Using structural equation modeling to model compliance with COVID-19 related
non-pharmaceutical interventions amongst university students in the United States

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Abstract

The world is currently dealing with a devastating pandemic. Although growing COVID-19 case numbers, deaths, and hospitalizations are concerning, this spread is particularly alarming in the United States where polarizing opinions, changing policies, and misinformation abound. In particular, American college campuses have been a venue of rampant transmission, with concerning spillover into surrounding, more vulnerable, communities. We surveyed over 600 college students from across the United States and modeled predictors of compliance with non-pharmaceutical interventions. We identified concern with severity ($p < .001$), constitutional originalist ideology ($p < .001$), news exposure ($p < .001$) and religiosity ($p < .05$) as significant positive correlates with compliance, and general trust in science ($p < .05$) as a significant negative correlate. To determine how applicable nationwide modeling might be to individual local campuses we also administered this same survey to nearly 600 students at two large universities in Utah County. In this population, concern with severity was the only significant positive correlate with compliance ($p < .001$); Additionally, feelings of inconvenience was negatively correlated ($p < .001$). The effects of feelings of inconvenience, and news exposure were significantly different between populations ($p < .001$, $p < .001$). These results suggest that we should focus our efforts on increasing knowledge about the pandemic's effects on our society and informing about constitutionality amongst college students. However, we also show that nationwide surveys and modeling are informative, but if campuses are to efficiently curb the spread of COVID-19 this coming semester, they would be best served to utilize data collected from their student populations as these might significantly differ from general consensus data.

Introduction

The emergence of the novel coronavirus Sars-Cov-2, which causes the disease COVID-19, rapidly spread from an outbreak to a global pandemic (1). As of November 19, 2020, the World Health Organization has reported nearly 56 million confirmed cases, and over 1.3 million deaths globally (2), and other estimates have reported much higher numbers in both categories (3). Additionally, the subsequent economic (4) and psychological (5) fallout from the pandemic have been felt across the globe.

Experts have suggested that increased compliance with non-pharmaceutical interventions could have reduced the consequences of the pandemic (6,7), and increased compliance in the future could save tens of thousands of lives in America alone (3,8,9). Non-pharmaceutical interventions include wearing masks, practicing social distance, washing hands, and sanitizing surfaces, among other things. A CDC study from 2008 found that most Americans would be willing to practice mitigation measures to slow the spread of a pandemic influenza (10), but this is not the reality that is seen today. Despite the scientific evidence behind the efficacy of interventions such as masks (6,8,11–13), social distancing (11) and increased handwashing (11), many Americans refuse to take these precautions (6,14–20).

The spread of COVID-19 has been of particular concern on university campuses. As of November 19, 2020, there have been over 321,000 cases at over 1,700 American colleges and universities (21). While college students are typically at a low risk for severe infection and death, spread of COVID-19 on campuses has the potential to spill over into more vulnerable communities adjacent to campuses (22,23). Additionally, long-term consequences of COVID-19 infections are not well understood (24), thus widespread infections amongst college students could plausibly lead to complications in the future.

One instance where COVID-19 originating on a college campus, spread to the surrounding community increasing case counts has been seen in Utah County, Utah (USA) (25). As of November 19, 2020, the state of Utah has reported nearly 166,000 total COVID-19 cases, 7,215 hospitalizations, and 756 deaths (26). Doctors and public health officials have warned of the strain on Utah's healthcare system, as ICU capacity has been exceeded in several major hospitals across the state (27–30). Two weeks after seeing a spike in cases, Utah's governor declared a "COVID-19 State of Emergency" (31). Overall, 8,881 cases have been reported at 10 universities and colleges, however 2,993 have been reported at one of the state's larger universities (21). During the time the survey in this study was administered, the United States had approximately 9.3 million total cases of COVID-19, and Utah County had reported approximately 30,000 cases (26).

Work has been conducted in the United States and internationally to identify predictors of compliance with non-pharmaceutical interventions. On an international level Clark et al. (32) found that a belief in the effectiveness of precautionary measures was a significant predictor of whether individuals took precautions. Plohl and Musil (33) found that COVID-19 risk perception and trust in science were able to independently predict compliance, and political conservatism, religious orthodoxy, conspiracy ideation and intellectual curiosity were found to be predictors via the mediating role of trust in science. In America, political conservatism and party identification have consistently been identified as predictors of precautionary behaviors; those who identify as conservative and/or Republican are the least likely to be compliant, while those who identify as liberal and/or Democrat are most likely to be compliant (15–20,34).

