A House Divided: How U.S. Politics Could Shape Contact-Tracing Adoption in Future Pandemics

Garrett Smith
Brigham Young University
Provo, Utah, USA
gds33@byu.edu

Kirsten Chapman
Computer Science
Brigham Young University
Provo, Utah, USA
kac273@byu.edu

Tzu-Yu Weng
Brigham Young University
Provo, Utah, USA
zoe.weng@byu.edu

Haijing Hao
Bentley University
Waltham, Massachusetts, USA
hhao@bentley.edu

Mainack Mondal
Department of Computer Science and Engineering
Indian Institute of Technology, Kharagpur
Kharagpur, West Bengal, India
mainack@cse.iitkgp.ac.in

Staci Smith
Brigham Young University
Provo, Utah, USA
sbsmithphd@gmail.com

Yunan Chen
Informatics
University of California Irvine
Irvine, California, USA
yunanc@ics.uci.edu

Xinru Page
Department of Computer Science
Brigham Young University
Provo, Utah, USA
xinru@cs.byu.edu

Abstract

Contact tracing has shown to be an effective tool in limiting the spread of transmittable diseases in countries where it is widely adopted. During the COVID-19 pandemic, contact tracing app adoption in the United States was low despite having the highest number of recorded cases worldwide. To better understand why, we conducted a survey (N=302, matched to U.S. census demographics) and found that political orientation overwhelmingly predicted attitudes towards COVID-19 and the adoption of contact tracing apps. These attitudes also overwhelmingly shaped people's willingness to participate in contact tracing for diseases in future pandemics. Our findings suggest that the politically charged environment surrounding COVID-19 in the U.S. may have a long-term impact on American's willingness to utilize contact tracing for diseases in future pandemics. We conclude with recommendations for technology designers and policymakers on how to overcome the sharp divide that has been driven by the political discourse in the U.S.

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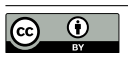

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1 Introduction

COVID-19 emerged in 2019 and had devastating effects across the globe. With over 700 million cases of the disease and over 7 million deaths worldwide [91], many countries went into lockdown to prevent its spread [60]. These lockdowns have had devastating economic effects in many countries [86], and the resulting social isolation led to a significant increase in suicidal ideation and actual suicide rates for men [10, 23]. Researchers continue to uncover the residual social harms that have resulted from the pandemic [79]. Given the profound and long-lasting negative impact of this most recent pandemic, it is critical to find a way to balance physical, mental, and economic health during a pandemic. Contact tracing applications can be a useful tool to limit the spread of disease without unnecessarily restricting public activity, and have been shown to be effective at flattening the infection curve when used in countries with high adoption rates such as in China [61, 94]. Unfortunately, during the COVID-19 pandemic, adoption rates throughout the United States lagged behind the majority of the rest of the world, and the United States ended up with the highest number of recorded COVID-19 cases of any country [7].

Extensive research has been conducted worldwide on the factors that influenced the adoption of contact tracing apps during the COVID-19 pandemic. This work has identified how privacy concerns [88], trust in the government [87], and willingness to follow other precautionary measures [87] are leading factors influencing digital contact tracing adoption. While adoption is a first step, for contact tracing applications to be effective, individuals must also willingly choose to disclose their health status [17]. Willingness to disclose health information for contact tracing is shaped by social factors, privacy concerns, organizational trust, age, and perceived benefits to society [13, 24, 38].

During the onset of the COVID-19 pandemic, the United States was in the middle of the 2020 presidential primary elections. As such, the pandemic became a primary issue that voters were concerned about [63], likely due to an especially polarized political climate [42] and politicized news coverage of the pandemic [30]. Specifically, liberals tended to be more concerned about the spread of COVID-19, while conservatives tended to be more concerned about expanding government interventions and economic effects [66]. Political ideology also shaped acceptance of COVID-19 related misinformation [31], threat perceptions of COVID-19 [11], and the adoption of mask wearing and social distancing [84]. However, past pandemics like the recent H1N1 pandemic of 2009 did not see political ideology shaping individuals' behavior or beliefs [57]. If app adoption and disclosure attitudes can be shaped by political discourse, this has major implications for designing and deploying such public health technologies. As such, our objective was to measure how political ideology affected user attitudes and behavior with respect to contact tracing adoption in the United States.

While the need for contact tracing applications for an endemic disease such as COVID-19 has diminished for the general population, contact tracing is still a vital tool to fight other infectious diseases around the world today including Tuberculosis, Measles, and HIV [33]. Given the powerful role contact tracing apps can play to combat many infectious diseases, we want to learn from the recent COVID-19 pandemic and identify the factors that limited its adoption in the U.S. Being prepared for the next pandemic only becomes more important over time given scientists' projections that, due to environmental changes, the likelihood of future pandemics will double in the coming decades [54]. As such, we asked the following research questions:

> **RQ1:** *What factors impacted contact tracing app adoption during the COVID-19 pandemic?*
>
> **RQ2:** *What factors influence individuals' willingness to share their health status in a future disease outbreak?*

We investigated these questions via a survey-based study administered on a U.S. sample (N=302) from January 24-26, 2022. In January 2022, the U.S. was nearing 75 million total cases of COVID-19 with the Omicron variant causing a significant third wave in the U.S. This surge in cases ended up being the largest wave of the pandemic. Our survey was deployed near the end of the third wave as seen in Figure 1. We developed several hypotheses to explore our research questions, constructing a theoretical model. Using structural equation modeling, we tested these hypotheses using the survey data. We qualitatively analyzed the open-ended survey data to further unpack how privacy and politics shape digital contact tracing adoption and disclosure. Our work makes several contributions:

- We identify political orientation as a significant factor that affects how concerned individuals are about COVID-19 while also significantly influencing their likelihood of adopting contact tracing applications during the pandemic.
- We find that these political views overshadowed users' privacy concerns when choosing to adopt contact tracing applications.
- These political views overshadowed past personal experiences with COVID-19, including serious hospitalization or death of a loved one.
- We show that COVID-19 concerns also impact individuals' willingness to share health information in future pandemics by influencing whether they perceived benefits of contact tracing systems.
- We provide guidance for contact tracing application designers and policymakers for combating future pandemics.

This paper presents these findings and discusses implications for the design of contact tracing apps and for policymakers. Pandemic management will involve designing for the sociopolitical contexts, such as carefully planning public health communication. In addition, pandemic management should include working with politicians to avoid polarized opinions that can be detrimental from a public health standpoint. This can be just as important as designing the actual technology used for contact tracing. We conclude by providing design guidelines that focus on providing a societal benefit to motivate people to participate in contact tracing systems.

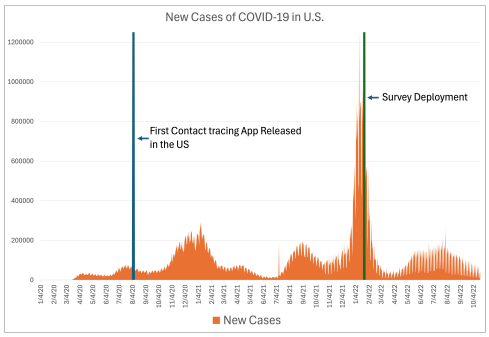

Figure 1: Timeline of COVID-19 and Survey Deployment in U.S.

2 Background and Related Work

Our work falls at the intersection of political ideology, digital contact tracing adoption, information disclosure, and privacy. We summarize the related work in these areas.

2.1 Contact Tracing and Adoption

Contact tracing has been used effectively in public health emergencies including (but not limited to) SARS, Foot and Mouth Disease, Influenza, Zika, and Ebola [22, 25, 44, 49, 85]. Digital contact tracing has emerged alongside the proliferation of smartphones and has been shown to suppress the spread of diseases such as Ebola, and Tuberculosis [18, 28, 67]. Several simulation studies have also demonstrated how COVID-19 contact tracing apps could help manage the pandemic, contingent on sufficient adoption rates [40, 48, 72].

However, while people seemed willing to adopt contact tracing apps at the beginning of the pandemic, the reality was different in most countries. For example, Altmann et al. surveyed participants from the U.K., Germany, Italy, France, and the U.S. before contact tracing apps had been released and found that 74.8% of respondents were willing to use COVID-19 contact tracing apps [3].

However, actual adoption rates turned out to be much lower. For instance, the average adoption rate in European countries is approximately 22.9% [41]. In the U.S., adoption has been even lower at approximately 14% [12, 64].

To fully understand what caused such low adoption rates, many studies have investigated the factors that influence users' intention to adopt and the actual adoption of contact tracing apps. These studies have focused primarily on demographic factors (age, gender, education, race), privacy concerns, and concerns about COVID [29, 37, 37, 46, 59, 81, 83, 88, 93]. This prior work has shown that older people were motivated to use contact tracing apps because they perceived personal benefit, but they were privacy concerned. On the other hand, younger people were motivated by societal benefit and tended to be more familiar with technology, less concerned about themselves becoming sick with the virus, and felt more in control of their information than the older generations [24, 37, 46, 93]. Additionally, studies have shown that privacy concerns negatively influenced usage intention and actual adoption [36, 37, 45, 46, 51, 81, 83, 88]. Some studies have noted a significant gap between intention and behavior, with many individuals intending to use a COVID-19 contact tracing app, but ultimately deciding not to [29, 37]. Häring et al. discuss this intention-behavior gap suggesting that ideological and technical reasons may explain some of this gap in Germany [29]. Interdisciplinary work has investigated a variety of technology adoption frameworks, such as UTAUT and UTAUT2, to understand the factors which influence technology adoption [21]. These frameworks emphasize how users' adoption decisions are affected by perceived usefulness and ease of use of technologies. Later models studying contact tracing app adoption during the COVID-19 pandemic emphasize the influence of social factors on adoption decisions [59]. In this study, we expand on these models to examine how contact tracing adoption is affected by political ideology and perceived usefulness of the tool for protecting oneself and for protecting others.

