition with a moderate effect size, $F(2, 155) = 4.80$, $p = .01$, $\eta^{2 =}$ .06. There was no interaction between training condition and the covariate, $F(2, 153) = 1.07$, $p = .34$, $\eta^{2 =}$ .01. The estimated marginal means represent the adjusted means on a 5-point scale with 5 representing the highest trust. The hypothesis was partially supported. When controlling for the covariate, posttest trust in science was greater in the trust training group (M = 3.63) than the empty control group (M = 3.32), p = .01, but not significantly different from the COVID training group (M = 3.37), p = .052. The difference between the COVID training group and the empty control was not significant, $p = .95$. Thus, participants posttest trust in science was influenced strongly by individual differences in their pre-existing trust in science and more moderately by the trust training, at least when comparing the trust training and control groups.

Misinformation Recognition

I assessed misinformation recognition between true and false items, using the items where participants rated the likelihood of a statement being true for true and false items, with 1 = definitely true and 4 = definitely false. Misinformation discriminability was represented by d-prime, i.e., subtracting the average standardized scores on the false items minus the average standardized scores on the true items. The hypothesis was that participants in the trust training group would show the best misinformation recognition compared to the COVID training and empty control group.

Given the expected positive correlation between the pretest trust in science score and misinformation recognition, an ANCOVA was used with the pretest score as a covariate. Results from the ANCOVA showed significant differences across the three groups, $F(2, 155) = 3.42$, $p = .04$, $\eta^{2} = .04$. Pretest trust in science was correlated with misinformation recognition, $r = .21$, $p = .007$. There was no interaction between training condition and the covariate, $F(2, 153) = 0.18$, $p = .84$, $\eta^{2} = .002$. The hypothesis was partially supported with the trust group ($M = 0.42$) performing significantly better than the empty control ($M = -0.40$), $p = .03$. However, the trust group was not significantly better than the COVID training group ($M = -0.04$), $p = .37$. Comparing COVID training and the empty control group showed no significant difference, $p = .60$. As with trust in science, posttest misinformation recognition was influenced by both trust in science training and pre-existing differences in trust in science. The latter effect is consistent with Study 1.

Vaccination Intention

Vaccination intention was measured using three items that asked participants' willingness to receive the vaccine (past or present), recommend the vaccine, and take a hypothetical future vaccine. All three items were strongly positively correlated with each other, *r's* from .65 to .80. Thus, they were combined to measure vaccination intention. Appendix F shows additional analyses conducted for individual question items.

Vaccination intention was predicted to be highest for participants in the trust training group compared to the COVID training and empty control group. Pretest trust in science score was positively correlated with vaccination intention, $r = .40$, $p < .001$. There was no interaction between training condition and the covariate, $F(2, 153) = 0.88$, $p = .42$, $\eta^{2 =}$ .01. An ANCOVA with the pretest as a covariate showed no significant differences between the groups, $F(2, 155) = 0.57$, $p = .57$, $\eta^{2 =}$ .01. Thus, the hypothesis was not supported. On a 7-point scale, with 7 representing the highest vaccination intention, the three groups showed similar estimated marginal means. Vaccination intention for the trust training group ($M = 4.02$) was not significantly different from the empty control ($M = 4.13$), $p = .99$, or from the COVID training group ($M = 4.41$), $p = .66$. The COVID training group was not significantly different from the empty control, $p = .83$. Although neither the trust nor the COVID-19 training influenced vaccination intention, individual differences in pre-existing trust in science was associated with vaccination intention, with a medium to large effect size. The latter effect is consistent with the findings of Study 1.

CHAPTER FOUR

GENERAL DISCUSSION

The motivation behind this research was the health disparities evidenced early in the pandemic by lagging vaccination rates and disproportionate impacts of the virus particularly among Black people in the United States (CDC, 2020). Study 1 helped identify the factors associated with vaccine hesitancy and compared these differences between Black and White participants. These results shaped the intervention that was developed and tested in Study 2.

Findings from Study 1

Study 1 contributes to the literature by testing a hierarchical model that captured the relationship between various predictors of vaccine hesitancy. One of the key findings from this model was that for all the participants combined, higher-level factors of trust in science, misinformation recognition, and conservatism indirectly predicted vaccine hesitancy through the mediating effects of attitudes towards the vaccine. Many prior studies of predictors of vaccine hesitancy use regression to test non-hierarchical models of how a set of predictors is related to vaccine hesitancy.

Study 1 also identified differences in the model based on racial demographics. Among White participants, conservatism, misinformation recognition, trust in science, and medical mistrust were all significant higher-level predictors. But for Black participants, only trust in science and misinformation recognition were significant higher-level predictors. Furthermore, Black participants showed lower trust in science and misinformation recognition compared to White participants. This finding shaped the intervention by identifying the two factors that would be most relevant to focus on to benefit Black participants.

Despite the differences in the higher-level, trust measures, Black and White participants showed similar attitudes toward the vaccine and vaccination intention. Throughout the progression of the pandemic, there may have been several other factors involved in shaping people's beliefs towards the vaccine. These factors could include personal experience and social norms that were contextual and changing rapidly. However, these are difficult to control and modify. In this research, I identified relevant factors that are more persistent. A focus on improving trust in science and misinformation recognition has the potential for longer-lasting impacts and applications in various health-related contexts.

Findings from Study 2

Findings from Study 2 are promising and hopeful for future research. As a reminder, these findings are specific to Black participants and may not generalize across demographics. The trust training intervention was successful in significantly increasing trust in science when compared to the empty control group. To my knowledge, there has only been one experimental study that developed and tested a trust in science intervention. Agley et al. (2021) showed some evidence for a successful trust intervention by using infographics about the scientific process that slightly increased trust in science and reduced belief in COVID-19 misinformation. The current study contributes to the literature by providing a different type of intervention that has shown success in improving trust in science. The intervention itself is an online training module making it very easy to access and administer.

However, the trust training intervention was not significantly better at improving trust in science when compared to the COVID training group, although this difference approached significance ($p = .052$). A possible explanation for this finding could be the content and structure of the two training modules. The trust training was designed to teach participants about specific methods in scientific research that convey how scientists conduct accurate and honest work. This was done through direct explanations of the scientific methods and examples of scientific research that demonstrated these concepts. In the COVID training, the content was structured specifically around how the vaccine was developed and ways scientists ensured safety and effectiveness. In comparing these training descriptions, the parallels are evident in that the COVID training could serve as a specific example of real-world research that exemplifies the scientific methods discussed in the trust training intervention. It is feasible that participants who received the COVID training could have extrapolated concepts of honesty and accuracy that are demonstrated in the details of the vaccine research. This may have contributed to participants' trust in science scores for the COVID training group.

That same pattern was evident for misinformation recognition as trust training improved recognition relative to the empty control group, but not when compared to the COVID training group. This is consistent with the findings from Agley et al.'s intervention study (2021). I expected misinformation recognition to improve with increased trust because increased understanding of the scientific process provides insight about the characteristics of scientific research that make it accurate and credible. Given that the items used for the misinformation recognition scale were social media posts with brief captions, participants could not see any information about the details of the research that led to the claims made in the posts. Instead, they had to rely on cues like information sources and short captions associated with the posts to make judgments about the credibility of the information. Increasing trust in science may have led to a more positive bias toward posts that appear to come from scientific sources and captions that conveyed aspects of scientific methods.

One possible explanation for why the trust training group did not improve significantly more than the COVID training group is that the COVID group could have been induced to think carefully about COVID-related misinformation. The COVID training included a section for common concerns and myths that could have served as a cue to think about the credibility of information. Pennycook et al. (2020) showed that a simple nudge to think about the accuracy of a post could help increase misinformation recognition.

In addition to Pennycook et al.'s nudge intervention study, previous intervention research has shown success by targeting misinformation posts directly, and in one example, teaching people how to identify typical cues for spotting misinformation, like fear mongering and using fake experts (Roozenbeek et al., 2020). The current study contributes to the literature by providing a different approach that indirectly improves misinformation recognition. By learning about the scientific methods, people can understand why sources from reputable scientific organizations should be trusted.

Finally, none of the training conditions affected vaccination intention. Agley et al. also found no evidence for the effects of their trust intervention on vaccination behavioral measures (2021). Placing this finding within the context of the pandemic may explain the results. Vaccination intention was centered around the COVID-19 vaccine both retrospectively and prospectively. However, with increasing vaccination rates and reduced COVID-19 risk over the course of this research, this scale may not accurately reflect vaccine hesitancy in 2023. Thus, although vaccination intention was not impacted by the intervention in Study 2, further research is necessary to better assess the impacts of increasing trust in science on various health intentions and behaviors.

Implications and Future Direction

Study 1 provides a hierarchical model of the indirect and direct predictors associated with COVID vaccine hesitancy. This model could help paint a more cohesive picture of the complex relationships between variables that play a role in vaccination decisions. Additionally, the finding is valuable because it highlights how the factors involved in this decision-making process could have varying influence across demographics. This has implications for future research or public health messaging to focus on factors most relevant to a target audience. One of the limitations in Study 1 was that I could not include all the factors associated with vaccine hesitancy as it would greatly increase the complexity of the model. Future research can expand on our understanding by incorporating other relevant factors.

Study 2 has leveraged previous research to develop a successful intervention to improve trust in science, which is an important construct that plays a role in predicting health behavior. Findings from this study invite opportunities to utilize a scalable training intervention to assess its impacts in various contexts. One of the limitations of developing this training was the duration of the intervention. When considering the impacts on the budget, participant satisfaction, and comfort, I had to limit the duration to about one hour. In addition to budget restrictions limiting the number of measures that could be included in the pretest, vaccination intention was omitted from the pretest in order to reduce demand characteristics. This could be improved in future studies to increase power by having a within subjects pre and post assessment for vaccination intention and other variables like misinformation recognition and science reasoning.

Modifications to the training could break it up into multiple training sessions to allow for distributed practice and to include additional relevant content. Another direction for future research could assess the effectiveness among a younger population, such as high school students. High school students may not have a deep understanding of the scientific methods compared to college students and thus could gain a lot of knowledge from the training. Additionally, in this digital age, a lot of youth consume news and other information through social media. This type of intervention could help them understand how to identify trustworthy scientific information online. Overall, further assessments of the training's effectiveness are warranted. It would also be valuable to assess the duration of the training effects.

Another factor to consider is how well the sample population in this study reflects the trends in national data. Data from the CDC and Kaiser Family Foundation found that older adults had higher vaccination intention and vaccination rates in late 2021, around the time data for Study 1 was collected. Participants in Study 1 did not show this age difference in vaccination intention or vaccination rates. However, participants did have higher education levels than the national average. According to 2021 Census data, about 35% of U.S. adults had attained a bachelor's or higher education degree. Meanwhile, about 55% of the participants in Study 1 had attained a bachelor's or higher education degree. The trend was also evident in the Study 2 sample with 50% of Black participants reporting bachelor's or higher education degree compared to 24% of the Black population from the 2022 Census data. These findings suggest that participants in these studies recruited online tend to have higher education levels than the general population.

The pandemic has shone a light on several issues including the ongoing health disparities, the impacts of misinformation in a digital age, and reduced trust. This study was conducted to understand some of the factors that were specific to Black people's experience in the United States during this pandemic. By identifying the factors that are relevant in the decision-making process for Black people, we can provide an intervention that could address vaccine hesitancy that is pertinent to the Black community. This is a small step in the right direction to help bridge the gap between the scientific research community and the general public in hopes of improving public health through fostering trust. With further research on the impacts of improved trust in science, this intervention has the potential to be implemented in various settings as an educational tool.

APPENDICES

APPENDIX A – Measures for Study 1

Trust in Science Information

Scale developed by Nadelson et al., 2014. Nadelson, L., Jorcyk, C., Yang, D., Smith, M. J., Matson, S., Cornell, K., & Husting, V. (2014). I Just Don't Trust Them: The Development and Validation of an Assessment Instrument to Measure Trust in Science and Scientists. *School Science and Mathematics*, *114*(2), 76–86. https://doi.org/10.1111/ssm.12051

Directions: Rank your level of agreement to each of these statements on the scale provided.
Strongly Disagree/ Disagree/ Neutral/ Agree / Strongly Agree

1. Scientists ignore evidence that contradicts their work.*
2. Scientific theories are weak explanations.*
3. Scientists intentionally keep their work secret.*
4. Scientists don't value the ideas of others.*
5. We should trust the work of scientists.
6. We should trust that scientists are being honest in their work.
7. We should trust that scientists are being ethical in their work.
8. Scientific theories are trustworthy.
9. We can trust science to find the answers that explain the natural world.
10. We cannot trust scientists because they are biased in their perspectives.*
11. Scientists will protect each other even when they are wrong.*
12. We cannot trust scientists to consider ideas that contradict their own.*
13. We cannot trust science because it moves too slow.*

*items reverse scored.

Susceptibility and Exposure to Misinformation

Susceptibility to Misinformation - Scale developed by the researchers of this study.
Directions: Please answer the questions below based on your own knowledge. Please do NOT talk to anyone or look for info on the internet when answering. In this survey, you will see statements about COVID-19 that appeared on traditional media (newspapers, TV, radio) or on social media at various times during the pandemic. Each statement will have the date when the story appeared. For each statement, you will answer two questions:

1. decide whether the ideas in the statement are:
   Completely false, Mostly false, Mostly true, or Completely true
2. Would the ideas in this statement influence your decision to take the vaccine?
   Definitely not, Probably not, Probably yes, Definitely yes

Statements - participants will only see about 12-16 of these statements; True statements are bolded here (but not for participants)

- False 3: April 29, 2021. COVID-19 vaccines have been shown to cause infertility and miscarriages in women.
- False 5: March 10, 2021. More people will die from side effects of the COVID-19 vaccine than would actually die from the virus.
- False 6: November 15, 2020. COVID vaccines deliver a microchip into your body that can track your movements.

- False 7: June 8, 2021. Receiving COVID vaccines causes your body to become magnetized.
- False 9: November 25, 2020.   COVID-19 is not a very dangerous disease. The annual death rate in the US for 2020 did not exceed the average death rate of previous years.
- False 11: April, 12, 2021.   Breakthrough cases, where individuals who are fully vaccinated against COVID-19 still get the disease, show that COVID-19 vaccines are not effective.
- False 12: July 2, 2020. Exposing yourself to the sun or temperatures higher than 77°F protects you from COVID-19.
- False 14: February 3, 2021. Cheap home remedies using spices in your pantry can effectively treat COVID.
- True 4: June 25, 2021. Since January 2021, hospitalization rates in adults ages 85 years or older have fallen dramatically and have reached the lowest rates since the pandemic began in early 2020.
- True 5: June 23, 2021. In the US, 1 to 3% of people who got COVID-19 have died from the disease.
- True 6: February 9, 2021. The US Food and Drug Administration (FDA) has authorized the use of monoclonal antibodies for treating COVID-19 in high-risk patients.
- True 7: April 21, 2021. A small percentage of people fully vaccinated against COVID-19 will still develop COVID-19 illness.

Trust in Medical System

Williamson and Bigman, 2018 in a review study noted that the Group-Based Medical Mistrust Scale (GBMMS) and the Health Care System Distrust Scale are 2 of the more frequently used scales to measure trust in the medical system. (Williamson, L. D., & Bigman, C. A. (2018). A systematic review of medical mistrust measures. *Patient Education and Counseling*, *101*(10), 1786–1794.)

Health Care System Distrust Scale + **Group-Based Medical Mistrust Scale**

Developed by Shea, J. A., Micco, E., Dean, L. T., McMurphy, S., Schwartz, J. S., & Armstrong, K. (2008). Development of a Revised Health Care System Distrust Scale. *Journal of General Internal Medicine*, *23*(6), 727–732.

Developed by Thompson, H. S., Valdimarsdottir, H. B., Winkel, G., Jandorf, L., & Redd, W. (2004). The Group-Based Medical Mistrust Scale: Psychometric properties and association with breast cancer screening. *Preventive Medicine*, *38*(2), 209–218.

Directions: Rank your level of agreement to each of these statements on the scale provided.
Strongly disagree, disagree, neither agree nor disagree, agree, or strongly agree

1. The Health Care System covers up its mistakes.
2. The Health Care System puts making money above patients' needs.
3. Patients get the same medical treatment from the Health Care System, no matter what the patient's race or ethnicity.*
4. The Health Care System lies to make money.
5. People of my ethnic group cannot trust doctors and health care workers.

6. People of my ethnic group should be suspicious of information from doctors and health care workers.
7. People of my ethnic group should not confide in doctors and health care workers because it will be used against them.
8. People of my ethnic group should be suspicious of modern medicine.
9. Doctors and health care workers treat people of my ethnic group like ‘‘guinea pigs.’’
10. Doctors and health care workers do not take the medical complaints of people of my ethnic group seriously.

Subscale: Lack of support from healthcare providers

1. Doctors have the best interests of people of my ethnic group in mind.*
2. Doctors and health care workers sometimes hide information from patients who belong to my ethnic group.
3. I have personally been treated poorly or unfairly by doctors or health care workers because of my ethnicity.

*items reverse scored.

Benefits1 - Perceived Risk (seriousness) of COVID-19

Benefits scales below partly based on:

Bostrom, A., Böhm, G., O’Connor, R. E., Hanss, D., Bodi-Fernandez, O., & Halder, P. (2020). Comparative risk science for the coronavirus pandemic. *Journal of Risk Research*, *23*(7–8), 902–911.

Freeman, D., Loe, B. S., Chadwick, A., Vaccari, C., Waite, F., Rosebrock, L., Jenner, L., Petit, A., Lewandowsky, S., Vanderslott, S., Innocenti, S., Larkin, M., Giubilini, A., Yu, L.-M., McShane, H., Pollard, A. J., & Lambe, S. (2020). COVID-19 vaccine hesitancy in the UK: The Oxford coronavirus explanations, attitudes, and narratives survey (Oceans) II. *Psychological Medicine*, 1–15. https://doi.org/10.1017/S0033291720005188

1. How **concerned** are you about the COVID-19 outbreak in the United States?

not concerned at all, a little concerned, moderately concerned, very concerned, extremely concerned

2. How much does the thought of getting COVID-19 fill you with **dread**? Getting COVID is …

not dreadful at all, a little dreadful, moderately dreadful, very dreadful, extremely dreadful

3. How serious a **threat** is COVID-19 to peoples’ health?

no threat at all, a little serious, moderately serious, very serious, extremely serious

Benefits2 – effectiveness of COVID-19 vacc

1. The COVID-19 vaccines:

Work for almost everyone, Work for most people, I am unsure how many people they work for, Do **not** work for most people, Do **not** work for anyone

2. COVID-19 vaccines reduce the spread of the COVID-19 virus:
Not at all, a little bit, a moderate amount, a large amount, almost completely

Benefits3 - Moral responsibility

1. How much responsibility do you feel to help reduce the effects of COVID-19 on others by your actions?

no responsibility, a little bit of responsibility, a moderate amount of responsibility, a lot of responsibility, a great deal of responsibility

2. Getting the COVID-19 vaccine will be:

Really helpful for the community around me, Helpful for the community around me, Neither helpful nor unhelpful for the community around me, Unhelpful for the community around me, Really unhelpful for the community around me

3. If individuals like me get the COVID-19 vaccine it will:

Lead to a large number of deaths, Lead to some deaths, Have no impact, Save some lives, Save a large number of lives

4. If many people do **not** get the COVID-19 vaccine this:

Will be dangerous, May be dangerous, Will have no consequences at all, May be good, Will be good

COSTS 1 - Perceived Risk of COVID-19 Vaccine

Directions: Rank your level of agreement for each of the statements below on the scale provided. Strongly disagree, disagree, neither agree nor disagree, agree, or strongly agree

Seriousness of side eff

1. The COVID-19 vaccines can cause dangerous side effects.
2. The COVID-19 vaccines are safe.

Uncertainty re side effects

3. Due to the **rapid development** of the vaccines, I am **unsure about their safety**.
4. I am worried there may be **side effects** of the vaccine that we **do not know about**.

COSTS 2 - Reactance

Scale adapted from Conway, L. G., Woodard, S. R., & Zubrod, A. (2020). *Social Psychological Measurements of COVID-19: Coronavirus Perceived Threat, Government Response, Impacts, and Experiences Questionnaires* [Preprint]. PsyArXiv. https://doi.org/10.31234/osf.io/z2x9a

Directions: Rank your level of agreement for each of the statements below on the scale provided. Strongly disagree, disagree, neither agree nor disagree, agree, or strongly agree

1. I am upset at the thought that the government or businesses would force people to wear masks against their will.
2. It makes me angry that the government or businesses would tell me where I can go and what I can do, even when there is a crisis such as COVID-19.

3. I am upset at the thought that the government or businesses would require people to take a COVID-19 vaccine against their will.
4. I think people should be able to make a free choice about whether to take a COVID-19 vaccine.

COSTS 3 - Barriers to Accessing Vaccine

Survey taken from: Baack, B. N., Abad, N., Yankey, D., Kahn, K. E., Razzaghi, H., Brookmeyer, K., Kolis, J., Wilhelm, E., Nguyen, K. H., & Singleton, J. A. (2021). COVID-19 Vaccination Coverage and Intent Among Adults Aged 18–39 Years—United States, March–May 2021. *MMWR. Morbidity and Mortality Weekly Report*, *70*(25), 928–933. https://doi.org/10.15585/mmwr.mm7025e2

Directions: Rank your level of agreement for each of the statements below on the scale provided.
Strongly disagree, disagree, neither agree nor disagree, agree, or strongly agree

1. I do not know where to go to get vaccinated.
2. It is difficult to find or make an appointment for the COVID-19 vaccine.
3. I do not have time off work to get vaccinated or recover from potential short-term side effects.
4. Vaccination sites are too far away.
5. I do not have transportation to get to vaccination sites.