While there has been some modeling of compliance with non-pharmaceutical interventions (referred to as NPIs for the remainder of this paper) amongst the general population, to our knowledge there has not been any modeling of compliance amongst undergraduate students, one of the populations that is greatly contributing to the spread of the current pandemic. In this study we use structural equation modeling to identify the predictors of compliance amongst university students across the country, and at large campuses in Utah County that, as of the time of submission, were experiencing a large amount of community spread among its students.

Materials Methods

Study Population

The nationwide survey was administered through the Qualtrics survey platform, with parameters given to match the national profile of undergraduate students as reported by the national center for education statistics (35). We targeted students currently enrolled in a college or university. We used 608 responses in our analyses. The local survey (Utah Valley) was administered to students enrolled in both general non-majors biology classes and entry level majors biology classes at two Universities in Utah, one private institution with enrollment around 35,000 students and one public institution with open-enrollment around 41,000 students, both located in Utah County. We used 566 responses in our analyses.

Survey Development

Literature Review and Interviews

To begin construction of our instrument we surveyed literature about predictors of COVID-19 compliance, and trust in science in general. We found 5 factors shown to be predictors of compliance (table 1), and 3 plausible factors based on their influence on trust in science generally (table 2).

Table 1. Factors shown to influence compliance with non-pharmaceutical interventions

Predictor	References
<i>Political Ideology</i>	(15–20,33)
<i>Trust in Science and Scientists</i>	(19,33)
<i>Geographic Location</i>	(14,34)
<i>Trust in Gov't Handling of Pandemic</i>	(36)
<i>Fear of racial profiling</i>	(37–41)

Table 2. Plausible predictors of compliance

Predictor	References
Vaccine hesitancy	(42–44)
Acceptance of Evolution	(45–47)
Religiosity	(45,47,48)

We then conducted interviews with undergraduate students at one of the Utah County schools to refine our instrument and test for validity. We asked students questions about their age, major, political ideology, party identification, news source and exposure to news, feelings regarding the government’s response to the pandemic, practice of NPIs, trust in science generally, trust in medical science, trust in public health officials and their doctor, religiosity, and acceptance of organic evolution. Interviews were transcribed using software from temi.com and responses were coded by three students independently, who then collaboratively agreed upon a score for each part of the interview transcript. From the most common themes found in the surveys, we created a multiple-choice survey instrument.

We developed two surveys, one to be administered to students in Utah Valley, and another that was sent to students nationwide. They were largely identical, with the exception being that the nationwide survey asked students what type of institution they attended and their gender, while the Utah Valley instrument asked respondents which university they attended. We settled on the following demographics and latent variables.

Demographic Measures

We measured participant age, the type of institution the student attends (i.e., public/private, 4-year institution, 2-year institution, trade school), where the students grew up, where the students are currently attending college, and what year of college they are in. In addition, we asked for student identified gender (only in the nationwide survey) as well as political party identification (Democrat, Republican, Independent, or Other).

Latent Variables

We identified and measured the following latent variables:

Political ideology. To measure political ideology students were asked to rate their view of economic, social and scientific views on a scale of 1 (meaning very left leaning or liberal) to 7 (meaning very right leaning or conservative).

Religiosity. To measure participant religiosity we chose to use the Duke Religiosity Index (DUREL) (49) due to its brevity, and optimization for use in public health surveys. Question one was changed from, *How often did you attend church or other religious meetings?* to, *Before the emergence of COVID-19, how often did you attend church or other religious meetings?* We felt

that attendance at church or other religious meetings could currently be influenced by local mandates about gatherings and fear of contracting COVID-19, and may not be an indicator of religiosity at the present time.

Religiosity and COVID. Participants were asked to answer which response most accurately described their view of each of the following statements with a scale from 1 to 5 (*Definitely not true, tends not to be true, unsure, tends to be true, definitely true of me*): *My religion influences my beliefs about the current COVID-19 pandemic; My religion influences my approach to the current COVID-19 pandemic; and My religious beliefs shape how I have interacted with others during the COVID-19 pandemic.*

General trust in science. For this section, we consulted Nadelson et al. (2014) (50). Their twenty-one-item instrument is designed to assess the level of trust an individual has in the scientific method and scientists. The concept of trust is difficult to define, and even more difficult to measure. However, based on the literature, we believe trust in science to be one of the best predictors of compliance with recommended COVID-19 health practices. Furthermore, we believe that the Nadelson et al. instrument adequately assesses a person's trust in science. Participants were asked to answer the following questions on a 5-pt Likert-type scale:

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

We removed questions 1, 5, 7, 8, 13, 14, and 16 from the original Nadelson instrument based on rationale provided by Plohl and Musil (33).

