COVID-19 Vaccine Attitudes Among Veterans in the Veteran Affairs Pittsburgh Healthcare System

by

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Abstract

Vaccine hesitancy has been an obstacle for ending the COVID-19 pandemic in the United States, especially among vulnerable populations like non-white communities, healthcare workers, and the elderly. The pandemic demonstrated the clear public health significance of risk communication as well as understanding reasons for mistrust of scientific and government institutions. Appropriate science communication, both to the general public and to scientifically literate audiences, is a critical component of public health campaigns, both in COVID-19 vaccination efforts and more broadly.

I worked with a Veterans Affairs Pittsburgh Healthcare System (VAPHS) group to design materials to help disseminate the results of a recent quality improvement project. Researchers from the Center for Health Equity Research and Promotion (CHERP) at the VAPHS recently conducted two quality improvement projects to understand vaccine attitudes and hesitancy among healthcare workers and patients within the medical system. The main findings from the patient project were the characterization of four clusters of patient responses based on levels of concern about COVID-19 and beliefs in vaccine safety and efficacy. The working group highlighted this and other findings to create data visualizations to convey the results to stakeholders, mainly providers within the VAPHS.

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Preface

I would like to thank Riley Wolynn for partnering with me on creating visual abstracts and the whole CHERP team for letting me use their data and being so helpful and welcoming.

1.0 Overview

Few infectious disease outbreaks have been as disruptive to modern life as the SARS-CoV-2 pandemic (hereafter referred to as COVID-19) that the World Health Organization (WHO) declared in March 2020. The mRNA vaccines, approved for emergency use in December 2020, were a critical component of managing the COVID-19 pandemic; however, the United States has lagged behind vaccination goals. Even from the beginning, when the nation's goal was 20 million vaccinations by December 2020, the rollout fell far short of that goal, with only 2.8 million Americans receiving a COVID vaccine before December 31, 2020.[1]

The reasons why Americans were hesitant to get the COVID-19 vaccine were multi-faceted, especially among the populations most vulnerable to COVID-19. Care homes and group living facilities were among the first groups to have access to the vaccine, due to the high-risk nature of such living arrangements. But even among care these workers, there was hesitation to get vaccinated.

The Veterans Affairs Pittsburgh Healthcare System (VAPHS) saw low vaccination rates among staff and launched a quality improvement (QI) project with the Center for Health Equity Research and Promotion (CHERP). The quality improvement project was initiated because vaccination rates were lowest among two crucial groups: (1) respiratory therapists and Community Living Center (CLC) employees who worked with some of the patients most vulnerable to COVID-19 and (2) Veterans over 85 years old, despite being the most at-risk group. VA leadership was also interested in characterizing differences in vaccine attitudes and experiences influenced by important demographics, including race/ethnicity, sex, gender, and age.

In this essay, I will review the QI activities undertaken to characterize COVID-19 vaccine hesitancy among CLC and patients in the VAPHS. I will then explain our efforts to create data visualizations that communicate the lessons learned from this investigation in simple, graphical ways.

1.1 COVID-19 and Vaccine Attitudes

COVID-19 is a diseased state caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). This name distinguishes it from SARS-CoV-1, a disease outbreak of a related coronavirus that occurred in 2003 which had lower total mortality due to successful containment.[2]

Since its first appearance in late 2019, there have been over 700 million cases and 6.8 million cumulative deaths worldwide attributable to COVID-19 as of April 2023.[3] The fatality rate is about 2%, but about 14% of people who contract COVID-19 develop severe symptoms, while as much as 80% are either asymptomatic or have mild symptoms.[4] The asymptomatic transmission of COVID-19 has made it challenging to control the pandemic, which was exacerbated by the disease's high rate of complications that strain hospital systems.[5]

There have been over 12 billion doses of vaccine administered worldwide since the vaccine's initial rollout in December 2020. The unprecedented speed with which the vaccine was developed has been a critical factor in mitigating the pandemic's toll in high-income countries, even though distribution and uptake fell short of goals. The first human trials of the vaccine began in March 2020, a mere three months after the novel disease outbreak started.[1] The rapidity with which the vaccine was developed was due to several factors, such as existing applications of the

novel vaccine technology; past research on Coronaviruses; emergency use authorization and expedited FDA review; concurrent conduct of phases I, II, and III trials; and considerable government resources and funding being poured into vaccine development.[6] Though the expedience undoubtedly saved much disease burden, it also contributed to concerns among some groups about the safety and efficacy of the vaccines.

Even as early as December 2020, when the vaccine became available to healthcare workers and high-risk groups, there was hesitancy among American consumers about the safety, effectiveness, and distribution of the vaccines.[7] The vaccine was rapidly politicized after rollout to the general public, which was driven partially by misinformation dissemination on social media. Politics was such a strong driver of vaccine attitudes that the Republican incumbent President of the United States, Donald Trump, was cited as one of the biggest drivers of vaccine misinformation on Twitter.[9] Exposure to misinformation was strongly correlated with vaccine hesitancy.[8] However, even among demographics that generally have high proportions of pro-vaccine sentiment, there was significant COVID-19 vaccine hesitancy not seen for other vaccines, such as pediatric vaccinations or the yearly flu vaccine. Members of these populations cited reasons such as believing the vaccine was developed too quickly to be safe, believing COVID-19 was not a serious enough threat to merit the risk of side effects, and doubting whether the vaccine was effective.[10]

Veterans are a population of interest for the COVID-19 vaccine specifically because they are at higher risk for COVID-19[11] and because they have a special relationship with the United States government that may complicate their healthcare and vaccine attitudes.[12] Additionally, there is mounting evidence that current COVID-19 vaccines can protect people who are vaccinated from severe disease but do not confer transmission-blocking immunity.[13] Therefore, vaccines

alone cannot achieve herd immunity, so unvaccinated populations are still at risk rather than being able to rely on protection from the vaccinated individuals around them.

1.2 Vaccine Hesitancy

Anti-vaccine sentiment has existed for as long as the concept of variolation has, beginning with Edward Jenner's smallpox prevention efforts.[14] Some of these concerns have risen from legitimate safety concerns caused by vaccine recalls and contaminations such as the Cutter Incident, where defective vaccines caused 40,000 cases of polio and killed 10 children.[16] Safety concerns about the DTP (Diphtheria, Tetanus, and Pertussis) vaccine garnered attention in the 1970s and early 1980s when children allegedly developed neurological problems after vaccination, leading to increased safety and monitoring systems.[15]

However, perhaps the most infamous factor leading to the mainstream popularity of anti-vaccine sentiment was the paper published by Andrew Wakefield in 1998 attempting to show a link between the MMR (Measles, Mumps, Rubella) childhood vaccine and the development of autism.[17] Wakefield's paper was later found to have massive conflicts of interest and falsified data, and it was subsequently retracted by the publishing journal. Even though he has been barred from practicing medicine in Great Britain, his claims linking childhood vaccination to autism persist to this day.

