Generational differences in beliefs about COVID-19 vaccines

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ABSTRACT

Vaccine uptake variation across demographic groups remains a public health barrier to overcome the coronavirus pandemic despite substantial evidence demonstrating the effectiveness of COVID-19 vaccines against severe illness and death. Generational cohorts differ in their experience with historical and public health events, which may contribute to variation in beliefs about COVID-19 vaccines. Nationally representative longitudinal data (December 20, 2020 to July 23, 2021) from the Understanding America Study (UAS) COVID-19 tracking survey (N = 7279) and multilevel logistic regression were used to investigate whether generational cohorts differ in COVID-19 vaccine beliefs. Regression models adjusted for wave, socioeconomic and demographic characteristics, political affiliation, and trusted source of information about COVID-19. Birth-year cutoffs define the generational cohorts: Silent (1945 and earlier), Boomer (1946–1964), Gen X (1965–1980), Millennial (1981–1996), and Gen Z (1997–2012). Compared to Boomers, Silents had a lower likelihood of believing that COVID-19 vaccines have many known harmful side effects (OR = 0.52, 95%CI = 0.35–0.74) and that they may lead to illness and death (OR = 0.53, 95%CI = 0.37–0.77). Compared to Boomers, Silents had a higher likelihood of believing that the vaccines provide important benefits to society (OR = 2.27, 95%CI = 1.34–3.86) and that they are useful and effective (OR = 1.97, 95%CI = 1.17–3.30). Results for Gen Z are similar to those reported for Silents. Beliefs about COVID-19 vaccines markedly differ across generations. This is consistent with the idea of generational imprinting—the idea that some beliefs may be resistant to change through adulthood. Policy strategies other than vaccine education may be needed to overcome this pandemic and future public health challenges.

1. Introduction

Mass vaccination against COVID-19 is a major public health goal to return to normalcy, but vaccine uptake variation across demographic groups remains a major obstacle to achieving this goal. While vaccine incentives and mandates have driven up vaccination rates across different populations, many eligible adults in the United States (US) remain unvaccinated (Centers for Disease Control and Prevention, 2021). Evidence regarding COVID-19 vaccine hesitancy to date has largely focused on socioeconomic and demographic characteristics such as race/ethnicity, sex, education, income level, and health insurance coverage. Studies using nationally representative surveys suggest that vaccine uptake is relatively low for populations characterized as female, Black, young adults (ages 18–34 years), having a high school education, low income, or without health insurance coverage (Daly and Robinson, 2021; Savoia et al., 2021; Nguyen et al., 2021). Concerns about vaccine safety, potential side effects, spread of misinformation, experience of racism, and political party leaning have been reported as drivers of

vaccine hesitancy (Daly and Robinson, 2021; Savoia et al., 2021; Fridman et al., 2021). However, we know much less about how political views and consumption of news information shape our perceptions of vaccine threats and benefits. These perceptions can be explained by heuristics and prior similar experiences. Different heuristics informing our understanding of transmissibility of the coronavirus and severity of the disease can motivate or discourage vaccination uptake (Madison et al., 2021).

Anchoring bias, the idea of remaining focused on initial knowledge despite new and updated information availability about that knowledge (Southwell et al., 2020), may explain the impact of political and health beliefs on vaccination decisions. More specifically, "generational imprinting" suggests that political views formed during our youth persist, are resilient to change into adulthood, and may differ by generation (Alwin et al., 1991). Stemming from Mannheim's 1952 work *The Problem of Generations*, a rich literature has investigated the relative importance of generational effects that stem from the unique experiences of that cohort, or life cycle effects, which result from one's age and

that shape political views (Elder Jr, 1985; Braungart and Braungart, 1986). Some of that literature has demonstrated the importance of generational context for conceptualizing families, defining conservatism and liberalism, as well as views on materialism, abortion, and social mobility (Barringer et al., 2020; Fisher, 2020; Cleveland and Chang, 2009; OECD, 2018).

Generational differences are also consistent with the use of personal technology which may be particularly relevant since social media plays a significant role in spreading misinformation (Wilson and Wiysonge, 2020). Misinformation about vaccine safety affecting perceptions are more likely to spread through social media platforms than traditional media such as local TV and newspapers. People who rely on traditional media, largely Baby Boomers born in 1946–1964, have higher vaccine acceptance compared to those who rely on social media (Wang et al., 2019; Piltch-Loeb et al., 2021).