Demographics

Race/ethnicity: Which of these options is closest to describing your race or ethnicity?

a. White
b. Hispanic, Latino/Latina or Spanish
c. Black or African American
d. Asian
e. American Indian or Alaska native
f. Native Hawaiian or other Pacific Islander
g. Some other race or ethnicity

Ideology: Which of these options is closest to the political party you identify with?

a. strong democrat
b. democrat
c. independent lean democrat
d. independent
e. independent lean republican
f. republican
g. strong rep

Ideology: Which of these options comes closest to your political views?

a. very liberal
b. liberal
c. moderate

d. conservative
e. very conservative

Education: Select the highest education level you have reached.

a. Some high school or less
b. High school
c. Degree from 2 year college
d. Degree from 4 year college
e. Master's degree (2 year)
f. Ph.D., law or medical school degree

Vaccine acceptance vs. resistance (Outcome Variable)

1. Have you received a COVID-19 vaccine? (If you have only received one shot of a two-shot vaccine, answer Yes)
   Yes, No

2a. If answer to #1 is Yes: When you decided to get your COVID-19 vaccination, how willing were you to get the vaccine?
   Extremely unwilling, moderately unwilling, slightly unwilling, neither willing nor unwilling, slightly willing, moderately willing, extremely willing

2b. If answer to #1 is No: If one of the COVID-19 vaccines were available for you to take today, how willing would you be to take it?
   Extremely unwilling, moderately unwilling, slightly unwilling, neither willing nor unwilling, slightly willing, moderately willing, extremely willing

3. How likely would you be to recommend the COVID-19 vaccine to family or friends who have NOT taken it?

Extremely unlikely, unlikely, somewhat unlikely, neither unlikely or likely, somewhat likely, likely, extremely likely

APPENDIX B – Measures for Study 2

Scientific Reasoning Scale for Posttest of Science Knowledge

1. *Confounding variables*
   A scientist has participants in a study put together a jigsaw puzzle either in a cold room with a loud radio or in a warm room with no radio. Study participants solve the puzzle more quickly in the warm room with no radio.

   True or False? The scientist cannot tell if the radio caused study participants to solve the puzzle more slowly.
   True

2. *Control group*
   A team of researchers wants to test an anti-acne cream on teenagers with acne to see if it works.

   True or False? To see if the cream works, the researchers should give it to all the teenagers in the study.
   False

3. *Random assignment to condition*
   Researchers want to test if an online tutoring program helps children get better grades in school. School children are sorted into either a group that gets online tutoring or a group that gets no tutoring.

   True or False? To test if the tutoring program works, the researchers should assign the children with the lowest grades in school to the group that gets online tutoring.
   False

4. *Representative sampling*
   A team of education researchers wants to understand how to improve the quality of a local high school in the city. They are determined to understand the needs of the school so they can best serve all the students and teachers. So, they decide to ask a sample of the senior students, since they have been there the longest, for their opinions and ideas on ways to improve the school.

   True or False? The researchers will be able to understand the needs of the school by asking the senior students.
   False

5. *Peer Review*
   A team of scientists develops a new drug to treat many types of cancer. They test it in a large study with tens of thousands of people and it is safe and effective for these people. Then they write an article describing what they found. The scientists are excited because the new drug could save many lives.

They decide NOT to publish the article in a scientific journal, because this is very difficult and takes a long time. Instead, they plan to contact journalists to announce the results of the study in the media (online, on TV, and in newspapers). This is easier to do and quicker.

True or False? The scientists should share their research with the media and skip publishing the article in a scientific journal.
False

6. *Converging evidence*
   A team of researchers (Team A) is trying to understand whether using social media is related to depression among teenagers. Let's assume that there are only two scientific studies that have been done so far on this question. One study showed that teenagers who used social media more often were much more likely to have depression than teenagers who used social media less often. The other study showed that teenagers who used social media more were no more likely to have depression than teenagers who used it less.

   Team A did one of these studies. Team A is highly motivated to use scientific studies to get a clear and accurate answer to this important question. What should Team A do now? True or False? They should conclude that because the two studies don't agree with each other, this question is too complex, and scientists just can't figure out an answer to it.
   False
7. *Blind/double blind*
   In a taste test, a researcher puts Brand A coffee in a cup with white tape on it and Brand B coffee in an identical cup with black tape on it. A lab assistant gives tasters one of the cups, while the researcher watches their facial expressions.

   True or False? The lab assistant should not watch the cups being filled.
   True

8. *Maturation*
   Participants in an experiment must press a button whenever a blue dot flashes on their computer screen. At first, the task is easy for the participants. But as they continue to perform the task, they make more and more errors.

   True or False? The participants may be making errors because they are getting more tired as they continue to perform the task.
   True

9. *Reliability*
   A researcher develops a new method for measuring the surface tension of liquids. This method is more consistent than the old method.
   True or False? The new method shows more reliability than the old method.
   True

Interest in Art and Literature

Aesthetic Appreciation (O:AesA) [Alpha = .83]
Directions: Rank your level of agreement to each of these statements on the scale provided.
Strongly Disagree/ Disagree/ Neutral/ Agree / Strongly Agree

+ keyed
  Believe in the importance of art.
  Get deeply immersed in music.
  See beauty in things that others might not notice.
  Enjoy feeling "close to the earth."
  Have read the great literary classics.

- keyed
  Do not like art.
  Seldom notice the emotional aspects of paintings and pictures.
  Do not like poetry.
  Do not like concerts.
  Do not enjoy watching dance performances.

Trust in Science Information

Scale developed by Nadelson et al., 2014. Nadelson, L., Jorcyk, C., Yang, D., Smith, M. J., Matson, S., Cornell, K., & Husting, V. (2014). I Just Don't Trust Them: The Development and Validation of an Assessment Instrument to Measure Trust in Science and Scientists. *School Science and Mathematics*, *114*(2), 76–86. https://doi.org/10.1111/ssm.12051

Directions: Rank your level of agreement to each of these statements on the scale provided.
Strongly Disagree/ Disagree/ Neutral/ Agree / Strongly Agree

1. Scientists ignore evidence that contradicts their work.*
2. Scientific theories are weak explanations.*
3. Scientists intentionally keep their work secret.*
4. Scientists don't value the ideas of others.*
5. We should trust the work of scientists.
6. We should trust that scientists are being honest in their work.
7. We should trust that scientists are being ethical in their work.
8. Scientific theories are trustworthy.
9. We can trust science to find the answers that explain the natural world.
10. We cannot trust scientists because they are biased in their perspectives.*
11. Scientist will protect each other even when they are wrong.*
12. We cannot trust scientists to consider ideas that contradict their own.*
13. We cannot trust science because it moves too slow.*

*items reverse scored.

Vaccination Intention

1. Have you received a COVID-19 vaccine? (If you have only received one shot of a two-shot vaccine, answer Yes)
   Yes, No

Directions: Rank your response to each of these statements on the scale provided.
Extremely unwilling, moderately unwilling, slightly unwilling, neither willing nor unwilling, slightly willing, moderately willing, extremely willing

2a. If answer to #1 is Yes: When you decided to get your COVID-19 vaccination, how willing were you to get the vaccine?

2b. If answer to #1 is No: If one of the COVID-19 vaccines were available for you to take today, how willing would you be to take it?

3. How likely would you be to recommend the COVID-19 vaccine to family or friends who have NOT taken it?

4. In 5 years, if the United States experienced another pandemic with a new virus and scientists develop a new vaccine to protect against the virus, how willing would you be to take the new vaccine?

Demographics

Race/ethnicity: Which of these options is closest to describing your race or ethnicity?

h. White
i. Hispanic, latino/latina or Spanish
j. Black or african am
k. Asian
l. Amer Indian or Alaska native
m. Native Hawaiian or other Pacific Islander
n. Some other race or ethnicity

Ideology: Which of these options is closest to the political party you identify with?

h. strong democrat
i. democrat
j. independent lean democrat
k. independent
l. independent lean republican
m. republican
n. strong rep

Ideology: Which of these options comes closest to your political views?

a. very liberal
b. liberal
c. moderate
d. conservative

e. very conservative

Education: Select the highest education level you have reached.

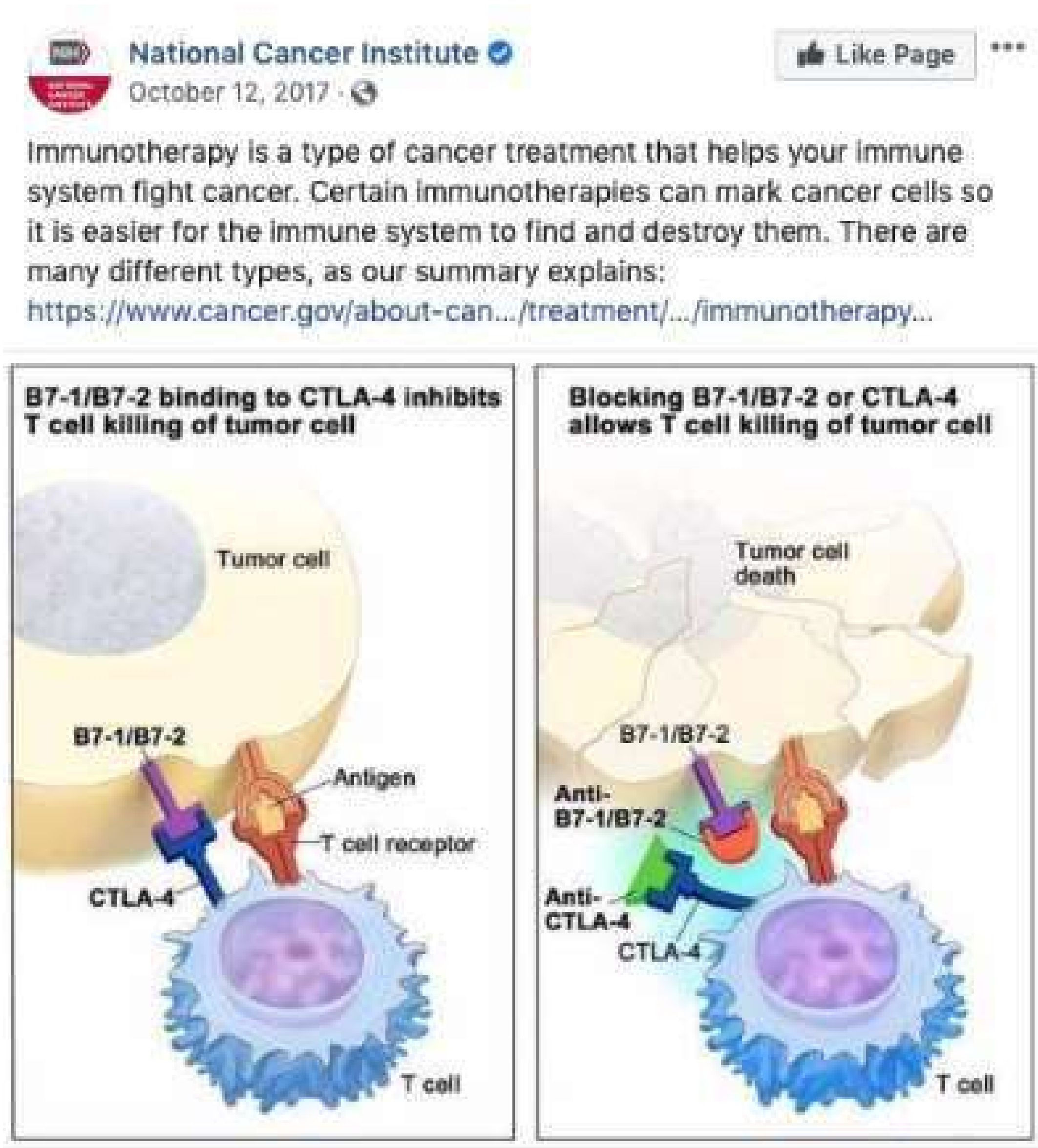
a. Some high school or less
b. High school
c. Degree from 2 year college
d. Degree from 4 year college
e. Master's degree (2 year)
f. Ph.D., law or medical school degree

APPENDIX C – Misinformation Scale

Items were rated on the following scale:

1. Definitely True, 2. Probably True, 3. Probably False, 4. Definitely False

1. Cancer - True

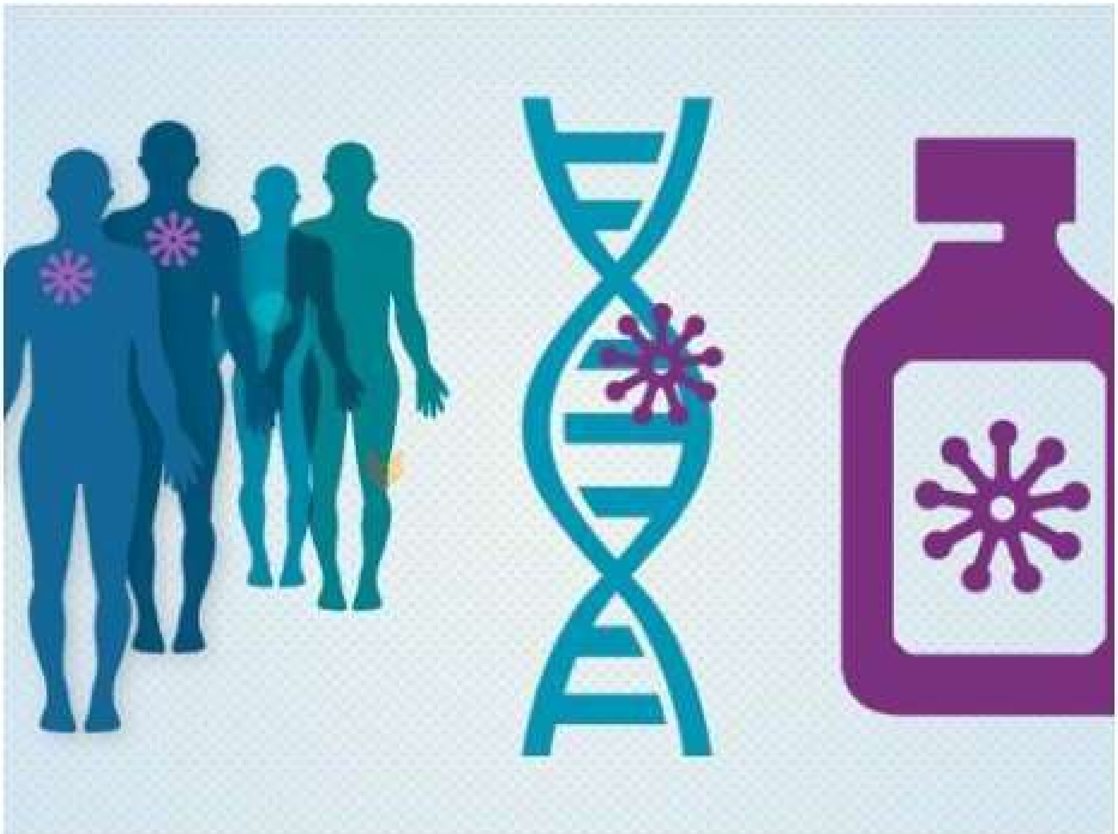


2. Cancer - True

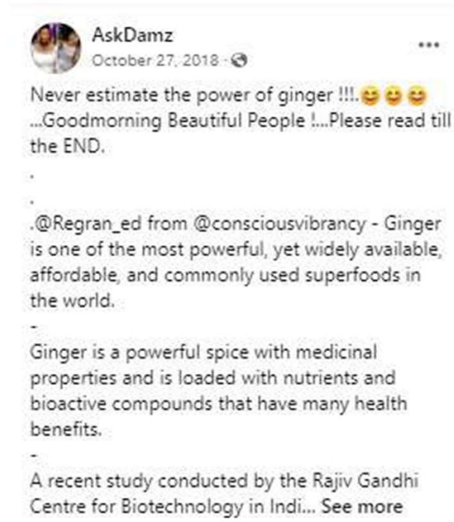
National Cancer Institute
October 10 at 6:15 AM ·

Like Page

Targeted therapy is a type of cancer treatment that targets the changes in cancer cells that help them to grow, divide, and spread. Our summary explains: https://www.cancer.gov/about-can.../.../types/targeted-therapies



3. Cancer - False



4. Cancer - False

5. Statin - True

Harvard Health @HarvardHealth · Oct 4

Study supports **benefit** of **statin** use for older adults. bit.ly/2oeD6Lk #HarvardHealth

6. Statin - False

7. Statin - False

ConsumerLab.com
May 28, 2017 ·

#Redyeastrice lowered #cholesterol as well as a #statin drug but with a lower rate of muscular side-effects, according to a new study. Get the details in ConsumerLab.com's Red Yeast Rice Supplements Review: http://tiny.cc/7ncgly

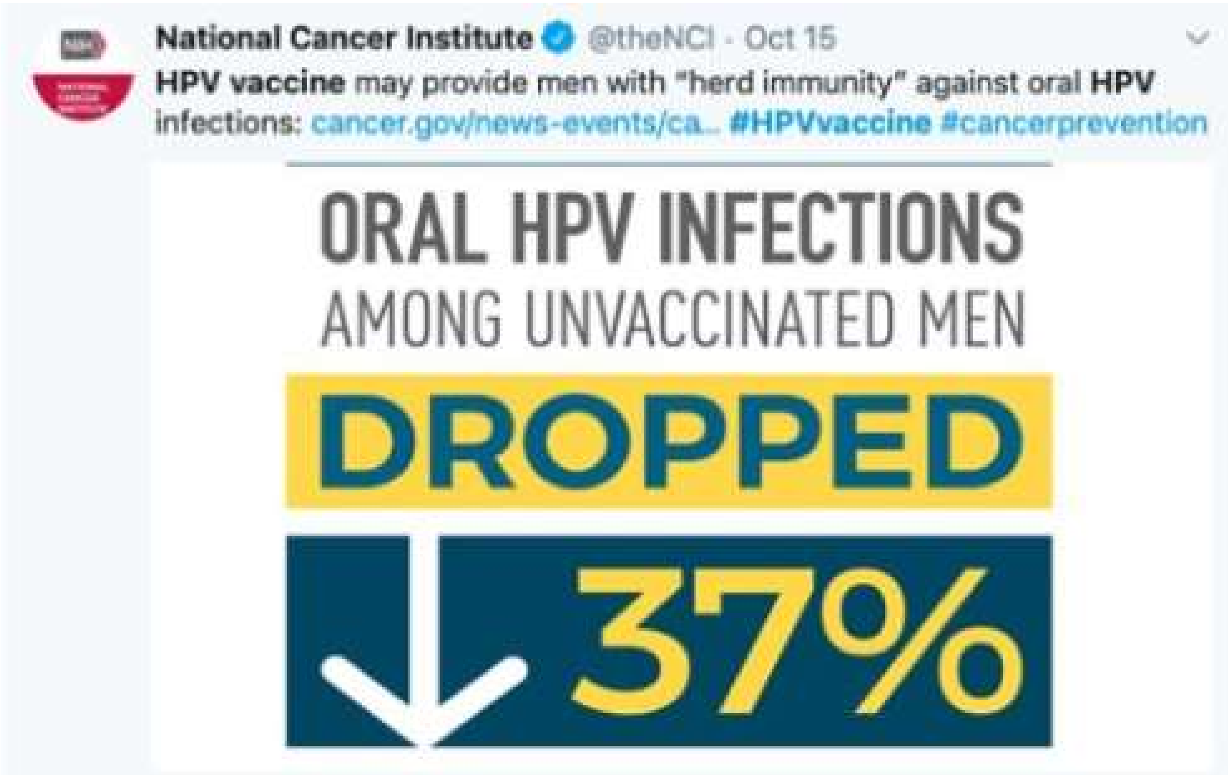
8. HPV - True

CDC
August 26 ·

Like Page

Did you know that the HPV vaccine protects against the types of HPV that most commonly cause several types of cancers including cervical cancer and oropharyngeal cancer? Read more in the latest MMWR. http://bit.ly/_HPV_

9. HPV - True


National Cancer Institute @theNCI · Oct 15
HPV vaccine may provide men with "herd immunity" against oral HPV infections: cancer.gov/news-events/ca... #HPVvaccine #cancerprevention
ORAL HPV INFECTIONS
AMONG UNVACCINATED MEN
DROPPED
37%

10. HPV - False

James Lyons-Weiler @lifebiomedguru · Oct 14

The evidence of increased, not decreased cervical cancer in countries that adopted the **vaccine** does not bode well for the **HPV** vaccination program. #TypeReplacementIsReal

Cervical Cancer Rates Increase Despite Use of HPV Vaccine

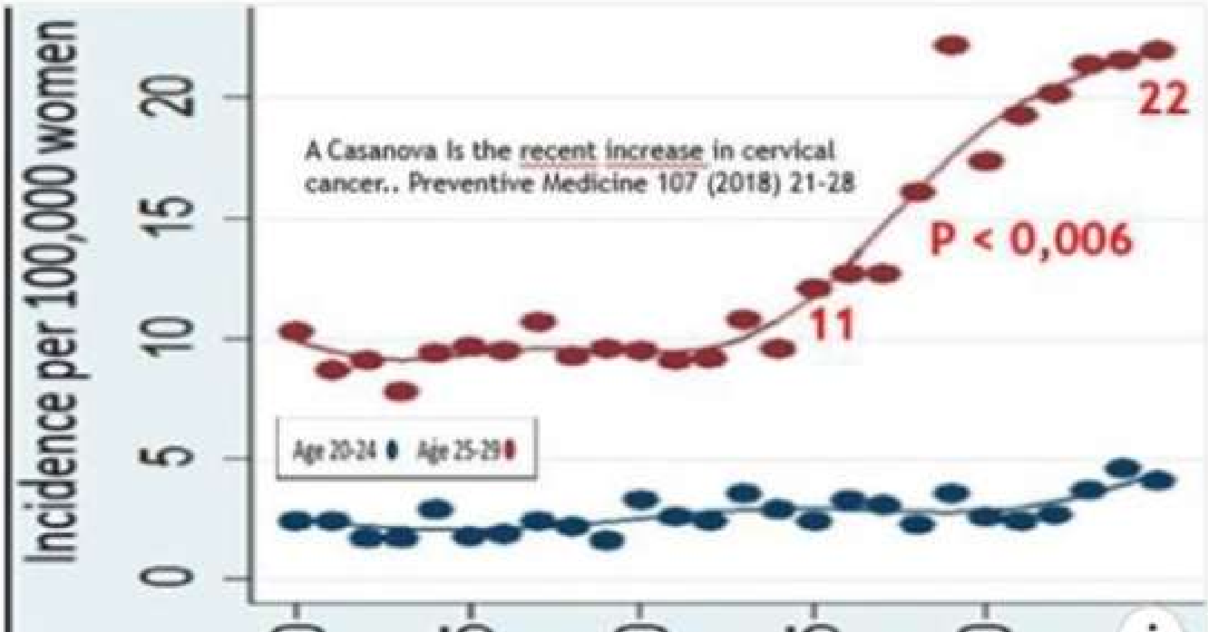
Although the HPV vaccine is often referred to as the cervical cancer vaccine, it is debatable whether this vaccination can in fact prevent ...

thetruthaboutvaccines.com

11. HPV - False

Gemma O'Doherty
February 7 ·

New research shows cervical cancer has risen since Gardasil was introduced. This isn't surprising to those informed about the HPV vaccine. Given everything we now know about the dangers of this vaccine, parents only have themselves to blame for trusting the HSE with their children's health



DOCTEUR.NICOLEDELEPINE.FR

PARADOXICAL EFFECT OF ANTI-HPV VACCINE GARDASIL ON CERVICAL CANCER RATE – Docteur Nicole Delépine

12. HPV - False

Benny D. Rasmussen @BennyDRasmussen · Oct 27

Gardasil is one of the most dangerous **vaccines** on the market, it's a drug that contains a lot of aluminum. Warning **about** this deadly **vaccine** is everywhere, so I would highly recommend everyone to watch this video.