The WHO declared vaccine hesitancy among one of the ten biggest threats to global health in 2019.[18] Social media has also been a double-edged sword, serving to easily disseminate healthcare information quickly while also contributing to the spread of misinformation. Vaccine skepticism is driven both by good faith concerns and by pseudoscience spearheaded by influential

figures such as Jenny McCarthy and Robert F. Kennedy. This has contributed to sub-optimal vaccination rates.[19]

The Gardasil HPV vaccine has also been a target of anti-vaccine sentiment both because of safety concerns and stigma about HPV as a sexually transmitted infection.[20] Despite abundant evidence that the Gardasil vaccine is safe and effective, there has been considerable pushback against inclusion of the vaccine in the regimen of shots required for public school attendance.[21] False claims pushed by Republican politician Michele Bachmann that the vaccine is linked to "mental retardation"[22] have also contributed. Parental objections frequently include vocal beliefs that the vaccine will encourage promiscuity.[21] Critics have also cited the vaccine's high cost, limited availability, and lack of targeting at-risk populations as reasons for low uptake.[23]

The yearly influenza vaccine is also subject to hesitancy and scrutiny from the general public, partially because of a lack of confidence in its efficacy and a lack of perceived threat from the flu.[24] A study of healthcare workers in Hong Kong in March and April 2020 showed that uptake of the flu vaccine was only 49% and that the "5C constructs" (more confidence and collective responsibility, less complacency, constraints, and calculation) were associated with vaccine uptake both for the flu and a potential COVID-19 vaccine.[25] Flu vaccine hesitancy in healthcare workers was found to be at least partially attributable to a perceived lack of vulnerability and lack of trust. In contrast, vaccine uptake behavior was associated with feelings of professional duty.[26] The flu vaccine is also unique in that it is required yearly on a massive scale and its effectiveness can vary substantially from year to year. These factors lead to conceptions that the vaccine is ineffective or even can cause the flu itself.[24]

Clearly, the COVID-19 vaccine is only the latest vaccine in a long line to be subjected to controversy among the general public and raise concerns about safety, efficacy, and perceived lack

of risk to remaining unvaccinated. Vaccine hesitancy is consistently a major barrier to public health, and especially in times like the COVID-19 pandemic, appropriate education and tailored communication are needed to combat it.

1.3 Best Practices of Infographics for Public Health Communication

Infographics are an increasingly popular method of quickly presenting data to large audiences due to their ability to garner attention, simplify data presentation, and increase ease of sharing.[27] Generally, any visual representation of data should be kept as simple as possible, considering the intended audience's literacy level, interest, and time they will spend reviewing.[28] Keeping designs and vocabulary simple is critical, especially when disseminating information to the general public. The average American adult has a reading level comparable to a 12 to 14 year old; in the UK the recommendation is to make content readable by nine-year-olds.[29] Engaging with the audience in accessible language is one of the universal key principles of public health communication, as part of a larger overall framework of tailoring messaging to the audience.

The artistic practice of graphic design and the data-driven practice of science merge in public health communication. Although art is inherently subjective, there are many guides written for best practices of data visualization in public health communication that can guide adaptation of data into infographics while tailoring it for the chosen audience. Unfortunately, there is a dearth of standardized, evidence-based publications on the best way to design infographics to either a lay or scientific audience.[30] There are some best practice guidelines, including:

- The *CDC's Guide to Writing for Social Media*[31] is one example of guidelines for best practices and outlines some principles: make it relevant to the audience based on their time,

geography, and interests; make it easy to understand and share; make it friendly, conversational, engaging, and action-oriented.

- The *7 G.R.A.P.H.I.C. Principles of Public Health Infographic Design*[28] is another example of guidelines for creating graphical representations of data. This particular set of guidelines is written with an eye for presenting health information, but these principles can be applied to most types of data visualization in other fields as well. The G.R.A.P.H.I.C. principles include:
    1) Get to Know your Audience (tailor the message for the expected audience)
    2) Restrict Colour (stick to a color palette and design color around readability)
    3) Align elements (be mindful of the spacing of elements on the page
    4) Prioritise parts (direct audience's attention purposefully)
    5) Highlight the heading (use heading effectively)
    6) Invest in imagery (choose images to work with the design)
    7) Choose charts carefully (only use charts that will be effective for the audience, and use them correctly)
- *Infographics: Healthcare Communication for the Digital Age*[32] outlines some basic types of infographics and their benefits and drawbacks, including isotype arrays, polar area diagrams, word clouds, hub and spoke diagrams, and charticles.
- *Preparing Infographics for Post-publication Promotion of Research on Social Media*[33] summarizes that infographics are more enjoyable, easier, and faster to read than article abstracts, which can appeal to a viewer base pressed for time and energy. It also outlines the importance of content appeal (making sure the content is audience appropriate and presented accurately) and visual appeal (making the content easily accessible and

engaging), as well as listing a variety of software helping infographics, including Canva, the program used to make the illustrations presented later in this essay.

- *Creating Effective Infographics and Visual Abstracts to Disseminate Research and Facilitate Medical Education on Social Media*[34] assign the steps of creating an infographic as deciding content and layout; choosing platform, color schemes, and graphics; and soliciting feedback, in that order. They also lay out the principles of multimedia (pictures and words together are more effective than words alone), spatial contiguity (placement of words in relation to graphics), signaling (cues should highlight the essential material), and coherence (minimizing irrelevant elements).

A recent study on digital communications during the COVID-19 pandemic showed that 72% of university students were more likely to share an infographic on social media than a written article, and 90% said that scientists should use more infographics on social media.[34] A 2019 study also found that infographics were significantly more popular on Twitter and Facebook than research articles alone.[35] Hamaguchi et al. detail their efforts to create a simplified yet comprehensive infographic portraying the key facts about COVID-19 to be rapidly disseminated on social media, validating it through physician peer review. The graphic was so popular, the authors received requests to have it translated into numerous other languages.[36]

Though artistic design is subjective, the abundance of peer-reviewed guides written to guide communicators with designing graphics can help make the output simple, informative, appealing, and audience-specific, increasing the effectiveness. I will describe how these principles were applied to the findings of the VAPHS quality improvement project infographics in section 3.0. First, in section 2.0, I will briefly summarize the findings of that project, to walk through the process of picking out key information and deciding what should be highlighted.

2.0 Quality Improvement Study at the VAPHS

The VAPHS, which cares for over 72,000 Veterans, is a care referral center for the Veterans Integrated Service Network 4 (VISN 4), with dozens of medical centers and outpatient clinics over 13 counties in Pennsylvania, Delaware, New Jersey, New York, and Ohio. It has an acute care facility, a community living center, and ambulatory care services including: primary care, dental, pharmacy, and rehabilitation services.[32] In 2021, the Center for Health Equity Research and Promotion (CHERP) at VAPHS started a quality improvement (QI) project at the request of the VAPHS Chief of Staff to improve understanding of healthcare worker beliefs about COVID and the COVID vaccine. The goal was to use this information to improve vaccination rates among their staff. There were three main takeaways from this project. First, unvaccinated staff were more concerned about infecting patients and less concerned about their own personal health and risks of illness than vaccinated staff. Second, a major motivator for vaccination uptake was the influence of family, colleagues, and patients. Third, hesitation to get vaccinated against COVID-19 was rooted in concern about the rapidity with which the vaccine was developed and concerns about the safety of the vaccine.

In March 2021, CHERP conducted a similar, scaled-up QI project for VAPHS Veteran patients. From December 2020 through July 2021, only 45.6% of patients in the VA reported being vaccinated against COVID-19.[37] Thus increasing vaccine uptake among the vulnerable population served at the VA was a critical goal for slowing the spread of COVID-19 within the VAPHS. These two QI projects were done in parallel, but the Veterans survey had a much larger sample size and, thus, took longer to implement and complete. For purposes of this essay, I focus primarily on the Veteran patient survey.