2.2 Online Information Disclosure and Privacy

Privacy concerns have shown to be a primary factor behind whether an individual will disclose information [90]. There have been multiple widely-used scales developed to measure information disclosure privacy concerns, such as the Internet Users' Information Privacy Concerns (IUIPC) scale [53] and Concern for Information Privacy (CFIP) scale [75]. Often individuals perform a privacy calculus when deciding whether or not to disclose information [90]. In other words, individuals weigh the perceived risks of sharing information against the benefits of doing so [82].

In the context of contact tracing, information disclosure is critical. Users are expected to report a positive diagnosis to the application so it can notify users who may have been exposed. However, individuals may have additional privacy concerns regarding disclosing the necessary health-related information [38, 50, 70, 89]. Before the COVID-19 pandemic, Romero et al. surveyed U.S. residents and found they were generally concerned about sharing sensitive health information with for-profit companies [65]. However, following the onset of the pandemic, Romero et al. interviewed a subset of those surveyed and found that individuals who were initially unwilling to disclose information decided that they were willing to share in the "interest of public health and safety" [65]. Subsequent work by Goetzen et al, found that the COVID-19 pandemic may have greatly reduced user concern for disclosing health related data, especially when used in a public health crisis [26]. Using cross-sectional surveys before and during the pandemic, they found that privacy sentiments related to the use of health-related data underwent a dramatic shift. Before the pandemic, users were very concerned about applications such as fitness trackers sharing user data with medical researchers. However, during the pandemic, users became much more accepting of sharing health data with researchers for the benefit of the public good.

2.3 Political Ideology and Technology Adoption

Political ideologies represent a collection of "interconnected attitudes, beliefs, and values that people use to organize and process social and political information." [80] The use of a left-right continuum for political ideology began during the French Revolution and is often replaced in the U.S. as a continuum from liberal to conservative. Although there has been significant debate regarding the underlying constructs of this scale, political ideology remains a prominent aspect of understanding individuals' political beliefs. While voters may have individual reasons for supporting a given candidate or party, their political ideology is most often a deep seated, ubiquitous, and unchanging aspect of their lives [80]. These ideologies are also interestingly related to non-political differences such as disgust sensitivity, taste in art, and desire for closure [32]. Measuring users' political ideology on a unidimensional scale provides a simple explanatory variable that has been shown to consistently predict attitudes and behavior [39].

Political ideology also shapes individuals' acceptance of technological innovations [14, 52]. This effect has been suggested to originate from the moral foundations on which these ideologies rely or emphasize. For example, liberals are more likely to adopt a moral foundation of preventing or mitigating harm, and promoting fairness, while conservatives place a stronger emphasis on group loyalty, authority, and purity [77]. Although we know political ideology impacts the acceptance of some technologies, our work focuses on understanding whether political ideology affected contact tracing application acceptance.

Alternative theories in social psychology suggest a different mechanism by which political views shape attitudes and behaviors. The Perceived Anxiety-Ideology Relationship (PAIR) model demonstrates that "ideological groups who feel a pandemic will benefit their own ideological ends will be more likely to view it (the pandemic) as a threat; ideological groups who feel a pandemic will hurt their own ideological ends will be less likely to view it as a threat." [16] Based on this model, conservatives are more likely to discount the seriousness of COVID-19 than liberals since the higher the severity of COVID-19, the higher the likelihood of government intervention [16, 58]. Additionally, Kowalewski et al. found that positive attitudes towards authorities managing the pandemic increased user willingness to use COVID-19 applications [45]. However, this prior work did not investigate how political ideology affects digital contact tracing adoption. Interestingly, prior work has also shown that privacy concerns can often be overshadowed by

one's political orientation [26]. In our work, we specifically investigate the interplay between political ideology, technology adoption, and privacy in the context of digital contact tracing during the COVID-19 pandemic.

3 Hypotheses and Research Model

Our model includes factors commonly cited to affect adoption (privacy concerns, concerns about COVID-19) as well as political orientation. We describe how we operationalized each of these constructs. The final hypothesized model is shown in Figure 2.

3.1 Political Orientation

Political orientation plays a significant role shaping people's attitudes about COVID-19 vaccination and other health-protective behaviors [8, 78]. Based on the PAIR model described in the background section [16], conservatives may be less likely to perceive the COVID-19 pandemic to be as severe as their liberal counterparts because more severe health risks implies the need for increased government control. This leads us to hypothesize:

> **Hypothesis 1 -** There is a positive relationship between liberal political views and concern for the effects of COVID-19.
>
> **Hypothesis 2 -**There is a positive relationship between liberal political views and the likelihood of adopting contact tracing applications.

3.2 Privacy Concern

Personal health information has long been considered highly private information [4]. One method for measuring individuals' privacy concerns is through the Internet Users Information Privacy Concern Scale [53]. The IUIPC scale was specifically developed to measure individuals' privacy concerns with their data being collected and processed by organizations. The IUIPC scale is made up of three sub-scales: Collection, Control, and Awareness. The collection sub-scale measures users' concerns about data collection practices, the control sub-scale measures users' concerns about the level of control users have over the data being collected, and the awareness sub-scale measures users' concerns regarding their awareness of the privacy practices of organizations. In the U.S., contact tracing apps were largely developed by private organizations independently, or contracted by local governments. As these apps are primarily managed by these technology organizations, IUIPC is a reasonable scale to use to measure individuals' privacy concerns. Utz et al. found that in the U.S., individuals' concerns about data collection practices, as measured by the IUIPC collection subscale, were negatively associated with one's willingness to adopt a hypothetical contact tracing app, while the control and awareness subscales had no effect. [83]. From this, we hypothesize:

> **Hypothesis 3 -** There is a negative relationship between privacy concerns and the likelihood of adopting contact tracing applications.
>
> **Hypothesis 4 -** There is a negative relationship between privacy concerns and one's willingness to share one's diagnosis.

Despite prior work finding that neither the Control nor Awareness sub-scales had a significant effect on digital contact tracing adoption, we still included them in the initial saturated model.

3.3 COVID-19 Attitudes

Evidence suggests a positive correlation exists between COVID-19 risk perception and the belief that contact tracing [27] is beneficial. From this, we hypothesize:

> **Hypothesis 5 -** Individuals' concerns about COVID-19 are positively associated digital contact tracing adoption.
>
> **Hypothesis 6 -** Individuals' concerns about COVID-19 are positively associated with the belief that contact tracing helps protect the health of others.
>
> **Hypothesis 7 -** Individuals' concerns about COVID-19 are positively associated with the belief that contact tracing helps protect their own health.

3.4 Contact Tracing Usefulness

By participating in the contact tracing process, individuals gain access to crucial information about potential exposure to infectious diseases. This notification could empower individuals to take proactive measures, such as timely testing and early treatment. This incentive could lead individuals to be more willing to participate in the system. We hypothesize:

> **Hypothesis 8 -** There is a positive relationship between the belief that contact tracing is helpful in protecting one's own health and willingness to share one's own diagnosis.

Public health interventions such as contact tracing are grounded in the principle of social responsibility, which emphasizes that we must act in ways that promote the common good. Prior work finds that social responsibility and altruism were positively correlated with people's willingness to share publicly beneficial information for contact tracing during COVID-19 [20] and public health research [34]. Those who believe that contact tracing helps protect the health of others may be likely to feel a sense of social responsibility to share their health status. Thus, we hypothesize:

> **Hypothesis 9 -** There is a positive relationship between believing that contact tracing is helpful in protecting the health of others and one's willingness to share their own diagnosis.

4 Methods

4.1 Survey Instrument

Our survey instrument investigated individuals' opinions about COVID-19, contact tracing adoption, individuals' perceptions about the usefulness of contact tracing in a future pandemic, willingness to share diagnosis or exposure, and finally, demographics.