This study uses nationally representative survey data on US adults to investigate how beliefs about COVID-19 vaccines vary by generational cohort since the first COVID-19 vaccine became available in the US in December 2020. The findings may help determine whether public health strategies to address vaccine hesitancy should be developed in ways that focus on the different characteristics of these generations that go beyond factors such as age, ethnicity, or race.

2. Methods

2.1. Study sample

We analyzed data from the Understanding America Study (UAS), a probability-based Internet panel representative of noninstitutionalized adult US residents that are recruited using address-based sampling. The panel members were invited to participate in a longitudinal biweekly web-based COVID tracking survey that was conducted from March 10, 2020 to July 20, 2021. Respondents were provided a tablet and Internet access as needed and received $20 for every 30 min they spent answering survey questions.

The survey included topics ranging from risk perceptions to behaviors and socioeconomic and health impacts. While these core topics are covered in every wave, other topics, such as COVID-19 vaccine acceptance, were asked in a subset of waves. This study includes data from the first wave after the first COVID-19 vaccine became available (Wave 21, administered between December 23, 2020 and January 19, 2021) until the last wave of the tracking survey (Wave 29, administered between June 9, 2021 and July 20, 2021). These nine waves included the outcomes of interest, which are four statements on beliefs about COVID-19 vaccines.

UAS is maintained by the Center for Economic and Social Research (CESR) at the University of Southern California, which follows the American Association for Public Opinion Research (AAPOR) reporting guidelines for survey studies. Survey weights were constructed by CESR to account for respondent recruitment and differential nonresponse rates. A detailed description of how survey weights were estimated is available from the CESR COVID-19 Task Force (Kapteyn et al., 2020).

Distribution of outcomes and predictors of interest for each wave are listed in Table S1. Each respondent included in this study participated on an average of seven waves. Our final and unweighted sample included a total of 7279 unique respondents and 50,940 observations with no missing data in the variables used in the study.

2.2. Measures

2.2.1. Outcome variables

Beliefs about COVID-19 vaccines were the outcomes of interest in this study. Beginning in Wave 21, UAS asked respondents the following question: *Do you agree or disagree with the following statements?* Survey participants responded whether they *strongly disagree, disagree, agree,* or *strongly agree* the following four items: *COVID-19 vaccines have many*

known harmful side effects; COVID-19 vaccines may lead to illness and death; COVID-19 vaccines provide important benefits to society; COVID-19 vaccines are useful and effective (Cronbach's alpha = 0.90). The responses to these four statements were converted to a binary outcome of disagree (strongly disagree or disagree) and agree (agree or strongly agree).

2.2.2. Predictor

Generational cohort was the exposure of interest, which is determined based on the birth-year cutoffs defined by the Pew Research Center (Dimock, 2019) as follows: Greatest Generation/Silent ("Silent"), born 1945 and earlier; Baby Boomer ("Boomer"), born 1946–1964; Generation X ("Gen X"), born 1965–1980; Millennial, born 1981–1996; and Generation Z ("Gen Z"), born 1997–2012. The Greatest Generation (born 1901–1927) contributes to 1.88% ($N = 74$) of the Silent cohort.

2.2.3. Covariates

Key socioeconomic, demographic and health-related characteristics were included to depict the variations across the sample population: sex (male, female), race/ethnicity (non-Hispanic (NH) White, NH Black, Hispanic, NH American Indian or Alaskan Native, NH Asian, Hawaiian/Pacific Islander, Multiracial), immigrant status (non-immigrant, first/s/third generation immigrant), marital status (married, not married), education (less than high school (HS), HS graduate, and Bachelor's degree and above), household income (<$30,000, $30–$74,999, $75,000+), employment status (yes, no), residence by Census Bureau-designated regions and divisions ("Census region" and "Census division"), and six trusted sources of information about COVID-19—CNN, Fox News, your contacts on social media (Facebook, Twitter, etc.), your coworkers, classmates or other acquaintances, your physician, and your close friends or family (do not trust at all, trust somewhat, trust mostly, and trust completely).

