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COVID-19 vaccine perceptions and uptake in a national prospective cohort of essential workers

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Introduction: In a multi-center prospective cohort of essential workers, we assessed knowledge, attitudes, and practices (KAP) by vaccine intention, prior SARS-CoV-2 positivity, and occupation, and their impact on vaccine uptake over time.

Methods: Initiated in July 2020, the HEROES-RECOVER cohort provided socio-demographics and COVID-19 vaccination data. Using two follow-up surveys approximately three months apart, COVID-19 vaccine KAP, intention, and receipt was collected; the first survey categorized participants as reluctant, reachable, or endorser.

Results: A total of 4,803 participants were included in the analysis. Most (70%) were vaccine endorsers, 16% were reachable, and 14% were reluctant. By May 2021, 77% had received at least one vaccine dose. KAP responses strongly predicted vaccine uptake, particularly positive attitudes about safety (aOR = 5.46, 95% CI: 1.4–20.8) and effectiveness (aOR = 5.0, 95% CI: 1.3–19.1). Participants’ with prior SARS-CoV-2 infection were 22% less likely to believe the COVID-19 vaccine was effective compared with uninfected participants (aOR 0.78, 95% CI: 0.64–0.96). This was even more pronounced in first responders compared with other occupations, with first responders 42% less likely to believe in COVID-19 vaccine effectiveness (aOR = 0.58, 95% CI 0.40–0.84). Between administrations of the two surveys, 25% of reluctant, 56% reachable, and 83% of endorser groups received the COVID-19 vaccine. The reachable group had large increases in positive responses for questions about vaccine safety (10% of vaccinated, 34% of unvaccinated), and vaccine effectiveness (12% of vaccinated, 27% of unvaccinated).

Abbreviations: FDA, U.S. Food and Drug Administration; CDC, Centers for Disease Control and Prevention; EUA, Emergency Use Authorization; KAP, Knowledge, attitudes, and practices; HEROES, Arizona Healthcare, Emergency Response and Other Essential Workers Surveillance RECOVER Study and Research on the Epidemiology of SARS-CoV-2 in Essential Response Personnel; H-R, HEROES-RECOVER; HCP, Health care personnel; FW, Frontline workers; PPE, Personal protective equipment.

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1. Introduction

The SARS-CoV-2 pandemic has resulted in high levels of morbidity and mortality in the US [1]. In response, a global effort to develop COVID-19 vaccines generated evidence leading to the U.S. Food and Drug Administration (FDA) authorizing COVID-19 vaccines under an Emergency Use Authorization (EUA) mechanism, beginning in mid-December 2020 [2]. Essential workers, including healthcare personnel (HCP), first responders, and other frontline workers (FW), may be at an increased risk of SARS-CoV-2 infection because of their high rates of contact with patients, coworkers, and/or the general public [3–7]. They were prioritized to receive COVID-19 vaccines by the Centers for Disease Control and Prevention (CDC) Advisory Committee on Immunization Practices during initial, staggered distribution.

The COVID-19 vaccines have been shown to be safe and effective in adults and children ages 12 and older; despite this, vaccination rates are suboptimal, ranging from 40 to 75% of the surveyed population, with first responders reporting low rates of vaccine acceptance [8–18]. Common reasons for vaccine hesitancy included the novelty of the COVID-19 vaccines, concerns about potential adverse effects, and/or a distrust in government [8–13]. There is some indication that COVID-19 vaccine acceptance has changed over time, but evidence has been limited to cross-sectional surveys [11,19]. It remains unclear how individual vaccination intention has evolved as the public has gained more information regarding symptoms and outcomes of COVID-19 disease and risks and benefits of vaccinations.

Knowledge, attitudes, and practices (KAP) toward vaccination are often examined to understand factors associated with the acceptability of vaccines and inform strategies for increasing vaccine uptake [20]. We utilize a multi-center prospective cohort of essential workers with the following objectives: 1) examine KAP as predictors of vaccine uptake; 2) assess differences in KAP by vaccine intention, prior SARS-CoV-2 positivity, and occupation group; and 3) assess individual-level change in KAP over time.