Trust in public health officials. The trust in public health officials is a modification of Nadelson et al. (50). We rephrased the questions to use the phrase 'public health authority', which we defined as follows: "For this next section, you will see the term 'public health authority' used a number of times. We are using this term to mean individuals employed by tax-funded government health agencies, whether that be local, state, or federal. Specifically, a public health authority communicates with the public with statements about health concerns and recommended health practices. A prominent example would be Anthony Fauci, M.D., director of NIAID (National Institute of Allergy and Infectious Diseases)." We believe this definition to provide a clear and easily understood definition of the term, as well as providing a colloquial

example for reference. We believe ‘public health authority’ is a politically weighted term that is commonly used. Participants were asked to answer the following questions on a 5-pt Likert-type scale:

1. When public health authorities provide conflicting advice, it diminishes my trust in their work.
2. Public health authorities ignore evidence that contradicts their work.
3. Public health authorities intentionally keep some information secret.
4. Public health authorities are seeking to fulfill an agenda.
5. Public health authorities don’t value the ideas of others.
6. I trust that public health authorities want to make life better for people.
7. We should trust that public health authorities are being honest in their work.
8. We should trust that public health authorities are being ethical in their work.
9. When public health authorities give health instruction, they are just guessing.
10. We cannot trust public health authorities because they are biased in their perspectives.
11. We cannot trust public health authorities to consider ideas that contradict their own.
12. Today’s public health authorities will sacrifice the well-being of others to advance their agenda.

In question 12, the word “research” was changed to “agenda” from the original Nadelson et al. instrument. We removed questions from the original Nadelson instrument that did not fit with our topic of focus in the interest of clarity and brevity, leaving us with 12 questions.

Priorities of Public Health Officials. Blendon et al. (10) asked respondents which of a public health official’s duties was most important. For comparison to understand how attitudes towards public health officials may have shifted, we repeated this question, and instead asked respondents to rank the following priorities of public health officials: to *Treat everyone as equally as possible*; *Protect the health of the greatest number of people*; *Give priority to sick and frail people in getting attendance*; *Aim to preserve essential community services like electricity and law enforcement*; and *To not interfere with the civil liberties or freedoms of people in your communities*.

Constitutionalism. Participants were asked to answer which response was closest to their view of each of the following statements on a five-point Likert scale (*Definitely not true, tends not to be true, unsure, tends to be true, definitely true of me*): *I don’t mind masks, but mask mandates are unconstitutional*; *Mask mandates interfere with my constitutional rights*; *Mask mandates interfere with my personal freedoms*; *COVID-19 restrictions restrict my constitutional rights*; *I have the constitutional right to refuse to wear a mask in public*; and *Wearing a mask should be a personal choice, not a legal mandate*. We created this section of the questionnaire because we found in our preliminary interviews that constitutionalism was a common theme for those who refused to wear a mask, and we hypothesized that many only refused to wear a mask because of their ideas about their constitutional rights.

Convenience. Many of our questions for the convenience portion of the survey were based on the information that was found in a survey sent out by YouGov (15). The questions were slightly modified to fit our needs. Participants were asked to rank the following statements on a 5-point Likert scale (*Definitely not true, tends not to be true, unsure, tends to be true, definitely true of me*): *The discomfort of a mask is enough to make me not wear them; Physical issues (e.g., glasses fogging up, facial breakouts, difficulty breathing) prevent me from wearing a mask; The lack of availability of masks prevents me from wearing one; and Forgetting to bring a mask with me is often a reason I don't wear one.*

Concern with severity. To test for perceived impression of severity of the COVID-19 virus we asked four questions modified from a 2007 study on barriers to flu vaccines (51). In that survey respondents were asked: "How concerned are you about getting the flu?" and "How would getting the flu affect your life?". Both of these questions had three possible answer choices. We changed the answer scale to a five-point scale for more statistical power. We changed the wording of their questions to apply to COVID-19, for example, instead of asking, "How concerned are you about getting the flu?", we asked "How concerned are you with getting COVID-19?". We separated the second question into two questions and adjusted it to be COVID-19 specific. We asked about how they felt the novel coronavirus could affect them physically, and how they thought it could affect other aspects of their life. We added one more question asking about how they felt the novel coronavirus would affect others in their community. This question was added to give us the greater statistical power associated with four questions instead of two.