Age was rescaled (divided by 10) and included as a continuous variable. Immigrant status by generation was generated by the team behind the UAS and defined and designated based on country of birth of the respondents, their parents, and their grandparents. First generation immigrants ("1st gen") are those who migrated to the US; second generation immigrants ("2nd gen") are US-born children to at least one foreign-born parent; and third generation immigrant ("3rd gen") are US-born children to at least one US-born parent, with at least one foreign-born grandparent. Four Census regions correspond to nine Census divisions (Northeast–New England, Middle Atlantic; Midwest–East North Central, West North Central; South–South Atlantic, East South Central, West South Central; and West–Mountain, Pacific) and were displayed as two separate covariates, but only Census divisions were included in the final model. Survey questions about political affiliation were not asked in the waves included in this study; however, evidence has shown that Americans who lean Democrat are more likely to prefer CNN whereas those who lean Republican are more likely to prefer Fox News, and polarizing opinions and behaviors remain evident during the coronavirus pandemic (Iyengar and Hahn, 2009; Motta et al., 2020). Therefore, we included responses to the following question regarding trust in CNN or Fox News as a trusted source of information about the coronavirus for representation: "How much do you trust the following sources of information about the coronavirus (COVID-19)?" Wave was included as a continuous variable.

2.3. Statistical analysis

We performed descriptive analyses to assess the differences across generational cohorts in individual-level and household-level characteristics, including age, sex, race/ethnicity, immigrant status, marital status, education, household income, employment status, and trust of information source and beliefs about COVID-19 vaccines with χ^2 tests. To account for the nonindependence of repeated measures of respondents across the waves and control biases due to unmeasured

respondent heterogeneity, we constructed four multilevel logistic regression models with a random intercept for respondents. Socioeconomic and demographic variables were considered time-fixed variables in our study, including age, sex, race/ethnicity, immigrant status, marital status, education, household income, employment status, residence by Census division, political affiliation, and trusted source of information about COVID-19. For the regression models, We first assessed the unadjusted association between generational cohort and beliefs about COVID-19 vaccines, and then with multivariate models, we adjusted for wave, socioeconomic and demographic characteristics, political affiliation, and trust in four different information sources. Odds ratios (ORs or adjusted ORs, AORs) and 95% confidence intervals (95% CIs) were reported. Statistical significance was assessed at the $p < 0.05$ level. The analyses were conducted with survey weights and were performed using Stata 17 (StataCorp, College Station, TX).

3. Results

This analysis included 7279 unique respondents and 50,940 observations from nine waves. The sample size for each of the nine waves ranged from 5428 to 5813 responses. Table 1 presents the pooled characteristics of UAS respondents by generational cohort between December 23, 2020 and July 30, 2021. As of January 1, 2021, Gen Z referred to those 18-24 years; Millennial referred to those 25–40 years; Gen X referred to those 4156 years; Boomer referred to those 57–75 years; and Silent referred to those ages 76 years and above.

Female-to-male ratio was two to one for Gen Z (67.8 vs. 32.2%) and one to two for Silent (35.9 vs. 64.1%). Gen Zers had the highest proportion of Hispanic (25.2% vs. lowest among Silents, 7.9%) and Asian (11.6% vs. lowest among Boomers, 3.4%) populations and the lowest proportion of NH white (45.9% vs. highest among Silents, 81.0%) and Hawaiian/Pacific Islander (0.0% vs. highest among Millennials, 0.2%) respondents. Millennials had the highest proportion of non-immigrants (62.2% vs. lowest among Silents, 49.6%); 12.8% of Gen Z were of 1st gen (vs. highest among Gen Xers, 17.1%); Gen Z had the highest proportion of 2nd gen (24.6% vs. lowest among Boomers, 9.0%) and the lowest proportion of 3rd gen (5.2% vs. highest within Silent, 28.8%). Gen Zers had the lowest marriage rate (6.1% vs. highest among Boomers, 63.1%). Gen Zers had the lowest rate of attaining a bachelor's degree and above (17.9% vs. highest rate among Millennials, 49.8%). Gen Zers had the highest proportion earning less than $30,000 (39.6% vs. lowest among Gen X, 24.0%; $p < 0.001$) and unemployed (51.6%), except for Silents (91.7%) who were least likely to be a part of the workforce at a retirement age.

Generational cohorts varied in their residence in terms of Census Region and Census Division. About 16% of Gen Zers lived in the Northeast (15.7% vs. largest share of Silent, 20.7%); Gen Zers had the largest share living in the Midwest (24.5% vs. smallest share of Silents, 16.4%) and the West (25.8% vs. smallest share of Boomers, 22.4%); and Gen Zers had the smallest share living in the South (34.1% vs. largest share of Gen X, 41.4%).