The Truth About Vaccines, about HPV:
bitchute.com/video/9im5s0oh...

LotusOak @ViraBurnayeva · Oct 26

Diane Harper, MD, #HPV Expert, on Risk of #Gardasil Vaccine

huffingtonpost.com/marcia-g-yerma...

#LearnTheRisk #vaccines

Let’s Talk About Science

Scientists are experts who specialize in a particular subject such as biology, chemistry, psychology, and many more.

Scientists conduct research to find answers to life's questions both big and small:

In health research, scientists have worked to find answers to address the pandemic. They may ask, how well does the covid vaccine help prevent infection and death?

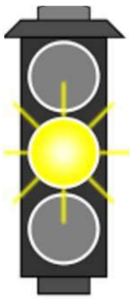
Research can be long and complex, so scientists must take careful steps to reduce and avoid errors. **The two main questions** you need to answer when you are deciding whether to **trust** information from a scientist is:

1. Is the information **true**, in other words, **accurate**?

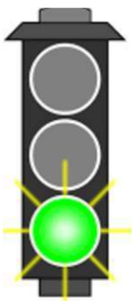
2. Did the scientists produce this information in an ***unbiased** manner?

***Unbiased** means free from any prejudice or favoritism.
If you are **unbiased**, you are fair and impartial.

When trying to answer difficult scientific questions, scientists recognize that they can sometimes be ***biased**.



For example, a scientist might be **biased** because they came up with an answer to a complex question and like their answer so much that they don't want to find that it is wrong. So, they don't check it out well enough. This sometimes means that they end up accepting an **inaccurate** answer as true. So, you would **not trust** information from a scientist who is thinking in a **biased** way like this.

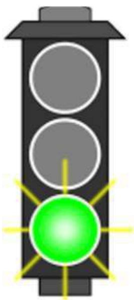


Because scientists want the information they come up with to be **trustworthy**, **all scientists are educated and trained to use rules and guidelines that help them be unbiased and produce accurate information**. In a minute, you will learn about some of the rules and guidelines that make scientific information **trustworthy**.

***Biased** means showing prejudice or favoritism. If you are **biased**, you are unfair.

The **rules and guidelines** that increase accuracy and reduce bias are part of the **scientific method**.

You can **trust** scientists' ideas because they follow these key **scientific methods:**

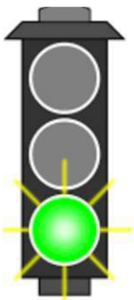


- Gather info from the right kinds of people - Representative Sampling
- Think smart about cause and effect - Randomized Controlled Trials
- Have others check their work - Peer Review
- Look at ALL the evidence & see if they find Converging Evidence

The **rules and guidelines** that increase accuracy and reduce bias are part of the **scientific method**.

Now we'll go over each of these methods, starting with the first one.

You can **trust** scientists' ideas because they follow these key **scientific methods:**



- **Gather info from the right kinds of people - Representative Sampling**
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Trust ahead 1 mile

Gather Information from the Right Kinds of People

Representative Sampling

The goal: In a recent study, scientists wanted to know whether young adults in the US who use social media too much are more depressed than young adults who use social media less. They wanted to learn something about **ALL US young adults** because they are a group that uses social media heavily. This means they needed to study people who reflected the various genders, races, and ages of United States young adults.

The group of people that scientists gather information from in a study is called the **sample**, because it's a small group or "sample" that is supposed to reflect or **represent** a larger group (in this case, all the young adults in the US).

<u>The sample:</u> To learn about this diverse group of people, the scientists studied about 1700 adults between the **age of 19 and 32**. Half of this group was **female** and half was **male**. About 57% were **white**, 13% **black**, 20% **Hispanic**, and 9% "**other race or ethnicity**," which roughly matches the racial and ethnic breakdown of the United States adult population based on Census reports. This matching is called **representative sampling**. It allowed the scientists to understand how different genders and races may be affected.

<u>What the scientists learned:</u> The study found that too much social media use ***IS*** associated with having more depressive symptoms. Among the sample of 1700 young adults, the more heavily someone used social media, the more depressive symptoms they reported. Also, people who identified as multiracial or "other race or ethnicity" were more likely to experience depressive symptoms than white, black, or hispanic participants.

Question: (Highlight your selection below)

Can the scientists in this study **trust** that **what they learned in the study applied to the diverse groups of people that make up the 19-32 age group in the US?**

a. No, they did not choose the right participants for the study
b. Yes, they made sure that a variety of genders, races and ethnic groups were in the study
c. Yes, they asked all the young adults in the United States

Question: Can the scientists in this study **trust** that **what they learned in the study applied to the diverse groups of people that make up the 19-32 age group in the US?**

Correct answer: b. Yes, they made sure that a variety of genders, races and ethnic groups were in the study.

Explanation:

The scientists in the social media study chose a **representative sample** that matched the gender and racial/ethnic breakdown of young adults in the US based on Census data. Since their sample does a good job of representing the diverse kinds of people within this age group, you can **trust** that what the scientists found in their study will probably be true for all US young adults.

Why you should **trust** a **representative sample**

<u>What is a representative sample?</u> When the larger group is made up of different types of people, the sample should **include ALL of those different types of people**. This way the sample will truly **represent** the diverse larger group.

<u>More accurate and less biased =</u> <u>TRUSTWORTHY:</u> When scientists conduct research, they use a **representative sample** that reflects the needs and characteristics of the larger population (or group). This means the results will **more accurately** represent the whole population. The results will also be **less biased** because ALL the different types of people are included in the sample. No groups are left out.

Representative sampling is very important when scientists want to find out **if new medicines are safe and effective** before they are approved for use by the public. Scientists must test new medicines on **representative samples** so that people can **trust** that the medicine will be safe and effective for **ALL of the diverse groups of people in the general population**.

Review Questions:

1a. Imagine that a group of medical researchers working at a university have developed a new over-the-counter painkiller that is similar to Advil and Tylenol. Their new painkiller is designed to be used by anyone from young children to older adults. As part of the development process, they need participants to try out the painkiller to see how well it works. Which of the following is the best sampling option to recruit participants? **Highlight your selection below:**

a. The researchers should recruit undergraduate students to participate in this study since they are already available at the university.
b. The researchers should recruit participants from the broader community including children, adolescents, and adults that represent different races.
c. The researchers should recruit adults who are experiencing chronic pain.

1b. Why did you choose that answer (why was it the best?)

Type your answer here: _

Feedback

Correct answer: b. The researchers should recruit participants from the broader community including children, adolescents, and adults that represent different races.

Explanation:

In this scenario, the university wants to study the effectiveness of their new painkiller. Because they hope this painkiller will be used by everyone regardless of age and race, it is important to have participants that represent all the age ranges and races in the population.

Choice a would not be appropriate because it only considers a narrow age group of young adults at the university. Meanwhile, **choice c** only focuses on a specific group of the population who experience chronic pain. Both options are limited because they only focus on a subset of the population which are not representative of the rest of the population. The researchers want to know how well it works for the general population so their sample should match the diversity of the population.

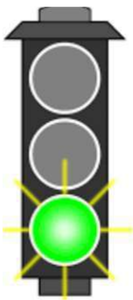
Think Smart about Cause and Effect

Randomized Controlled Trials

The **rules and guidelines** that increase accuracy and reduce bias are part of the **scientific method**.

You can **trust** scientists' ideas because they follow these key **scientific methods:**

Now we'll go over the second method.



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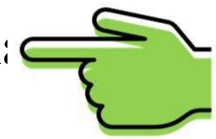


Trust ahead 1 mile

We are going to look at **two** scientific studies of whether nicotine patches are **effective**, in other words, whether patches **cause** smokers to quit smoking.

Let's see which of these studies really helped the scientists **think smart about cause and effect.**

<u>Initial Visit:</u> All the people that come into a new **smoking-cessation clinic** at a hospital have an initial visit with a doctor where they do 3 things to help them quit smoking:

1. They **talk with a doctor** about why quitting smoking is important and how to do it.
2. The doctor also gives each person a **brochure** with tips on how to quit smoking.
3. Finally, the doctor **recommends that they use a nicotine patch**. Anyone who wants to use the nicotine patch is given a free supply of patches that will last them for 12 weeks, which should be enough time for the patches to work.

The goal: The doctors at the clinic want to see **how well the patches work.**

How their study worked: The doctors contacted **each person** who comes into the clinic 12 weeks after they have their initial visit and asked them whether they used the nicotine patches or not.

There were **two groups of people**. Those who **chose to use** the patch and those who **chose NOT to use it**.

All the people in both groups filled out a questionnaire about **how much they smoked** in the last 4 weeks of the 12-week period.

2 groups of people

No patch at all

Nicotine patch

<u>What the doctors learned … maybe:</u> After one year, the doctors find that **26%** of the people who **chose to use the nicotine patch** stopped smoking in the last 4 weeks after their initial visit. This was much higher than the **12%** of people who **chose NOT to use the patch** who stopped smoking.   See below.

One of the doctors says: **The patch worked really well. A lot more people stopped smoking because of the patch.**

2 groups of people

Possible CAUSE	**Nicotine patch**	**No patch**
EFFE	**26% stopped**	**12% stopped**

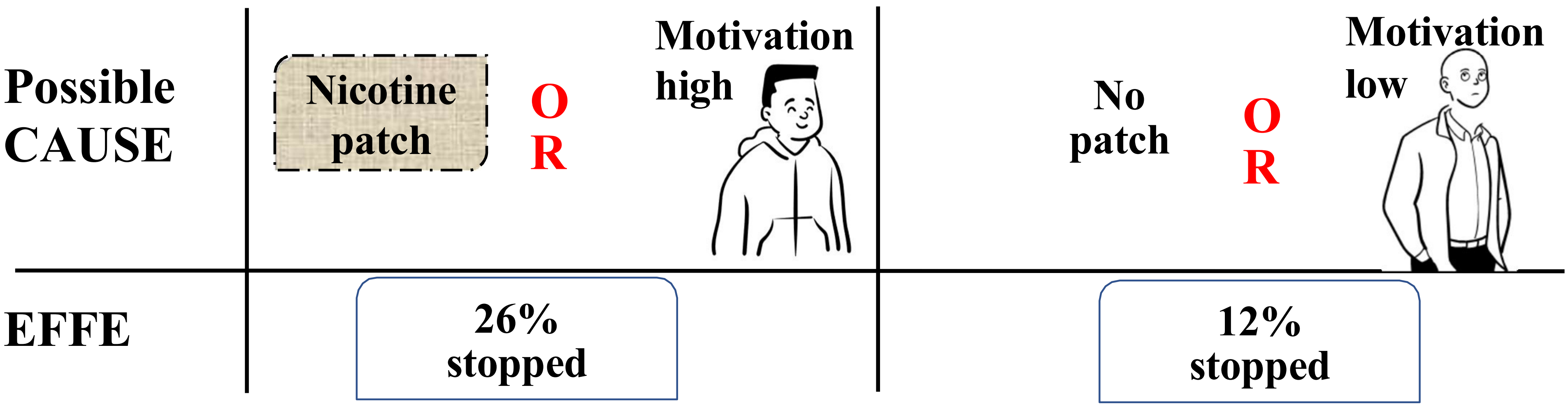
The problem: But another doctor says: Maybe not. The **big mistake** we made was to let the people visiting the clinic **choose** whether to use the patch or not.

- Maybe the people who **chose** to use the nicotine patch were **MORE motivated** to quit smoking.
- And maybe the people who **chose NOT** to use the patch were **LESS motivated** to quit.

It could be that **the patch does not work at all, and greater motivation is the real cause.**

From the information we have now, **we CANNOT TELL whether the NICOTINE PATCH or MOTIVATION is the real cause**.

2 groups of people

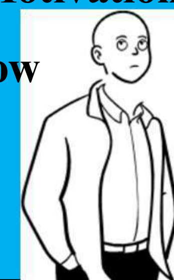


2 groups of people

Possible CAUSES

Nicotine patch OR **Motivation high**

No patch at all OR **Motivation low**



EFFECT

26% stopped smoking

12% stopped smoking

The problem: This diagram shows the study we've been talking about. Because the clinic visitors made their own choice about using the patch, the two groups were different in BOTH whether they used the patch AND their motivation. So, the doctors CAN'T TELL whether the NICOTINE PATCH or HIGH MOTIVATION is the real cause of less smoking.

Question: How could they do a study where both groups have **equal motivation** and they ONLY differ in **whether or not they used the patch?**

a. Don't let the clinic visitors choose whether to use the patch. Out of all the clinic visitors who say they want to quit smoking, the doctors should randomly assign each of these people to use or not use the patch.

b. Still let the clinic visitors choose whether to use the patch or not but have a lot more people in the study.
c. Compare participants from a clinic that receives nicotine patches to participants from another clinic that does not receive patches.

Question: How could the doctors do a study where both groups have **equal motivation** and they ONLY differ in **whether or not they used the patch?**

Correct answer: a. Don't let the clinic visitors choose whether to use the patch. Out of all the clinic visitors who say they want to quit smoking, the doctors should randomly assign each of these people to use or not use the patch.

Explanation:

The problem is that because the people in the study **chose for themselves** whether to use the patch, the group that used the patch could have been more motivated to quit. So, better motivation might be the real cause of smoking less. The solution is to **not** let people choose for themselves. **The *scientists* should choose** who uses the patch and who does not, and they should **do this *randomly***. This is called random assignment. This way the patch and no-patch groups have roughly equal levels of motivation. They have an **equal starting point**.

Choice b is incorrect because the clinic visitors choose for themselves whether to use the patch. Although it is a good idea to have more participants in the study, the groups would not be equal in motivation and possibly other factors.

Choice c suggests recruiting participants from different clinics to be in different groups. Participants from one clinic might have more motivation than the other clinic and might differ in other ways that could affect their quitting (like more money). So, the groups would not be equal.

Now you will learn about a better study of nicotine patches.

<u>How the study worked:</u> In the 1990s, scientists in England ran a study of whether nicotine patches caused people to smoke less. This study fixed the problem in the study we just discussed (Study 1) by using **random assignment**.

Over 1600 **smokers** volunteered to be in the study.

All the smokers wore a patch for 12 weeks. However, **the patches were NOT all nicotine patches**.

Study 2 – with **random assignment**

Comparison groups:

- Half of the patches were **nicotine patches** that were intended to help people quit smoking.
- The other patches looked and felt the same; but they did NOT have the active ingredient that is supposed to help people quit smoking. These are called **placebo patches**.

Random assignment: The researchers **randomly assigned** the 1600 people to the **nicotine patch** ***OR*** the **placebo patch** group. The people in the study **did NOT know** whether they got a real nicotine patch or a fake placebo patch until **after** the study was over.

2 groups of people

CAUSE

Nicotine Patch

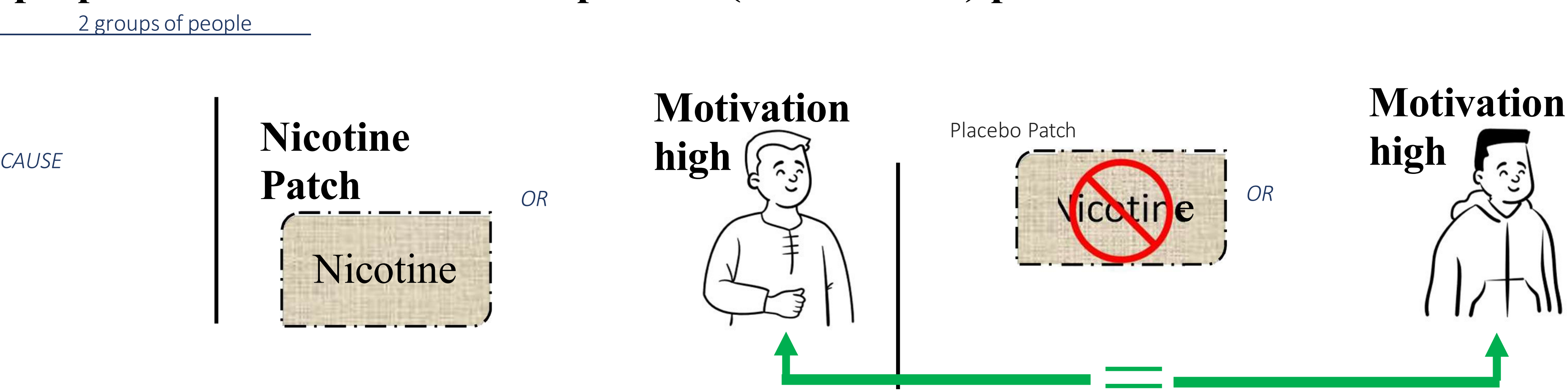
Placebo Patch

Study 2 – with **random assignment**

<u>Equal starting point:</u> Because all the people in this study were willing to use the nicotine patch, they probably all had high motivation to quit smoking. The **random assignment** meant that the people in the nicotine and placebo patch groups were about **equally motivated** to quit smoking.

Also, the two groups were about **equal** in ***other* factors** that could affect how easy it would be for them to quit smoking, like how much they smoked, or how stressed they were.

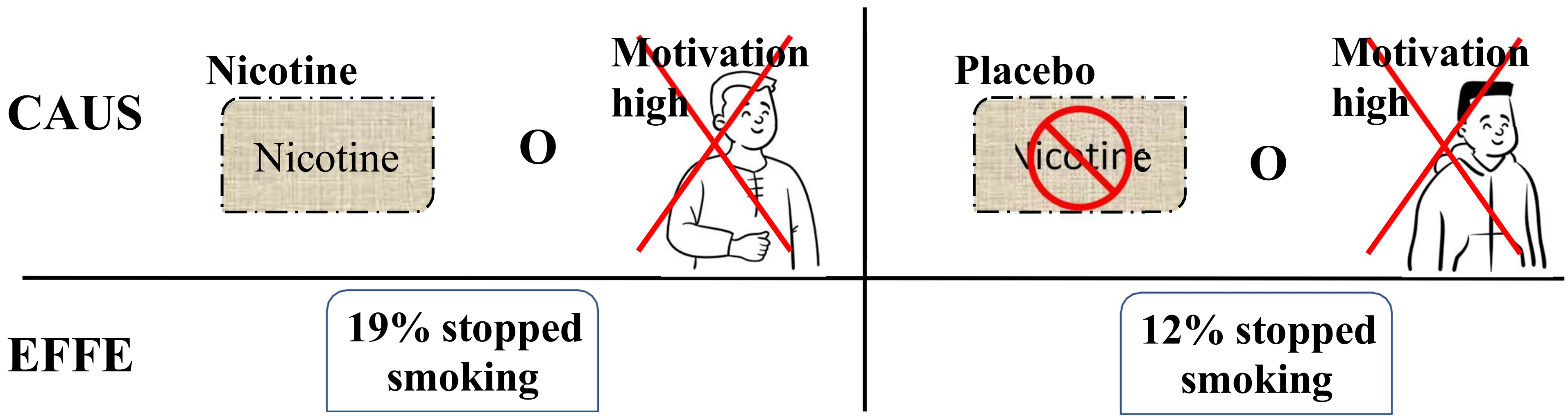
Because of **random assignment, the only difference** between the two groups was whether the **people used the nicotine or the placebo (non-nicotine) patch**.



What the doctors found: When the nicotine and placebo (fake) patches were compared, more people who wore the nicotine patches avoided smoking completely during the last 4 weeks, as shown below.