2. Methods

2.1. Study design & population

The HEROES-RECOVER studies represent a multi-center network of prospective cohorts, including Arizona Healthcare, Emergency Response and Other Essential Workers Surveillance Study (HEROES) and Research on the Epidemiology of SARS-CoV-2 in Essential Response Personnel (RECOVER) funded by the CDC with sites in Phoenix, Tucson, and other areas in Arizona; Miami, Florida; Duluth, Minnesota; Portland, Oregon; Temple, Texas; and Salt Lake City, Utah. Details of the protocols of the studies have been previously published [21,22]. Ongoing enrollment began in July 2020 and included HCP, first responders, and FW who worked at least 20 hours per week and had routine occupational exposure to coworkers or the public.

Participants completed detailed epidemiologic surveys at enrollment and at approximately three-month intervals (Follow-up surveys 1 and 2). Text message-based surveys were completed weekly to monitor illness and potential COVID-19 contact in the past 7 days. The study is ongoing; for this analysis, only participants actively enrolled during the Follow-up 1 survey distribution were included. Data analyzed included SARS-CoV-2 infection, COVID-19 vaccination, and KAP data through May 19, 2021.

To identify SARS-CoV-2 infections, participants self-collected mid-turbinate nasal swabs weekly for SARS-CoV-2 RT-PCR testing and provided blood specimens at enrollment and three-month intervals (supplemental Figure 1 for study timing). Beginning in December 2020, participants were prompted to report uptake of the COVID-19 vaccine; vaccine survey distribution was based on vaccine availability data from state and county health departments. Vaccination was verified by participant-provided vaccination cards, electronic medical records, or State Immunization Information Systems.

All protocols were reviewed and approved by each site’s Institutional Review Boards; study participants provided informed consent for all study activities.

2.2. Primary outcomes

Vaccine intention and KAP questions were included in two follow-up surveys: Follow-up survey 1 (distributed late December 2020-February 2021) and Follow-up survey 2 (distributed late March-May 2021). Participants that joined the studies during the follow-up periods received the KAP questions at the time of enrollment.

Vaccine intention was derived using participants’ first response to the question, “What are the chances that you will get a COVID-19 vaccination?” and vaccination status at the time of Follow-up survey 1. Participants were grouped into three intention categories: 1) reluctant as those who answered, “almost zero chance” or “very small chance” and were unvaccinated, 2) reachable as those who answered, “small chance”, “do not know”, or “moderate” and were unvaccinated, or 3) endorser as those who answered, “large chance”, “very large chance”, or “almost certain”, or were vaccinated at Follow-up survey 1. Participants’ vaccine intention group did not change based upon Follow-up survey 2 KAP responses or a change in vaccination status between surveys.

The surveys included six questions to assess the KAP constructs regarding COVID-19: knowledge of SARS-CoV-2 and COVID-19 vaccines; attitudes about safety, effectiveness, trust in the government; and perceived risk of becoming ill if they were not vaccinated (Table 1). Responses to each question were rated on a 5- or 7-level Likert scale indicating lowest to highest ranking.

2.3. Predictors and confounders

For models examining KAP differences and predictors of vaccination the following variables were included: socio-demographic (including gender, age, race, ethnicity, education, household income), study site, occupation and occupational setting, and participant health status (including SARS-CoV-2 infection status and medical history), and COVID-19 vaccination status. HCP were categorized into “HCP inpatient” for any individual that works in a...
Table 1
Knowledge, Attitude, and Practice (KAP) Questions.