Generational cohorts also varied in their trusted source of information about COVID. About 41.2% of Gen Zers did not trust CNN at all (vs. 43.5% of Silents) and about 53.9% of Gen Zers did not trust Fox News at all (vs. 44.2% of Silents). About 45.5% of Gen Zers did not trust their contacts on social media at all (vs. 61.7% of Silents).

About 1.2% of Gen Zers completely trusted their coworkers, classmates, or other acquaintances (vs. 0.4% of Silents). About 18.3% of Gen Zers completely trusted their physician (vs. 26.3% Silents). About 22.3% of Gen Zers did not trust their close friends or family at all (vs. 12.3% of Silents).

Table 2 reports the respondents' beliefs about COVID-19 vaccines across generational cohorts. Most respondents agreed or strongly agreed that the COVID-19 vaccines provide important benefits to society (45.6% and 37.5%, respectively) or are useful and effective (48.5% and 33.3%, respectively) and disagreed or strongly disagreed that the

vaccines have many known harmful side effects (44.1% and 17.5%, respectively) or may lead to illness and death (39.8% and 20.6%, respectively).

Among Gen Zers, 44.6% strongly agreed/agreed that vaccines have many known harmful side effects, 44.2% strongly agreed/agreed that vaccines may lead to illness and death, 79.7% strongly agreed/agreed that vaccines provide important benefits to society, and 77% strongly agreed/agreed that the vaccines are useful and effective. In contrast, among Silents, 18.7% strongly agreed/agreed that vaccines have many known harmful side effects, 22.1% strongly agreed/agreed that vaccines may lead to illness and death, 94.6% strongly agreed/agreed that vaccines provide important benefits to society, and 94.2% strongly agreed/agreed that the vaccines are useful and effective.

Table 3 reports the results of the multilevel logistic regression models examining the association between generational cohort and beliefs about COVID-19 vaccines. The unadjusted models showed that compared to Boomers, Gen Zers had a higher likelihood of agreeing that COVID-19 vaccines have many known harmful side effects (OR = 5.20, 95% confidence interval (CI) = 3.29–8.21) and that they may lead to illness and death (OR = 4.95, 95% CI = 3.04–8.04) and had a lower likelihood of agreeing that COVID-19 vaccines provide important benefits to society (OR = 0.33, 95% CI = 0.22–0.50) and are useful and effective (OR = 6.52, 95% CI = 2.53–16.80). Millennials and Gen Xers had similar results to those of Gen Zers when compared to Boomers. Compared to Boomers, Silents had a lower likelihood of agreeing that COVID-19 vaccines have many known harmful side effects (OR = 0.18, 95% CI = 0.14–0.23) and may lead to illness and death and had a higher likelihood of agreeing that the vaccines provide important benefits to society (OR = 4.01, 95%CI = 2.87–5.59) and are useful and effective (OR = 3.91, 95%CI = 2.84–5.38).

After adjusting for socioeconomic and demographic characteristics, political affiliation, and trusted source of information about COVID-19, results from the regression model for Gen Zers beliefs in vaccines were reversed—compared to Boomers, Gen Zers had a lower likelihood of agreeing that COVID-19 vaccines have many known harmful side effects (OR = 0.23, 95% CI = 0.11–0.50) and may lead to illness and death (OR = 0.19, 95% CI = 0.09–0.43). For the most part, both Millennials and Gen Xers were no different from Boomers in their beliefs about COVID-19 vaccines. However, Gen Xers still had a lower likelihood of believing that the vaccines are useful and effective (OR = 0.62, 95%CI = 0.44–0.89) compared to Boomers. Silents' likelihood of believing in these vaccine statements compared to Boomers remained the same in unadjusted and adjusted models.

4. Discussion

While other studies have suggested the role of age in predicting beliefs about COVID-19 vaccines (Karpman et al., 2021; Adams et al., 2020; Schwarzinger et al., 2021; Bhagianadh and Arora, 2021), to our knowledge this is the first study to examine the beliefs across different generations using a longitudinal and nationally representative survey. Consistent with other studies, COVID-19 vaccine beliefs had strong age effects, where the likelihood of believing in benefits and harms of COVID-19 vaccines increased and decreased with age, respectively. However, there were also generational cohort effects that persisted after controlling for survey wave, age, and socioeconomic and demographic characteristics, political affiliation, trusted source of information, and random effects within individuals over time.