Personal responsibility. In a thorough search of the literature no studies were found that correlated personal responsibility to a role in compliance with non-pharmaceutical methods of decreasing viral infection. We did find one study that researched public risk perceptions, personal responsibility, and self-isolation habits during the recent COVID-19 pandemic (52). As they mostly focused on self-isolation habits, no survey instrument from their study could reasonably be used in our survey. Another study analyzes how different social norms including both impression of severity and personal responsibility affect compliance to precautionary guidelines, but this study didn't involve surveys of any kind, thus, no instrument was developed (53). We mimicked the way questions were asked in the Baal research study and asked our respondents to rank the following five statements on a seven-point Likert scale (from Strongly Disagree to Strongly Agree): *I shouldn't be mandated to wear a mask because those who are at high risk for contracting the virus should be responsible for keeping themselves safe; I am responsible for the health of others in my community*; Everyone should take responsibility for their own health and act accordingly; Those who are at high risk should stay out of public places, rather than having everyone else take precautions for their health; and I should feel responsible and take action to protect the health of those most vulnerable in the population** (with asterisks indicating reverse-coded items).

Exposure to News. We formulated our own questions regarding news exposure based on the results from our preliminary interviews. In the interviews, we asked the questions, "Do you keep up with science-related news?" and, "Do you keep up with COVID-19 related news?"

Students had various responses to how well they kept up with these specific news types, so we decided to gauge how often they checked both science and COVID-19 related news on a 6-point Likert scale of everyday to never. Additionally, to gauge how often students kept up with non-science and COVID-19 related news, we used the same scale (everyday to never).

Precautionary behaviors. After conducting the preliminary interviews, we found that students had given various responses on their extent of mask wearing, social distancing, and hand washing. For mask wearing, we found that there were certain situations where students were more or less likely to wear masks. From this, we asked students to rank their mask wearing, on a scale of always to never, for three distinct situations: where masks are required, in small groups of individuals not of their immediate household, and in large groups and outdoors within six feet of others. Additionally, we created questions using the same scale (always to never) to address the extent of social distancing, hand washing, and sanitizing nearby surfaces (the full survey is available in the Supplemental Materials).

Statistical Analysis of Survey

We split each dataset (from Utah County and from the General population) in half and created two datasets, each consisting of approximately 300 Utah respondents and 300 General respondents. We used one dataset to conduct Exploratory Factor Analysis (EFA) on our instruments and the other to conduct Confirmatory Factor Analysis (CFA). EFA was performed using Geomin rotation and a scree plot, eigenvalues, and percentage variance explained were used to determine which factors to retain. Items were removed in order to reach the best fitting model for the latent variables. For the CFA model, we used several fit indices, including Tucker-Lewis index (TLI), comparative fit index (CFI), root mean square error of approximation (RMSEA), and Chi square statistics. A CFA was then performed both on the General population and the Utah population to confirm fit of the model. Structural Equation Modeling (SEM) was then performed on each individual full dataset (Utah and General) to create two models (Muthen and Muthen, 1998-2010). The models were compared for invariance of structural path coefficients across groups using the DIFFTEST command. EFA, CFA, SEM, and DIFFTEST procures were performed using the Mplus software, version 8.

Exploratory Factor Analysis. EFA was performed on the latent variables in the model that were created for this instrument. (General trust in science was excluded from EFA analysis since it was a previously published and validated instrument). EFA rendered 6 factors with eigenvalues above 1 that explained over 5% of the variance. These factors, used as our predictors, were Concern with severity, Constitutionality, Convenience, Exposure to news, Political ideology, Religiosity (note that general religiosity and religiosity regarding the pandemic did not sort as two independent factors and were therefore left as one), and General trust in science. The General Trust in Science instrument was modified for better fit by removing all reverse-coded items (Items 5-9), which did not appear to be functioning well with the data. The outcome variable, Precautionary behaviors, had to be modified by removing three items (behavior in large groups, hand washing, and sanitizing surfaces) to get marginal fit. However, CFA confirmed a good fit with the data. Trust in public health officials and Personal

responsibility appeared to not offer a good fit to the data and no significant relationships to our outcome variables so we chose to remove them from the analysis.