2.1 Questionnaire Methods

Veterans who had been assigned a primary care provider at the VAPHS within the last year (n=32,271) comprised the population of interest. To capture the diversity of underrepresented groups, all female (n=1,980) and Hispanic or non-white (n=1,708) eligible Veterans were invited to participate. The remaining non-Hispanic, white male Veterans were separated into four age categories (<50, 50-64, 65-84, and >84) and 500 participants were solicited from each category, for a total of 2,000. Thus, the sample size (n=5,688) was not representative of the demographics, but rather aimed to capture as much diversity of opinion as possible. A total of 1,208 patients completed the questionnaire either by email or phone. All data were collected between July 15, 2021 and September 3, 2021.

The questionnaire had 60 items total, but some items were skipped depending on answers to previous items (e.g., vaccinated and unvaccinated individuals were directed through different branches of questions). The questionnaire asked for sociodemographic, personal, and clinical information/medical history; COVID-19 infection and vaccine; thoughts and feelings on COVID-19 infection and vaccine, and social processes, including trust in various people and institutions like the government and the VA healthcare system; and practical factors such as logistics of getting the vaccine. Chi-square and Fischer's Exact tests were used to identify associations between responses and vaccination status. Additionally, cluster analysis was used to look for patterns in answers to the questions about thoughts and feelings on COVID-19 infection and on the COVID-19 vaccine.

2.2 Questionnaire Results

Of the 1,208 respondents, 86% (n=1,034) were vaccinated for COVID-19. Vaccinated respondents were generally older and more likely to be Black or Hispanic, reside in urban areas, and have more liberal political views than unvaccinated respondents. The percentage of respondents who said they were "very concerned" about experiencing long-term COVID-19 vaccine complications was 61% for unvaccinated respondents and 19% for vaccinated, which supports the trend of safety concerns being associated with COVID-19 vaccine hesitancy. Additionally, 53% of vaccinated respondents perceived the COVID-19 vaccine to be "very effective" in preventing infection, while that number was only 7% for unvaccinated respondents, suggesting that hesitancy is also driven by lack of perceived benefit.

Trust and social processes also differed significantly between the vaccinated and unvaccinated groups. For example, with regard to trust in the accuracy of COVID-19 information provided by state and local government, 65% of unvaccinated respondents selected 'not at all,' while only 18% of vaccinated respondents said so. With regard to trust in the information provided by the CDC, 46% of vaccinated respondents trusted the accuracy of COVID-19 information compared to only 15% for the unvaccinated group. These are examples of strong trends seen in the data, so we decided this was a key point to touch on while presenting the data visually.

The team also chose to summarize visually the four categories identified as part of the cluster analysis.

Table 1. Characterization of the four clusters

Cluster name	Number of individuals in cluster	% of total population in cluster	General characteristics	Vaccination rate
Concerned Believers	375	31.7%	•Moderately/very concerned about infection or becoming very ill from COVID-19 •Believe vaccine is moderately/very effective in preventing infection and severe illness/death •Only slight concern for short- or long-term side effects from vaccine	98.9%
Unconcerned Believers	336	28.4%	•No/slight concern about risk of COVID-19 infection and illness •Believe vaccine is effective in preventing infection •Unconcerned about vaccine short-term or long-term side effects	93.5%
Concerned Ambivalents	298	25.2%	•Moderately/very concerned about infection or becoming ill from COVID-19 •Believe the vaccine is moderately/very effective in preventing infection •Moderately/very concerned about short- and long-term side effects from the vaccine	93.3%
Unconcerned Disbelievers	174	14.7%	•No/slight concern about risk of COVID-19 infection and severe illness •Believe the vaccine was not at all/slightly effective at preventing infection and severe illness •Moderately/very concerned about short- and long-term side effects from vaccine	29.9%

Table 1 show the characteristics by the four clusters for which at least 77% of the Veterans in the sample endorsed that option. The Unconcerned Disbelievers cluster was the only one to have a vaccination rate below 90%, with a rate of 30%, and most unvaccinated participants were in the Skeptical and Indifferent cluster.

2.3 Discussion of Questionnaire Results

The existence of the four clusters illustrates that even among groups that have the same behaviors (such as getting vaccinated against COVID-19), there can be differences in motivation and concerns leading to such behavior. Since populations being communicated to are heterogenous, messaging should be carefully tailored to reflect the fact that different groups may respond differently to public health efforts based on the nuances in their attitudes about vaccines. For example, unvaccinated individuals who fall in the cluster that we labeled as "Unconcerned Believers" believed the vaccine to be effective but had low levels of concern about COVID-19 itself being dangerous. Based on this, we might expect that presenting them with information about the effectiveness of the vaccine might be less effective than illustrating the severity of COVID-19 when someone in that group was making the decision on whether or not to get vaccinated. In contrast, the fact that the Concerned and Ambivalent cluster were concerned both about the health effects of the COVID-19 vaccine and COVID-19 itself suggests that information about vaccine safety could be more effective in increasing vaccine uptake for such individuals.

Concerned Believers had the highest vaccination rate, at 98.9%, so they were identified as the group least in need of intervention. These findings could be taken into account to shape messaging directed at the remaining 1.1% of unvaccinated participants, but targeting other groups

with lower vaccine uptake would be a more effective strategy to decrease vaccine hesitancy in the overall population.

By contrast, the dramatic difference between the Unconcerned Disbelievers cluster and the three other clusters can provide useful insight into what drives vaccine hesitancy. Individuals in this cluster were mistrustful of the COVID-19 vaccine and the institutions recommending it, as well as disbelieving that COVID-19 was dangerous in the first place. However, like the participants of the CLC study, trusted interpersonal relationships played a factor in vaccine attitudes. Many Veterans in this cluster reported that they perceived local community or religious leaders would want them to get vaccinated. Thus, an effective tactic for individuals following this line of thinking may be less about emphasizing the dangers of COVID-19, but rather engaging local community or faith-based leadership to encourage mistrustful individuals to get vaccinated. However, even among the most skeptical groups, trust was highest in an individual's local VA healthcare provider. This suggests an even more effective method of outreach might be through interactions with their healthcare provider, which is why we decided to emphasize this in the final draft of the infographics.

3.0 Methods

To help disseminate the findings outlined in section 2.0, I worked with the CHERP project team to make infographics depicting the key findings from the Veteran questionnaire. At the start of the infographic project, we did not have a clear picture of the audience. As we continued to design drafts, we refined them as the project team provided more insight into specific audiences and distribution methods. Initially work was split evenly between myself and Riley Wolynn, a fellow graduate student at the University of Pittsburgh School of Public Health, but eventually I took over the bulk of the responsibility for creating the data visualizations. All our designs were workshopped in a group setting with the CHERP project team providing feedback both on how the audience might receive it and if we were highlighting the most important data. We also considered whether the graphic designs were aligned with the best practices outlined in the overview. Conducting focus groups with potential audiences was outside the scope of the project, so our feedback was limited to input from the CHERP working group, so this may influence the results. All visualizations were made in Canva, an online design tool available at Canva.com.

Originally, we attempted to condense all the main points into one graphic depiction, which is described in section 3.1. When that proved to be too unwieldly, we split up our efforts to make multiple infographics with each centered on a particular theme from the data. We identified the key themes to be the clusters (section 3.2), the factor of trust (section 3.3), misinformation (3.4), and experiences regarding vaccination and incentives to get vaccinated (section 3.5).

3.1 Initial Summary

The first visual data summary was supposed to present the key findings of the study both to laypersons and to providers who may be viewing it at a glance. The goal of this infographic was to touch on all the key findings of the study, and to represent them in a way that either a physician or a layperson could understand.