It has been argued that generational cohorts described in our study differ by "a specific set of social, economic, technological, and/or political circumstances" during their formative years. Silents were born to families who experienced the 1918 Great Influenza and have been characterized by conformity given that they grew up during World Wars and the Great Depression (Warner, 2018).In contrast to other generational cohorts, Silents (including the Greatest Generation in this analysis) in our study remained persistent in their vaccine beliefs (i.e.,

Table 1

Socioeconomic and demographic characteristics and trust in seven sources of information about coronavirus by generational cohort among US adults 18 and above in the Understanding America Study panel, December 23, 2020 to July 20, 2021 (N = 7279).[†,‡]

		Generational cohort					
	Total	Gen Z (1997–2002) 1322 (4.1%)	Millennial (1981–1996) 11,451 (32.18%)	Gen X (1965–1980) 14,916 (25.44%)	Boomer (1946–1964) 19,307 (31.17%)	Silent (−1945) 3944 (7.11%)	p-value
Age (mean, SE)	49.5 (0.10)	21.1 (0.06)	33.3 (0.05)	47.8 (0.06)	64.4 (0.05)	80.2 (0.10)	<0.001
Sex (%)							
Male	49.1	32.2	43.0	49.1	54.4	64.1	<0.001
Female	50.9	67.8	57.0	50.9	45.6	35.9	
Race/ethnicity (%)							
Non-Hispanic (NH) white	63.4	45.9	59.0	55.4	72.7	81.0	<0.001
NH Black	11.4	12.2	10.9	14.8	10.0	7.9	
Hispanic	16.2	25.2	18.7	21.0	11.2	4.9	
American Indian/ Alaskan native	0.4	1.9	0.5	0.3	0.3	0.0	
Asian	5.4	11.6	6.7	5.6	3.4	4.2	
Hawaiian/Pacific Islander	0.1	0.0	0.2	0.1	0.1	0.1	
Multiracial	3.0	3.2	4.0	2.8	2.4	1.9	
Immigrant status (%)							
Non-immigrant	59.4	57.3	62.2	59.6	58.8	49.6	<0.001
1st generation	11.9	12.8	11.9	17.1	8.6	6.6	
2nd generation	13.1	24.6	16.5	11.3	9.0	14.9	
3rd generation	15.7	5.2	9.4	12.0	23.6	28.8	
Marital status (%)							
Married	56.7	6.1	53.5	60.9	63.1	57.3	<0.001
Not married	43.3	93.9	46.5	39.1	36.9	42.7	
Education (%)							
Less than high school (HS)	5.5	3.9	4.4	4.2	4.5	4.2	<0.001
HS graduate	76.6	46.3	48.7	55.6	49.7	51.6	
Bachelor's degree and above	17.9	49.8	47.0	40.2	45.8	44.2	
Household income (%)							
<$30,000	25.9	39.6	22.7	24.0	28.2	29.5	<0.001
$30,000-74,999	37.3	29.7	37.5	32.6	40.6	43.0	
$75,000+	36.8	30.7	39.9	43.5	31.2	27.5	
Currently employed (%)							
Employed	55.1	48.4	72.9	70.0	36.0	8.3	<0.001
Not employed	44.9	51.6	27.1	30.0	64.0	91.7	
Residence (census region) (%)							
Northeast	17.3	15.7	15.1	16.1	20.0	20.7	<0.001
Midwest	20.9	24.5	22.2	19.6	21.2	16.4	
South	38.0	34.1	37.3	41.4	36.5	38.0	
West	23.8	25.8	25.3	22.9	22.4	24.9	
Residence (census division) (%)							
Division 1: New England	4.0	5.2	3.4	3.9	4.5	3.7	<0.001
Division 2: Middle Atlantic	13.3	10.5	11.7	12.2	15.5	17.1	
Division 3: East north central	14.4	17.6	15.0	14.0	14.2	11.7	
Division 4: West north central	6.5	6.9	7.2	5.6	7.0	4.7	
Division 5: South Atlantic	20.0	16.0	20.6	21.7	18.4	21.4	
Division 6: East south central	7.8	5.2	8.0	8.2	7.8	7.4	
Division 7: West south central	10.1	12.8	8.8	11.5	10.3	9.1	
Division 8: Mountain	7.8	5.3	8.5	7.6	8.0	5.3	
Division 9: Pacific	16.0	20.4	16.8	15.3	14.4	19.6	
How much do you trust the following sources of information about the coronavirus (COVID-19):							
CNN (%)							
Do not trust at all	43.9	41.2	46.1	43.0	42.9	43.5	<0.001
Trust somewhat	34.4	37.0	35.5	36.5	31.5	32.9	
Trust mostly	18.4	18.2	16.6	17.1	21.0	20.1	
Trust completely	3.3	3.6	1.8	3.4	4.6	3.4	
Fox News (%)							
Do not trust at all	56.5	53.9	62.3	55.9	54.3	44.2	<0.001
Trust somewhat	32.6	34.5	29.6	34.9	32.8	36.6	
Trust mostly	9.3	10.8	7.1	7.7	10.7	17.6	
Trust completely	1.6	0.9	1.1	1.5	2.2	1.7	
Your contacts on social media (Facebook, Twitter, etc.) (%)							
Do not trust at all	51.3	45.5	50.0	49.9	52.2	61.7	<0.001
Trust somewhat	42.7	45.0	43.7	44.2	41.8	34.5	
Trust mostly	5.4	8.8	5.6	5.2	5.4	3.6	
Trust completely	0.6	0.7	0.7	0.7	0.6	0.2	
Your coworkers, classmates or other acquaintances (%)							
Do not trust at all	30.3	33.7	30.0	31.4	29.5	29.8	<0.001
Trust somewhat	56.6	49.8	55.8	56.2	58.0	59.2	