4.1.1 Future Pandemic - Contact Tracing. Participants were given the following scenario about a future pandemic:

> *It is a future year, and a new disease is spreading through the world. There are many uncertainties concerning the*

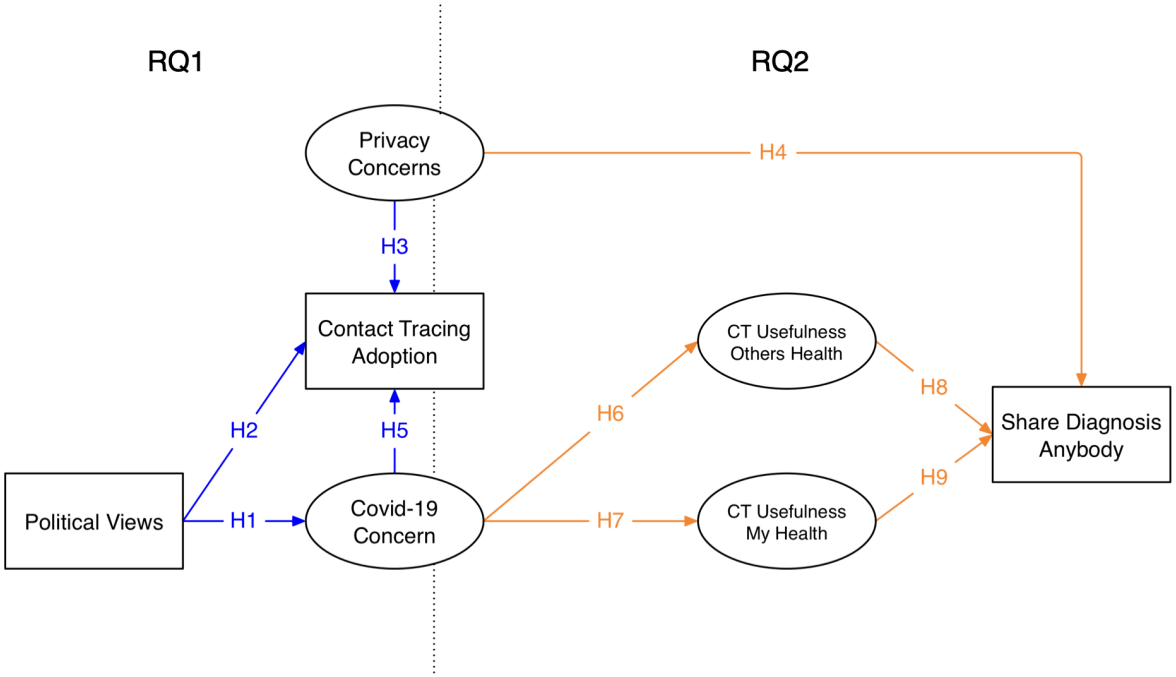

Figure 2: Hypothesized SEM Model Describing Contact Tracing Adoption and Willingness to Share. In this figure oval items represent latent variables while rectangles represent observed variables. The lines represent a causal relationship between variables.

diseases. Many suggest actions that were taken in previous pandemics, such as quarantine when you are sick, wearing masks in public, staying a certain distance away from other people, not gathering in large groups or events, and staying home whenever possible.

The survey additionally assigned participants to one of three conditions (a) There is a 50% chance that I could die, (b) I will most likely end up in the hospital and have long-term side effects, (c) I will probably only be sick for a week.

Following this description, participants were asked to provide their opinions on the usefulness of two different contact tracing approaches with 7 point Likert scale responses. In the first approach we asked users (1) how useful they felt contact tracing is towards protecting their health and (2) how useful they felt it protected others' health. We refer to this as first-degree contact tracing. We additionally asked participants about a predictive contact tracing approach that showed users the number of people in their network (people they come into contact with frequently) who are exposed to the disease. This approach shows users how "close" the disease is to them. Participants were asked how useful they felt this approach was at (1) protecting their health and (2) protecting others' health. We refer to this as second-degree contact tracing. Each of these questions did not refer to any specific technological implementation and was followed up with open-ended questions for participants to provide additional insights that aren't able to be captured through closed-ended responses.

4.1.2 Future Pandemic - Information Sharing. Next, we wanted to understand people's attitudes regarding participating in a contact tracing system by sharing their personal health information such as a positive diagnosis. Participants were asked how much they believed sharing a positive diagnosis would benefit others health. Participants were then asked how willing they were to share an anonymous positive diagnosis using a 7-point Likert Scale item.

4.1.3 Demographics. Finally, we collected demographic information from the participants. This includes usage probes on whether respondents had ever used a contact tracing app, regardless of their current usage status. While past research has identified low rates of contact tracing adoption in the U.S., the type of non-use is important to understand. The technology literature highlights how different types of non-use result from different barriers and attitudes [5, 62, 68, 92]. In particular, those who have never used technology may have very different barriers than those who have used it and abandoned it. Thus, we asked participants if they had ever used a contact tracing app (regardless of current usage). We measured individuals' political views (coded 1 for Very Conservative to 5 for Very Liberal), religious affiliation and attendance [74] and Privacy Concerns using the Internet Users Information Privacy Concern (IUIPC) [53]. We also collected which candidate participants reported voting for in the 2020 election. However, this item had to be removed from the analysis as it was so highly correlated with political views that this led to multicollinearity with the model. Finally, we collected information regarding participants' beliefs and opinions about COVID-19 (e.g., concern for hospital capacity, worry

about getting COVID-19, worry about variants). For the full text of the survey items and instrument see Appendix B.

4.2 Recruitment

We developed and deployed our survey using the Qualtrics survey software. Participants were recruited from the Prolific crowdsourcing platform using their representative sampling option (N=302) which cross-stratifies across gender, age, and ethnicity to match the simplified U.S. census [1]. This allowed us to get a broad range of responses. Earlier studies have shown that participants recruited from Prolific provide high-quality results regarding user perception about software and digital platforms [73]. Survey data was collected from January 24th-26th, 2022. Participants were compensated $2.50. The survey had a median time of 14 minutes and 51 seconds. The average compensation per hour was $10.11. The demographics of the study population are shown in Appendix A. Our survey contained five quality check questions (e.g., reverse-coded questions, attention checks, and English comprehension questions). We planned to discard responses that failed more than 2 of these. However, no participants failed this criterion.

4.3 Quantitative Analysis

We used the STATA 17.0 statistical software to analyze the quantitative data. We took a Structural Equation Modeling (SEM) approach using a robust weighted least squares method to evaluate our nine hypotheses [2]. SEM provides a comprehensive framework for testing and analyzing complex relationships between multiple dependent and independent variables. SEM coefficients are interpreted similarly to correlation or regression coefficients, i.e., the coefficient represents how much the dependent variable changes from a one-unit change in an explanatory variable with the remaining variables in the model being held constant. Handling multiple dependent relationships simultaneously within a single model, SEM produces more accurate estimates of relationships between variables without increasing the family-wise error rate [43]. SEM also provides goodness-of-fit indicators to evaluate how the collected data fit our theoretical model. Our full hypothesized model is shown in Figure 2. We included the respective hypotheses regarding the dependency of the variables in the model.

We started with a saturated model with paths from contact tracing adoption to contact tracing usefulness and willingness to share a diagnosis. This saturated model included paths from political orientation to privacy concerns, perceived usefulness of contact tracing applications, and willingness to share diagnosis. Furthermore, paths from COVID-19 concerns to diagnosis disclosure. Finally, we added a path from the usefulness of contact tracing for one's health to the usefulness of contact tracing for protecting others' health. These paths were added to potentially uncover other interesting relationships. Following best practice, we iteratively trimmed non-significant paths that were not hypothesized before creating the model [43]. In addition, we added the following control variables to our model: age, gender, education level, income level, previous diagnosis of COVID-19, being seriously ill from COVID-19, having someone in a close relationship die from COVID-19, religious affiliation, religious attendance, and the randomly assigned hypothetical disease severity. The final model shown in Figure 3 shows our model after trimming.

4.4 Qualitative Analysis

Two researchers collaboratively coded *all* qualitative responses, inductively identifying emergent themes from the responses and creating a codebook [9]. The two coders consulted with a third researcher whenever there was a difference of opinion and discussed until reaching consensus. Data saturation was reached during the qualitative analysis by the 50th response as evidenced by the repetitive emergence of consistent themes. The remaining responses were subsequently recoded and no new themes emerged. We use the identified themes to unpack user attitudes about contact tracing apps and disclosure.

4.5 Ethical Considerations

Our study was approved by the first author's institutional IRB. Our survey collected potentially sensitive information, such as experiences during the COVID-19 pandemic. However, we did not collect any personally identifiable information.

4.6 Limitations

This study relies on self-reported survey data. As such, we are able to examine user attitudes toward contact tracing applications. Though this does not provide insights into user behavior beyond self-reported contact tracing app adoption, it does provide valuable information on the perceptions that can drive future behavior. We leave it to future work to examine user behavior.

The representative sampling provided by Prolific only allows sampling based on the simplified U.S. census. This led to possible under-sampling of certain demographics such as Hispanics. Moreover, despite the higher proportion of liberal-leaning participants, there was enough variation in political orientation for us to detect meaningful and statistically significant relationships between that and other constructs. Furthermore, additional factors may come into play in future adoption decisions and so future studies could consider investigating factors such as societal trust, social cohesion, altruism, and pro-social orientation. In addition, this work focuses exclusively on contact tracing adoption within the U.S. Future work should further investigate how this model can be applied to other contexts especially in non-WEIRD countries.

Our work primarily investigated how political ideology affects users' willingness to adopt contact tracing applications. Future research should investigate the specific mechanism in which political ideology affects adoption. As suggested in prior work, we focus our attention on the perceived threat of COVID-19 acting as a mediator between political ideology and contact tracing app adoption. We find that while political ideology does affect the perceived threat of COVID-19, the perceived threat did not have a direct effect on contact tracing adoption when controlling for individuals' political views. This suggests a different mechanism by which political ideology influenced the decision to adopt contact tracing applications. We leave this investigation to future work.