The scientists agreed that because of random assignment, both groups were about equal in motivation; so, **motivation could not be causing the differences in quitting smoking in this study**. (See red **X**'s)

This meant that the only difference between the two groups was whether they used the nicotine patch. So now they had **good evidence that in this study, the nicotine patch CAUSED people to smoke less.**



In this **second study**, the scientists **compared** two groups of smokers, one who wore a nicotine patch and one who wore a placebo (fake) patch. They also **randomly assigned** the people in the study to these two groups.

By doing these two things, the scientists could **trust** that the reason more people in the nicotine patch group stopped smoking was **because** they used the nicotine patch and not some other reason like being more motivated to quit.

How Random Assignment Helps: Random assignment allowed the scientists in the **second study** to get **more accurate** information about the real cause of quitting smoking. Whether someone can follow through on quitting smoking is probably affected by **many** possible causes, like whether they use a nicotine patch, their motivation, how much they smoke, stress levels, etc. It's a complex situation.

Random assignment of study participants to the groups that are compared in a study (like the nicotine or placebo patch groups) helps scientists get good information about just **the one cause** they are interested in.

In the **first nicotine patch study**, where the clinic doctors **did NOT do random assignment**, they were **not sure** whether the cause of more people quitting was motivation or the nicotine patch.

Scientific studies of new medicines that use **random assignment** are called randomized controlled trials.

- "**Randomized**" refers to random assignment.
- "**Controlled**" means that a group of people who use a new medicine is **compared** to a "control" group of people who do NOT use the new medicine.
- "**Trial**" is just another word for a scientific study.

So, if you read in the **news** that a **randomized controlled trial** found that some medicine is safe and effective, you can **trust** that this information is probably accurate.

Review Questions:

1a. Imagine scientists developed a new weight loss supplement pill. They want to conduct an experiment to see how well it works at helping people lose weight. They put out fliers throughout the hospital to recruit volunteers to participate. Which of the following is the best way for the scientists to set up the experiment so they can figure out whether the weight loss supplement **causes** people to lose weight?

Highlight your selection below:

a. Give the weight loss supplement to all the people who volunteered, then measure how much weight they lose over the next 10 weeks.

b. Randomly assign the participants into a group that receives the weight loss supplement and a comparison group that does not receive any supplements. Then compare how much weight people lose in each group.

c. Ask all the people who volunteered to rate their level of concern with their weight. Then assign all the volunteers who expressed greater concern about their weight into the group to receive the weight supplement. Assign those who expressed lower concern about their weight into the comparison group that does not receive any supplements. Then compare how much weight people lose in each group.

1b. Why did you choose that answer? **Type your answer here: _**

Feedback

Correct answer: b. Randomly assign the participants into a group that receives the weight loss supplement and a comparison group that does not receive any supplements. Then compare how much weight people lose in each group.

Explanation:

The best answer is **choice b**, because people in the study were **randomly assigned** to the supplement or no-supplement group. This allows people in each group to be fairly equal in concern for their health, motivation to lose weight and other factors that could affect weight loss. Therefore, the only difference between the supplement and no-supplement group is whether they received the supplement. So, if the scientists find that the supplement group lost more weight than the no-supplement group in this study, they can be pretty sure it was caused by the supplement because motivation or other factors could not have caused the weight loss.

If you only study the people who took the supplement **without** using a comparison group, you do not have enough evidence to show cause and effect. You would only know how much weight the supplement group lost, and you have no other group to compare to. So, **choice a** is incorrect.

When you have a comparison group, **both groups** must have an equal starting point except for the one thing you are changing between the groups (in this case, supplement or no supplement). In **choice c**, participants with greater concern may have more motivation to improve their health and therefore could be taking extra steps to live a healthier life. It is difficult to determine if the weight loss was from the extra healthy steps taken or because of the weight loss supplement.

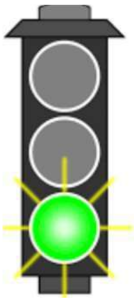
Have Others Check Their Work

Peer Review

The **rules and guidelines** that increase accuracy and reduce bias are part of the **scientific method**.

You can **trust** scientists' ideas because they follow these key **scientific methods:**

Now we'll go over the third method.



- Gather info from the right kinds of people - Representative Sampling
- Think smart about cause and effect - Randomized Controlled Trials
- **Have others check their work - Peer Review**
- Look at ALL the evidence & see if they find Converging Evidence

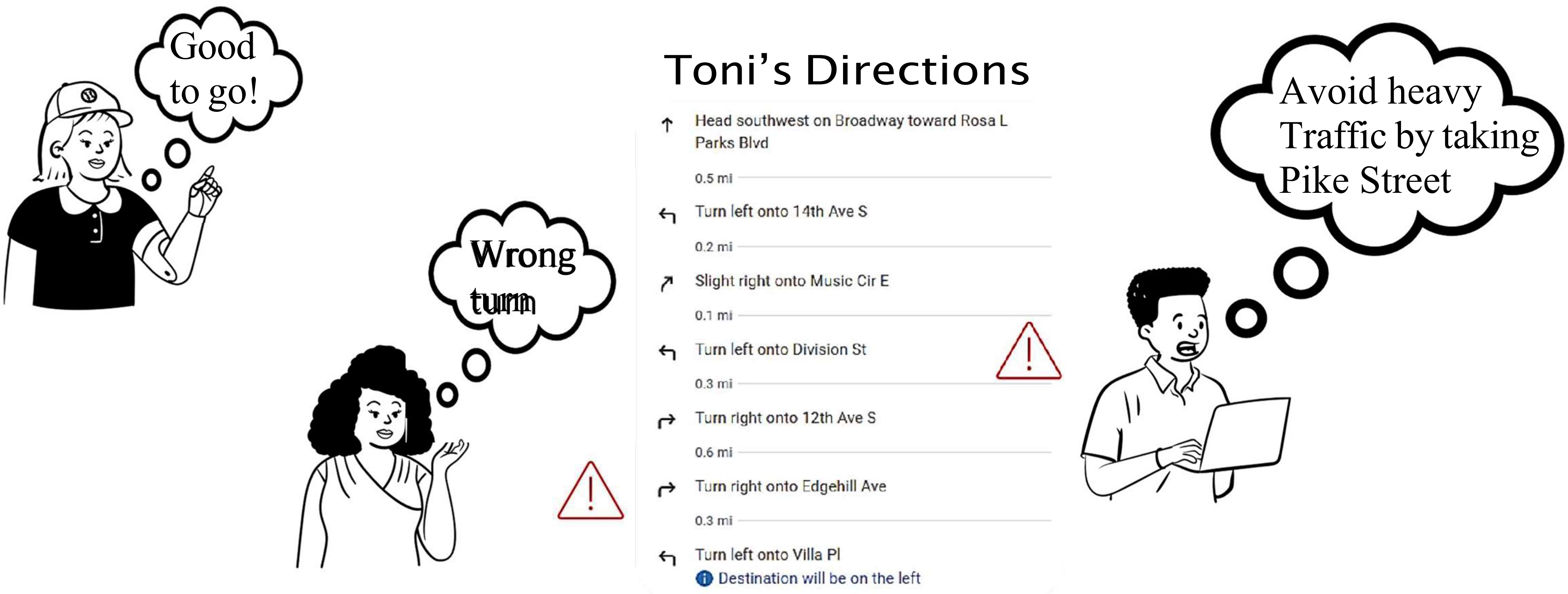
Whenever someone writes something important that might be true or false, they should have someone else check their work before they have other people use what they wrote.

The goal: Jamil and Toni live near each other in the same neighborhood in a large city. By coincidence **each of them is having family visit for Thanksgiving** from a city on the other side of the state. Each family is visiting the city for the first time, so **the families don't know the driving directions.** This happened before cell phones, GPS, and car or phone navigation systems, so Jamil and Toni both sent their families written directions of what roads to take and where to turn, etc.

The problem: Jamil and Toni did not talk to each other about their directions, but they each created exactly the same directions. **They each put the same wrong turn near the end of their directions** that would get their families completely lost. Also, they are both very proud of the historical district downtown so **each of their directions take their families through this district**.

<u>The solution:</u> Jamil **doesn't have anyone check his directions** before sending them to his family.

However, **Toni has 3 friends who** are very familiar with the city **check her directions**. One says the directions are fine. Another finds the wrong turn. The third finds that mistake and points out that there is usually a lot of traffic around the historical district and suggests a better route that would avoid the traffic. Toni sends out the much-improved directions.



Using the directions: When the relatives follow the directions, Jamil's relatives are delayed by the downtown traffic and then get lost; so, they arrive 3 hours late. Toni's relatives have no traffic delays and do not get lost. This shows the advantage of having multiple knowledgeable people check your work when it's important that it's done right. After the checking, Toni's directions were accurate; but without checking, Jamil's had multiple errors.

Jamil's family is stuck in traffic and lost because of the wrong directions

Toni's relatives arrive on time using the right directions

Question: (Highlight your selection below)

Why is it important to have others check your work?

a. It's not needed if you do your work carefully the first time.
b. The checkers can identify biases that you may not be aware of.
c. The checkers can find mistakes that you missed.
d. Both b and c.

Question: Why is it important to have others check your work?

Correct answer: d. Both b (The checkers can identify biases that you may not be aware of) and c (The checkers can find mistakes that you missed).

Explanation:

In addition to **finding mistakes**, checking also **reduces biases**. Jamil and Toni each have a "bias" to show off the city's historical district, which made them forget that this route would get their relatives frustrated from traffic delays. One of the people who checked Toni's directions didn't have this bias, so that person noticed Toni's mistake. Having other people check your work reduces bias because **they often don't have the same biases you do**.

Example 2: Scientific Peer Review

Scientists always have other scientists check their work for errors and biases. This process is called peer review. It’s a key part of the process of publishing a scientific article. The scientists who check over a study are experts in the topic of the study.

They are also **independent**, which means that:

- they were not part of the team that did the study;
- AND they do not talk to the other reviewers.

Reviewer 1

Reviewer 2

Reviewer 3

Here's how peer review works:

1. When scientists do a study, they must write up how they did the study and what they discovered in full detail. They then submit their written paper to a scientific journal to be published.

2. At the journal, 3 or more expert scientists who are not part of the original research team check the work of the scientists who did the study to identify any errors or biases and make detailed recommendations to improve the quality of the article.

3. Then, the scientists who did the study fix the errors and remove the biased parts and then send the more accurate paper to the journal again.

4. If all the reviewers are satisfied with the study, the paper can be published in the journal for anyone to read. If the reviewers are **not satisfied**, the paper is **not published**.

All scientific journals use peer review, so if you read in a news article that a study has been published in a scientific journal, you can trust that it has gone through the careful checking of peer review.

Peer review improves accuracy - This checking process will make the final paper on the scientific study more accurate, because it helps the scientists who did the study find and fix their errors.

Peer review reduces biases -The scientists who did a study might be biased. For example, the scientists who did the nicotine patch study discussed earlier might **really hope that the patch turns out to be effective**. This **bias** might lead them to make mistakes or to overlook information that shows the patch is not effective. But the 3 expert reviewers probably do not all have the same biases as the scientists who did the study, so they can spot errors that were missed.

Because peer review reduces biases and improves accuracy, you can trust the information in scientific studies that have gone through peer review.

What if there is no peer review? In urgent situations, newspapers sometimes publish information from a scientific study before it has been published in a scientific journal. When you read about a scientific study in the newspaper and it says, “this study has not yet been peer reviewed,” this means that it **hasn’t yet been checked for errors by scientists outside the team** who did the study. So, you can’t trust it as much as a study that’s been peer reviewed and published in a scientific journal.

Review Questions:

1a. Imagine that you read about a scientific study in your local newspaper. Which of the following news stories about the study would give you the most trust that the study was accurate and unbiased?

a. The news article mentions that the study was done by scientists at a large university in your state. It also says that the study has not yet been peer-reviewed.
b. The news article does not mention who did the study. It says that the study has not yet been peer-reviewed.
c. The news article mentions that the study was done by scientists at a large university in your state. It also says that the study has been published in a prestigious scientific journal.

1b. Why did you choose that answer (why was it the best?)

Type your answer here: _

Feedback

Correct answer: c. The news article mentions that the study was done by scientists at a large university in your state. It also says that the study has been published in a prestigious scientific journal.

Explanation:

In this scenario, **choice c** offers the most credible and accurate information because it provides a source for the study and states that the **study has been published in a scientific journal.** Remember, in order to publish a study in a scientific journal, it must first go through the peer review process and be approved by the reviewers.

Choice a would not be the most trustworthy choice because even though it tells you who conducted the study, it has not been peer reviewed. Meanwhile, **choice b** is even less trustworthy because the study has not been peer reviewed and you do not know who conducted the study.

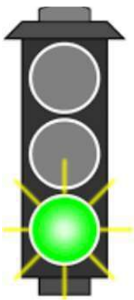
Look at ALL the Evidence for…

Converging Evidence

The **rules and guidelines** that increase accuracy and reduce bias are part of the **scientific method**.

You can **trust** scientists' ideas because they follow these key **scientific methods:**

Now we'll go over the fourth method.



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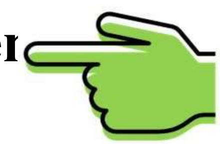


In the 1940's and 1950's, medical researchers conducted scientific studies on the effects of smoking and suggested that **smoking cigarettes might cause lung cancer and other lung diseases.** At the time, smoking was very common in the US and there were no warnings about the dangers of smoking on cigarette packages. The tobacco industry pushed back against the idea that smoking caused lung cancer.

By the 1960's, thousands of scientific studies on the effects of tobacco smoking had been done by independent scientists in multiple fields. These scientists used many different types of studies.

Question: (Highlight your selection below)

When looking at the thousands of studies on the effects of smoking, how can scientists **determine** whether **there is converging evidence** that smoking cigarettes causes lung cancer?

a. They must consider ALL the evidence both in support of and against the idea that cigarettes cause lung cancer.
b. Scientists must consider only the studies funded by tobacco producers.
c. They must randomly select a few studies from the past few years.

Question: When looking at the thousands of studies on the effects of smoking, how can scientists **determine** whether **there is converging evidence** that smoking cigarettes causes lung cancer?

Correct answer: a. They must consider ALL the evidence both in support of and against the idea that cigarettes cause lung cancer.

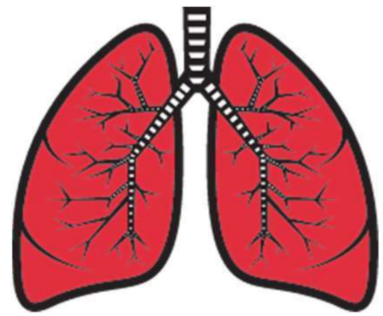
Explanation:

When scientist look to see whether there is converging evidence for one of their hypotheses (like the idea that “smoking cigarettes causes lung cancer”), they search for **ALL the scientific studies on this topic.** They are careful not to overlook studies that go against their hypothesis. This helps them make an **accurate** and **unbiased** conclusion.

When scientists looked at all of the thousands of studies on whether smoking caused lung cancer, they found that **most** of these studies supported the idea that tobacco smoking causes cancer and other diseases. Here are some more details about what they found…

For example, studies showed that:

- People who smoked cigarettes for longer periods or more heavily have more lung cancer than people who smoked less.
- Cigarette smokers tend to get lung cancer; but cigar or pipe smokers (who don't usually inhale the smoke) tend to get lip cancer.
- Toxic substances in tobacco smoke cause tumors.
- Tobacco smoke harms the hair-like structures in our lungs that helps us filter out the toxic substances in tobacco smoke.



Given the clear risks to individuals, it would not be ethical to give people cigarettes in a randomized controlled trial. Despite not being able to conduct randomized controlled trials with people, these **thousands** of scientific studies of many different types came together to provide **strong** converging evidence that smoking causes cancer and other diseases. The **converging evidence** helped us improve public health by educating people about the dangers of smoking and by laws like mandatory warnings on tobacco products.

Scientists are trained to always tell people whether they have found **converging evidence** from many scientific studies supporting a new scientific idea. This means they:

1. Have gathered as much evidence as they can find about whether the new idea is true or false
2. After looking at ALL the evidence they found about their idea, most of it supports the truth of the new idea and very little of it suggests that the new idea is false.

If these two things are true, the scientists have found **converging evidence** and can **trust** that the new idea is true. If scientists **do** have converging evidence from many studies, they will tell you about the converging evidence and say, "We are very confident about this new idea." So, if you read an article about a scientific issue in the news and the article includes many **different independent pieces of evidence** and **most of them agree with a new idea**, then you **can trust that this idea is true**.

On the other hand, if scientists **have only done a few studies**, they might say, "This new idea looks promising, but we need to do more research before we can be confident that it is true." So, if you read a science news article and only a few studies have been done to test a new idea, and especially if the studies do not agree with each other, **then you cannot trust that the new idea is true.**

Review Questions:

1a. A professor assigns his class a research project to figure out if screen time (such as phones, tablets, and tv) before bed reduces sleep quality. The professor divides his class into 3 teams to work on this assignment. At the end of the project, the students shared their findings. Which of the following teams provided the best argument?

a. Team A finds an article that suggests that screen time is not as bad as previously thought. They decide to explore some of the studies related to this article. After reviewing several related studies, they concluded that screen time before bed does not reduce sleep quality.

b. Team B splits up the task, and each student reviewed many studies. When they came together as a team, they had combined a large list of studies to discuss. The team found that although some studies showed no effect of screen time on sleep quality, most of the studies found that screen time before bed reduces sleep quality. They concluded that overall, screen time before bed has a negative effect on sleep quality.

c. Team C splits up the task, and each student reviewed a few studies to start. When they came together as a team, they found that some studies showed no effect of screen time on sleep quality while others showed that screen time reduced sleep quality. Team C decided to stop their search and concluded that the evidence is mixed so there is no clear answer.

1b. Why did you choose that answer (why was it the best?) **Type your answer here: _**

Feedback

Correct answer: b. Team B splits up the task, and each student reviewed many studies. When they came together as a team, they had combined a large list of studies to discuss. The team found that although some studies showed no effect of screen time on sleep quality, most of the studies found that screen time before bed reduces sleep quality. They concluded that overall, screen time before bed has a negative effect on sleep quality.

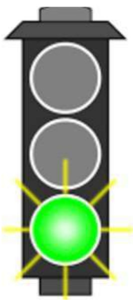
Explanation:

Team B provided the **best argument** because among the four team members, they reviewed **several studies and put together a large set of evidence.** After reviewing all the evidence they could find, the team provided **converging evidence** to suggest the screen time before bed generally reduces sleep quality.

Team A's conclusion was incorrect because they were **biased** in their search. By only looking at studies related to the one article, they only focused on **one side of the argument** and did not consider the other side. **Team C's** strategy does not provide sufficient evidence because the team only considered a small set of studies as their evidence. Without doing enough research, they incorrectly concluded that there was no clear answer.

Here is what you've covered so far…

You can **trust** scientists' ideas because they follow these key **scientific methods:**



- Gather information from the right kinds of people - **Representative Sampling**
- Think smart about cause and effect - **Randomized Controlled Trials**
- Have others check their work - **Peer Review**
- Look at ALL the evidence & see if they find **Converging Evidence**

Let’s use our training by considering some real-world examples…

We often come across news articles and social media posts that claim that **scientists** have found something to be true. How do we decide whether to trust that it really is true?

In the next few pages, you will see side by side comparisons of real articles that have been shared online.

Based on what you have just learned, please pick which of the articles is more trustworthy.

Let’s begin

Example 1

Limit Consumption of Red and Processed Meat

Source: World Cancer Research Fund International

One of our Cancer Prevention Recommendations is to eat no more than moderate amounts of red meat, and eat little, if any, processed meat.
Our research suggests there is strong evidence that consumption of either red or processed meat are both causes of colorectal cancer.

In total, we analyzed 99 studies from around the world, comprising more than 29 million adults and over 247,000 cases of colorectal cancer.

Selected findings from this report have been published in peer-reviewed journals. Details of the papers and links to the abstract in PubMed are listed.

Example 2

3 Reasons You Should Stop Eating Reese's Cups

Source: David Wolfe

If you're reading this, I'll assume you've had a Reese's peanut butter cup at least once in your lifetime. Who hasn't? As delicious as they are, Reese's peanut butter cups can be detrimental to your health because of these ingredients:

1. Soy lecithin has been found to have detrimental effects on fertility and reproduction.
2. PGPR is short for polyglycerol polyricinoleate. It has been linked to gastrointestinal problems.
3. TBHQ stands for tertiary butylhdroquinone. It's derived from petroleum and can be extremely toxic. It can damage the lungs and cause stomach cancer.

Example 1

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If you're reading this, I'll assume you've had a Reese's peanut butter cup at least once in your lifetime. Who hasn't? As delicious as they are, Reese's peanut butter cups can be detrimental to your health because of these ingredients:

Which of the two examples do you think is more trustworthy?

a. Example 1: Limit Consumption of Red and Processed Meat
b. Example 2: 3 Reasons You Should Stop Eating Reese's Cups

Why did you choose that answer?

Type here_

Example 1

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FEEDBACK

Example 1 is more **trustworthy**.

This article claims that eating red or processed meat can cause colorectal cancer.

You **can trust** that this claim is true because:

1. the article provides **converging evidence** from multiple sources to support the claim. The evidence is the 99 studies.

2. The article has been published in **peer reviewed** journals, which means it's been carefully checked for errors and biases.

Example 2 is **not trustworthy**.

This article claims that Reese's Cups are bad for your health because some of its ingredients cause health problems.

This article is **not trustworthy** because:

1. **It doesn't mention any evidence** that the ingredients of Reese's Cups actually cause these problems. It just says that they do.

Later research debunked the claims made in **example 2** and found that those ingredients are considered safe food additives.

Example 2

3 Reasons You Should Stop Eating Reese's Cups

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Example 3

<u>**Why You've Never Heard of the Raw Milk Cure**</u>

Source: The Bullvine

In the early 1900s, Mayo Clinic doctors were curing just about every disease with just one simple medicine — raw, grass-fed, cow's milk. The protocol for his "Milk Cure" was simple – put patients on bed rest and feed them nothing but a couple of gallons of milk a day.