(continued on next page)

Table 1 (*continued*)

	Total	Generational cohort					
		Gen Z (1997–2002)	Millennial (1981–1996)	Gen X (1965–1980)	Boomer (1946–1964)	Silent (−1945)	
		1322 (4.1%)	11,451 (32.18%)	14,916 (25.44%)	19,307 (31.17%)	3944 (7.11%)	*p*-value
Trust mostly	12.0	15.3	12.9	11.2	11.7	10.6	
Trust completely	1.0	1.2	1.3	1.2	0.8	0.4	
Your physician (%)							
Do not trust at all	6.7	13.1	9.5	7.0	3.9	1.7	<0.001
Trust somewhat	27.9	30.3	31.1	31.7	23.0	19.5	
Trust mostly	44.0	38.3	41.7	41.6	47.1	52.5	
Trust completely	21.4	18.3	17.7	19.7	25.9	26.3	
Your close friends or family (%)							
Do not trust at all	17.1	22.3	18.3	19.7	14.2	12.3	<0.001
Trust somewhat	51.6	45.7	49.4	51.6	53.4	57.8	
Trust mostly	26.2	27.2	26.7	23.6	27.6	26.1	
Trust completely	5.1	4.8	5.6	5.1	4.8	3.8	

[†] Understanding America study (UAS) is a probability-based Internet panel representative of US adults. Waves 21–29 included in this study are part of a bi-weekly tracking survey, which was first administered on March 20, 2020 and ended on July 20, 2021. Details about the methodology and the complete questionnaire can be found in elsewhere (USC Dornsife Center for Economic and Social Research, 2021).

[‡] # of observations = 50,940.

Table 2

Generational difference in beliefs about COVID-19 vaccines among adults ages 18 years and above, the Understanding America Study panel, December 23, 2020 to July 20, 2021 (N = 7279).[†,‡]

n(%)	Total	Generational cohort					
		Gen Z (1997–2002)	Millennial (1981–1996)	Gen X (1965–1980)	Boomer (1946–1964)	Silent (−1945)	
		1320 (4.1%)	11,436 (32.18%)	14,896 (25.44%)	19,299 (31.17%)	3944 (7.11%)	*p*-value
COVID-19 vaccines have many known harmful side effects (%)							
Strongly disagree	17.5	10.4	17.9	14.2	19.5	22.6	<0.001
Disagree	44.1	45.0	37.4	42.6	48.7	58.7	
Agree	30.3	35.7	34.0	33.9	26.1	16.2	
Strongly agree	8.1	8.9	10.7	9.3	5.7	2.5	
COVID-19 vaccines may lead to illness and death (%)							
Strongly disagree	20.6	14.3	20.6	17.0	22.7	27.1	<0.001
Disagree	39.8	41.5	33.6	39.4	43.8	50.8	
Agree	32.1	35.6	35.6	35.2	28.3	20.4	
Strongly agree	7.5	8.6	10.3	8.4	5.2	1.7	
COVID-19 vaccines provide important benefits to society (%)							
Strongly disagree	4.3	3.9	6.1	4.5	3.0	1.2	<0.001
Disagree	12.6	16.4	16.8	13.3	9.2	4.1	
Agree	45.6	49.8	41.6	49.9	46.0	44.5	
Strongly agree	37.5	29.9	35.6	32.2	41.8	50.1	
COVID-19 vaccines are useful and effective (%)							
Strongly disagree	4.7	4.2	6.8	5.0	3.0	1.3	<0.001
Disagree	13.5	18.8	17.7	14.3	9.9	4.4	
Agree	48.5	52.3	44.1	52.8	49.0	48.9	
Strongly agree	33.3	24.7	31.4	27.9	38.1	45.3	