Confirmatory Factor Analysis. We used CFA to confirm the match of our instrument to the intended latent variables. Using the combined second half of each dataset, we found marginal fit statistics (RMSEA = 0.06; CFI = 0.89; TLI = 0.88; SRMR = 0.07; $\chi^2 = 1446.09$, $p < .001$); however, we suspected that populations were not behaving equivalently and therefore expected potential issues with fit. We alternatively performed a CFA on each individual dataset and found acceptable fit statistics within each population, as listed in Table 3. Factor loadings for each latent variable are shown in Figure 1.

Table 3. Fit statistics for CFA in each population.

Population	RMSEA	CFI	TLI	SRMR	$\chi^2(df)$	p-value
General	0.06	0.90	0.89	0.05	1287.55(443)	<.001
Utah	0.06	0.91	0.90	0.05	1312.71(443)	<.001

An individual CFA for the General trust in science scale, after removing the aforementioned items, yielded decent fit statistics (RMSEA = 0.07; CFI = 0.91; TLI = 0.90; SRMR = 0.05; $\chi^2 = 682.07$, $p < .001$)

Figure 1: Culminating Measurement Model

Figure 1. Culminating measurement model. Bidirectional arrows indicate correlation coefficients; directional arrows indicate factor loading values for each item on their respective factor. Significance is indicated for correlations: * $p < .05$. All factor loadings were significant at the $p < .001$ level.

Comparison between populations

To compare our populations, we summed the total score in each category (e.g., political conservatism, concern, compliance with NPIs, etc.) for each individual. The data were not normally distributed, so we used a two-sample sign test to compare our Utah Valley and general populations.

Results

Interview Results

Our interviews were highly informative. While our sample size was small, we observed the following patterns which are reflected in our instrument:

- Those who specifically mentioned that their religiosity influenced their attitude about the pandemic tended to take NPIs more seriously, even when compared to those who had a high religiosity in general.
- View of governmental response was captured by political party and ideology.

Initial SEM Model

Based on our interviews and literature surveys we developed the theoretical model shown in figure 2. We hypothesized that impressions of severity, belief in the importance of personal responsibility, belief in personal liberty, feelings of inconvenience, news exposure, political ideology, religiosity, religious views on the pandemic, trust in science and trust in public health officials would all directly influence taking precautionary behaviors. We also hypothesized that political ideology, religiosity, and the influence of religious views on the pandemic would influence precautionary behaviors through the intermediate of trust in science; and news exposure and political ideology would affect precautionary behaviors through the mediating factor of trust in public health officials.

Figure 2: Hypothesized SEM Model

Figure 2. The hypothesized structural equation model that characterizes relationships between factors. Lines indicate predictive relationships.

Structural Equation Modeling

SEM analysis on the General population indicated that Concern about the severity of COVID-19, News exposure, and Religiosity all positively predicted precautionary behaviors. In contrast, feelings of Constitutionality issues negatively impact a student's willingness to practice precautionary behaviors. Interestingly, a students' general trust in science had a slight negative correlation with practicing precautionary behaviors. Surprisingly, political ideology and feelings of inconvenience did not affect behaviors. We included both gender and age in the model as covariates, but neither were significant. The structural model, shown in Figure 3,

showed robust fit to the data as indicated by fit statistics and probability scores (RMSEA = 0.05; CFI = 0.90; TLI = 0.89; SRMR = 0.06; $\chi^2 = 2079.34$, $p < .001$).

Figure 3: SEM Model for the General Population

Figure 3. The structural equation model for the General Population that characterizes relationships between factors. Lines indicate predictive relationships. Significance is indicated * $p < .05$, ** $p < .001$

SEM analysis on the Utah County population indicated some differences from the General population. The only positive predictor of taking precautionary behaviors was a concern with severity. The only negative predictor was feelings of inconvenience. In other words, those who felt that the disease impact is more severe were more likely to take precautionary behaviors, whereas those not wearing a mask are most likely refraining out of inconvenience. We included age in the model as a covariate but it was not significant (gender was not asked on the Utah County population survey). Again, the structural model, shown in Figure 4, showed robust fit to the data as indicated by fit statistics and probability scores (RMSEA = 0.05; CFI = 0.92; TLI = 0.91; SRMR = 0.05; $\chi^2 = 1826.86$, $p < .001$).

Figure 4: SEM Model for Utah Population

Figure 4. The structural equation model for the Utah Population that characterizes relationships between factors. Lines indicate predictive relationships. Significance is indicated * $p < .05$, ** $p < .001$

A comparison of the models for invariability of structural path coefficients across groups indicated that the two factors that varied significantly between populations were feelings of inconvenience ($\chi^2 = 17.94$, $p < .001$) and exposure to news ($\chi^2 = 16.74$, $p < .001$). All other comparisons between populations were non-significant.