| Topic                      | Question Text                                      | Range       |
|----------------------------|---------------------------------------------------|-------------|
| Vaccine Intention          | What are the chances that you will get a COVID-19 vaccination? | 8-point Likert (1 = Don’t know, 8 = Almost certain) |
| Chance of getting sick if not vaccinated | If you are unable to or don’t get a COVID-19 vaccination, what do you think your chance of getting sick with COVID-19 this year will be? | 7-point Likert (1 = Almost zero, 8 = Almost certain) |
| Virus Knowledge            | How much do you know about the SARS-CoV-2 (COVID-19) virus and the illness it causes? | 5-point Likert (1 = Nothing at all, 5 = A great deal) |
| Vaccine Knowledge          | How much do you know about the COVID-19 vaccine? Would you say…? | 5-point Likert (1 = Not at all, 5 = Extremely safe) |
| Vaccine Safety             | How safe do you think the COVID-19 vaccine is? | 5-point Likert (1 = Not at all, 5 = Extremely effective) |
| Vaccine Effectiveness      | How effective do you think the COVID-19 vaccine is in preventing you from getting sick with COVID-19? | 5-point Likert (1 = Not at all, 5 = Extremely effective) |
| Trust in government vaccine | I trust what the government says about the COVID-19 vaccine | 5-point Likert (1 = Strongly disagree, 5 = Strongly agree) |

3. Results

Overall Participants. From December 2020 to February 2021, 4,803 (87%) of 5,527 participants responded to Follow-up survey 1; 1,105 (23%) HCP inpatient, 1,323 (28%) other HCP, 729 (15%) firefighter, 255 (5%) other first responders, 990 (21%) FW public, and 285 (6%) other FW (Table 2). Most participants were female (62%) and aged < 45 years (58%). Additionally, 72% were non-Hispanic White and 14% Hispanic. Participants were highly educated, including 76% with at least a college degree. Participants were healthy, with only 24% reporting an underlying condition. At the time of the Follow-up 1 survey, 960 (20%) of participants had previously been infected with SARS-CoV-2 and 1720 (36%) had received a COVID-19 vaccination.

Vaccination Intention. Most participants were categorized as endorsers (70%), having either indicated a high likelihood to receive the COVID-19 vaccine (35%) or having already received it at the time of Follow-up 1 survey (36%); 16% of participants were considered reachable, and 14% reluctant. Prior SARS-CoV-2 infection was more common among reluctant (35%) and reachable participants (25%) compared with endorsers (16%). By May 19, 2021, 72% of participants had received at least one dose of a COVID-19 vaccine (Table 2); 86% of endorser, 53% of reachable, and 25% of reluctant groups having received at least one dose.

3.1. Objective 1: KAP as predictor for vaccine uptake

After adjusting for socio-demographic factors, health status, and hours of direct contact with the public, KAP responses strongly predicted vaccine uptake. Participants reporting more positive attitudes about COVID-19 vaccine safety were 5.5 times more likely to receive a COVID-19 vaccine compared with those reporting more negative attitudes (aOR = 5.46, 95% CI: 1.43–20.82). Those with a belief that the vaccine is effective were 5 times as likely to receive a COVID-19 vaccine (aOR = 4.98 95% CI: 1.30–19.14) (Table 3).
Table 2
Descriptive Statistics, Stratified by Vaccine Intent Group in a Survey of Essential Workers December 2020 through May 2021.