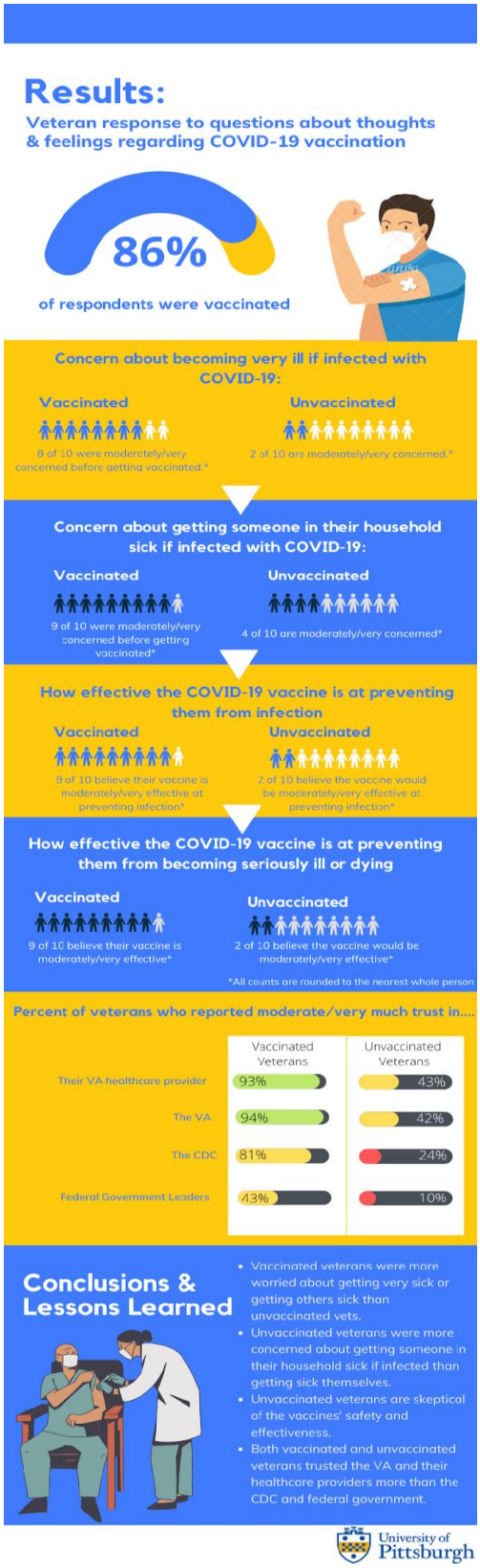


Figure 1. Graphical summary of some key points from the Veteran patient quantitative study

At the start, we wanted to design something that might be amenable to being printed on a single sheet of paper and mailed to Veteran study participants to provide them with some key study results.

This design had some limitations and we eventually decided to scrap it without further revision. This design failed to avoid complexity, placing an overwhelming amount of tangentially related information together. It was also too long and wordy, for either a lay or physician audience. We decided that the data could be communicated in a more useful and nuanced way by splitting it into multiple graphical summaries, each with a narrower focus.

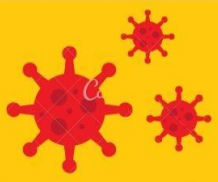
This draft demonstrates the importance of starting with a clear audience, a list of key points to be communicated, and an intended delivery method. This was a good exercise in picking out what the most important findings of the study were, but ultimately this design proved to be only a steppingstone to other products.

With this decision, we also decided to focus on designing the summaries for physician audiences and not lay audiences, as well as to distribute through email and not from a mass-printing, given practical limitations.

3.2 Cluster Visualization

We made several different visualizations to explain the four clusters. The names of the clusters were charged partway through the project, so initial drafts had the old versions. These names were more evocative, but less precise in their meaning, and the different sets of names may be more optimal to use with different audiences.

Biggest Differences



How concerned are you about COVID19?

The Vigilant and Encouraged and Guarded yet optimistic groups were concerned about illness from COVID19.

The Carefree and Confident and Skeptical and Indifferent groups weren't as concerned about illness from COVID19.

How effective do you think the vaccine is?

The Vigilant and Encouraged, Guarded yet Optimistic, and Carefree and Confident groups all thought that the vaccine was effective at preventing COVID19.

The Skeptical and Indifferent group didn't think the vaccine was effective.

How safe do you think the vaccine is?

The Skeptical and Indifferent and Guarded yet optimistic groups were concerned about side effects from the vaccine.

The Carefree and Confident and Vigilant and encouraged groups weren't as concerned about side effects from the vaccine.

Group	Concern about COVID19	Belief on vaccine effectiveness	Concern about vaccine side effects	Vaccination rates
Vigilant and Encouraged	High	Effective	Low	Highest
Guarded yet Optimistic	High	Effective	High	High
Carefree and Confident	Low	Effective	Low	High
Skeptical and Indifferent	Low	Not effective	High	Low

Important takeaways:

There was significant diversity even among the opinions of people who were vaccinated. Most unvaccinated participants were in the cluster that was worried about side effects, unconcerned about COVID19 itself, and didn't believe that the vaccine was effective.

Figure 2. Other visualizations to explain the clusters

The summaries in Figure 2 were aimed at an audience that was scientifically literate and possibly interested in how to increase vaccine uptake among the general population. The summary at the bottom draws attention to the reasons for hesitation among unvaccinated individuals. The three images heading the three columns represent a good mix of some of the ten types of images cited in the GRAPHIC guidelines,[28] namely "Biological" (the cartoon of the COVID virus), "Subject" (needle to represent vaccination), and "People-active," performing the health-related behavior in question (vaccination). This graphic failed to minimize complexity; however, scientifically literate audiences may have experience reading charts like this and not find the presentation detrimental to the intake of information. We also produced a version of this visual that had bar charts representing the vaccination rates, but it increased the visual complexity without making it more readable. This is a good reference image to quickly identify some of the key concepts of the cluster findings for someone who is familiar with them, but it's not ideal for quickly conveying the findings to new audiences.

Another way we tried to represent the data was a Venn Diagram with key characteristics (Figure 3).

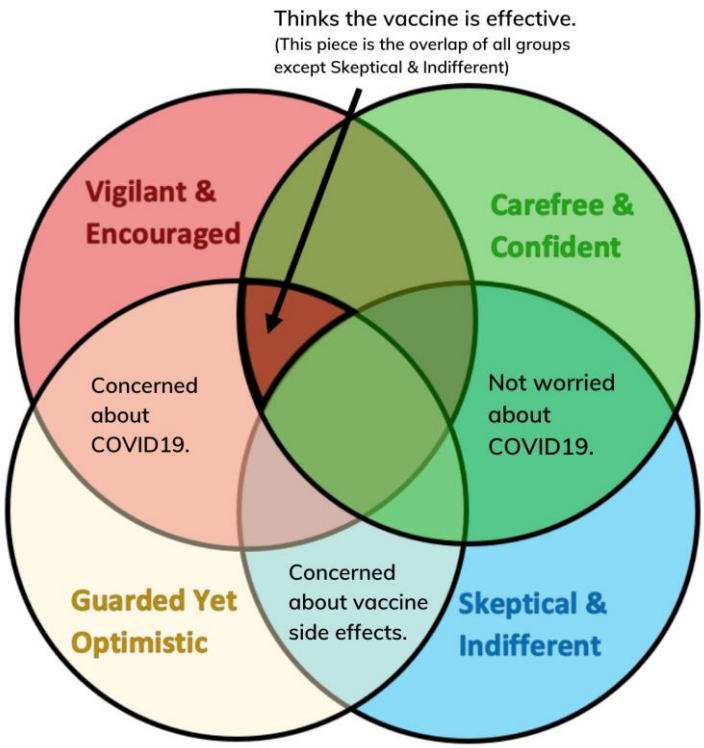


Figure 3. Venn diagram of overlap between clusters in prominent characteristics

Some members of the working group found the Venn Diagram to be simpler than the previous incarnations of the data, but others found it unclear. The coloration was an attempt to make the presentation of the data intuitive, but it verges dangerously on the edge of overwhelming the audience with color. The general guideline is to limit the color palette to 3-5 colors. The colors could also potentially cause accessibility issues with things like color blindness[28] or reproducibility if black and white is the only available option for coloring.