Theoretical Constructs	Items	Loading
IUIPC Data Collection	It usually bothers me when online companies ask me for personal information.	0.84
	When online companies ask me for personal information, I sometimes think twice before providing it.	0.77
	It bothers me to give personal information to so many online companies.	0.93
	I'm concerned that online companies are collecting too much personal information about me.	0.82
COVID-19 Attitudes	I am concerned about the hospital capacity during the COVID-19 pandemic.	0.72
	I believe that COVID-19 is more dangerous than the common flu.	0.77
	I worry about the effects of variants of the disease.	0.87
	I am very worried about getting COVID-19.	0.69
Contact Tracing Usefulness My Health	First Degree Contact Tracing Notification - My Health	0.71
	Second Degree Contact Tracing Notification - My Health	0.83
	First and Second Degree Notification Combined - My Health	0.86
Contact Tracing Usefulness Other's Health	First Degree Contact Tracing Notification - Other's Health	0.56
	Second Degree Contact Tracing Notification - Other's Health	0.80
	First and Second Degree Notification Combined - Other's Health	0.87

Table 1: Table of Measurement Model and Factor Loadings

5 Results

We tested our hypothesized model through a quantitative analysis. Following this analysis we looked at the qualitative data to gain insight into the reasons behind these findings.

5.1 Measurement Model

Included in the model are three latent variables constructed from a subset of survey items found in Appendix B. The measurement portion of the model is presented in Table 1. The *COVID-19 Concern* latent variable is specified by four indicators measuring participants' concerns regarding the COVID-19 pandemic. The *contact tracing usefulness - other's health* latent variable is specified from three indicators measuring how effective the various contact tracing approaches are at protecting other's health. The *contact tracing usefulness - my health* latent variable is specified from three indicators measuring the effectiveness of the same approaches at protecting their own health. To account for the shared variance in the error terms for each pair of items, we allowed the paired item's error terms to covary. This led to a significant covariance for the second-degree items (.59) and network-level items (.46). The full measurement models with error terms are shown in Appendix B.

5.2 Model Evaluation

The structural model in Figure 2 provided a good fit for the data, with a root-mean-square error of approximation (RMSEA) = .042; confirmatory fit index (CFI) = .969; Tucker-Lewis index (TLI) = .960. Each of these model fit indicators measure how closely the proposed model fits the data. Specifically, RMSEA measures how well the model fits the covariance matrix per degree of freedom. Measures below .05 indicate a good fit [35]. The CFI and TLI indices compare the model fit compared to a baseline model with each model being affected by model complexity differently. Scores above .95 are indicative of good fit [35].

The reported model coefficients are standardized, with the model controlling for age, gender, income, education level, positive COVID-19 diagnosis, serious illness from COVID-19, and losing someone to COVID-19. Of these control variables, only age, gender, and income had a significant effect on any of the dependent variables.

5.3 Influence of Politics on COVID-19 Concern and Contact Tracing Adoption

Based on the data analyzed, it can be concluded that more liberal political views are linked to higher levels of concern for COVID-19 ($\beta = 0.62$, $p < .001$), which supports Hypothesis 1. Age had a significant effect ($\beta = 0.11$, $p < .036$) on concern for COVID-19. This is unsurprising given that COVID-19 posed a disproportionate risk to older adults [15]. Additionally, the data also supports Hypothesis 2, which suggests a positive relationship between liberal political views and the actual adoption of contact tracing applications ($\beta = 0.23$, $p = .004$). Non-significant paths that were trimmed from the final model included political views influencing the perceived usefulness of contact tracing apps in protecting oneself and society, as well as political views influencing individuals' willingness to share diagnosis status. Without these significant effects, we can not assert that one's political views have a direct effect on the usefulness of contact tracing apps, nor their willingness to share a positive diagnosis within a contact tracing system.

5.3.1 Differences in COVID-19 Attitudes Between Conservatives and Liberals. Across responses, individuals who identified as more conservative tended to have fewer concerns regarding the severity of COVID-19 than participants who identified as more liberal. This presented itself both in the participant's attitudes toward contact tracing applications and statistics. We present these findings below.

Liberal leaning participants perceived greater benefit for adopting contact tracing. Participants who considered themselves more liberal found a greater benefit to contact tracing applications than those who were more conservative. Among the responses from participants who identified as very liberal or liberal, approximately 72% (127 responses) described finding contact tracing applications beneficial. Some liberal participants noted that they found contact tracing applications useful because it allows for better-informed plans of action on how to mitigate the disease:

> *"Contact tracing apps allow individuals to adjust their behaviors to evolve with their individual situations" (Participant 124).*

Other liberal participants found contact tracing apps to be beneficial because they felt that COVID-19 is a severe disease and contact tracing apps allow them to know when to take precautions:

> *"who wouldn't want to know if they have been exposed?! this is a life or death situation for many people. you do not want to get the disease not quarantine and give it to an elderly that has no chance of surviving. the apps would help everyone and benefit everyone" (Participant 10).*

Responses describing the benefit of contact tracing applications were less common among moderate participants (42 responses - approx. 57% of moderate participants responses) and even less frequent among respondents that described themselves as conservative or very conservative (23 responses - approx. 50% of conservative or very conservative respondents).

Some participants tied their perceptions of contact tracing applications with the usefulness of case count statistics. One liberal participant described this as a

> *"...convenient way to collect data and statistics regarding the disease, which can then be used to create plans of action regarding public health and keep people informed to protect their health" (Participant 15).*

Conservative participants tended to be less concerned regarding taking precautions in response to case count changes in COVID-19 spread. 104 (59%) liberal or very liberal participants stated that their level of precaution would depend on the spread of COVID-19, 40 (54%) moderates similarly stated this, while just 12 (26%) of very conservative or conservative participants shared this sentiment.

Some conservative participants noted concerns about the efficacy of the case counts: *"Schools do mass testing at certain times the spikes are related to the accelerated testing, the same as the spikes when funding allowed for accelerated testing"* (Participant 283). Others had doubts about the disease itself:

> *"Because it is all lies! Even the "experts" have said that the numbers are incorrect. Masks work, then they didn't, now they do. It's ridiculous that anyone would believe any of this anymore" (Participant 255).*

This participant felt that the high variability in case counts caused uncertainty about whether they are meaningful.

5.4 Privacy Concerns and Contact Tracing Participation

However, the data did not support Hypothesis 3, which proposed a negative association between privacy concerns and the likelihood of adopting contact tracing applications ($\beta = -0.07$, $p = .266$). Hypothesis 4 was supported, revealing that individuals who have privacy concerns related to data collection are less willing to share their health status ($\beta = -0.17$, $p = .004$). While we included the additional IUIPC subscales, Awareness and Control, as additional privacy concern factors, these were not found to significantly affect contact tracing adoption or willingness to share diagnoses.

5.4.1 Impact of privacy concern on willingness to share. Thirteen participants noted privacy concerns about sharing their health status with others, and an additional twenty-one participants shared privacy concerns about contact tracing applications in general. Across responses to both questions, participants shared that they would be concerned about sharing their information with governments or tech companies.

Some participants shared that they felt that technology companies would act perfidiously with their information, and because of that, they would be unwilling to use and share their information with contact tracing apps. One participant shared their concern for third-party data vendors as:

> *"...This information could be used for other than contact tracing and therein lies the problem. If 3rd party vendors use this type of data for uses other than contact tracing like for marketing purposes, then I would be highly discouraged in using an app such as this" (Participant 242).*

Another respondent was cautious share information with tech companies who may not handle their user data ethically: *"... I would be wary of sharing information with tech companies, who often operate unscrupulously with regard to privacy concerns" (Participant 229).*

Participants also shared concerns about the possible repercussions of sharing information with the government. One participant shared that they were concerned with government-imposed mandates: *It would let people I could have exposed know to isolate. I would be somewhat worried about being forcibly quarantined, though. (Participant 11).* While another participant explained their general mistrust in the government: *"I don't trust government or civic authorities to be responsible with the information tracked." (Participant 296).*

5.5 COVID-19 Concern, Contact Tracing Usefulness, and Willingness to Share Positive Diagnoses

Surprisingly, individuals who had a higher concern for COVID-19 were not more likely to have used contact tracing applications during the COVID-19 pandemic leaving Hypothesis 5 unsupported($\beta = .07$, $p = .412$). However, the findings further demonstrate that individuals who express concern about COVID-19 are more likely to believe that contact tracing helps protect the health of others ($\beta = 0.28$, $p < .001$) and self ($\beta = 0.19$, $p = .005$), which supports Hypothesis 6 and Hypothesis 7. It was also discovered that individuals who believe that contact tracing is effective in protecting others' health are more willing to share their own health status ($\beta = 0.23$, $p = .002$), thus supporting Hypothesis 8. On the other hand, Hypothesis 9 was not supported by the data, as there was no significant relationship between the belief that contact tracing is beneficial for oneself and willingness to share a positive diagnosis ($\beta = -.07$, $p = .307$).

5.5.1 Perceived personal and perceived societal benefit drives willingness to share.

Too Late for Contact Tracing Apps to Help Me. The primary reason that participants felt like contact tracing applications wouldn't be

useful for themselves was that they believed they had already been exposed to the disease. This sentiment came up among respondents about both the 1st (126 participants) and 2nd degree (49 participants) features of contact tracing applications.