One patient reduced from 325 pounds to 284 in two weeks, on four quarts of milk a day. Another patient with diabetes improved in every way and was sugar free in 8 weeks.

Despite the wild success of "The Milk Cure," it has since been long forgotten. Likely for two reasons:

1. Mainstream milk is no longer a medicinal super-food.
2. The medical industry can't make any money from it.

Example 4

<u>**Exercise May Boost Effects of Therapy**</u>

Source: Science Daily

In this study, researchers recruited 150 adults who were experiencing major depressive episodes. Half of them were randomly assigned to cycle for 30 minutes; the other half sat still for 30 minutes. All participants filled out surveys immediately before and after the cycling or sitting session, and then 75-minutes after the session.

The study participants were less depressed after 30 minutes of cycling than after the same amount of sitting still, and this improved mood after cycling lasted for up to 75 minutes. The results suggest that exercise improves the mood of depressed people for a short time, so they might want to exercise before doing something mentally demanding…like giving a presentation, taking a test, or going to therapy.

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Example 4

Exercise May Boost Effects of Therapy

Source: Science Daily

In this study, researchers recruited 150 adults who were experiencing major depressive episodes. Half of them were randomly assigned to cycle for 30 minutes; the other half sat still for 30 minutes. All participants filled out surveys immediately before and after the cycling or sitting

Which of the two examples do you think is more trustworthy?

a. Example 3: Why You've Never Heard of the Raw Milk Cure
b. Example 4: Exercise May Boost Effects of Therapy

Why did you choose that answer?
Type here_

FEEDBACK

Example 4 is more **trustworthy**.
This article claims that exercise can improve the mood of depressed people for up to 75 minutes.

This article is **more trustworthy** because:
1. This study has two groups: the exercise group (cycling) and a no-exercise group (sitting) for comparison. So, there is **a comparison group**.
2. Half the participants were **randomly assigned** to the sitting or cycling group. This makes it likely that both groups of people were about equal in terms of how depressed they were, how fit they were, and other things that could affect how the study turned out.

Because of these two things, this article provides **good evidence** that 30 minutes of cycling **caused** depressed people to improve their mood for up to 75 minutes. This study is a randomized controlled trial.

Example 4

Exercise May Boost Effects of Therapy

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1. Mainstream milk is no longer a medicinal super-food.
2. The medical industry can't make any money from it.

FEEDBACK

Example 3 is **not trustworthy**.
This article claims that raw milk cures several medical conditions.

You **cannot trust** that this claim is true because:

1. There is **no comparison group.** You are only told what happens to the people who drank a lot of raw milk. You don't know what happened to people who did NOT drink any raw milk.
2. There is **no random assignment** of study participants to a group who drank a lot of raw milk and a group who did not drink any raw milk.

Because of these two problems, this article provides **poor evidence** that drinking raw milk **caused** people to lose weight or to improve their diabetes.

Let’s Review

You can **trust** information from scientists if:

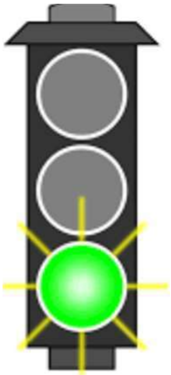
1. the information is **true or accurate**
2. the scientists produced this information in an **unbiased** manner

HOW do scientists do accurate and unbiased work?

By following **rules and guidelines.** These are called the **scientific method.**

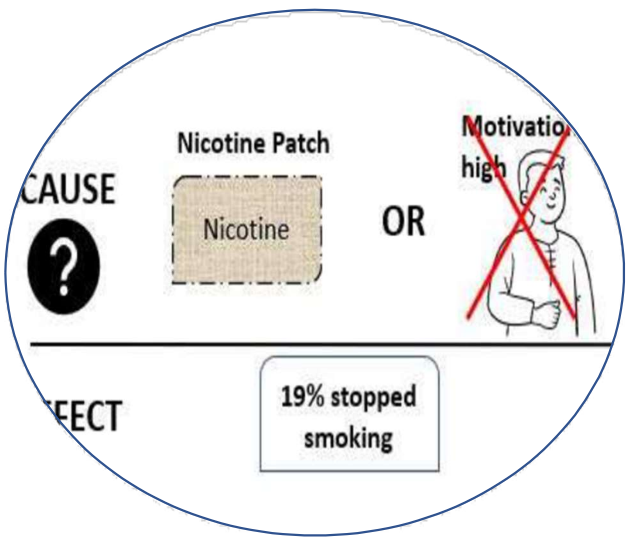
We covered **4 methods** that help scientists do **trustworthy** work**:**

- Gather information from the right kinds of people - **Representative Sampling**
- Think smart about cause and effect - **Randomized Controlled Studies**
- Have others check their work - **Peer Review**
- Look at all the evidence & check for **Converging Evidence**



Representative Sampling.

When scientists are studying a large group of people that is made up of different groups of people, the scientists choose people for the study (the sample) that include ALL of those different types of people. This means that whatever the scientists discover about the sample of people in their study will probably **represent** (or be true of) **the larger group.**



Randomized Controlled Trials.

Scientists can accurately identify **cause and effect** by using comparison groups and random assignment.

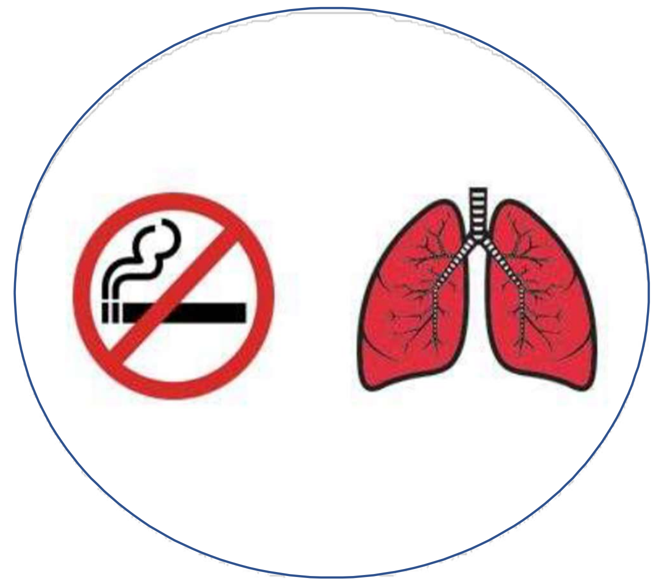
Using a **comparison group** lets scientists know if there is an effect and how big that effect is.

By **randomly assigning** participants to different groups in the study, scientists can more accurately identify what's causing the effect.

Peer Review

They conduct **peer reviews** to check each other's work before it is published.

This allows scientists to double check each other and avoid any biases in their own work.



Converging Evidence

Scientists gather multiple sources of evidence before deciding that a new claim (or idea) is true. When they have checked **all** the evidence they can find and most of it supports the new claim, then the scientists have found **converging evidence.**

Converging evidence makes information more **trustworthy.**

Great job!

You have completed the module.

Let's Talk About the

COVID-19 Vaccines

Overview: What you should know about COVID-19 vaccines

- There are four COVID-19 vaccines, which include primary series and boosters, recommended in the United States.
- Vaccine recommendations are based on age, the first vaccine received, and time since last dose.
- Minor side effects after a COVID-19 vaccine are common
    - Serious side effects can occur but are very rare.

Table of Contents

In this module, we will cover the following topics:

1. Different types of vaccines and how they work
2. Developing the vaccines
3. Effectiveness and safety
4. Protecting the Community: Community Immunity
5. Common concerns and misconceptions

Different Types of Vaccines and How they Work

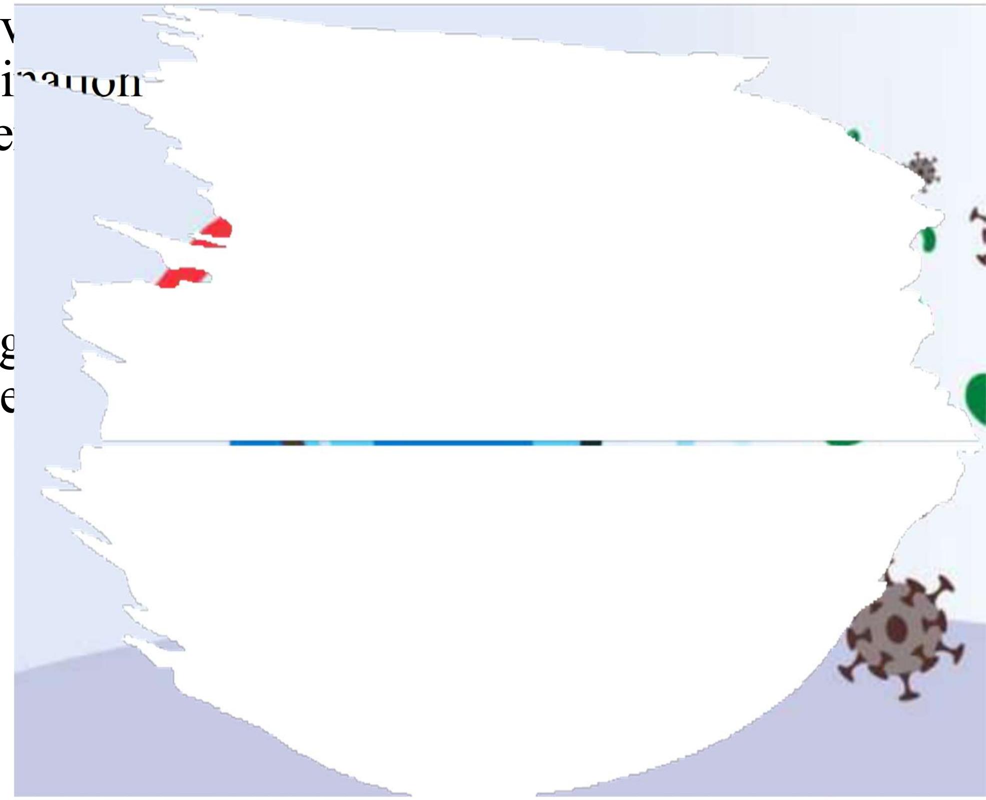
COVID-19 vaccines help our bodies develop immunity to the virus that causes COVID-19 without us having to get the illness.

- Different types of vaccines work in different ways to offer protection from viruses. **But with all vaccines**, the body's immune system is left with a supply of **antibodies** that can fight the virus in the near future.

- The process of building up antibodies is called an immune response. When there are enough of these antibodies in the body, you have immunity and have a good chance of fighting off the virus if you get infected.

- It typically takes a few weeks after vaccination for the immune system to produce these antibodies. Therefore, it is possible that a person could be infected with the v that causes COVID-19 just before or just after vaccination and then get sick because the vaccine did not have e time to provide protection.

- Sometimes after vaccination, the process of building immunity can cause symptoms, such as fever. These symptoms are normal signs the body is building immunity.



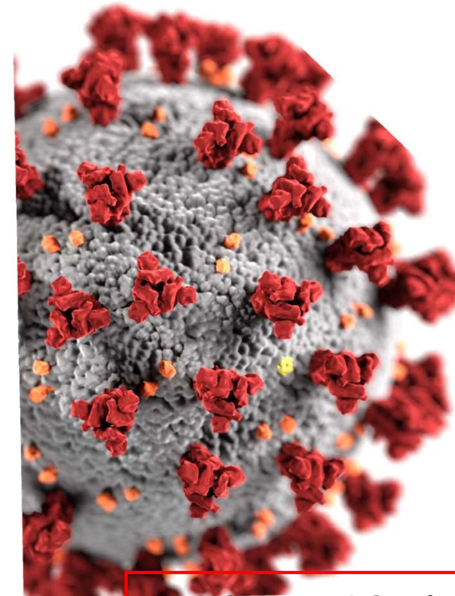
Currently, there are three main **types** of COVID-19 vaccines that are approved or authorized for use in the United States: mRNA, viral vector, and protein subunit. Each type of vaccine prompts our bodies to recognize and help protect us from the virus that causes COVID-19.

None of these vaccines can give you COVID-19.

- These vaccines do **not** use any live virus.
- These vaccines **cannot** cause infection with the virus that causes COVID-19 or other viruses.

They do not affect or interact with our DNA.

- These vaccines do **not** enter the part of the cell where our DNA (genetic material) is located, so it cannot change or influence our genes.



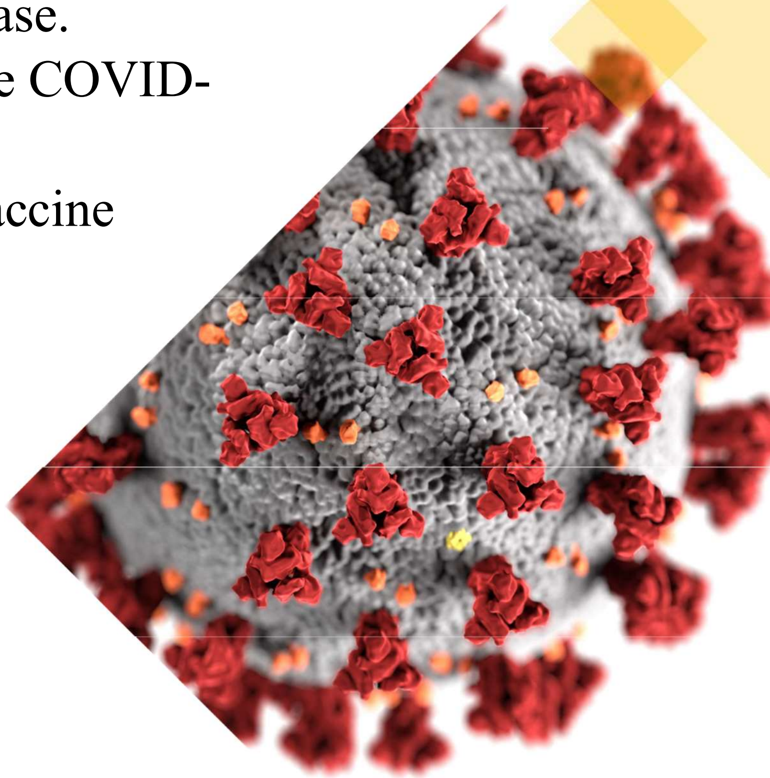
- **Pfizer and Moderna** **(mRNA)**
  - These vaccines use mRNA, which is a molecule that carries instructions on how to make a **spike protein**. A spike protein impersonates what the COVID-19 virus would look like so that our bodies can learn how to fight it.

- **Johnson and Johnson's Janssen (J&J)** **(Viral Vector)**
  - These vaccines use a modified version of a **different virus** (a vector virus) to deliver the instructions to our cells on how to make that spike protein.

- **Novavax** **(Protein Subunit)**
  - These vaccines contain pieces of the spike protein. They also contains another ingredient called an **adjuvant** that helps the immune system respond to that spike protein in the future.

A COVID-19 virus with red spikes. Our immune system recognizes the virus as "foreign" by its spikes.

- The red spike protein is found on the surface of the virus that causes COVID-19. (see picture on right)
- Once the vaccine enters our body, it produces spike proteins on cells that are **NOT** COVID-19 viruses and cannot cause the disease.
  - Remember, this piece of spike protein **impersonates** the COVID-19 virus **without** being dangerous.
- After the protein piece is made, our cells break down the vaccine and remove it; so, it leave the body as waste.



How the Vaccines Work in our Bodies

- Next, some of our cells display the "fake" spike protein piece on their surface. Our immune system recognizes that the spike protein does not belong there. This triggers our immune system to **produce antibodies** to fight off what it thinks is an infection. This is what your body might do if you got sick with COVID-19.
- At the end of the process, our bodies have learned how to help protect against future infection with the virus that causes COVID-19.

- **The benefit is that people get this protection from a vaccine without having to risk the potentially serious consequences of getting sick with COVID-19.**
- **Most side effects from getting the vaccine are normal signs that the body is building protection.**

Why Booster Shots are Needed

- The virus that causes COVID-19 **mutates** (or changes) over time
  - Similar to the flu in this regard
- Also, the immunity from vaccinations wears off after several months.

Therefore, booster shots are needed:

- To **target new strains** as they change over time; and
- To **boost up immunity** after it weakens.

How do COVID-19 vaccines protect us from the virus that causes COVID-19?

a. They infect us with a mild form of the COVID-19 virus, so our body builds up natural immunity.
b. The change the DNA in some of the cells in our body so these cells can fight the virus.
c. They simulate a real virus so our immune system can create antibodies that recognize and fight the real virus.
d. All of the above

Feedback A: None of the COVID-19 vaccines contain the actual COVID-19 virus. Instead, they help create spike proteins which imitate what the COVID-19 virus would look like so our bodies can build an immune response to it. This way, if our body is exposed to the real COVID-19 virus, our immune system will be prepared to fight the virus.

Feedback B: None of the COVID-19 vaccines change our DNA. They provide information to our cells to help create spike proteins which imitate what the COVID-19 virus would look like so our bodies can build an immune response to it. This way, if our body is exposed to the real COVID-19 virus, our immune system will be prepared to fight the virus.

Feedback C: Correct, COVID-19 vaccines imitate what the COVID-19 virus would look like so our bodies can build an immune response to it. This way, if our body is exposed to the real COVID-19 virus, our immune system will be prepared to fight the virus.

Feedback D: None of the COVID-19 vaccines contain the actual COVID-19 virus OR change our DNA. Instead, they help create spike proteins which imitate what the COVID-19 virus would look like so our bodies can build an immune response to it. This way, if our body is exposed to the real COVID-19 virus, our immune system will be prepared to fight the virus.

Developing the Vaccines

Developing the Vaccine

While COVID-19 vaccines were developed rapidly, all steps have been taken to make sure they are safe and effective.

Bringing a new vaccine to the public involves many steps including:

- **Vaccine development**
- **Clinical trials**
- **U.S. Food and Drug Administration (FDA) authorization or approval**
- **Safety Monitoring**
    - **As COVID-19 vaccines are distributed to the public, the health care system monitors and checks them to make sure that they are safe.**