Comparisons Between Populations

Our sample from Utah County was significantly less conservative ($p < .001$), more religious ($p < .001$), less constitutionalist ($p < .001$), more trusting in science ($p < .001$), less concerned with the pandemic ($p < .001$), earlier in their college careers ($p < .001$), and younger ($p < .001$) than the general population; News exposure was not significantly different between the populations (Table 4).

Table 4: Summary of predictor variables.

Predictor	Scale	Mean	SD	Median	z	p
<i>Conservatism (general)</i>	3-21	13.91	5.04	14	212	<.001*
<i>Conservatism (Utah)</i>		12.40	4.33	12		
<i>Religiosity (general)</i>	8-40	28.56	8.11	30	328	<.001*
<i>Religiosity (Utah)</i>		31.83	9.00	34		
<i>Constitutionalism (general)</i>	6-30	18.06	7.56	18	207	<.001*
<i>Constitutionalism (Utah)</i>		14.74	7.37	14		
<i>News exposure (general)</i>	3-18	13.55	3.07	15	174	.7869
<i>News exposure (Utah)</i>		10.70	3.50	15		
<i>Trust in science (general)</i>	14-74	44.76	9.91	42	406	<.001*
<i>Trust in science (Utah)</i>		52.63	8.48	52		
<i>Concern (general)</i>	4-20	15.64	3.17	9	43	<.001*
<i>Concern (Utah)</i>		9.98	3.43	16		
<i>Year (general)</i>	N/A	3.46	1.42	3	57	<.001*
<i>Year (Utah)</i>	N/A	1.71	1.06	1		
<i>Age (general)</i>	N/A	31.19	9.27	30	47	<.001*
<i>Age (Utah)</i>		20.27	3.15	20		

Table 4: This table compares the demographic measures of our two study populations: nationwide (general) and in Utah County (Utah). It also reports the z-statistic, and p-value from the sign test comparing the medians of both populations. *Denotes statistical significance.

Our sample from Utah was significantly more likely to wear a mask when required ($p < .001$), although both populations were highly likely to wear a mask when required. Our general sample was significantly more likely to wear a mask in small groups of close associates from outside their household ($p < .001$), to wear a mask in large groups within six feet of others ($p < .001$), and to socially distance ($p < .001$), see Table 5.

Table 5. Summary of Outcome Variables.

Predictor	Mean	SD	Median	z	p
<i>Wear a mask when required (general)</i>	4.55	0.55	5	152	<.001*
<i>Wear a mask when required (Utah)</i>	4.75	0.55	5		
<i>Wear a mask in small groups (general)</i>	4.07	1.06	4	31	<.001*
<i>Wear a mask in small groups (Utah)</i>	2.26	1.15	2		
<i>Wear a mask in large groups (general)</i>	4.14	1.08	5	95	<.001*
<i>Wear a mask in large groups (Utah)</i>	3.04	1.37	3		
<i>Socially distance (general)</i>	4.07	1.06	4	99	<.001*
<i>Socially distance (Utah)</i>	3.40	1.01	4		

Table 5: This table reports the summary statistics of the sums of precautionary behaviors taken among undergraduates nationwide (general) and in Utah County (Utah). A score of 5 means compliant all the time, and a 1 means compliant none of the time. It also reports the z-statistic, and p-value from the sign test comparing both populations. *Denotes statistical significance.

Discussion

We surveyed students spread across the nation and within Utah County and ran SEM analysis on each population separately. Although much of our discussion is focused on the differences between populations, we feel the uniqueness of the Utah County population discussed is important. This demonstrates that nationwide opinions on COVID-19 data may not reflect the opinions and subsequent compliance NPI of students in various localities. Nonetheless, we feel the national data is a valuable resource for anyone trying to understand shifting opinions on COVID-19.

Significant Predictors

Within the nationwide survey of college students, two of the strongest predictors for compliance with NPIs were a concern with the severity of the COVID-19 pandemic and exposure to news (Figure 2). This suggests that a potential method for achieving widespread compliance with precautionary behaviors could be an increase in media promoting the behaviors and warning of the severity of the pandemic. Another significant predictor in the

general population was ideas of constitutional originalist ideologies. Those individuals with stronger beliefs that their personal constitutional rights and liberties were being infringed upon by COVID regulations were less likely to comply with NPIs. The constitutionality of mask mandates has been largely debated in the news; thus, this result is not surprising (54). It may also be due to some of the more nuanced political views of young conservatives (55).