A participant expressed their feelings about the 1st-degree feature: *"If I am already infected it's too late to save myself" (Participant 24).* Some other participants explained that it is too late for them to protect themselves from the disease, but they will still take action to mitigate the impending symptoms: *"If I am already infected there is no protection I have. I can, however, try to start taking higher doses of vitamin C & stay hydrated. I would immediately go in quarantine [sic]" (Participant 7).*

Despite the second-degree feature allowing for a more proactive approach, many participants still felt that it would not protect them from getting ill. Some participants felt that if they weren't already infected, they would be shortly: *"I could wear a mask but if I'm often in the same room as person A and don't know who they are it's not likely that I could distance myself from them" (Participant 14).* While others felt that they would have already been in contact with the disease vector: *"If I'm already infected from being in close contact with person A, there's not much I can do with this information" (Participant 12).*

Not Too Late to Help Others. While many participants didn't find contact tracing applications useful for themselves, they frequently found it useful for others. Respectively, 207 participants found the 1st degree features beneficial for others, and 120 participants found 2nd degree features useful for others. Participants felt that because they were already most likely infected, they could quarantine and help others avoid the illness. One participant stated: *"This is more pertinent to the health of others, not necessarily me. Bit too late for me, but I can take action to protect others" (Participant 85)* and another participant similarly stated: *"If I already may have it then it's too late for me to do anything about it. Its only useful to know so I don't spread it to others too" (Participant 96).*

Participants similarly found the second-degree contact tracing feature more beneficial for others than themselves. Participants felt that by knowing this information, they were better equipped to protect others. The primary way that participants felt they could help others was to go into quarantine and limit contact: *"I could isolate from all others to protect them" (Participant 108).* Some participants also felt that this information would be beneficial because they could relay the information of possible exposure to those closest to them. One such participant explained: *"I could let others know that I had possibly been exposed" (Participant 188).* While another participant described how they would use this to help their family: *"Warn my family ahead of time" (Participant 239).*

Desire to Help Others. In our open-ended responses about willingness to share health status with others, participants valued societal responsibility over their own concerns about sharing such information. Twenty-six participants explicitly stated that they felt driven to disclose their symptoms to help others. Participants cited a social or ethical duty, frequently expressing feelings of accountability toward protecting others. Specifically, supporting others' ability to protect themselves with the knowledge of potential exposure:

> *"If the symptoms are from the disease, then it's my duty to inform others so they can know that they may have been exposed to it. If it turns out that I don't have it, I would then also notify them so they can stop worrying" (Participant 293).*

For many participants, there was an element of obligation in their responses: *"I would feel obligated to do so in order to protect those around me" (Participant 302).* These individuals valued the importance of personal health status disclosure over their own privacy. The responses indicate that there is a positive influence of social responsibility on disclosing health status.

Nonetheless, the large majority of responses (211) explicitly mentioned that they would share their health information due to concern for others and not just because they felt an obligation to do so. There were multiple reasons respondents felt this information could help others. Others could make informed decisions on whether they want to be around the person: *"Because I care about other people and would want them to know so they can decide if they wish to have contact with me" (Participant 163).* Others could get tested and social distance themselves from others: *"It could help others in taking precautions to avoid spreading the disease" (Participant 14).*

5.6 Contact Tracing Control Variables

Gender and income were the only control variables to have a significant effect on contact tracing adoption, with males being less likely to use these apps($\beta = -.12$, $p = .035$) and higher income increasing app adoption ($\beta = .14$, $p = .011$).

5.7 Other Direct Effects

Of note, paths that were trimmed from our saturated model included the direct effect of contact tracing adoption on the perceived usefulness of contact tracing and willingness to disclose a positive diagnosis. Additionally, the paths from political orientation to perceived usefulness were also trimmed as they were insignificant. Only two non-hypothesized paths remained significant. One path is the relationship between COVID-19 concern and individuals' willingness to anonymously share their diagnosis ($\beta = .29$, $p \leq .001$). Individuals concerned about COVID-19 may be more likely to be concerned about a future disease and, thus, more likely to be willing to share their diagnosis to help others. A second untrimmed path was from the usefulness of contact tracing for my health and for others' health ($\beta = .49$, $p \leq .001$). This path suggests a high level of correlation between these factors.

5.7.1 Accuracy Concerns. While the quantitative model did not measure for accuracy concerns, in open-ended responses 75 participants noted that they were less likely to find contact tracing apps useful as they were concerned about the accuracy of such apps. There were multiple factors leading to these accuracy concerns. First, some participants believed there to be a patchwork of contact tracing applications leading to greater inaccuracies. For instance, one participant shared:

> *"Tracking spread and identifying common areas of infection or common actions could help to slow down the disease. However it seems like there are a patchwork of*

> *these apps and I'm not convinced they all communicate with each other effectively, harming their efficacy."*(P38)

Other participants also felt that inaccuracies would be due to other users not providing correct information. For example, one participant shared:

> *"I think lots of people won't be honest regarding their actions and exposure to others. Too many people in this country only think about themselves and not the good of the community." (P128)*

Finally, participants also noted that access issues would lead to accuracy issues. For instance, one participant noted that older adults may not have access to smartphones or the digital literacy to use such apps:

> *"Mainly because not everyone has a smartphone. My generation, the Baby Boomers, tends to be tech challenged; we haven't all had exposure to computers and smartphone, and even some who have them barely know how to use them. Seniors are at high risk, and a high-risk group that can't use an app is going to make that app not reliable."* (P180)

Overall, these accuracy concerns seemed to play a major role in whether or not individuals found contact tracing apps useful for themselves or others.

5.8 Disease Severity and Control Variables

Our models specifically included the assigned severity of the hypothetical disease as a direct effect on the dependent variables. We fail to find any significant effect of severity on the perceived usefulness of contact tracing for one's health or others' health. Additionally, this did not result in a significant effect on participants' willingness to share their diagnosis.

Of the control variables that were included in the model all except for income, gender, and age did not have a significant effect on any of the variables in our model. We find that both income and gender were significantly associated with contact tracing adoption. Namely, higher income is associated with a .14 ($p \leq .01$) standard deviation increase in having used contact tracing applications, and females are associated with a .12 ($p \leq .036$) standard deviation increase in the likelihood of having used contact tracing apps in the past. Unsurprisingly, as COVID-19 has had a disproportionate effect on the elderly, we find that an increase in participant age is associated with a .11 ($p \leq .037$) standard deviation increase in concern for COVID-19. Surprisingly, we do not find adverse prior experience with COVID-19 to be a significant predictor in the model.

5.9 Mediation Effects

To further examine the relationship between political orientation and the perceived usefulness of contact tracing we additionally conducted a mediation analysis, with the attitudes about COVID-19 acting as a mediator. The direct effect of political orientation on the belief that contact tracing benefits others ($\beta = .026$, $p = .534$) and the belief that contact tracing benefits themselves ($\beta = .039$, $p = .6984$) indicate that when controlling for individuals attitudes towards COVID-19, ones political views did not have a significant direct effect on their contact tracing benefits beliefs. In contrast, the indirect effect of political orientation on contact tracing benefiting others ($\beta = .10$, $p \leq .001$) and self ($\beta = .12$, $p = .055$) through COVID-19 was significant. The ratio of indirect effect to direct effect of political views on contact tracing beliefs is 2.97 for benefiting self and 4.04 for others, indicating the relationship between political orientation and perceived contact tracing benefits to be nearly fully mediated by individuals' concerns for COVID-19.

To summarize, the data support H1, H2, H4, and H6-H8, however, fails to support H3, H5, and H9. This suggests that current political opinions and the climate surrounding COVID-19 attitudes significantly impact users' perceived utility of contact tracing for future pandemics. Further, political opinions play a significant role in shaping the adoption of contact tracing apps during the COVID-19 pandemic. Surprisingly, our model does not support previous findings that privacy concerns impact contact tracing adoption in the U.S. However, it does find that privacy concerns do influence people's willingness to share a positive diagnosis for a hypothetical disease.

While we find that politics and privacy influence contact tracing app adoption and willingness to share information, we aim to further understand these relationships. To achieve this, we conducted a qualitative analysis of the open-ended survey responses, delving into users' experiences and motivations, aiming to further explore the interplay between these factors.

6 Discussion

In this work, we show how contact tracing app adoption in the U.S. during the COVID-19 pandemic was primarily influenced by political orientation. While privacy concerns have been found to hinder technology adoption in some circumstances [6], our work confirms the supposition made by Goetzen et al. that user privacy concerns were significantly reduced in relation to health related data during the pandemic [26]. In some ways this could explain why privacy concerns didn't play a significant role in the adoption of contact tracing applications in this study, similar to other studies [29]. We find that one's political views also significantly determined the level of concern about COVID-19 - liberals expressed more concern about the severity of the disease. However, we discover that these concerns about COVID-19 have a much longer lasting impact. They drove perceptions of whether future contact tracing systems would be useful for protecting oneself and others from a future disease, as well as the willingness to disclose one's diagnosis for contact tracing. The sizeable impact of these politically-driven attitudes should serve as a warning that political discourse can have long-lasting impact on public health attitudes, beyond the current pandemic and regardless of the severity of the future disease. This is troubling given that the effectiveness and implementation of a future contact tracing app can vary widely for a different disease. System designers need to consider how to clearly differentiate future contact tracing apps so that they overcome the perceived limitations of the COVID-19 contact tracing apps. Public health officials must learn from the highly politicized rhetoric around COVID-19 that such messaging can be detrimental to our ability to use contact tracing in a future public health crisis.