|                         | TOTAL N (%) | Reluctant N (%) | Reachable N (%) | Endorser* N (%) | P-value |
|-------------------------|-------------|-----------------|-----------------|-----------------|---------|
| **Socio-demographic Characteristics** |             |                 |                 |                 |         |
| Gender*                 |             |                 |                 |                 | 0.03    |
| Female                  | 2960 (61.3%)| 387 (59.3%)     | 513 (66.6%)     | 2060 (60.9%)    |         |
| Male                    | 1827 (37.8%)| 265 (40.6%)     | 255 (33.1%)     | 1307 (38.7%)    |         |
| Age (years)             |             |                 |                 |                 | <0.01   |
| 18–24                   | 143 (3.0%)  | 24 (3.7%)       | 32 (4.2%)       | 87 (2.6%)       |         |
| 25–44                   | 2651 (54.9%)| 358 (54.8%)     | 449 (58.3%)     | 1844 (54.6%)    |         |
| 45–64                   | 1908 (39.5%)| 259 (39.7%)     | 265 (34.4%)     | 1384 (40.9%)    |         |
| 65+                     | 101 (2.1%)  | 12 (1.8%)       | 24 (3.1%)       | 65 (1.9%)       |         |
| Race/Ethnicity*         |             |                 |                 |                 | <0.001  |
| Non-Hispanic-White      | 3449 (71.4%)| 431 (66.0%)     | 525 (68.2%)     | 2493 (73.8%)    |         |
| African American        | 90 (1.9%)   | 18 (2.8%)       | 23 (3.0%)       | 49 (1.4%)       |         |
| Asian Am./Island Pacific| 141 (2.9%)  | 14 (2.1%)       | 13 (1.7%)       | 114 (3.4%)      |         |
| Hispanic-White          | 694 (14.4%) | 117 (17.9%)     | 121 (15.7%)     | 456 (13.5%)     |         |
| Multi-Racial/Other      | 429 (8.9%)  | 73 (11.2%)      | 88 (11.4%)      | 268 (7.9%)      |         |
| Education*              |             |                 |                 |                 | <0.001  |
| Less than college       | 154 (3.2%)  | 35 (5.4%)       | 40 (5.2%)       | 79 (2.3%)       |         |
| Some college            | 856 (17.7%) | 186 (28.5%)     | 201 (26.1%)     | 469 (13.9%)     |         |
| College degree or above | 3685 (76.3%)| 413 (62.2%)     | 513 (66.6%)     | 2795 (81.6%)    |         |
| Annual Income*          |             |                 |                 |                 | <0.001  |
| < 50 k                  | 702 (14.6%) | 128 (19.6%)     | 152 (19.7%)     | 422 (12.5%)     |         |
| 50 k-100 k              | 1955 (40.7%)| 244 (37.4%)     | 280 (36.4%)     | 898 (26.6%)     |         |
| 100 k+                  | 2000 (41.6%)| 261 (40.0%)     | 317 (41.2%)     | 1965 (58.1%)    |         |
| Occupation              |             |                 |                 |                 | <0.001  |
| HCP inpatient           | 1105 (22.9%)| 100 (15.3%)     | 115 (14.9%)     | 890 (26.3%)     |         |
| HCP other               | 1323 (27.4%)| 148 (22.7%)     | 163 (21.2%)     | 1012 (29.9%)    |         |
| First responder firefighter | 729 (15.1%) | 119 (18.2%)     | 78 (10.1%)      | 532 (15.7%)     |         |
| First responder other   | 255 (5.3%)  | 54 (8.3%)       | 41 (5.3%)       | 160 (4.7%)      |         |
| FW public               | 950 (20.5%) | 156 (23.9%)     | 261 (33.0%)     | 573 (17.0%)     |         |
| FW other                | 285 (5.9%)  | 57 (8.7%)       | 80 (10.4%)      | 148 (4.4%)      |         |
| **Underlying Medical Conditions** |             |                 |                 |                 | 0.990   |
| Asthma                  | 4292 (88.9%)| 578 (88.5%)     | 685 (89.0%)     | 3029 (89.6%)    |         |
| Yes                     | 446 (9.2%)  | 59 (9.0%)       | 72 (9.4%)       | 315 (9.3%)      |         |
| Diabetes                | 4576 (94.7%)| 615 (94.2%)     | 733 (95.2%)     | 3228 (95.5%)    | 0.920   |
| Yes                     | 162 (3.4%)  | 22 (3.4%)       | 24 (3.1%)       | 116 (3.4%)      |         |