We eventually decided to go with a more simplified and streamlined presentation, with graphics to augment understanding at a glance. We also altered the color scheme, since previously, we received feedback that the colors made it hard to read the text.

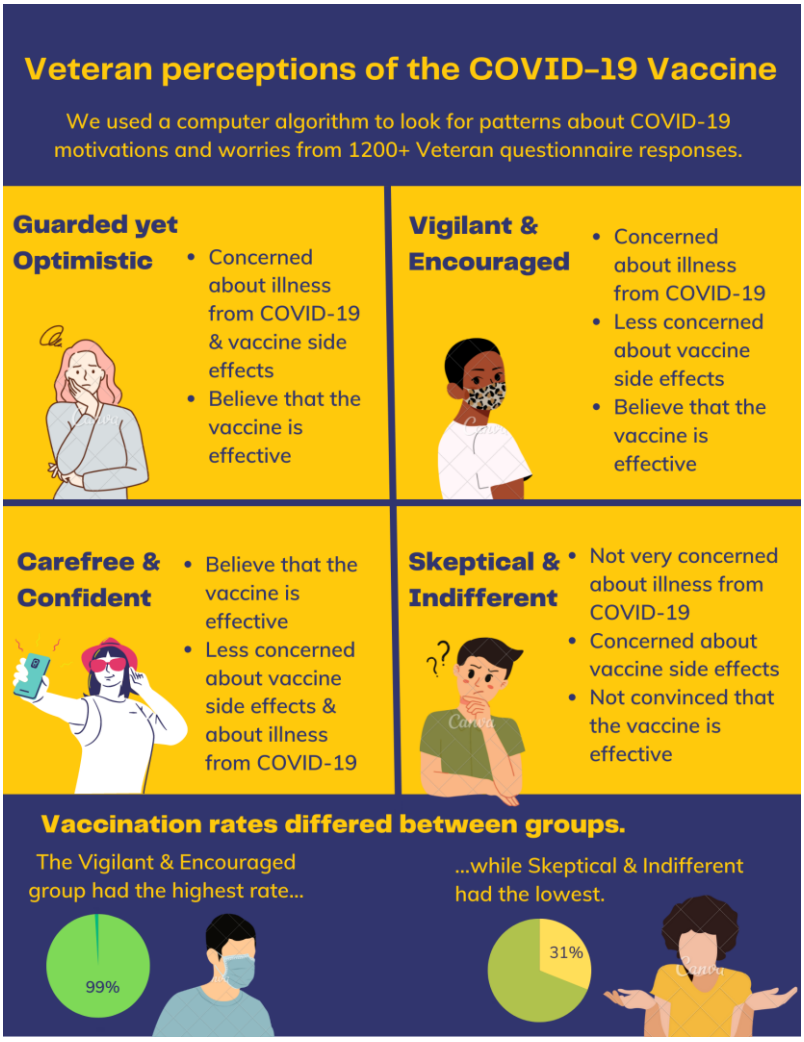


Figure 4. Final version of cluster visual summary

The simplified language in Figure 4 makes this graphical representation more accessible to lay-audiences, for example to be shared on social media, and the visual elements to represent the data make it easier to understand and remember. This graphic would need to be accompanied by something to explain the context, for example the body of a social media post, to specify the study these results are from and the conclusions that should be drawn. We eventually decided that this was the best way to summarize the concept of the clusters and to use this one as a visual abstract for submission for publication. The color palette was kept simple, to avoid overwhelming

viewers,[28] and the four main clusters were represented by simple cartoon figures to aid in quick intake and interpretation. We chose the simple, basic definitions of the clusters and the two groups with the most extreme difference in vaccination rates to highlight as the most important takeaways for this graphic. The clusters were eventually renamed to more accurately represent the characteristics of each group in a uniform way (Figure 5), so we also produced a version that had the updated cluster names with the more descriptive names as subtitles.