Although this work was conducted within the U.S., we uncovered user concerns about the technological limitations of contact tracing

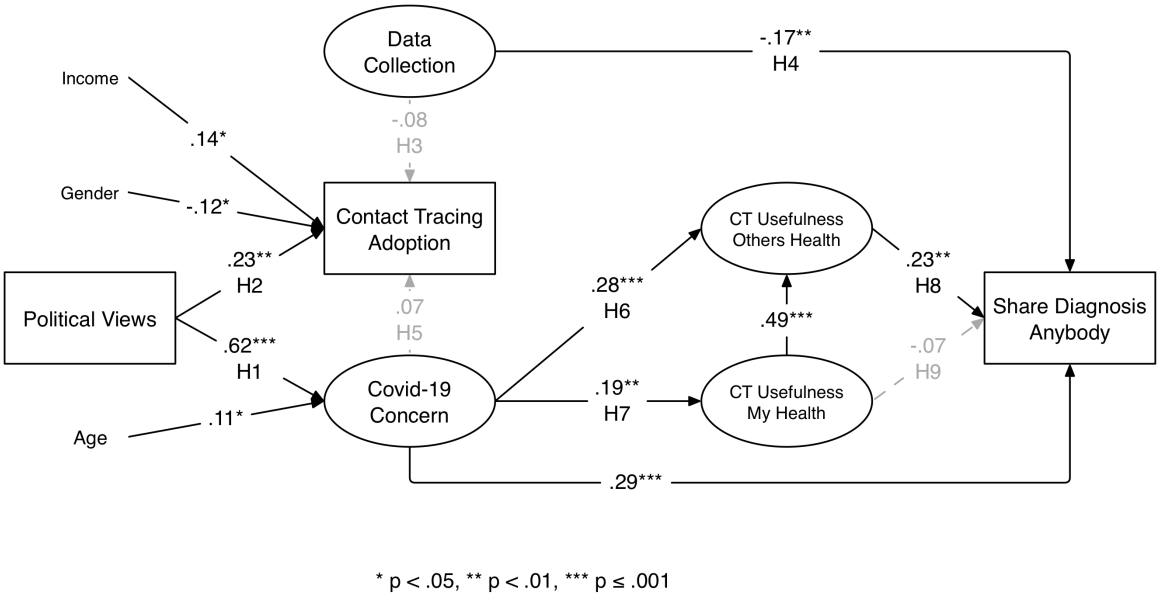

Figure 3: Final SEM Model Describing Contact Tracing Adoption and Willingness to Share.

applications that may pose issues in countries with a different technological infrastructure. Specifically, users discuss accuracy concerns and digital literacy concerns as reasons why applications may not be effective. Countries with comparatively lower digital literacy may need to incorporate educational messaging to help users with less technical knowledge. Furthermore, our results hint that countries with a higher population density may be more likely to have false positive contacts, depending on the accuracy of the applications themselves.

In line with previous work by Matt et al. [55], we found that willingness to share one's diagnosis is driven by the belief that contact tracing will benefit others rather than concerns for one's own health. Messaging focused on benefiting society could increase willingness to engage in contact tracing. Specifically, we validate their supposition that users perform a privacy calculus in determining whether to share health-related information - they weigh personal privacy concerns against benefits to society. While we did find data collection privacy concerns factor into disclosure decisions, this is a smaller predictor than the usefulness of the application itself. Nonetheless, system designers should limit data collection as much as possible to address these concerns. Unfortunately, COVID-19 attitudes still had a bigger impact on attitudes about sharing diagnosis than either altruism or privacy concerns. Thus, we see that feelings about the present disease overshadow other factors. Future work should investigate whether this effect attenuates over time, giving us hope that we can overcome the attitudinal shadows created by the COVID-19 pandemic.

6.1 Designing Contact-tracing Interfaces and Systems to Promote Social Benefit

Using the framework of privacy calculus, our results indicate that participants make a trade-off between data collection privacy concerns and the benefit provided to society in deciding whether they would be willing to disclose their health status in a contact tracing system. While prior research in China [95] and the U.S. [71] suggest that privacy concerns are often overridden by the health concerns posed by pandemics, our findings suggest that these health concerns are primarily manifest through a desire to help others instead of themselves. Prior literature also suggests that age influences the motivation for disclosing health information, with younger users sharing to help others while older users share for their own benefit [24]. Our findings suggest that age certainly increases one's concern for COVID-19. In contrast, people did not report disclosing health information for their own benefit, regardless of age. Users are willing to disclose their health information for contact tracing if they believe it would benefit others.

These findings suggest that when creating technologies that require the disclosure of health information, it is important to recognize the user's desire to help society. Being cognizant of this allows designers to design interfaces that emphasize societal benefit and therefore encourage disclosure.

With political beliefs, disease perception, and a desire to benefit society being fundamental to contact tracing participation, our work indicates five possible implications for the design of contract-tracing apps going forward.

- Design contact tracing systems that encourage and support users' desire to help others, perhaps by communicating the

relevance of their participation in the system to helping others. Diethei et al. reinforce the importance of communicating this relevance when motivating individuals to participate in citizen science systems [19]. As both systems require voluntary adoption, and the benefits provided are primarily for society, contact tracing systems could learn from the strategies used in citizen science systems.

- Contact tracing applications should be designed to appeal to a broad spectrum of political ideologies. Claudy et al. find that the negative effect of one's political ideology on technology acceptance can be mitigated by framing the technology to be in line with the moral foundations of their respective political ideology [14]. Designers could potentially increase acceptance of contact tracing applications by conservative individuals by using a loyalty moral foundation, framing participation as a way to protect their families, communities, and nation. Similarly, systems could seek out endorsement from trusted authority figures within local communities.
- Design in-app nudges that increase the user's desire to participate in the system to benefit others. Dooley et al. found advertisements with collective-good appeals were effective at increasing the adoption of contact tracing applications [20]. In-app nudges with similar collective-good appeals could encourage participation in the system by encouraging users to share a positive diagnosis with the system.
- Educate users about contact tracing outside of the contact tracing ecosystem such as through public health campaigns. These could include persuasive video tutorials that encourage participation and emphasize helping others stay safe. Lee et al. find that the use of digital media such as videos, combined with critical self-reflection, can increase compassion and promote pro-social behavior [47]. In addition, designers and public health officials should partner with trusted institutions and organizations in public health campaigns, similar to the "Click it or Ticket" campaign [76]. In this example, the public health campaign specifically partnered with local law enforcement agencies to increase credibility with conservatives. Partnering with trusted organizations to promote contact tracing systems may increase credibility with individuals disenchanted with the political party in power.
- Contact tracing applications should highlight their interoperability with other contact tracing systems despite being developed by different organizations. Since accuracy was such a significant concern for users, in-app messaging and public health campaigns should emphasize the accuracy of the system itself and additionally encourage users to submit accurate information such as up-to-date diagnoses.

It will be challenging to implement some of these, but very much needed to promote contact tracing participation.

6.2 Policymaker Recommendations for Overcoming the Political Divide

In our model, political beliefs and, to a lesser degree, gender and income level were the only significant factors contributing to contact tracing app adoption during the COVID-19 pandemic. However, our results suggest that this need not be the case for future pandemics. While prior work has suggested that disease severity influenced people's willingness to adopt a hypothetical contact tracing app [37, 71], when it came to actual adoption amidst the COVID-19 pandemic, these were not significant predictors. Häring et al. investigated this intention-behavior-gap in Germany and found that this gap may be due to limitations of the utility of the COVID-Warn-App [29]. Our findings confirm this surprising paradox exists, where individuals did not adopt contact tracing apps during the COVID-19 pandemic, despite indicating a willingness to disclose contact tracing app-related information for a hypothetical disease. Our findings further illustrate the complexity of predicting technology adoption and indicate how sociopolitical factors, including political orientation, affected contact tracing adoption during the COVID-19 pandemic.

In the context of the COVID-19 pandemic, our study provides compelling evidence that aligns with the PAIR model discussed in Section 2.3. Specifically, we observed a distinct pattern wherein conservatives, who tend to have a higher tendency to oppose government intervention than liberals, were less inclined to adopt contact tracing measures compared to their liberal counterparts [16, 58]. Our study underscores the significance of ideological factors in shaping public health responses during pandemics. However, political orientation had an indirect effect on attitudes towards a hypothetical future disease. This suggests contact-tracing participation need not continue to be a partisan divide - it is possible that over time, attitudes about COVID-19 may fade and its impact on future attitudes diminish. Researchers should continue to study these attitudes and changes over time.

Another possible reason for the gap between intention and adoption could be related to the lack of trust in the organizations creating contact tracing applications and the government. Zakaria et al. suggest leveraging non-political government agencies, such as public health organizations, to increase user trust in contact tracing systems [93]. U.S. citizens could view health concerns as important but not be willing to risk any harm by participating in contact tracing apps controlled by the government or for-profit organizations. However, given our results showing the significant effect politics has on the adoption of contact-tracing apps, it also seems possible that contact-tracing adoption is symbolic of belonging to a specific political community, similar to mask-wearing during the COVID-19 pandemic [69]. The values associated with contact tracing may align with that of the governing political party or organization supporting it. Alternatively, this relationship could be explained by the (lack of) trust between public health officials and a political party.