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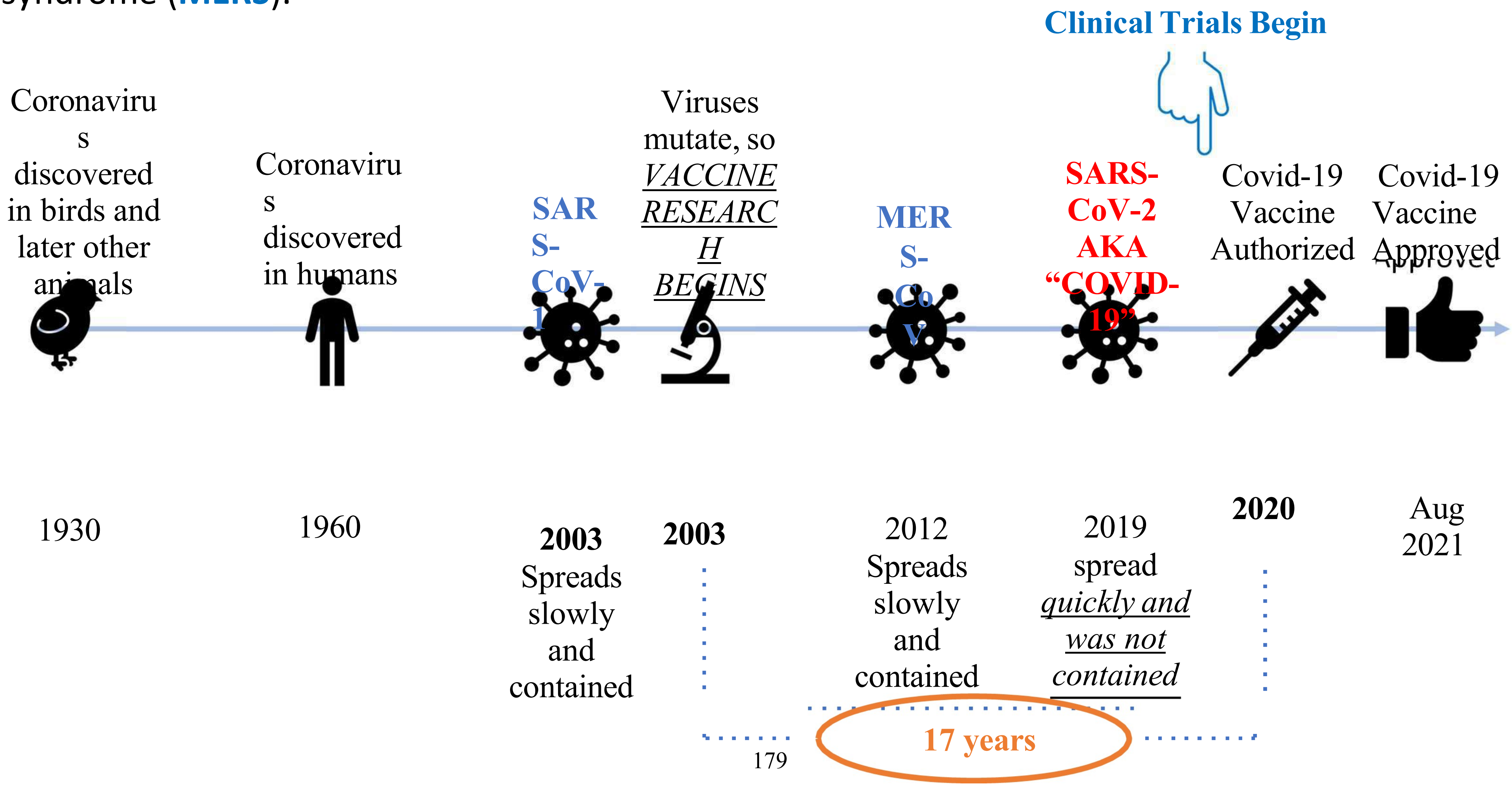
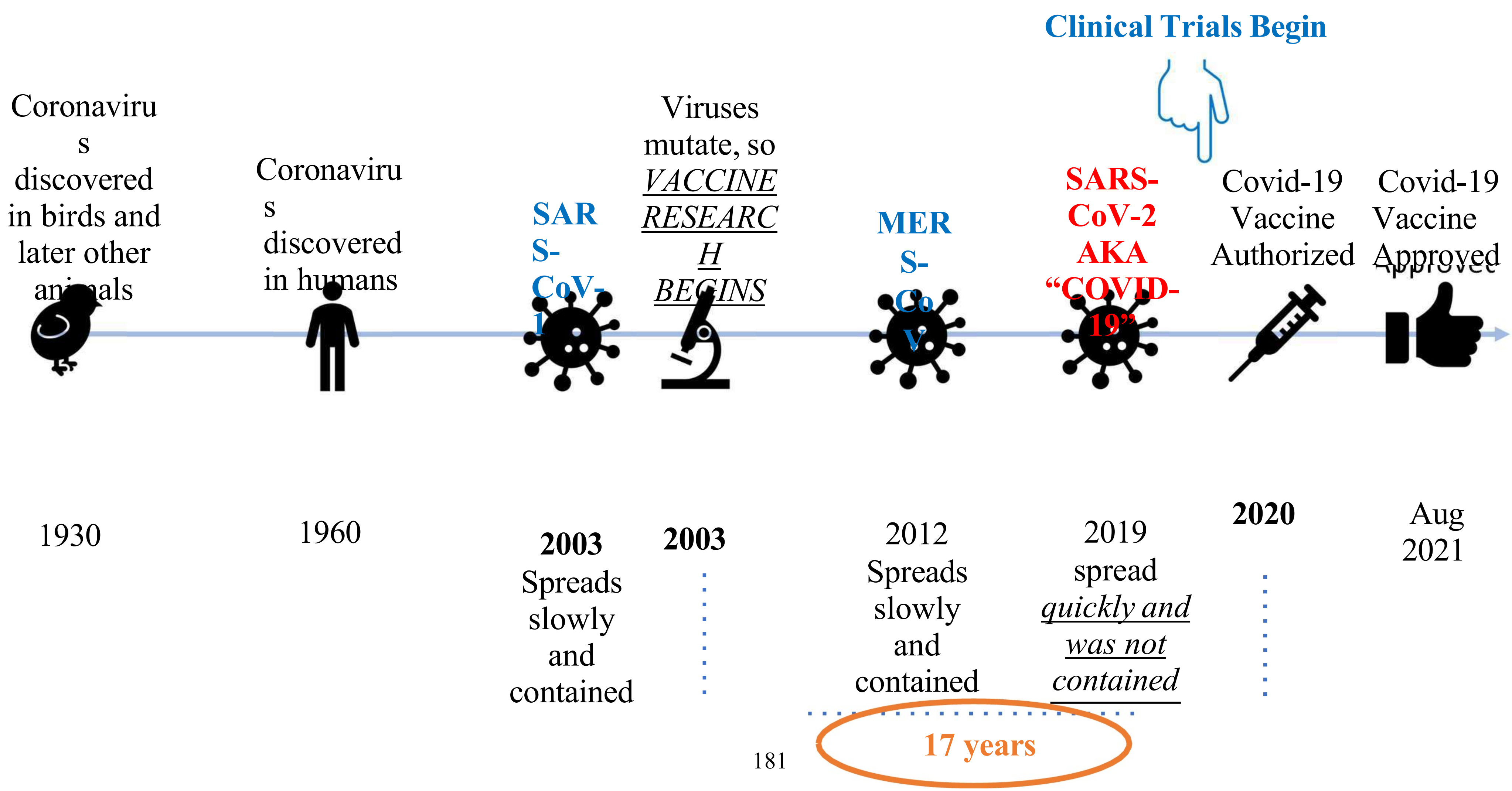
Scientists have been working for many years to develop vaccines against **coronaviruses**, such as those that cause severe acute respiratory syndrome (**SARS**) and Middle East respiratory syndrome (**MERS**).



Source: Kapoor et al., 2020. Images: Treado, 2021.

SARS-CoV-2, the virus that causes **COVID-19**, is related to these **other coronaviruses (SARS & MERS)**. The knowledge that was gained through **17 years of past research (see timeline)** on coronavirus vaccines helped speed up the development of the COVID-19 vaccines.



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  - **As COVID-19 vaccines are distributed to the public, the health care system monitors and checks them to make sure that they are safe.**

Clinical trials are medical research studies that are conducted on human volunteers in a controlled environment.

- Clinical trials for vaccines compare outcomes (such as how many people get sick) between **people who are vaccinated** and **people who are not**.
  - The results from these trials have shown that COVID-19 vaccines are **safe and effective.** This means that people who take the vaccine are still safe, but they have much less severe illness, hospitalization, and death compared to people who do not take it.

- After initial laboratory development, vaccines go through **three phases of clinical trials** to make sure they are safe and effective.
  - **All COVID-19 vaccines** went through each of the three phases of clinical trials.
  - The clinical trials for COVID-19 vaccines have involved **tens of thousands of volunteers** of **different ages, races, and ethnicities** to represent the diversity of the United States population.

Developing the Vaccine

While COVID-19 vaccines were developed rapidly, all steps have been taken to make sure they are safe and effective.

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  - **As COVID-19 vaccines are distributed to the public, the health care system monitors and checks them to make sure that they are safe.**

Emergency Use Authorization

Before vaccines are made available to people in real-world settings, **the Food and Drug Administration (FDA) looks at the findings from clinical trials.**

Emergency Use Authorizations can be issued more quickly than full approval. The emergency authorizations were granted before full approval because **COVID-19 spread quickly and was not contained**, so there were **millions of infections that resulted in thousands of hospitalizations and deaths**.

After the clinical trials, FDA determined that COVID-19 vaccines met FDA's safety and effectiveness standards and granted those vaccines Emergency Use Authorizations. These allowed the vaccines to be quickly distributed for use while maintaining the same high safety standards required for all vaccines.

By late December, 2020 and early 2021, COVID-19 vaccines became available to the general public.

The Food and Drug Administration (FDA) has granted full approval for some COVID-19 vaccines (including Pfizer and Moderna). Before granting approval, FDA reviewed evidence that built on the data and information submitted to support the Emergency Use Authorization. This included:

- Results from the clinical trials
- Details of the manufacturing process
- Vaccine testing results to ensure vaccine quality
- Inspections of the sites where the vaccine is made

These vaccines **were found to meet the high standards for safety, effectiveness**, and manufacturing quality FDA requires of an approved product.

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Bringing a new vaccine to the public involves many steps including:

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- **Safety Monitoring**
    - **As COVID-19 vaccines are distributed to the public, the health care system monitors and checks them to make sure that they are safe.**

Safety Monitoring

After the COVID-19 vaccines were tested in the clinical trials and authorized for human use, hundreds of millions of people in the United States have received these vaccines under the **most intense safety monitoring in U.S. history.**

CDC and FDA continue to closely monitor several reporting systems, like the Vaccine Adverse Event Reporting System (VAERS), Vaccine Safety Datalink, and V-Safe.

- These tools allow anyone including healthcare professionals, vaccine manufacturers, and the general public to report any side effects from taking the vaccine.
- Then, medical professionals check out every problem in these databases to figure out whether the problem was really caused by the vaccine.
- **If** any patterns of repeated bad side effects are found, then these are investigated carefully.

VAERS Vaccine Adverse Event Reporting System
www.vaers.hhs.gov

Which of the following is TRUE about the development of the COVID-19 vaccines?

a. Research on coronaviruses began in 2019.

b. COVID-19 vaccines went through 3 phases of clinical trials to test for safety and effectiveness

c. Scientists monitored side effects from the vaccine ONLY during the clinical trials.

d. COVID-19 vaccines did not meet the safety and effectiveness standards of the FD

Feedback A: Research on Coronaviruses began almost 20 years ago in 2003. There have been other outbreaks such as SARS-COV-1 and MERS-COV which have not been to the same scale and severity as COVID-19. The clinical trials for COVID-19 that tested the safety and effectiveness of the vaccines started in 2019.

Note:
The vaccines have successfully gone through ALL three phases of clinical trials and met the safety and effectiveness standards of the FDA. Scientists continue to monitor vaccine safety through reporting systems like VAERS.

Feedback B: Correct. After initial laboratory development, vaccines go through three phases of clinical trials to make sure they are safe and effective. All COVID-19 vaccines went through each of the three phases of clinical trials and met the safety and effectiveness standards of the FDA.
These trials involved tens of thousands of volunteers of different ages, races, and ethnicities to represent the diversity of the United States population.
Scientists continue to monitor vaccine safety through reporting systems like VAERS.
Note:
Research on Coronaviruses began almost 20 years ago in 2003. The clinical trials for COVID-19 that tested the safety and effectiveness of the vaccines started in 2019.

Feedback C: Even after the clinical trials, scientists continue to monitor any side effects through monitoring systems such as VAERS. There is on going safety monitoring to evaluate any patterns of adverse effects from the vaccines in the general population.
Note:
Research on Coronaviruses began almost 20 years ago in 2003. The clinical trials for COVID-19 that tested the safety and effectiveness of the vaccines started in 2019. The vaccines have successfully gone through all three phases of the clinical trials and met the safety and effectiveness standards of the FDA.

COVID Vaccine Effectiveness

How Well Do the Vaccines Work?

- People who are **up to date on their vaccines** have **lower risk of severe illness, hospitalization and death from COVID-19** than people who are **unvaccinated or who have only received the primary series**.

- Updated COVID-19 **boosters can help restore protection that has decreased since previous vaccination.**
  - The updated boosters provide added protection against the recent Omicron subvariants of the COVID-19 virus that are more contagious than the previous ones.

COVID-19

Vaccine Effectivenes s

Vaccination

- **Helps protect** you from getting COVID-19
- **Greatly reduces** chance of death and hospitalization
- **Reduces** the chance that you will **infect family and friends** with COVID-19

COVID Vaccine Safety

Safety of the Vaccines

COVID-19 vaccines have undergone—and will continue to undergo—the most **intensive safety monitoring in U.S. history**.

Evidence from the hundreds of millions of COVID-19 vaccines already administered in the United States, and the billions of vaccines administered globally, demonstrates that they are safe and effective.

Side effects that **happen within 7 days of getting vaccinated** are common but are mostly **mild**. Sometimes they may affect a person's ability to do daily activities.

Common side effects reported include:

- Fever
- Chills
- Tiredness
- Headache

These side effects are more common **after the second dose** of a Pfizer-BioNTech, Moderna, or Novavax COVID-19 vaccine.

Rare Side Effects

- Severe allergic reactions to vaccines are rare but can happen. These usually happen within 15 minutes of vaccination. That's why you are asked to wait for 15 minutes after your shot. The health care professionals can safely treat these severe allergic reactions if you wait.

- There is a rare risk of heart inflammation (myocarditis and pericarditis) associated with mRNA vaccination, mostly among males ages 12–39 years. The rare risk may be further reduced with a longer interval between the first and second dose.
  - Cases of myocarditis and pericarditis have also been reported in people who received Novavax COVID-19 vaccine.

- A rare but serious risk of blood clots with low platelets (thrombosis with thrombocytopenia syndrome) is associated with the J&J (Johnson & Johnson's Janssen) vaccine. This occurs at a rate of about 4 cases per million doses of the J&J vaccine and has resulted in deaths. **Because of this risk, vaccination with COVID-19 vaccines other than J&J vaccine is preferred**.

Benefits for yourself:

- **Prevents serious illness**: COVID-19 vaccines are safe and effective at **protecting people from getting seriously ill, being hospitalized, and dying**.
- A **safer way to build protection**: Getting vaccinated is a safer, more reliable way to build protection than getting sick with COVID-19.
    - The chances of an **unvaccinated** person dying from COVID-19 is **MUCH** greater than the chances of a **vaccinated** person dying from the COVID-19 vaccine
- Offers added protection: COVID-19 vaccines can offer **added protection** to people who had COVID-19, including protection against being hospitalized from a new infection.

Benefits for others:

- By getting vaccinated and keeping your vaccinations up to date, you will **protect your family, friends, and community from getting COVID-19** because you will be less likely to spread the virus to others.

Vaccination remains the **safest strategy** for avoiding hospitalizations, long-term health outcomes, and death.

Which of the following is a benefit of COVID-19 vaccines?

a. Reduces likelihood of hospitalization and death.

b. Reduces likelihood that you will infect family and friends.

c. It's a safer way to build protection than getting sick from the virus.

d. All of the above.

Feedback A: COVID-19 vaccines do reduce the likelihood of hospitalization and death. They also
- reduce likelihood that you will infect family and friends AND
- provide a safer way to build protection than getting sick from the virus.
So, the correct answer is, d. All of the above.

Feedback B: COVID-19 vaccines do reduce likelihood that you will infect family and friends They also
- reduce the likelihood of hospitalization and death AND
- provide a safer way to build protection than getting sick from the virus.
So, the correct answer is, d. All of the above.

Feedback C: COVID-19 vaccines do provide a safer way to build protection than getting sick from the virus. They also
- reduce the likelihood of hospitalization and death AND
- reduce likelihood that you will infect family and friends.

So, the correct answer is, d. All of the above.

Feedback D: Correct: COVID-19 vaccines:
- Reduce the likelihood of hospitalization and death,
- Reduce likelihood that you will infect family and friends, AND
- Provide a safer way to build protection than getting sick from the virus.

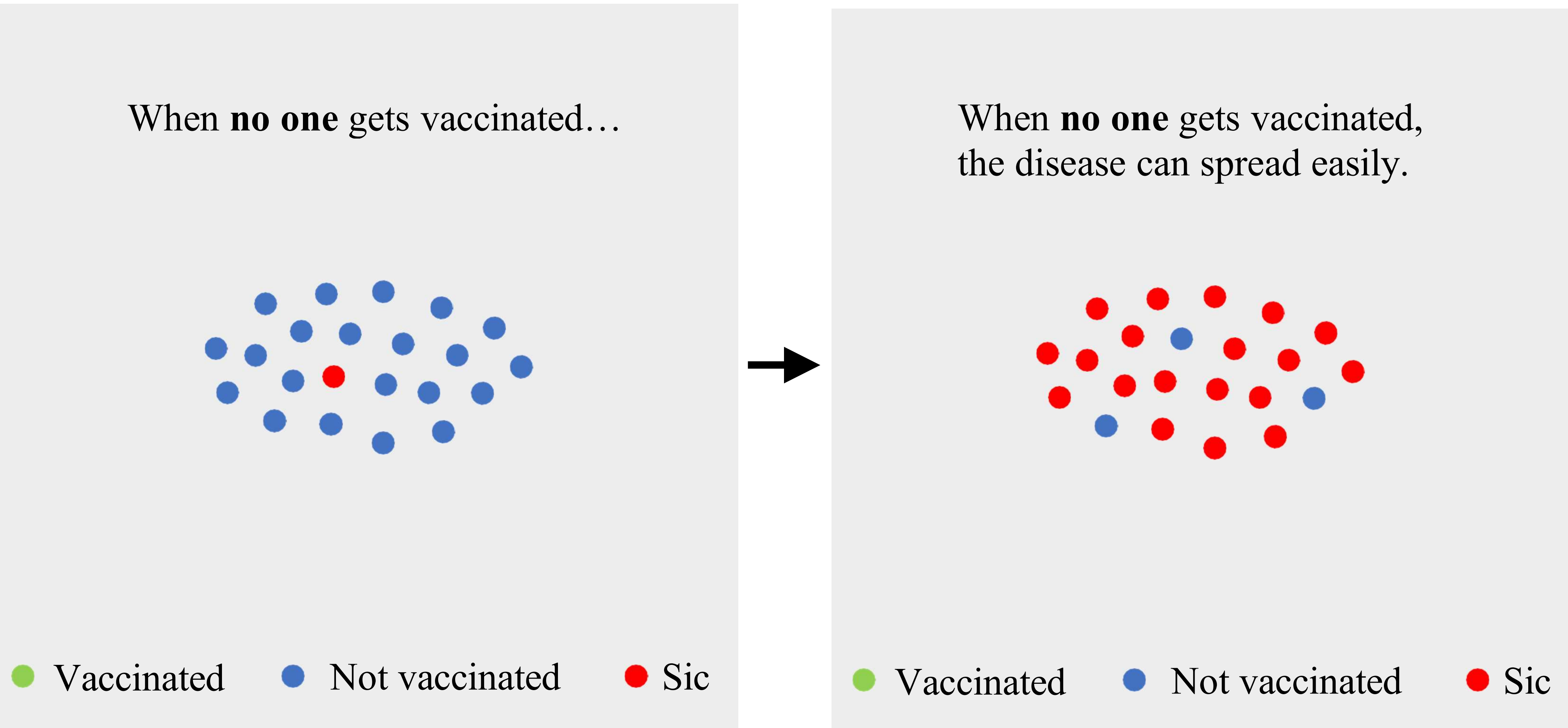
Protecting the Community: Community Immunity

How Vaccines Help to Provide "Community Immunity"

Community immunity is also called **herd immunity**

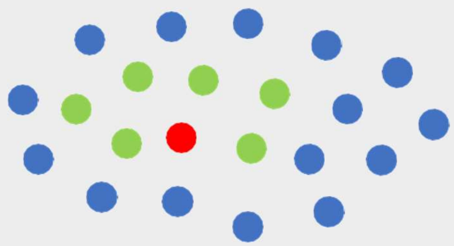
- Germs can travel **quickly** through a community and make a lot of people sick
- If enough people get sick, it can lead to an outbreak
- But when enough people are vaccinated against a certain disease, the germs can't travel as easily from person to person — and the entire community is less likely to get the disease
- That means even people who can't get vaccinated (because of a medical condition) will have some **protection** from getting sick

Community Immunity



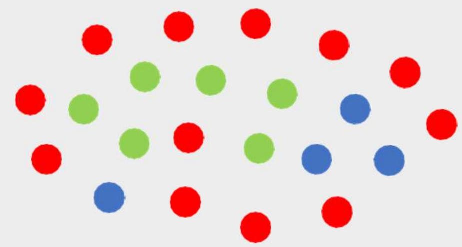
Community Immunity

When **some people** get vaccinated…



Vaccinated   Not vaccinated   Sic

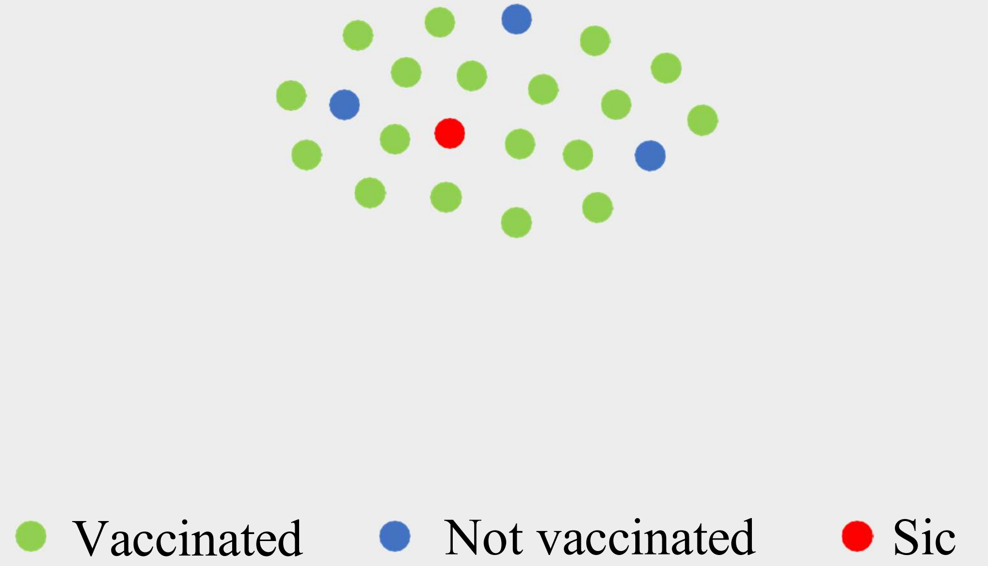
When **some people** get vaccinated,
the disease can spread a little slower.



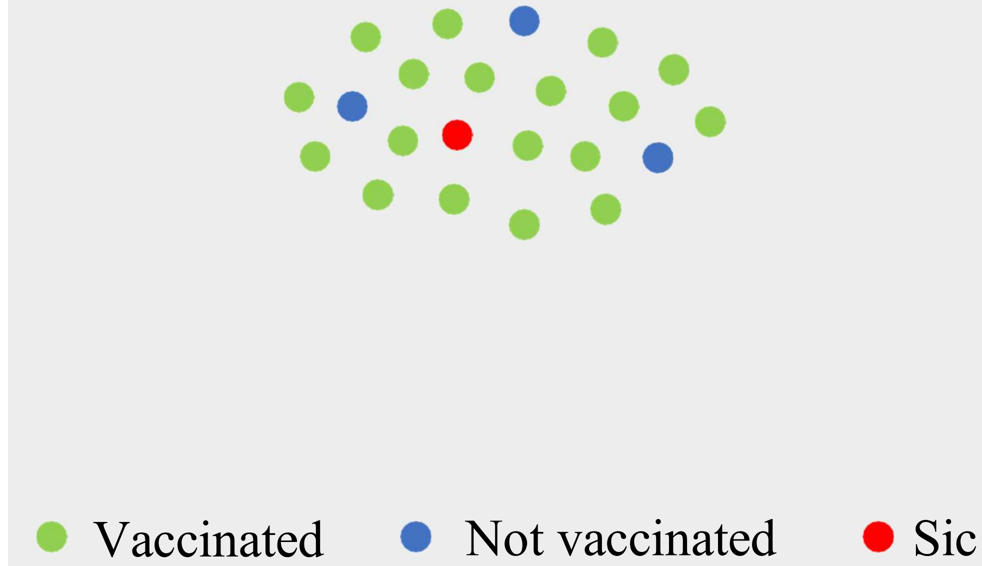
Vaccinated   Not vaccinated   Sic

Community Immunity – also called *herd immunity*

When **most people** get vaccinated…



When **most people** get vaccinated, the disease cannot spread.