[†] Understanding America Study (UAS) is a probability-based Internet panel representative of US adults. Waves 21–29 included in this study are part of a bi-weekly tracking survey, which was first administered on March 20, 2020 and ended on July 20, 2021. Details about the methodology and the complete questionnaire can be found in elsewhere (USC Dornsife Center for Economic and Social Research, 2021).

[‡] # of observations = 50,940.

COVID-19 vaccines are beneficial) even after adjusting for covariates. Silents experienced the promise of vaccination efforts against polio when it was first administered in 1955 during their formative years. The experiences of seeing scientific advances in vaccination against a deadly disease and growing up in a period of instability during an economic downturn are, to some extent, similar to what we are currently experiencing in the ongoing pandemic since early 2020. Generational imprinting suggests that the memories about these historical events may have followed them through adulthood into later years, where Silents may be more likely to believe that COVID-19 vaccines would do more good than harm.

In our study, over 80% of Gen Xers agreed that COVID-19 vaccines are useful and effective. Yet, Gen Xers had a lower likelihood of agreeing with this statement than Boomers. Unlike earlier generations, Gen Xers joined the workforce at a time when college or higher education was becoming essential for success (Currier, 2018). They also grew up during the rise of the Internet and are known for individualism and risk-taking behavior (Twenge, 2018; Howe and Strauss, 2007).

COVID-19 vaccine beliefs among Millennials did not differ from those held by the generation of their parents (Boomer generation)

Table 3

Multilevel mixed-effects logistic regression models: association between generational cohort and agreement with beliefs about COVID-19 vaccines among US adults ages 18 and above: the Understanding America Study panel, December 23, 2020 to July 20, 2021 (N = 7279).[†][**]

	COVID-19 vaccines...[‡]							
	Have many known harmful side effects		May lead to illness and death		Provide important benefits to society		Are useful and effective	
	OR[§]	AOR[¶]	OR	AOR	OR	AOR	OR	AOR
Gen Z (1997–2002)	5.20	0.23	4.95**	0.19**	0.33**	2.05	0.32**	2.19
	[3.29,8.21]	[0.11,0.50]	[3.04,8.04]	[0.09,0.43]	[0.22,0.50]	[0.83,5.05]	[0.21,0.47]	[0.91,5.25]
Millennial (1981–1996)	5.17**	0.74	5.39**	0.65	0.23**	0.60	0.19**	0.59
	[4.18,6.38]	[0.44,1.23]	[4.30,6.76]	[0.38,1.09]	[0.18,0.28]	[0.33,1.09]	[0.15,0.23]	[0.33,1.05]
Gen X (1965–1980)	3.39**	1.17	3.16**	0.97	0.42**	0.69	0.37**	0.62**
	[2.78,4.12]	[0.85,1.59]	[2.57,3.89]	[0.70,1.33]	[0.35,0.51]	[0.48,1.00]	[0.31,0.44]	[0.44,0.89]
Boomer (1946–1964)	Ref							
Silent (− 1945)	0.18**	0.55**	0.17**	0.59**	4.01**	2.27**	3.91	2.13**
	[0.14,0.23]	[0.38,0.79]	[0.13,0.22]	[0.41,0.85]	[2.87,5.59]	[1.35,3.82]	[2.84,5.38]	[1.28,3.56]

[**] $p < 0.01$.