These findings further highlight the complexity of predicting technology adoption. Given the significant effect age, income, and political orientation had on contact tracing adoption during the COVID-19 pandemic, policymakers, and public health communicators must design public health decisions and campaigns with the various sociopolitical contexts in mind. Given the significant influence that political beliefs had on concern about COVID-19, policymakers need to use caution when managing future public health crises. Our results reinforce the importance of divorcing politics from public health messaging. This finding also illustrated the importance of preventing the spread of misinformation as it relates to public health, similar to combating hate speech in political

discourse [56]. Thus, effective risk communication and generating public trust in public health information is a critical component to encouraging participation in contact tracing systems.

7 Conclusion

We ran a (n=302) survey in the United States to investigate perceptions of contact tracing utility for a future pandemic and willingness to share disease-related health information. Our results reveal that individuals perform a privacy calculus when sharing disease-related information; They balance their data collection concerns against benefiting others. However, when investigating actual contact tracing app adoption during the COVID-19 pandemic, we find that decisions are largely driven by political beliefs. We urge policymakers, public health officials, politicians, and technology designers to consider the current sociopolitical context so that they can be better prepared for the next pandemic.

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A Appendix A - Demographics

B Appendix B - Survey Instrument

B.1 Scenario

It is a future year and a new disease is spreading through the world. There are many uncertainties concerning the diseases. Many suggest actions that were taken in previous pandemics such as quarantine when you are sick, wearing masks in public, staying a certain distance away from other people, not gathering in large groups or events, and staying home whenever possible. If you contract the disease, based on your personal health, age, and fitness characteristics {(a) There is a 50% chance that I could die, (b) I will most likely end up in the hospital and have long-term side effects, (c) I will probably only be sick for a week.}

Based on what you read above, if you were infected with this disease how severe would your sickness be?
(a) There is a 50% chance that I could die.
(b) I will most likely end up in the hospital and have long-term side effects.
(c) I will probably only be sick for a week.
(d) I won't have any reaction to the disease.

B.2 Contact Tracing

You are notified that someone you were in contact with has been diagnosed with the disease and because of that you may already be infected.

This information would enable me to protect my health.
(a) Disagree Completely
(b) Disagree Mostly
(c) Disagree Somewhat
(d) Neither agree nor disagree
(e) Agree Somewhat
(f) Agree Mostly
(g) Agree Completely

This information would enable me to protect others' health.
(a) Disagree Completely
(b) Disagree Mostly
(c) Disagree Somewhat
(d) Neither agree nor disagree
(e) Agree Somewhat
(f) Agree Mostly
(g) Agree Completely

Why or why not?

You are frequently in the same room as person A. Person A is also frequently in the same room as person B. You are notified that person B has been diagnosed with the disease. Person A may or may not have been exposed. You do not know the identity of person A or person B.

This information would enable me to protect my health.
(a) Disagree Completely
(b) Disagree Mostly
(c) Disagree Somewhat
(d) Neither agree nor disagree
(e) Agree Somewhat
(f) Agree Mostly
(g) Agree Completely

This information would enable me to protect others' health.
(a) Disagree Completely
(b) Disagree Mostly
(c) Disagree Somewhat
(d) Neither agree nor disagree
(e) Agree Somewhat
(f) Agree Mostly
(g) Agree Completely

Why or why not?

Gender	xxds Age	Race	Political orientation
Female: 151 (50.0%)	18-24: 34 (11.3%)	American Indian or	Very Conservative : 12 (3.9%)
Male: 146 (48.3%)	25-34: 64 (21.2%)	Alaska Native: 1 (0.3%)	Conservative: 34 (11.3%)
Other: 5 (1.7%)	35-44: 54 (17.9%)	Asian: 26 (8.6%)	Moderate : 74 (24.5%)
	45-54: 55 (18.2%)	Black or African	Liberal: 110 (36.4%)
	55-64: 59 (19.5%)	American: 45 (14.9%)	Very Liberal: 67 (22.2%)
	65+: 36 (11.9%)	Native Hawaiian or	Prefer not to say: 5 (1.7%)
		other Pacific	
		Islander: 1 (0.3%)	
		White: 212 (70.2%)	
		Hispanic 11 (3.6%)	
		Other: 5 (1.7%)	
		Prefer not to say: 1 (0.3%)	

Table 2: Participant Demographics

You now know that person A was in the same room as person B after Person B was diagnosed.

This information would enable me to protect my health.
(a) Disagree Completely
(b) Disagree Mostly
(c) Disagree Somewhat
(d) Neither agree nor disagree
(e) Agree Somewhat
(f) Agree Mostly
(g) Agree Completely

This information would enable me to protect others' health.
(a) Disagree Completely
(b) Disagree Mostly
(c) Disagree Somewhat
(d) Neither agree nor disagree
(e) Agree Somewhat
(f) Agree Mostly
(g) Agree Completely

Why or why not?

B.3 Health Information Disclosure

If I was diagnosed with the disease I would be comfortable anonymously sharing my diagnosis anybody.
(a) Disagree Completely
(b) Disagree Mostly
(c) Disagree Somewhat
(d) Neither agree nor disagree
(e) Agree Somewhat
(f) Agree Mostly
(g) Agree Completely

B.4 Contact Tracing Behavior and Attitudes

For the following questions, please share your thoughts, attitudes, and actions during the COVID-19 pandemic: During pandemics such as with COVID-19, public health departments have used contact tracing apps to slow the spread of the disease. The mobile application usually does this by identifying individuals that may have been in contact with an infected person. Have you ever used a contact tracing app?
(a) Yes
(b) No
(c) I'm not sure

Why do you think contract tracing apps may or may not be useful?

Please share your opinions about topics related to the COVID-19 pandemic.

I am very worried about getting COVID-19.
(a) Disagree Strongly
(b) Disagree Somewhat
(c) Neither agree nor disagree
(d) Agree Somewhat
(e) Agree Strongly

I am concerned about the hospital capacity during the COVID-19 pandemic.
(a) Disagree Strongly
(b) Disagree Somewhat
(c) Neither agree nor disagree
(d) Agree Somewhat
(e) Agree Strongly

I believe that COVID-19 is more dangerous than the common flu.
(a) Disagree Strongly
(b) Disagree Somewhat
(c) Neither agree nor disagree
(d) Agree Somewhat
(e) Agree Strongly

I worry about the effects of variants of the disease.
(a) Disagree Strongly

(b) Disagree Somewhat
(c) Neither agree nor disagree
(d) Agree Somewhat
(e) Agree Strongly

B.5 IUIPC

Now please tell us about your attitudes towards online privacy. How much do you agree with each of the following?

User online privacy is really a matter of users' right to exercise control and autonomy over decisions about how their information is collected, used, and shared.
(a) Disagree Strongly
(b) Disagree Somewhat
(c) Neither agree nor disagree
(d) Agree Somewhat
(e) Agree Strongly

User control of personal information lies at the heart of consumer privacy.
(a) Disagree Strongly
(b) Disagree Somewhat
(c) Neither agree nor disagree
(d) Agree Somewhat
(e) Agree Strongly

I believe that online privacy is invaded when control is lost or unwillingly reduced as a result of a marketing transaction.
(a) Disagree Strongly
(b) Disagree Somewhat
(c) Neither agree nor disagree
(d) Agree Somewhat
(e) Agree Strongly

Companies seeking information online should disclose the way the data are collected, processed, and used.
(a) Disagree Strongly
(b) Disagree Somewhat
(c) Neither agree nor disagree
(d) Agree Somewhat
(e) Agree Strongly

A good user online privacy policy should have a clear and conspicuous disclosure.
(a) Disagree Strongly
(b) Disagree Somewhat
(c) Neither agree nor disagree
(d) Agree Somewhat
(e) Agree Strongly

Now tell us about how your personal information should be used by online companies. How much do you agree with each of the following?
It is very important to me that I am aware and knowledgeable about how my personal information will be used.
(a) Disagree Strongly
(b) Disagree Somewhat
(c) Neither agree nor disagree
(d) Agree Somewhat
(e) Agree Strongly

It usually bothers me when online companies ask me for personal information.
(a) Disagree Strongly
(b) Disagree Somewhat
(c) Neither agree nor disagree
(d) Agree Somewhat
(e) Agree Strongly

When online companies ask me for personal information, I sometimes think twice before providing it.
(a) Disagree Strongly
(b) Disagree Somewhat
(c) Neither agree nor disagree
(d) Agree Somewhat
(e) Agree Strongly

It bothers me to give personal information to so many online companies.
(a) Disagree Strongly
(b) Disagree Somewhat
(c) Neither agree nor disagree
(d) Agree Somewhat
(e) Agree Strongly

I'm concerned that online companies are collecting too much personal information about me.
(a) Disagree Strongly
(b) Disagree Somewhat
(c) Neither agree nor disagree
(d) Agree Somewhat
(e) Agree Strongly

B.6 Demographics

Some last questions to help us understand the different people taking our survey.