How does community (or herd) immunity provide protection for the community?

a. Prevents the virus from spreading quickly within the community

b. People with a strong immune system will stay protected

c. Those who cannot get vaccinated will stay protected from the virus

d. Both a and c

Feedback A: Herd immunity offers protection to the community by preventing the virus from spreading quickly. It also helps by protecting members of the community who may not be able to get vaccinated (perhaps due to a preexisting medical condition).
So, the correct answer is d. Both a and c.

Feedback B: Herd immunity occurs when most of the population gets vaccinated. This protects the community by preventing the virus from spreading quickly. It also helps by protecting members of the community who may not be able to get vaccinated (perhaps due to a preexisting medical condition). So, the correct answer is d. Both a and c.

Feedback C: Herd immunity offers protection to the community by protecting members of the community who may not be able to get vaccinated (perhaps due to a preexisting medical condition). It also helps by preventing the virus from spreading quickly. So, the correct answer is d. Both a and c.

Feedback D: Correct. Herd immunity offers protection to the community by preventing the virus from spreading quickly. It also helps by protecting members of the community who may not be able to get vaccinated (perhaps due to a preexisting medical condition).

Common Concerns and Misconceptions

MYTH: COVID-19 vaccines cause variants.

FACT: COVID-19 vaccines do not create or cause variants of the virus that causes COVID-19. Instead, COVID-19 vaccines can help prevent new variants from emerging.

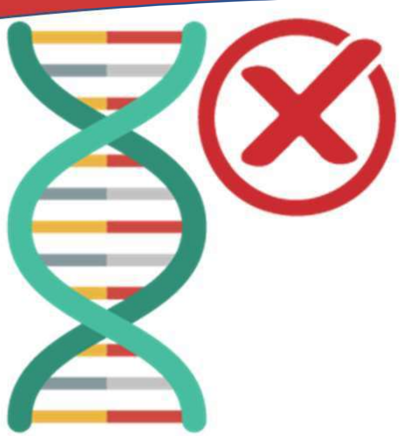
New variants of a virus happen because the virus that causes COVID-19 constantly changes through a **natural ongoing process of mutation (change)**. As the virus spreads, it has more opportunities to change. High vaccination coverage in a population reduces the spread of the virus and helps prevent new variants from emerging. CDC recommends COVID-19 vaccines for everyone ages 6 months and older, and boosters for everyone 5 years and older, if eligible.

MYTH: All events reported to the Vaccine Adverse Event Reporting System (VAERS) are caused by vaccination.

FACT: Anyone can report events to VAERS, even if it is not clear whether a vaccine caused the problem. Because of this, VAERS data alone cannot determine if the reported adverse event was caused by a COVID-19 vaccination.

Some VAERS reports may contain information that is incomplete, inaccurate, coincidental, or unverifiable. Vaccine safety experts study these adverse events and look for unusually high numbers of health problems, or a pattern of problems, after people receive a particular vaccine. Recently, the number of deaths reported to VAERS following COVID-19 vaccination has been misinterpreted and misreported as if this number means deaths that were proven to be caused by vaccination. Reports of adverse events to VAERS following vaccination, including deaths, do not necessarily mean that a vaccine caused a health problem.

MYTH: COVID-19 vaccines can alter my DNA.



FACT: COVID-19 vaccines do not change or interact with your DNA in any way.

Both messenger RNA (mRNA) and viral vector COVID-19 vaccines work by delivering instructions (genetic material) to our cells to start building protection against the virus that causes COVID-19.

After the body produces an immune response, it removes all the vaccine ingredients just as it would remove any information that cells no longer need. This process is a part of normal body functioning.

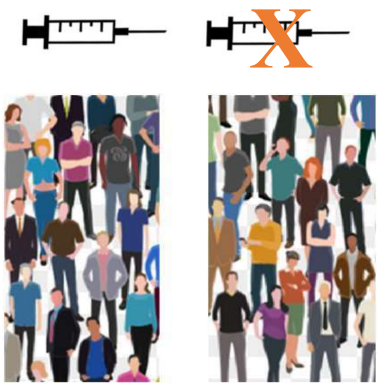
The genetic material delivered by mRNA vaccines never enters the nucleus of your cells, which is where your DNA is kept. Viral vector COVID-19 vaccines deliver genetic material to the cell nucleus to allow our cells to build protection against COVID-19. However, the vector virus does not have the machinery needed to integrate its genetic material into our DNA, so it cannot alter our DNA.

Let’s Review

The key things to remember about the vaccines:

- There are four COVID-19 vaccines, which include primary series and boosters, recommended in the United States.
- Vaccine recommendations are based on age, the first vaccine received, and time since last dose.
- Minor side effects after a COVID-19 vaccine are common
    - Serious side effects can occur but are very rare.

Large Clinical Trials



- **110,000+** people
- ½ vaccinated; ½ not vaccinated
- Authorized for Emergency Use

Full FDA Approval

- **Same 110,000+ people**
- Checked potential safety issues
- Inspected manufacturing plants
- Given full FDA approval

Ongoing Safety Monitoring

- **Over 200 million** fully vaccinated in US (Source: CDC)
- Potential safety issues recorded in national database (VAERS)
- All serious issues investigated

Fall 2020/Early 2021 — August 2021 — Present

TESTING TIMELINE

Vaccine Safety and Side Effects

- Some people worry about the possibility of future unknown side effects from the vaccine
  - Vaccine monitoring has historically shown that **side effects generally happen within six weeks of receiving a vaccine dose.**
  - Over 12 months, hundreds of millions of people have received COVID-19 vaccines, and no delayed side effects have been detected.
  - **Ongoing safety monitoring and effectiveness studies** based on these vaccinated people show that **the vaccine is safe and effective**

The benefits outweigh the risks:

- **Prevents serious illness:** COVID-19 vaccines are safe and effective at protecting people from getting seriously ill, being hospitalized, and dying.
- **A safer way to build protection:** Getting a COVID-19 vaccine is a safer, more reliable way to build protection than getting sick with COVID-19.
- **Offers added protection:** COVID-19 vaccines can offer added protection to people who had COVID-19, including protection against being hospitalized from a new infection.

People are best protected when they stay up to date with the recommended number of doses, including bivalent boosters, when eligible.

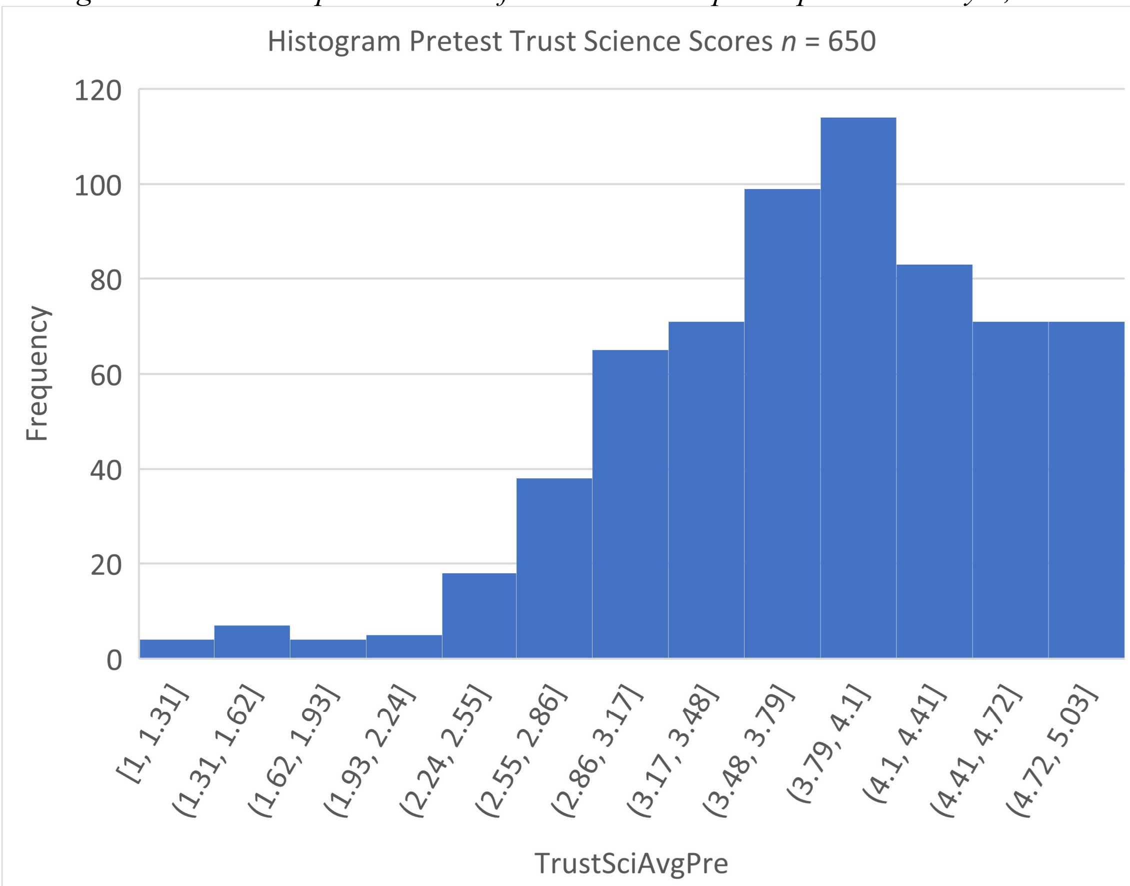
Great!
You have completed the training module.

Let's answer a few questions…

APPENDIX F – Additional Analysis

Figure F.1

Average trust in science pretest scores for all recruited participants in Study 2, n = 650.



Mean = 3.78; Median = 3.85; Skewness = -0.63

Vaccination Intention – Future Vaccination Question

- An ANCOVA with the pretest as a covariate and Future Vaccination question as the dependent variable showed no significant differences between the groups, $F(2, 155) = 0.83$, $p = .44$, $\eta^{2 =}$ .01.
- No interaction between condition and covariate, $F(2, 153) = 0.16$, $p = .85$, $\eta^{2 =}$ .002.

REFERENCES

Agley, J., Xiao, Y., Thompson, E. E., Chen, X., & Golzarri-Arroyo, L. (2021). Intervening on Trust in Science to Reduce Belief in COVID-19 Misinformation and Increase COVID-19 Preventive Behavioral Intentions: Randomized Controlled Trial. *Journal of Medical Internet Research*, *23*(10), e32425. https://doi.org/10.2196/32425

Alsan, M., Stanford, F. C., Banerjee, A., Breza, E., Chandrasekhar, A. G., Eichmeyer, S., Goldsmith-Pinkham, P., Ogbu-Nwobodo, L., Olken, B. A., Torres, C., Sankar, A., Vautrey, P.-L., & Duflo, E. (2020). Comparison of Knowledge and Information-Seeking Behavior After General COVID-19 Public Health Messages and Messages Tailored for Black and Latinx Communities. *Annals of Internal Medicine*. https://doi.org/10.7326/M20-6141

Armstrong, K., Rose, A., Peters, N., Long, J. A., McMurphy, S., & Shea, J. A. (2006). Distrust of the health care system and self-reported health in the United States. *Journal of General Internal Medicine*, *21*(4), 292. https://doi.org/10.1111/j.1525-1497.2006.00396.x

Baack, B. N., Abad, N., Yankey, D., Kahn, K. E., Razzaghi, H., Brookmeyer, K., Kolis, J., Wilhelm, E., Nguyen, K. H., & Singleton, J. A. (2021). COVID-19 Vaccination Coverage and Intent Among Adults Aged 18–39 Years—United States, March–May 2021. *MMWR. Morbidity and Mortality Weekly Report*, *70*(25), 928–933. https://doi.org/10.15585/mmwr.mm7025e2

Baden, L. R., El Sahly, H. M., Essink, B., Kotloff, K., Frey, S., Novak, R., Diemert, D., Spector, S. A., Rouphael, N., Creech, C. B., McGettigan, J., Khetan, S., Segall, N., Solis, J., Brosz, A., Fierro, C., Schwartz, H., Neuzil, K., Corey, L., … Zaks, T. (2021). Efficacy and Safety of the mRNA-1273 SARS-CoV-2 Vaccine. *New England Journal of Medicine*, *384*(5), 403–416. https://doi.org/10.1056/NEJMoa2035389

Banas, J. A., & Rains, S. A. (2010). A Meta-Analysis of Research on Inoculation Theory. *Communication Monographs*, *77*(3), 281–311. https://doi.org/10.1080/03637751003758193

Baron, J. (1995). Myside bias in thinking about abortion. *Thinking and Reasoning*, 221–235.

Basol, M., Roozenbeek, J., Berriche, M., Uenal, F., McClanahan, W. P., & Linden, S. V. D. (2021). Towards psychological herd immunity: Cross-cultural evidence for two prebunking interventions against COVID-19 misinformation. Big Data & Society, 8(1), 20539517211013868.

Betsch, C., & Sachse, K. (2013). Debunking vaccination myths: Strong risk negations can increase perceived vaccination risks. *Health Psychology*, *32*(2), 146–155. https://doi.org/10.1037/a0027387

Betsch, C., Schmid, P., Heinemeier, D., Korn, L., Holtmann, C., & Böhm, R. (2018). Beyond confidence: Development of a measure assessing the 5C psychological antecedents of vaccination. *PLOS ONE*, *13*(12), e0208601. https://doi.org/10.1371/journal.pone.0208601

Bostrom, A., Böhm, G., O'Connor, R. E., Hanss, D., Bodi-Fernandez, O., & Halder, P. (2020). Comparative risk science for the coronavirus pandemic. *Journal of Risk Research*, *23*(7–8), 902–911. https://doi.org/10.1080/13669877.2020.1756384

Bronstein, M. V., Pennycook, G., Buonomano, L., & Cannon, T. D. (2020). Belief in fake news, responsiveness to cognitive conflict, and analytic reasoning engagement. *Thinking & Reasoning*, 1–26. https://doi.org/10.1080/13546783.2020.1847190

Browne, M. (2018). Epistemic divides and ontological confusions: The psychology of vaccine scepticism. *Human Vaccines & Immunotherapeutics*, *14*(10), 2540–2542. https://doi.org/10.1080/21645515.2018.1480244

Bunch, L. (2021). A Tale of Two Crises: Addressing Covid-19 Vaccine Hesitancy as Promoting Racial Justice. *HEC Forum*. https://doi.org/10.1007/s10730-021-09440-0

Butterfoss, F. D., Morrow, A. L., Rosenthal, J., Dini, E., Crews, R. C., Webster, J. D., & Louis, P. (1998). CINCH: An Urban Coalition for Empowerment and Action. *Health Education & Behavior*, *25*(2), 212–225. https://doi.org/10.1177/109019819802500208

Byrne, K. A., Six, S. G., Ghaiumy Anaraky, R., Harris, M. W., & Winterlind, E. L. (2020). *Risk-Taking Unmasked: Using Risky Choice and Temporal Discounting to Explain COVID-19 Preventative Behaviors* [Preprint]. PsyArXiv. https://doi.org/10.31234/osf.io/uaqc2

Capp, K., Deane, F. P., & Lambert, G. (2001). Suicide prevention in Aboriginal communities: Application of community gatekeeper training. *Australian and New*

Zealand Journal of Public Health, *25*(4), 315–321. https://doi.org/10.1111/j.1467-842X.2001.tb00586.x

Carpenter, S. M., Yates, J. F., Preston, S. D., & Chen, L. (2016). Regulating Emotions during Difficult Multiattribute Decision Making: The Role of Pre-Decisional Coherence Shifting. *PLOS ONE*, *11*(3), e0150873. https://doi.org/10.1371/journal.pone.0150873

Carter, S., Garfied, S., Newbould, J., Rennie, T., Taylor, D., Bury, M., & Campling, N. (2006). *A Review of the use of the Health Belief Model (HBM), the Theory of Reasoned Action (TRA), the Theory of Planned Behaviour (TPB) and the Trans-Theoretical Model (TTM) to study and predict health related behaviour change*.

CDC. (2020, February 11). *Community, Work, and School*. Centers for Disease Control and Prevention. https://www.cdc.gov/coronavirus/2019-ncov/community/health-equity/race-ethnicity.html

CDC. COVID data tracker: demographic trends of people receiving COVID-19 --vaccinations in the United States. Atlanta, GA: US Department of Health and Human Services, CDC; 2021. https://covid.cdc.gov/covid-data-tracker/#vaccination-demographics-trends

Charura, D., Hill, A. P., & Etherson, M. E. (2022). COVID-19 Vaccine Hesitancy, Medical Mistrust, and Mattering in Ethnically Diverse Communities. *Journal of Racial and Ethnic Health Disparities*. https://doi.org/10.1007/s40615-022-01337-z

Chou, W.-Y. S., & Budenz, A. (n.d.). Considering Emotion in COVID-19 Vaccine Communication: Addressing Vaccine Hesitancy and Fostering Va. *HEALTH COMMUNICATION*, 6.

Cohen, J. (2016). A power primer. In A. E. Kazdin (Ed.), Methodological issues and strategies in clinical research (pp. 279–284). American Psychological Association. https://doi.org/10.1037/14805-018

Conway, L. G., Woodard, S. R., & Zubrod, A. (2020). *Social Psychological Measurements of COVID-19: Coronavirus Perceived Threat, Government Response, Impacts, and Experiences Questionnaires* [Preprint]. PsyArXiv. https://doi.org/10.31234/osf.io/z2x9a

Corace, K. M., Srigley, J. A., Hargadon, D. P., Yu, D., MacDonald, T. K., Fabrigar, L. R., & Garber, G. E. (2016). Using behavior change frameworks to improve healthcare worker influenza vaccination rates: A systematic review. *Vaccine*, *34*(28), 3235–3242. https://doi.org/10.1016/j.vaccine.2016.04.071

Corner, A., & Hahn, U. (2009). Evaluating science arguments: Evidence, uncertainty, and argument. *J. Mem. Lang*, 133–152.

Clancy, C. (2006). Highlights and implications from the findings of the National Healthcare Quality Report and Disparities Report. *Retrieved November*, *30*, 2006.

Cronbach, L. J., & Furby, L. (1970). How we should measure" change": Or should we?. Psychological bulletin, 74(1), 68.

Detoc, M., Bruel, S., Frappe, P., Tardy, B., Botelho-Nevers, E., & Gagneux-Brunon, A. (2020). *Intention to participate in a COVID-19 vaccine clinical trial and to get vaccinated against COVID-19 in France during the pandemic*. 6.

Dias, N., Pennycook, G., & Rand, D. G. (2020). Emphasizing publishers does not effectively reduce susceptibility to misinformation on social media. *Harvard Kennedy School Misinformation Review*. https://doi.org/10.37016/mr-2020-001

Dimock, M., & Wike, R. (2020, November 13). America is exceptional in the nature of its political divide. *Pew Research Center*. https://www.pewresearch.org/fact-tank/2020/11/13/america-is-exceptional-in-the-nature-of-its-political-divide/

Dohle, S., Wingen, T., & Schreiber, M. (2020). Acceptance and adoption of protective measures during the COVID-19 pandemic: The role of trust in politics and trust in science. *Social Psychological Bulletin*, *15*(4), e4315. https://doi.org/10.32872/spb.4315

Douthit, N., Kiv, S., Dwolatzky, T., & Biswas, S. (2015). Exposing some important barriers to health care access in the rural USA. *Public Health*, *129*(6), 611–620. https://doi.org/10.1016/j.puhe.2015.04.001

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving Students' Learning With Effective Learning Techniques: Promising Directions From Cognitive and Educational Psychology. *Psychological Science in the Public Interest*, *14*(1), 4–58.