In the Utah population, results differed slightly (Figure 3). There was a strong positive correlation between concern with severity and precautionary behaviors, but a strong negative correlation between convenience and precautionary behaviors. This suggests that in the Utah population, if compliance with mask wearing is deemed inconvenient, then individuals likely will not comply.

Non-significant Predictors

Aspects of our research were surprising and some even contrary to our initial predictions. For example, political ideology was not a predictor of compliance in either the Utah population or the general population. Although contrary to polling from earlier in the pandemic, this is in line with another recent publication which also found no strong correlation between political ideology and attitudes towards a future COVID-19 vaccine (56). Age was also not a predictor of compliance with precautionary behaviors in either population; however, age was rather homogenous between populations due to our targeted sample. Gender was not a predictor in the general population (gender was not measured in the Utah population).

We were especially surprised that the general trust in science was not a strong predictor of compliance in either population, although it was somewhat negative in the general population. Based on rationale provided by Nadelson et al. (50), we believed that mistrust in science (and medical science in particular) stemmed from a lack of understanding of how the scientific process operates. No correlation was found in the Utah population. In the general population a weakly negative correlation was found a trust in science and compliance with NPIs, meaning that the more trust an individual had in science, the less likely they were to comply with NPIs. This is an interesting finding and may reflect an idea that those who feel like they have a good understanding of the science may be less worried about the pandemic. The lack of strong correlation in either population may be due to the demographic we were surveying. We propose that perhaps because our population of college students likely had a similar basic level of exposure to scientific learning, we did not have enough variation in our data to detect meaningful correlations between trust in science and compliance to NPIs . Religiosity was weakly correlated with compliance with precautionary behaviors in the general population, and not correlated at all in the Utah population. The religious demographic in Utah County is predominantly members of the Church of Jesus Christ of Latter-Day Saints (CJCLDS) (57). It comes as no surprise that a more nuanced range of beliefs within a relatively homogenous religious culture were displayed. The Utah population differed from the general population in that the factors constitutionality and exposure to news were not significantly correlated with compliance, although only news exposure showed path inequalities in the modeling.

Differences Between Populations

With roughly half our survey given to students living in Utah County and the other half given to students spread out across the nation, we expected the populations to differ moderately. As we take a deeper look into the differences between the two populations, we feel it is important to re-emphasize that universities across the country should consider the implications this could have to their own hometown, university, or area of residence. As different as the Utah findings are from the rest of the United States, we suspect a multitude of uniquely different pockets of opinions nationwide.

The demographics of our sample from Utah County were markedly different than those of the general population (Table 4), which could explain some of the differences seen in correlates (Figure 2, Figure 3), and in compliance with NPIs (Table 5). Although there were minimal differences in the effect of many predictors, we found that there were two categories whose effects differed significantly between the Utah population and the general population, inconvenience ($p < .001$) and exposure to news ($p < .001$). Convenience was much more relevant in the Utah population with a correlation factor of -0.371, while the general population had a correlation factor of -0.133 (Figure 2, Figure 3). We believe the difference in these factors stems from the large age difference between populations. The median age in our Utah sample was 20, compared to 30 from the general sample ($p < .001$). We believe many of the other differences, including conservatism, trust in science, constitutionalism, and concern for the severity of the pandemic, are also potentially due to the younger age of the Utah County population.

One of the most striking differences between populations was the wearing of masks in small groups (Table 5). As has been mentioned earlier, many of those surveyed in Utah were members of the CJCLDS (58). Like typical university students, those we surveyed in Utah live with roommates and potentially have family members who live close by. Unlike a typical university, students in Utah are likely part of a highly active church community, as well. A 2016 Pew research poll found that Latter-Day Saints (CJCLDS) were among the most highly involved with their congregations (59), and church members have been described by experts as “the most pro-social members in American society” (60). With a difference in wearing a mask in small gatherings significantly lower than the general population it is likely that, because of the sociality of this culture, a “small group” or “bubble” could be interpreted differently than the rest of America. It is important to note that officials of the Church (CJCLDS) in Utah have encouraged members to follow guidelines (61,62).