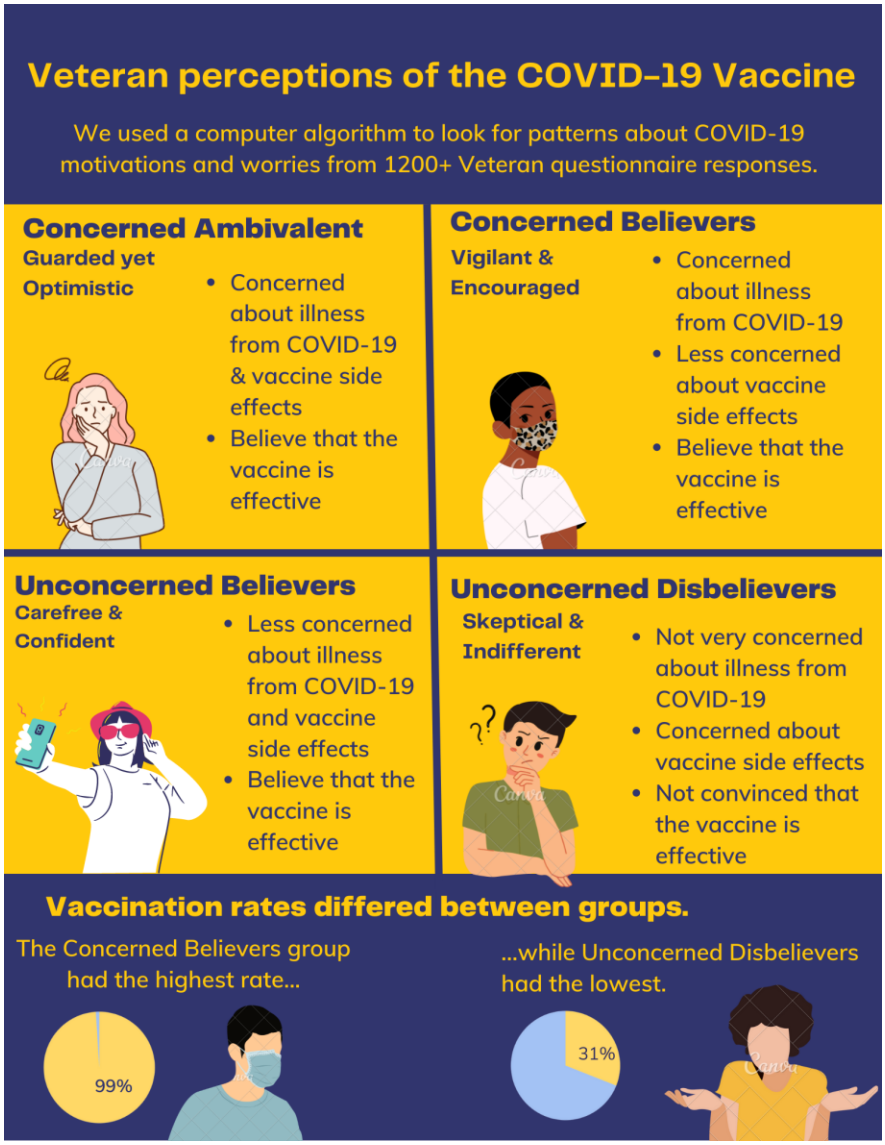


Figure 5. Alternate titles on the cluster summary

3.3 The Trust Factor

Trust was a major theme in the responses given from the unvaccinated Veteran participants for why they chose not to receive the vaccine, and as such, focusing in on it would give us a tool to highlight how trust can affect decision-making. We highlighted attitudes about the CDC with pie charts as this was a very polarizing issue throughout the pandemic, since the CDC was the primary federal entity delivering COVID-19 vaccine messaging and subject to much scrutiny. The pronounced difference in levels of trust between the vaccinated and unvaccinated groups highlights how trust attitudes inform vaccine decisions. We included some responses given during the questionnaire when the participants had the option to provide additional thoughts on open-ended questions. Finally, we ended by emphasizing that the most trusted source of information came from the veteran's VA healthcare provider, suggesting that interpersonal communications with trusted healthcare specialists may be a key strategy for decreasing vaccine hesitancy among Veterans.

Figure 6. First draft and first revision of graphical summary representing trust themes

The left version in Figure 6 had some issues that made it not ideal. It was once again difficult to pick key elements and keep the graphic simple. The introductory box was too text-

heavy. The first revision consisted of us shuffling the boxes around, and swapping out the pie charts, but in the end the effect was limited and it didn't fix the problems. We decided to highlight the difference between rates of trust in the CDC because that was the most extreme and would be the most striking visually. We chose pie charts (with the appropriate wedges pointed out) as well as a progress bar to make the contrast plain to see. We also moved the section detailing how Veterans trust VA healthcare providers the most from the end to the middle and swapped its place with the provider recommendations.

After discussing the drafts in Figure 6, we decided that highlighting the negative might be counterproductive. For example, prominently featuring the fact that unvaccinated participants were mistrustful of the CDC might be helpful to understand vaccination decisions, but it is probably not information a provider could actually use when interacting with a patient. We eventually decided to focus on strengths that providers can leverage. The figures about opinions on the CDC are helpful for illustrating the disparity in trust levels providers may face, but we decided to minimize factors that the providers would be unable to use or change for the next draft (Figure 7).

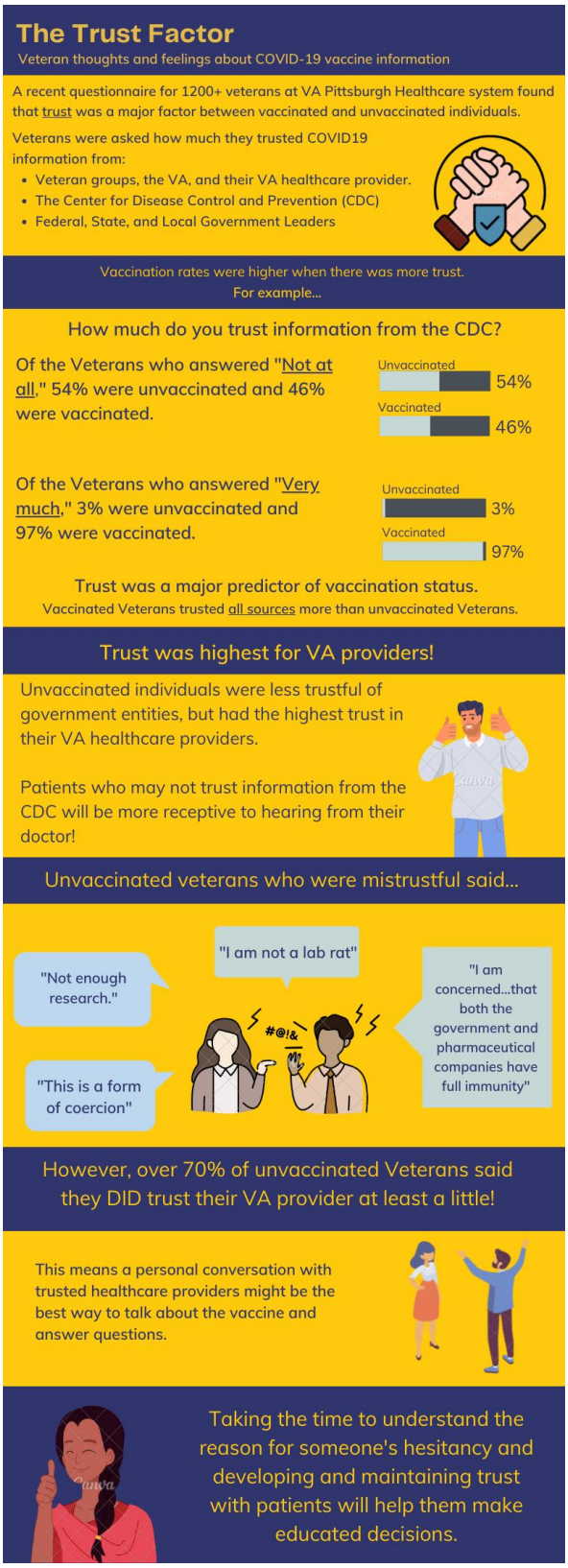


Figure 7. Second draft of selected highlights relating to the theme of trust discovered in the study

When editing draft 2 (Figure 7) to make the final draft (Figure 8), we mostly made minor changes to make the design more effective, such as streamlining and simplifying. For example, we changed "Trust was a major predictor of vaccination status," to "Vaccination rates were higher when there was more trust." This is simpler to understand, and even scientifically literate medical professions can benefit from being able to quickly understand the key points in a streamlined way. We also rearranged the panels to increase the logical flow, rather than jumping back and forth between trust and mistrust. We then ended with discussing how trust is highest for VA providers, to emphasize the possibilities of positive relationships with providers on this front and to de-emphasize the negatives of mistrust that providers face.

Figure 8. Final version of trust infographic

3.4 Misinformation

Misinformation was another common theme throughout the pandemic. A survey in June 2021, found that as high as 73% of respondents in Florida had been exposed to misinformation about the COVID-19 vaccine, and that being exposed to such misinformation was correlated with hesitancy about the vaccine.[8] In December 2020, when essential workers were the only group eligible for the vaccine in the United States, a poll found that 30% of respondents got most information about the COVID-19 vaccine from social media. Social media enables the rapid dissemination of misinformation through echo chambers, spaces where existing beliefs are reinforced through repetition and lack of challenge.[9] Mandating the vaccine without addressing ideological issues or safety concerns resulted in potential long-term psychological consequences and damaged trust.[7]

We pulled Veteran responses relating to misinformation, disinformation, confusing information, or incomplete information, all of which can affect vaccine uptake and attitudes, to make a visual data summary (Figure 9).

Figure 9. Misinformation and misleading information summaries

We pulled quotes again from Veterans who cited mis- or disinformation, as well as ones that highlighted perspectives that could complicate decisions to get vaccinated. As this graphic was aimed to inform leadership's messaging efforts surrounding the vaccine, we added a panel at the bottom to remind the reader that Veterans and consumers are overwhelmed with misleading information and may not have the appropriate tools to differentiate it from trustworthy information.

Following the same pattern as before, the first draft needed some work on simplifying and streamlining. Being able to pick out key points to cut away extraneous filling that clutters the graphic and hinders information uptake is a skill that is refined through practice.