Ernsting, A., Knoll, N., Schneider, M., & Schwarzer, R. (2015). The enabling effect of social support on vaccination uptake via self-efficacy and planning. *Psychology, Health & Medicine*, *20*(2), 239–246. https://doi.org/10.1080/13548506.2014.920957

Fall, E., Izaute, M., & Chakroun-Baggioni, N. (2018). How can the health belief model and self-determination theory predict both influenza vaccination and vaccination intention ? A longitudinal study among university students. *Psychology & Health*, *33*(6), 746–764. https://doi.org/10.1080/08870446.2017.1401623

Farias, M., Newheiser, A.-K., Kahane, G., & de Toledo, Z. (2013). Scientific faith: Belief in science increases in the face of stress and existential anxiety. *Journal of Experimental Social Psychology*, *49*(6), 1210–1213. https://doi.org/10.1016/j.jesp.2013.05.008

Freeman, D., Loe, B. S., Chadwick, A., Vaccari, C., Waite, F., Rosebrock, L., Jenner, L., Petit, A., Lewandowsky, S., Vanderslott, S., Innocenti, S., Larkin, M., Giubilini, A., Yu, L.-M., McShane, H., Pollard, A. J., & Lambe, S. (2020). COVID-19 vaccine hesitancy in the UK: The Oxford coronavirus explanations, attitudes, and narratives survey (Oceans) II. *Psychological Medicine*, 1–15. https://doi.org/10.1017/S0033291720005188

Funk, C., Kennedy, B., & Johnson, C. (2020, May 21). Trust in Medical Scientists Has Grown in U.S., but Mainly Among Democrats. *Pew Research Center Science & Society*. https://www.pewresearch.org/science/2020/05/21/trust-in-medical-scientists-has-grown-in-u-s-but-mainly-among-democrats/

Gauchat, G. (2012). Politicization of Science in the Public Sphere: A Study of Public Trust in the United States, 1974 to 2010. *American Sociological Review*, *77*(2), 167–187. https://doi.org/10.1177/0003122412438225

Gugerty, L., & Link, D. M. (2020). How heuristic credibility cues affect credibility judgments and decisions. *Journal of Experimental Psychology: Applied*, *26*(4), 620–645. https://doi.org/10.1037/xap0000279

Gugerty, L., Shreeves, M., & Dumessa, N. (2021). Biased belief updating in causal reasoning about COVID-19. *Journal of Experimental Psychology: Applied*, *27*(4), 695–721. https://doi.org/10.1037/xap0000383

Hopfer, S. (2012). Effects of a Narrative HPV Vaccination Intervention Aimed at Reaching College Women: A Randomized Controlled Trial. *Prevention Science*, *13*(2), 173–182. https://doi.org/10.1007/s11121-011-0254-1

Hornsey, M. J., & Fielding, K. S. (2017). Attitude roots and Jiu Jitsu persuasion: Understanding and overcoming the motivated rejection of science. *American Psychologist*, *72*(5), 459–473. https://doi.org/10.1037/a0040437

Hornsey, M. J., Harris, E. A., & Fielding, K. S. (2018). The psychological roots of anti-vaccination attitudes: A 24-nation investigation. *Health Psychology*, *37*(4), 307–315. https://doi.org/10.1037/hea0000586

Hornsey, M. J., Lobera, J., & Díaz-Catalán, C. (2020). Vaccine hesitancy is strongly associated with distrust of conventional medicine, and only weakly associated with trust in alternative medicine. *Social Science & Medicine*, *255*, 113019. https://doi.org/10.1016/j.socscimed.2020.113019

Hovland, C. I., Janis, I. L., & Kelley, H. H. (1953). *Communication and persuasion*. Yale University Press.

Huff, C., & Tingley, D. (2015). “Who are these people?” Evaluating the demographic characteristics and political preferences of MTurk survey respondents. *Research & Politics*, *2*(3), 2053168015604648. https://doi.org/10.1177/2053168015604648

Johansen, L. J., Stenvig, T., & Wey, H. (2012). The Decision to Receive Influenza Vaccination Among Nurses in North and South Dakota. *Public Health Nursing*, *29*(2), 116–125. https://doi.org/10.1111/j.1525-1446.2011.00966.x

Kahan, D. M., & Corbin, J. C. (2016). A note on the perverse effects of actively open-minded thinking on climate-change polarization. *Research & Politics*, *3*(4), 2053168016676705. https://doi.org/10.1177/2053168016676705

Kahan, D. M., Jenkins-Smith, H., & Braman, D. (2011). Cultural cognition of scientific consensus. *Journal of Risk Research*, *14*(2), 147–174. https://doi.org/10.1080/13669877.2010.511246

Kahan, D. M., Peters, E., Dawson, E. C., & Slovic, P. (2017). Motivated numeracy and enlightened self-government. *Behavioural Public Policy*, *1*(1), 54–86. https://doi.org/10.1017/bpp.2016.2

Kaiser Family Foundation. COVID-19 vaccine monitor—April 2021. Washington, DC: Kaiser Family Foundation; 2021. https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-april-2021/external icon

Karlsson, L. C., Soveri, A., Lewandowsky, S., Karlsson, L., Karlsson, H., Nolvi, S., Karukivi, M., Lindfelt, M., & Antfolk, J. (2021). Fearing the disease or the vaccine:

The case of COVID-19. *Personality and Individual Differences*, *172*, 110590. https://doi.org/10.1016/j.paid.2020.110590

Khubchandani, J., Sharma, S., Price, J. H., Wiblishauser, M. J., Sharma, M., & Webb, F. J. (2021). COVID-19 Vaccination Hesitancy in the United States: A Rapid National Assessment. *Journal of Community Health*, *46*(2), 270–277. https://doi.org/10.1007/s10900-020-00958-x

Kline, R. B. (2015). *Principles and Practice of Structural Equation Modeling, Fourth Edition*. Guilford Publications.

Koehler, D. J., & Harvey, N. (Eds.). (2004). *Blackwell handbook of judgment and decision making* (1st ed). Blackwell Pub.

Krause, N. M., Freiling, I., Beets, B., & Brossard, D. (2020). Fact-checking as risk communication: The multi-layered risk of misinformation in times of COVID-19. *Journal of Risk Research*, *23*(7–8), 1052–1059. https://doi.org/10.1080/13669877.2020.1756385

Kunda, Z. (1990). *The Case for Motivated Reasoning*. 19.

Larson, H. J., Jarrett, C., Schulz, W. S., Chaudhuri, M., Zhou, Y., Dube, E., Schuster, M., MacDonald, N. E., & Wilson, R. (2015). Measuring vaccine hesitancy: The development of a survey tool. *Vaccine*, *33*(34), 4165–4175. https://doi.org/10.1016/j.vaccine.2015.04.037

LaVeist, T. A., Nickerson, K. J., & Bowie, J. V. (2000). Attitudes about Racism, Medical Mistrust, and Satisfaction with Care among African American and White Cardiac

Patients. *Medical Care Research and Review*, *57*(1_suppl), 146–161. https://doi.org/10.1177/107755870005700 1S07

Levay, K. E., Freese, J., & Druckman, J. N. (2016). The Demographic and Political Composition of Mechanical Turk Samples. *SAGE Open*, *6*(1), 2158244016636433. https://doi.org/10.1177/2158244016636433

Lin, Y., Hu, Z., Zhao, Q., Alias, H., Danaee, M., & Wong, L. P. (2020). Understanding COVID-19 vaccine demand and hesitancy: A nationwide online survey in China. *PLOS Neglected Tropical Diseases*, *14*(12), e0008961. https://doi.org/10.1371/journal.pntd.0008961

Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, N. (2001). Risk as feelings. *Psychological Bulletin*, *127*(2), 267–286. https://doi.org/10.1037/0033-2909.127.2.267

Loomba, S., de Figueiredo, A., Piatek, S. J., de Graaf, K., & Larson, H. J. (2021). Measuring the impact of COVID-19 vaccine misinformation on vaccination intent in the UK and USA. *Nature Human Behaviour*, *5*(3), 337–348. https://doi.org/10.1038/s41562-021-01056-1

Lopes, L. & 2021. (2021, March 30). KFF COVID-19 Vaccine Monitor: March 2021. *KFF*. https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-march-2021/

MacDonald, N. E. (2015). Vaccine hesitancy: Definition, scope and determinants. *Vaccine*, *33*(34), 4161–4164. https://doi.org/10.1016/j.vaccine.2015.04.036

MacFarlane, D., Tay, L. Q., Hurlstone, M. J., & Ecker, U. K. H. (2020). Refuting Spurious COVID-19 Treatment Claims Reduces Demand and Misinformation Sharing. *Journal of Applied Research in Memory and Cognition*, S2211368120301248. https://doi.org/10.1016/j.jarmac.2020.12.005

Mercadante, A. R., & Law, A. V. (2020). Will they, or Won't they? Examining patients' vaccine intention for flu and COVID-19 using the Health Belief Model. *Research in Social and Administrative Pharmacy*. https://doi.org/10.1016/j.sapharm.2020.12.012

Metzger, M. J., Flanagin, A. J., & Medders, R. B. (2010). Social and Heuristic Approaches to Credibility Evaluation Online. *Journal of Communication*, *60*(3), 413–439. https://doi.org/10.1111/j.1460-2466.2010.01488.x

Miron, A. M., & Brehm, J. W. (2006). Reactance Theory—40 Years Later. *Zeitschrift Für Sozialpsychologie*, *37*(1), 9–18. https://doi.org/10.1024/0044-3514.37.1.9

Montano, D. (1986). Predicting and Understanding Influenza Vaccination Behavior. *Medical Care*, *24*, 438–453. https://doi.org/10.1097/00005650-198605000-00007

Nadelson, L., Jorcyk, C., Yang, D., Smith, M. J., Matson, S., Cornell, K., & Husting, V. (2014). I Just Don't Trust Them: The Development and Validation of an Assessment Instrument to Measure Trust in Science and Scientists. *School Science and Mathematics*, *114*(2), 76–86. https://doi.org/10.1111/ssm.12051

Nan, X., Wang, Y., & Thier, K. (2022). Why do people believe health misinformation and who is at risk? A systematic review of individual differences in susceptibility to health misinformation. *Social Science & Medicine*, *314*, 115398. https://doi.org/10.1016/j.socscimed.2022.115398

Nelson, A. (2002). Unequal treatment: Confronting racial and ethnic disparities in health care. *Journal of the National Medical Association*, *94*(8), 666–668.

Nickerson, R. S. (1998). *Confirmation Bias: A Ubiquitous Phenomenon in Many Guises*. 46.

Nyhan, B., & Reifler, J. (2010). When Corrections Fail: The Persistence of Political Misperceptions. *Political Behavior*, *32*(2), 303–330.

Nyhan, B., & Reifler, J. (2015). Does correcting myths about the flu vaccine work? An experimental evaluation of the effects of corrective information. *Vaccine*, *33*(3), 459–464. https://doi.org/10.1016/j.vaccine.2014.11.017

Nyhan, B., Reifler, J., Richey, S., & Freed, G. L. (2014). Effective Messages in Vaccine Promotion: A Randomized Trial. *Pediatrics*, *133*(4), e835–e842. https://doi.org/10.1542/peds.2013-2365

Pennycook, G., McPhetres, J., Zhang, Y., Lu, J. G., & Rand, D. G. (2020). Fighting COVID-19 Misinformation on Social Media: Experimental Evidence for a Scalable Accuracy-Nudge Intervention. *Psychological Science*, *31*(7), 770–780. https://doi.org/10.1177/0956797620939054

Pennycook, G., & Rand, D. G. (2019). Lazy, not biased: Susceptibility to partisan fake news is better explained by lack of reasoning than by motivated reasoning. *Cognition*, *188*, 39–50. https://doi.org/10.1016/j.cognition.2018.06.011

Piurko, Y., Schwartz, S. H., & Davidov, E. (2011). Basic Personal Values and the Meaning of Left-Right Political Orientations in 20 Countries. *Political Psychology*, *32*(4), 537–561. https://doi.org/10.1111/j.1467-9221.2011.00828.x

Plohl, N., & Musil, B. (2021). Modeling compliance with COVID-19 prevention guidelines: The critical role of trust in science. *Psychology, Health & Medicine*, *26*(1), 1–12. https://doi.org/10.1080/13548506.2020.1772988

Quinn, S. C., Jamison, A., An, J., Freimuth, V. S., Hancock, G. R., & Musa, D. (2018). Breaking down the monolith: Understanding flu vaccine uptake among African Americans. *SSM - Population Health*, *4*, 25–36. https://doi.org/10.1016/j.ssmph.2017.11.003

Reiter, P. L., Pennell, M. L., & Katz, M. L. (2020). Acceptability of a COVID-19 vaccine among adults in the United States: How many people would get vaccinated? *Vaccine*, *38*(42), 6500–6507. https://doi.org/10.1016/j.vaccine.2020.08.043

Roozenbeek, J., Linden, S. van der, & Nygren, T. (2020). Prebunking interventions based on "inoculation" theory can reduce susceptibility to misinformation across cultures. *Harvard Kennedy School Misinformation Review*, *1*(2). https://doi.org/10.37016//mr-2020-008

Roozenbeek, J., Schneider, C. R., Dryhurst, S., Kerr, J., Freeman, A. L. J., Recchia, G., van der Bles, A. M., & van der Linden, S. (2020). Susceptibility to misinformation about COVID-19 around the world. *Royal Society Open Science*, *7*(10), 201199. https://doi.org/10.1098/rsos.201199

San Francisco Health Department (2021, March 5). Vaccine champions training: Building COVID-19 vaccine confidence: Helping people make informed choices [Powerpoint Slides]. https://www.sfdph.org/dph/files/ig/vaccine/Vaccine-Champion-Training-pdf.pdf

Sarathchandra, D., Navin, M. C., Largent, M. A., & McCright, A. M. (2018). A survey instrument for measuring vaccine acceptance. *Preventive Medicine*, *109*, 1–7. https://doi.org/10.1016/j.ypmed.2018.01.006

Scherer, L. D., McPhetres, J., Pennycook, G., Kempe, A., Allen, L. A., Knoepke, C. E., Tate, C. E., & Matlock, D. D. (n.d.). *Who Is Susceptible to Online Health Misinformation? A Test of Four Psychosocial Hypotheses*. 11.

Shapiro, G. K., Holding, A., Perez, S., Amsel, R., & Rosberger, Z. (2016). Validation of the vaccine conspiracy beliefs scale. *Papillomavirus Research*, *2*, 167–172. https://doi.org/10.1016/j.pvr.2016.09.001

Shea, J. A., Micco, E., Dean, L. T., McMurphy, S., Schwartz, J. S., & Armstrong, K. (2008). Development of a Revised Health Care System Distrust Scale. *Journal of General Internal Medicine*, *23*(6), 727–732. https://doi.org/10.1007/s11606-008-0575-3

Shelton, R. C., Winkel, G., Davis, S. N., Roberts, N., Valdimarsdottir, H., Hall, S. J., & Thompson, H. S. (2010). Validation of the Group-Based Medical Mistrust Scale Among Urban Black Men. *Journal of General Internal Medicine*, *25*(6), 549–555. https://doi.org/10.1007/s11606-010-1288-y

Shreeves, M. (2020). *Preference Construction in Difficult Multi-attribute Health Decisions: Effects of Affect and Coherence Shifting* [Ph.D., Clemson University]. Retrieved January 24, 2022, from https://www.proquest.com/docview/2408895578/abstract/60A9BB9B9B884D3EPQ/1

Shulruf, B., Hattie, J., & Dixon, R. (2007). Development of a New Measurement Tool for Individualism and Collectivism. *Journal of Psychoeducational Assessment*, *25*(4), 385–401. https://doi.org/10.1177/0734282906298992

Simon, D., Krawczyk, D. C., Bleicher, A., & Holyoak, K. J. (2008). The transience of constructed preferences. *Journal of Behavioral Decision Making*, *21*(1), 1–14. https://doi.org/10.1002/bdm.575

Simon, D., Krawczyk, D. C., & Holyoak, K. J. (2004). Construction of Preferences by Constraint Satisfaction. *Psychological Science*, *15*(5), 331–336. https://doi.org/10.1111/j.0956-7976.2004.00678.x

Simon, D., & Spiller, S. A. (2016). The Elasticity of Preferences. *Psychological Science*, *27*(12), 1588–1599. https://doi.org/10.1177/0956797616666501

Sjoberg, L. (2000). Factors in Risk Perception. *Risk Analysis*, *20*(1), 1–12. https://doi.org/10.1111/0272-4332.00001

Slovic, P., Finucane, M. L., Peters, E., & MacGregor, D. G. (2004). Risk as Analysis and Risk as Feelings: Some Thoughts about Affect, Reason, Risk, and Rationality. *Risk Analysis*, *24*(2), 311–322. https://doi.org/10.1111/j.0272-4332.2004.00433.x

Soveri, A., Karlsson, L. C., Mäki, O., Antfolk, J., Waris, O., Karlsson, H., Karlsson, L., Lindfelt, M., & Lewandowsky, S. (2020). Trait reactance and trust in doctors as predictors of vaccination behavior, vaccine attitudes, and use of complementary and alternative medicine in parents of young children. *PLOS ONE*, *15*(7), e0236527. https://doi.org/10.1371/journal.pone.0236527

Stanislaw, H., & Todorov, N. (1999). Calculation of signal detection theory measures. *Behavior Research Methods, Instruments, & Computers*, *31*(1), 137–149. https://doi.org/10.3758/BF03207704

Stanovich, K. E., West, R. F., & Toplak, M. E. (2013). Myside Bias, Rational Thinking, and Intelligence. *Current Directions in Psychological Science*, *22*(4), 259–264. https://doi.org/10.1177/0963721413480174

Strully, K. W., Harrison, T. M., Pardo, T. A., & Carleo-Evangelist, J. (2021). Strategies to Address COVID-19 Vaccine Hesitancy and Mitigate Health Disparities in Minority Populations. *Frontiers in Public Health*, *9*. https://www.frontiersin.org/articles/10.3389/fpubh.2021.645268

Summers, J. (2021, March 12). *Little Difference In Vaccine Hesitancy Among White And Black Americans, Poll Finds*. NPR.Org. https://www.npr.org/sections/coronavirus-live-updates/2021/03/12/976172586/little-difference-in-vaccine-hesitancy-among-white-and-black-americans-poll-find

Swami, V., Voracek, M., Stieger, S., Tran, U. S., & Furnham, A. (2014). Analytic thinking reduces belief in conspiracy theories. *Cognition*, *133*(3), 572–585. https://doi.org/10.1016/j.cognition.2014.08.006

Thompson, H. S., Manning, M., Mitchell, J., Kim, S., Harper, F. W. K., Cresswell, S., Johns, K., Pal, S., Dowe, B., Tariq, M., Sayed, N., Saigh, L. M., Rutledge, L., Lipscomb, C., Lilly, J. Y., Gustine, H., Sanders, A., Landry, M., & Marks, B. (2021). Factors Associated With Racial/Ethnic Group–Based Medical Mistrust and Perspectives on COVID-19 Vaccine Trial Participation and Vaccine Uptake in the

US. *JAMA Network Open*, *4*(5), e2111629. https://doi.org/10.1001/jamanetworkopen.2021.11629

Thompson, H. S., Valdimarsdottir, H. B., Winkel, G., Jandorf, L., & Redd, W. (2004). The Group-Based Medical Mistrust Scale: Psychometric properties and association with breast cancer screening. *Preventive Medicine*, *38*(2), 209–218. https://doi.org/10.1016/j.ypmed.2003.09.041

Thomson, A., Vallée-Tourangeau, G., & Suggs, L. S. (2018). Strategies to increase vaccine acceptance and uptake: From behavioral insights to context-specific, culturally-appropriate, evidence-based communications and interventions. *Vaccine*, *36*(44), 6457–6458. https://doi.org/10.1016/j.vaccine.2018.08.031

Tomljenovic, H., Bubic, A., & Erceg, N. (2020). It just doesn't feel right – the relevance of emotions and intuition for parental vaccine conspiracy beliefs and vaccination uptake. *Psychology & Health*, *35*(5), 538–554. https://doi.org/10.1080/08870446.2019.1673894

Tormala, Z. L., & Petty, R. E. (2002). What doesn't kill me makes me stronger: The effects of resisting persuasion on attitude certainty. *Journal of Personality and Social Psychology*, *83*(6), 1298–1313. https://doi.org/10.1037/0022-3514.83.6.1298

Trevors, G. J., Muis, K. R., Pekrun, R., Sinatra, G. M., & Winne, P. H. (2016). Identity and Epistemic Emotions During Knowledge Revision: A Potential Account for the Backfire Effect. *Discourse Processes*, *53*(5–6), 339–370. https://doi.org/10.1080/0163853X.2015.1136507

U.S. Census Bureau, Current Population Survey, 2021 Annual Social and Economic Supplement (CPS ASEC).

U.S. Census Bureau, Current Population Survey, 2022 Annual Social and Economic Supplement (CPS ASEC).

US Department of Health and Human Services. (2019). 2018 National Healthcare Quality and Disparities Report.

Walker, A. S., Singhvi, A., Holder, J., Gebeloff, R., & Avila, Y. (2021, March 5). Pandemic's Racial Disparities Persist in Vaccine Rollout. *The New York Times*. https://www.nytimes.com/interactive/2021/03/05/us/vaccine-racial-disparities.html

Wallace, L. E., Wegener, D. T., & Petty, R. E. (2020). When Sources Honestly Provide Their Biased Opinion: Bias as a Distinct Source Perception With Independent Effects on Credibility and Persuasion. *Personality and Social Psychology Bulletin*, *46*(3), 439–453. https://doi.org/10.1177/0146167219858654

Watson, J. (2014). Young African American Males: Barriers to Access to Health Care. *Journal of Human Behavior in the Social Environment*, *24*(8), 1004–1009. https://doi.org/10.1080/10911359.2014.953416

Williamson, L. D., & Bigman, C. A. (2018). A systematic review of medical mistrust measures. *Patient Education and Counseling*, *101*(10), 1786–1794. https://doi.org/10.1016/j.pec.2018.05.007

Wise, A. (2021, March 16). Trump Encourages His Supporters To Get COVID-19 Vaccine, Within Limits of "Freedoms." *NPR*.

https://www.npr.org/2021/03/16/978008056/trump-encourages-his-supporters-to-get-covid-19-vaccine-within-limits-of-freedom

Xiao, X., & Wong, R. M. (2020). Vaccine hesitancy and perceived behavioral control: A meta-analysis. *Vaccine*, *38*(33), 5131–5138. https://doi.org/10.1016/j.vaccine.2020.04.076

Yaniv, I., & Kleinberger, E. (2000). Advice Taking in Decision Making: Egocentric Discounting and Reputation Formation. *Organizational Behavior and Human Decision Processes*, *83*(2), 260–281. https://doi.org/10.1006/obhd.2000.2909

Zampetakis, L. A., & Melas, C. (2021). The health belief model predicts vaccination intentions against COVID-19: A survey experiment approach. *Applied Psychology: Health and Well-Being*, *n/a*(n/a). https://doi.org/10.1111/aphw.12262

Zarocostas, J. (2020). How to fight an infodemic. *The Lancet*, *395*(10225), 676. https://doi.org/10.1016/S0140-6736(20)30461-X