What is your gender?
(a) Male
(b) Female
(c) Other
(d) Prefer not to say

What is your age?
(a) Under 18
(b) 18 - 24
(c) 25 - 34
(d) 35 - 44
(e) 45 - 54
(f) 55 - 64

(g) 65+
(h) Prefer not to say

What is your highest level of education?
(a) Some secondary education
(b) Graduated secondary education
(c) Some college/university
(d) Graduated college/university
(e) Started post-graduate degree
(f) Post-graduate degree (Masters, PhD, JD, etc.)
(g) Prefer not to say

What is your household income level?
(a) Less than $15,000
(b) $15,000 to $34,999
(c) $35,000 to $49,999
(d) $50,000 to $74,999
(e) $75,000 to $99,999
(f) $100,000 or more
(g) Prefer not to say

In general, how would you describe your political views?
(a) Very liberal
(b) Liberal
(c) Moderate
(d) Conservative
(e) Very conservative
(f) Prefer not to say

C Appendix C Measurement Model

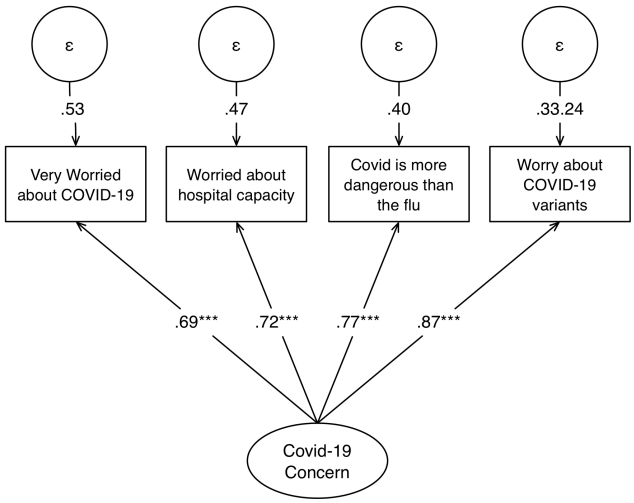
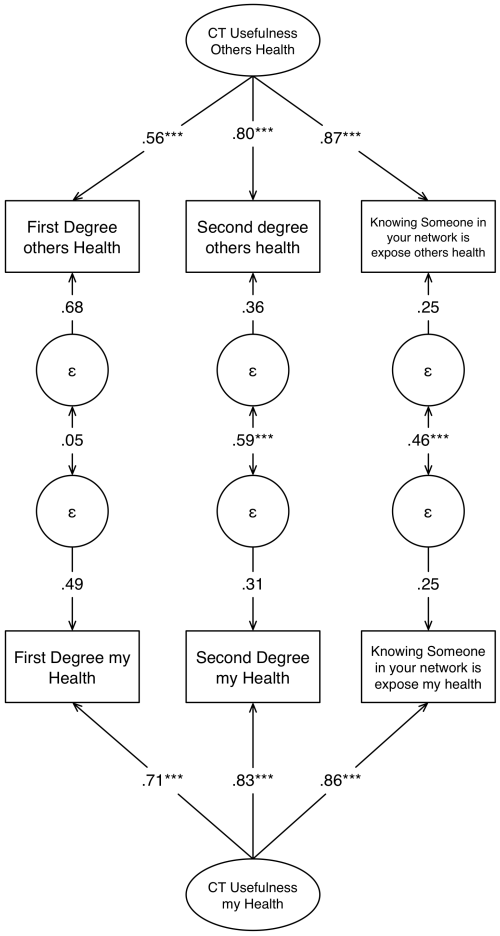
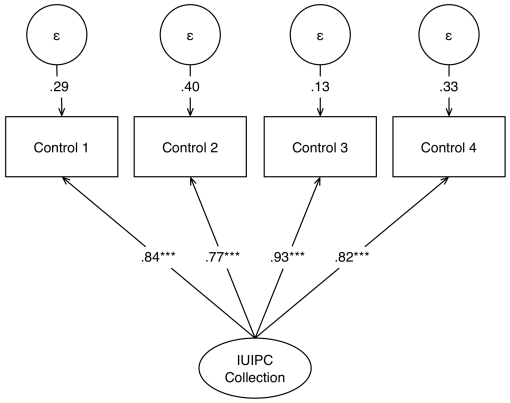


Figure 4: Measurement model for COVID-19 Attitudes Factor



(a) Measurement model for Perceived Usefulness of Contact Tracing Factors



(b) Measurement model for IUIPC - Collection

	(1)
contactTracing	
Attitudes	0.0399
	(1.03)
politicalViewsCorr	0.0667**
	(2.72)
gender	-0.0870*
	(-2.09)
income	0.0312*
	(2.55)
Collection	-0.0354
	(-1.36)
_cons	-0.160
	(-1.53)
diagAny	
Attitudes	0.698***
	(4.72)
CTMyHealth	-0.0927
	(-1.02)
CTOther	0.720**
	(3.13)
treatment	0.0314
	(0.28)
Collection	-0.374**
	(-3.23)
_cons	4.334***
	(14.31)
Attitudes	
politicalViewsCorr	0.401***
	(9.43)
age	0.0535*
	(2.07)
CTMyHealth	
Attitudes	0.352**
	(3.02)
treatment	-0.0783
	(-0.80)
CTOther	
Attitudes	0.221***
	(4.39)
CTMyHealth	0.217***
	(6.32)
treatment	-0.00324
	(-0.09)
hospital	
Attitudes	1
	(.)
_cons	2.552***
	(11.74)
dangerousFlu	
Attitudes	0.974***
	(12.55)
_cons	2.731***
	(13.16)
worryVariant	
Attitudes	1.120***
	(13.70)
_cons	2.320***
	(10.57)
worried	
Attitudes	1.217***
	(11.09)
_cons	1.227***
	(4.54)
firstdegreemy	
CTMyHealth	1
	(.)
_cons	4.374***
	(18.25)
secondmy	
CTMyHealth	1.217***
	(12.98)
_cons	4.069***
	(14.47)

personBMine	
CTMyHealth	1.125***
	(12.77)
_cons	4.585***
	(17.58)
firstdegreeother	
CTOther	1
	(.)
_cons	5.895***
	(46.09)
secondother	
CTOther	2.478***
	(9.45)
_cons	4.200***
	(15.04)
personBOther	
CTOther	2.170***
	(9.45)
_cons	4.714***
	(19.85)
informationBother	
Collection	1
	(.)
_cons	4.142***
	(74.91)
informationTwice	
Collection	0.768***
	(15.68)
_cons	4.460***
	(96.45)
informationTooMany	
Collection	1.056***
	(20.90)
_cons	4.268***
	(80.99)
informationTooMuch	
Collection	0.899***
	(17.19)
_cons	4.334***
	(85.35)
mean(politicalViewsCorr)	3.754***
	(50.00)
mean(gender)	1.510***
	(52.06)
mean(age)	4.493***
	(49.83)
mean(income)	3.914***
	(40.64)
mean(treatment)	0.990***
	(21.20)
var(e.hospital)	0.517***
	(10.28)
var(e.dangerousFlu)	0.365***
	(9.57)
var(e.worryVariant)	0.230***
	(6.79)
var(e.worried)	0.943***
	(10.74)
var(e.firstdegreemy)	1.589***
	(10.01)
var(e.secondmy)	1.097***
	(7.03)
var(e.personBMine)	0.716***
	(5.77)
var(e.firstdegreeother)	0.700***
	(11.14)
var(e.secondother)	1.099***
	(7.79)
var(e.personBOther)	0.507***
	(5.11)
var(e.informationBother)	0.271***
	(9.78)
var(e.informationTwice)	0.261***
	(10.60)
var(e.informationTooMany)	0.111***
	(5.53)
var(e.informationTooMuch)	0.252***
	(9.89)
var(e.contactTracing)	0.117***
	(12.02)
var(e.diagAny)	2.331***
	(11.91)
var(e.Attitudes)	0.353***
	(6.43)
var(e.CTMyHealth)	1.584***
	(6.68)
var(e.CTOther)	0.201***
	(4.79)
var(politicalViewsCorr)	1.379***
	(10.67)
var(gender)	0.250***
	(12.18)
var(age)	2.455***
	(12.29)
var(income)	2.801***
	(12.29)
var(treatment)	0.659***
	(12.29)
var(Collection)	0.652***
	(8.84)
cov(e.firstdegreemy,e.firstdegreeother)	0.0530
	(0.76)
cov(e.secondmy,e.secondother)	0.654***
	(6.16)
cov(e.personBMine,e.personBOther)	0.276***
	(3.71)
cov(politicalViewsCorr,gender)	0.114**
	(3.01)
cov(politicalViewsCorr,age)	-0.220
	(-1.88)
cov(politicalViewsCorr,income)	-0.108
	(-0.87)
cov(politicalViewsCorr,treatment)	0.0562
	(0.93)
cov(politicalViewsCorr,Collection)	-0.0518
	(-0.83)
cov(gender,age)	-0.00163
	(-0.04)
cov(gender,income)	-0.108*
	(-2.21)
cov(gender,treatment)	0.00867
	(0.37)
cov(gender,Collection)	0.0136
	(0.55)
cov(age,income)	-0.236
	(-1.56)
cov(age,treatment)	-0.104
	(-1.42)
cov(age,Collection)	0.255**
	(3.28)
cov(income,treatment)	-0.0936
	(-1.19)
cov(income,Collection)	0.129
	(1.59)
cov(treatment,Collection)	-0.0106
	(-0.27)
N	302

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$