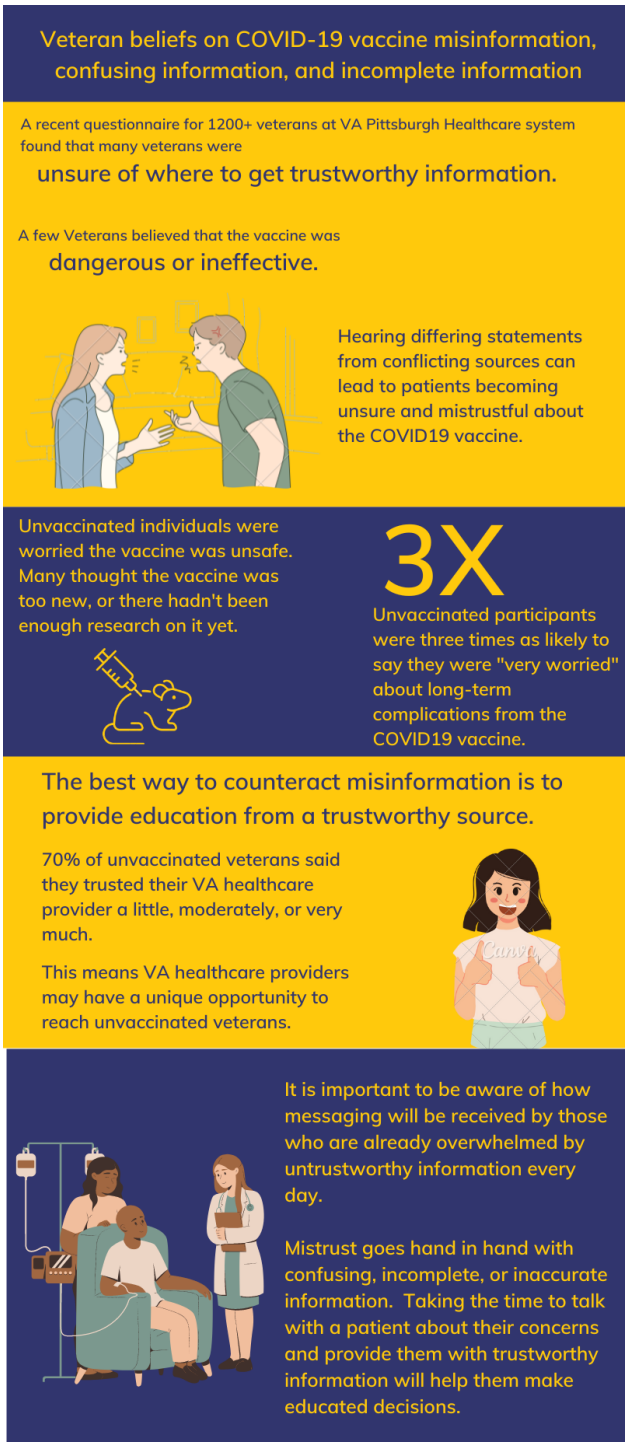


Figure 10. Second revision of misinformation infographic

The second draft (Figure 10) had some edits to make it less text-heavy, with some graphics added. For example, the initial box had less text, and key words and phrases were written in a

larger font to draw attention to them and to make it obvious at a glance what the theme of the panel was. The same is true with writing "3X" in large font, rather than writing out "three times as likely." We also revisited the data to update it for accuracy, as the previous version said twice as likely rather than three times.

We also did the same type of revision as the trust infographic, and focused in on information providers could use instead of highlighting negatives. We removed the panel illustrating various negative responses given by Veterans. We also retooled the sections on reasons for hesitation to make the framing more about how to establish connections with hesitant patients leveraging the trust put in VA healthcare providers.

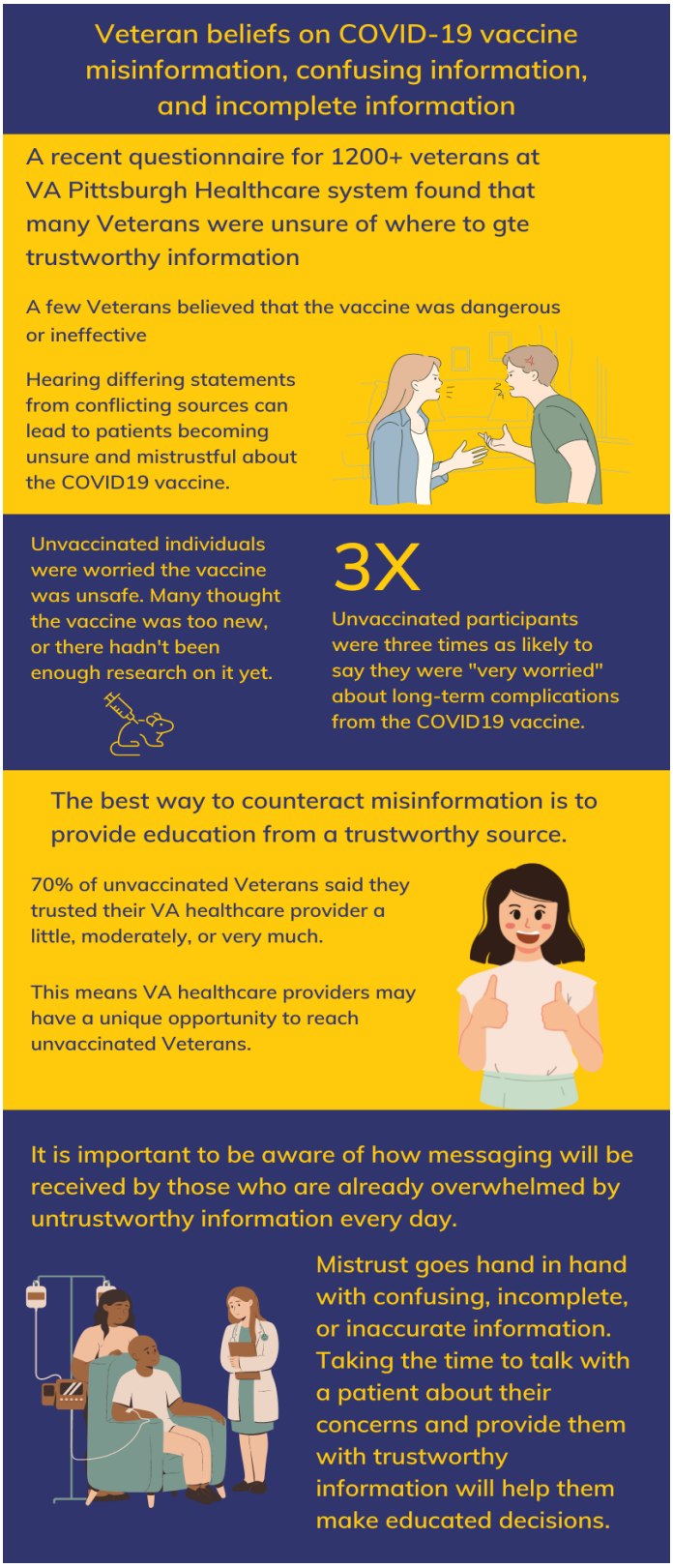


Figure 11. Final version of misinformation infographic

For the final version of the misinformation graphic (Figure 11), we made only minor tweaks to further refine the focus of the messaging. We reversed course on the alternating text sizes in the first box as it emphasized the negative vaccine attitudes.