During July of 2020 CJCLDS members residing in Utah valley received a letter from their ecclesiastical leaders strongly encouraging “all Latter-Day saints in the Utah Area to be good citizens by wearing face coverings while in public” (62). This advice early on in the pandemic likely correlates to some of the trends we see now. The only NPI in which the Utah population exceeded the general population was wearing a mask when it is mandatory (Table 5). While the mean score in Utah for wearing a mask when it is mandatory was slightly higher, it was notably higher than the other NPI scores in Utah. While we can only speculate at this time, the encouragement by church leaders provides a compelling reason for many Latter-Day Saints to comply publicly with NPIs.

The effect of exposure to news was the other significant difference between the populations. This category was much more significant in the general population with a correlation factor of 0.391 in the general population and a correlation factor of -0.009 in the

Utah population (Figure 2, Figure 3). Utah and the general population had about the same amount of exposure to news as the general population (Table 4) but, it was not an indicator of compliance in Utah. This suggests that perhaps the Utah population watched different news sources. A recent poll found that 56% of Utahns get their news online (63) compared to 37% of all Americans (64). Research has demonstrated that news sources can have a large influence on taking precautionary behaviors (65).

Religiosity scores proved to be one of the starker differences between the Utah population and the rest of the nation. Utah County is a highly religious community and may potentially provide useful insights into other religious communities. As stated earlier, the predominant religion in Utah County is CJCLDS, with one of the Universities surveyed being affiliated with that church. Religion, and especially the religious views of Latter-Day Saints, has proven in the past to be an important factor in political stances, trust in science, and evolutionary acceptance (47,66,67).

At the time the survey was administered political tension was high. Some news outlets around the time of the election reported skepticism of Latter-day Saints towards President Donald Trump (68,69). We submit this as one possible explanation for the lower score in conservatism among the traditionally more conservative Utah population. The students surveyed in Utah were selected from a mix of non-major and major specific introductory biology classes. As an additional explanation for the lower Utah scores on conservatism, we suggest that this population may have had higher proportions of science majors compared with the national average. While we are unaware of any studies looking at undergraduate biology students in particular, it is noteworthy that the scientific community is more left-leaning than the public as a whole (70), and was much more likely to support then-Democratic presidential candidate Joe Biden (71). In addition several major journals in the field of biology endorsed Joe Biden for president of the United States (72,73). It is possible that these factors could have tilted our Utah sample to the left, ideologically. The last explanation for the more liberal Utah population is the age difference. A 2019 Pew research poll found Generation Z to lean a little more liberal than older generations, a difference especially pronounced among Gen-Zers who identify as Republican (55).

Limitations

A quick search of a popular government funded medical search engine reveals over 75,000 published papers on COVID-19 thus far. Due to the rapidly evolving nature of the pandemic, we recognize that any survey published on the subject will be highly specific to the time frame it was published in. The survey was administered from October 14th to November 10th, 2020, in the midst of a heated United States presidential election. According to recent research, risk perception of COVID-19 is based highly upon the statements and actions of political leaders (52). During the time of an election, individuals are often highly involved in politics, thus their views on COVID-19 may be influenced by politics more than usual. Additionally, this was before Pfizer (74) and Moderna (75) had released promising phase 3 results about their vaccines. We acknowledge that these events may have, as of yet, not understood consequences into the modeling of our compliance with NPIs.

Conclusions

The SEM results from our survey of college students across the country can serve as a framework for universities to increase compliance. While we have not conducted any research on interventions, it is reasonable to conclude that addressing these predictors would increase the efficacy of interventions. It is important to note that predictors in our local sample significantly differed from our national population in the effect of convenience and news exposure on compliance. This suggests that it is highly likely that interventions at individual universities will be most effective when based upon data gathered in individual communities. For example, if officials in Utah were to base interventions on our national data, they may overemphasize sharing generic COVID news, and underemphasize increasing the convenience of compliance, making their interventions less effective than they could be.

Vaccines are on the horizon, but it will likely be months before they are available to the general public. COVID-related case numbers, deaths, and hospitalizations will continue to rise through the winter (76,77), and may very well persist for the following months, and even years (78). We call on universities across the country to survey their students, and better understand why they may, or may not, be compliant with NPIs. If this is not possible, we suggest they apply our general results, and results from other nationwide surveys. We believe doing so could be an important step for mitigating spread on campuses, and the subsequent overflow into surrounding populations.

Unfortunately, this will likely not be the last public health emergency or pandemic in the near future, especially as humans encroach further upon nature (79–82). We believe it is vital to learn all we can about combatting this pandemic, and we call on researchers across the globe to work on understanding predictors of compliance, so interventions can be prepared for the next outbreak.

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