[†] Understanding America Study (UAS) is a probability-based Internet panel representative of US adults. Waves 21–29 included in this study are part of a bi-weekly tracking survey, which was first administered on March 20, 2020 and ended on July 20, 2021. Details about the methodology and the complete questionnaire can be found in elsewhere (USC Dornsifie Center for Economic and Social Research, 2021).

[‡] Responses to the four statements in each corresponding model were included as a binary outcome of disagree (reference group; strongly disagree and disagree) and agree (agree and strongly agree).

[§] OR = unadjusted odds ratio; 95% confidence interval in brackets.

[¶] AOR = OR adjusted for wave, age, sex, race & ethnicity, immigrant status, education level, household income, employment status, residence by census division, and trusted source of information about COVID-19 (CNN, Fox News, your physician, your close friends or family, your coworkers, classmates, or other acquaintances, your contacts on social media (Facebook, Twitter, etc.))

(Dimock, 2019). Millennials experienced the 2008 Great Recession as young adults, grew up in an increasingly digitized world, and have relatively low rates of marriage and home ownership (Tyson, 2018).

Gen Zers readily connect with a global community through social media platforms and during their formative years voted for the first time in the 2016 and 2020 presidential elections. They are now experiencing the coronavirus pandemic as some of them enter the workforce. As suggested in our bivariate analyses, Gen Zers were most likely to trust contacts on social media and were least likely to trust their coworkers, classmates, or other acquaintances, physician, close friends, or family than previous generations. Although trust in different sources of information varied across generations and somewhat trended with age, in our regression analysis Gen Zers were just as likely as Silents to disagree with the negative consequences associated with COVID-19 vaccines, suggesting that trust in these different sources may not affect the vaccine beliefs in the same way. Further research is needed to examine these associations and how different sources of information contribute to health beliefs and actions across generations.

It should be noted that age plays a role in the generational differences observed. Table 1 illustrates the expected demographic patterns that differ across generations. Younger generations were more racially/ethnically diverse and less likely to be married and Boomers and Silents were more likely to be out of the workforce. Specifically, the relationship of Silents with doctors in our sample is consistent with the literature that trust in health care is associated with age (Tanco et al., 2016; O'Malley et al., 2004). Silents were the most likely to trust their physician of all generational cohorts—they were 40% more likely than Gen Zers to trust their physicians. Compared to Silents, Gen Zers were more than seven times more likely not to trust their physicians at all as a source of information about coronavirus. Silents not only have had more opportunities over the years to develop trusting relationships with their physicians due to their age but they are also more likely to utilize health care services. The physician–patient relationship in Silents may be stronger as a result, leading them to a higher likelihood of trusting vaccination efforts.

Our study has several strengths and limitations. UAS is a nationally representative survey. The large sample size and longitudinal nature of the UAS panel data allowed us to examine random and fixed effects over a seven-month period since the beginning of the vaccine rollout, so that we could account for the time effects on beliefs about the vaccines. The

richness of the data allowed us to consider important factors that are seldom captured in non-panel population-based surveys such as immigrant status by generation and trusted sources of information about COVID-19. We used trust in either CNN or Fox News as proxy to understand the context of political affiliation; these variables may not be fully aligned but they are highly correlated. Also, non-response bias could potentially impact our results. For Wave 29, for example, weighted data (benchmarked to the Current Population Survey) and unweighted data by age groups (18–34, 35–54, 55–64, and 65 years of age and over) deviate on average by only four percentage points. The margin of sampling error reported for the full sample is plus or minus one percentage point (Kapteyn et al., 2021). We did a robustness check to examine whether generational cohort masks the variation within each cohort. We found that the associations between vaccine beliefs and age group as increments of five were consistent within each generational cohort (Table S3), which justifies the use of generational cohort as a unique variable from age. Lastly, the generational cohort assignment may be limited to the US population.

5. Conclusion

The US remains divided by political affiliation on multiple public health issues, including the ongoing coronavirus pandemic. This study adds to the literature that generational membership may be a robust predictor of beliefs about COVID-19 vaccines as a result of connections with different momentous events by generations. Public health messaging should therefore be shaped differently for these cohorts. Whether the COVID-19 pandemic as a historic event and trust in news media explain future responses to national emergencies for younger generations like Gen Z remains an area for future research.

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Vivian Hsing-Chun Wang: Conceptualization, Data curation, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Diana Silver:** Conceptualization, Data curation, Methodology, Writing – review & editing. **José A. Pagán:** Conceptualization, Data curation, Methodology, Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2022.107005.

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