3.5 Experiences and Incentives

The answers Veterans gave on what would change their minds, and barriers to vaccination, were interesting data to inform future vaccination efforts. We made a visual abstract to display responses Veterans gave about incentives, and their experiences with the vaccine rollout (Figure 12).

Figure 12. Highlighted information Veterans provided about incentives

We started out by clarifying that very few Veterans cited logistical issues, and so that was not a target that needed intervention. We emphasized that most unvaccinated Veterans chose not to get vaccinated, as opposed to not remembering to do so or not having the time. Based on their responses, it seems that material incentives for getting vaccinated would generally not be as effective as informational interventions.

This draft was effective in laying out the key points we wanted to touch on to inform the provider audience of why Veterans might think or behave the way they do, but once again it was too long to allow effective uptake of information. The alternating text boxes with key points, while visually distinct and effective at partitioning, led to a level of visual clutter and complexity that detracted from the graphic as a whole. For draft 2, we focused on pruning to facilitate emphasizing the key points.

Figure 13. Finalized version of incentives infographic

The second and final draft (Figure 13) had fewer graphics, such as removing the needle in the first panel to have only the bus to represent transportation, since that panel discusses how most participants did not encounter logistical problems such as transportation. We moved the information where Veterans gave their own answers on incentives to one large panel, rather than several smaller ones. We grouped them in a bulleted list, since they shared a few general themes and reading it this way made more intuitive sense. The graphics on the side direct the audience's eyes to each of the three bullet points with a simple representation of its themes. We also gave more room for the conclusions box to expand on the third bullet point, since we wanted that to be the key takeaway for providers talking with hesitant Veterans.

4.0 Discussion

The cluster analysis of the Veteran data may be compared to the clusters of responses outlined by Hoffman et al.[38] from data garnered from anti-vaccine comments on Facebook. One sub-group in that analysis, called the "trust" subgroup, had heavy overlap with the sentiments expressed by the "Unconcerned Disbelievers" group characterized in the VAPHS study, with major motivators being mistrust of medical institutions and concerns about personal freedom. Hoffman et al. suggest that the existence sub-groups within schools of anti-vaccine thought indicates a "one-size-fits-all" approach to communicating information about vaccines to hesitant groups may be ineffective, and instead a more tailored approach is necessary. This dovetails with the results from the study at the VAPHS, which showed that different groups of patients will have different concerns and doubts. Communication methods that may be effective in dispelling misinformation in one patient may have negative effects and harm trust in another individual. That is also why throughout this essay, we have examined different ways in which framing messages about COVID vaccines can impact the reception of data summaries to both lay and professional audiences.

Additionally, the findings from the VAPHS study that showed Veterans pointing to their personal VA healthcare provider as the most trusted source of information on the COVID-19 vaccine suggest that providing appropriate information to PCPs, such as the infographics outlined in this essay, is critical. Considering that between 8-10% of PCPs do not agree that vaccines are safe, effective, and important[39], it is more important than ever to use clear, evidence-based, succinct methods of communicating accurate information to PCPs and their patients. This is the reason why at later stages, we decided to focus the graphics on communicating to providers and

equipping them with knowledge they could use to build positive relationships with patients. Moreover, providing messaging that includes information that isn't useful but shapes a negative worldview, such as emphasizing how many patients lacked trust in the CDC, may lead to discouragement. Sharing information that can be useful to providers is more productive, such as the critical information that VA providers were the most trusted source across all groups. It is important to balance disseminating objective results in plain language with framing negative realities in a useful way.

Tailoring messaging to the audience is of paramount importance in risk communication. Public health messaging from authorities like the CDC came under unprecedented scrutiny during the COVID-19 pandemic, as doctors and public health workers faced the challenge of disseminating complex and novel information quickly and accurately to a diverse array of audiences. The work outlined here demonstrates that even within a specific demographic, such as American Veterans, there can be significant diversity in ways of thinking and multiple distinct subgroups that respond to messaging differently.

The group found that trust was ultimately the biggest factor associated with willingness to get vaccinated. Veterans who had low levels of trust in the CDC, the federal government, the state/local government, and/or their VAPHS provider were less likely to have positive attitudes about the COVID-19 vaccine. This is consistent with existing findings about trust and the COVID-19 pandemic, such as findings that fears about COVID-19 were related to intrinsic variables like intolerance to uncertainty and lack of trust in institutions,[40] lack of trust in supply lines leading to purchase of excess food and supplies during the pandemic,[41] and threats being more difficult to adapt to when they are perceived as being poorly understood and unmanageable by society at large.[42] This finding also demonstrates that messaging and communication, such as the data

visualizations for this VAPHS study, are not negligible parts of the science of vaccination and public health, when whether or not the patient trusts the source is such a huge factor in if they are receptive to the information.

Even among the subgroups with the lowest levels of trust, an individual's personal VA healthcare provider was ranked as the most trusted authority on health information relating to COVID-19. Therefore, in the future, communications about preventative care such as vaccines may be most effective coming from a familiar doctor's office, and/or a provider the patient has been seeing for years. We tried to make this clear in several of the different infographics. These results also suggest that reaching certain distrustful subgroups has limited effectiveness when done through a large, centralized authoritative entity such as the CDC or the federal government. This is problematic, as oftentimes in rural areas local resources will be scarce, and federal efforts subsidized by tax dollars are the only recourse available to reach the target demographic. It may be effective to allocate tax dollars to funding locally driven efforts for things like vaccine outreach, rather than a national, standardized campaign. These results also suggest that building trust in these organizations would go a long way towards future pandemic preparedness.

A key point of communicating these findings was to select the most important points of information that could be used and present them in a way conducive to quick uptake. It was a recurring pattern that the first draft is typically too wordy, too complicated, or too cluttered and that later drafts were more effective with less text and simpler images. It was also a challenge to decide what the best visual representations were regarding diversity of demographics represented by human figures, as well as choosing visually pleasing and readable color palettes. This issue was addressed with input from the working group on things like readability and representation during drafting.

There are some limitations to our process of making these visual graphics. Testing for feedback with the target audience was outside the scope of this project as we had no focus groups or surveys to see what Veterans thought of our designs. Thus, our decisions were based on the CHERP project team's expertise and experience with the study population only. We targeted our final products to be distributed to providers, rather than disseminating results back to participants, so future work could rework these designs into something more suitable for lay audiences with less health literacy if the key findings were to be reported back to participants. The lack of a clear intended distribution method and the moving target of audience was a hindrance throughout the project, so future efforts in similar projects would benefit from having details like these settled ahead of time.

If we had more resources, we could have expanded the scope of this project. We could have tested the graphic depictions on a real population through a focus group during the editing process. With more data, we could make comparisons between the Veterans and other groups to comment on the generalizability of these results, and we could make another infographic explaining how Veteran status is likely to affect vaccine attitudes.

5.0 Conclusion

The COVID-19 pandemic demonstrated that science communication is a critical and sometimes-neglected component of implementing public health interventions. Hesitancy about the COVID-19 vaccine was a significant obstacle even among scientifically literate populations. Tailoring education about vaccines could be an effective method of intervention depending on demographics and individual concerns, which tend to predict vaccine attitudes and uptake. Making graphical summaries to display data easily and accessibly for education is a challenge that requires good graphic design sense, ability to translate complex scientific concepts, clear understanding of goals and audience, and the opportunity and resources to distribute information in a useful way. The lessons learned in the COVID-19 pandemic will hopefully shape and improve responses in future public health crises.

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