| Hypertension            | 4158 (86.1%)| 556 (85.1%)     | 659 (85.6%)     | 2943 (87.1%)    | 0.710   |
| Yes                     | 580 (12.0%) | 81 (12.4%)      | 98 (12.7%)      | 401 (11.9%)     |         |
| Any above condition*    | 3176 (66.1%)| 425 (65.1%)     | 502 (65.2%)     | 2249 (66.5%)    | 0.869   |
| No                      | 1562 (32.5%)| 212 (32.5%)     | 255 (33.1%)     | 1095 (32.4%)    |         |
| Yes                     |             |                 |                 |                 | <0.001  |
| **SARS-CoV-2 Infection Prior to Follow-Up 1 Survey** |             |                 |                 |                 |         |
| No                      | 3843 (79.6%)| 424 (64.9%)     | 576 (74.8%)     | 2843 (84.1%)    |         |
| Yes                     | 960 (19.9%) | 220 (35.1%)     | 194 (25.2%)     | 537 (15.9%)     |         |
| **COVID-19 Vaccine received during the study** |             |                 |                 |                 | <0.001  |
| Received Covid-19 Vaccine, Follow-up 1 No | 3083 (64.2%)| 653 (100%)      | 770 (100%)      | 1660 (49.1%)    |         |
| Yes                     | 1720 (35.8%)| 0 (0%)         | 0 (0%)         | 1720 (50.9%)    | <0.001  |
| Received Covid-19 Vaccine, Follow-up 2 No | 1332 (27.7%)| 489 (74.9%)     | 366 (47.5%)     | 477 (14.1%)     |         |
| Yes                     | 3471 (72.3%)| 164 (25.1%)     | 404 (52.5%)     | 2903 (85.9%)    |         |
| **Responses to KAP questions** |             |                 |                 |                 |         |
| Chances of getting sick if not vaccinated |             |                 |                 |                 | <0.001  |
| Negative/Neutral        | 2693 (55.8%)| 544 (83.3%)     | 515 (66.0%)     | 1634 (48.3%)    |         |
| Positive                | 1985 (41.1%)| 109 (16.7%)     | 252 (32.7%)     | 1624 (48.0%)    |         |
| Virus Knowledge         | 1575 (32.8%)| 282 (43.2%)     | 322 (41.8%)     | 971 (28.7%)     | <0.001  |
| Negative/Neutral        | 3191 (66.4%)| 371 (56.8%)     | 442 (57.4%)     | 2378 (70.4%)    |         |
| Positive                |             |                 |                 |                 | <0.001  |
| Vaccine Knowledge       | 2838 (58.8%)| 505 (77.3%)     | 582 (75.6%)     | 1751 (51.8%)    |         |
| Negative/Neutral        | 1935 (40.1%)| 148 (22.7%)     | 187 (24.3%)     | 1600 (47.3%)    |         |
| Positive                |             |                 |                 |                 | <0.001  |
| Vaccine Safety          |             |                 |                 |                 |         |

(continued on next page)
infection status in the adjusted models (Table 3). fire fighters and other first responders were each approximately 40% less likely than inpatient HCP to believe the COVID-19 vaccine was effective (aOR = 0.58, 95% CI: 0.40–0.84 and aOR = 0.61, 95% CI 0.49–0.76, respectively). the other FW category was 51% more likely to believe the COVID-19 vaccine was effective compared to inpatient HCP (aOR = 1.49, 95% CI 1.26–1.77), followed by public-facing FW (aOR = 1.25, 95% CI 1.02–1.53) (Table 3).

### Table 2 (continued)

| Vaccine Interventions | TOTAL | Reluctant | Reachable | Endorser* |
|-----------------------|-------|-----------|-----------|-----------|
| Negative/Neutral      | 1825  | 535       | 427       | 863       |
| Positive              | 2945  | 114       | 343       | 2488      |
| Vaccine Effectiveness  |       |           |           |           |
| Negative/Neutral      | 1825  | 498       | 392       | 935       |
| Positive              | 2944  | 152       | 375       | 2417      |
| Trust in the Government |      |           |           |           |
| Negative/Neutral      | 2371  | 513       | 443       | 1415      |
| Positive              | 2404  | 140       | 327       | 1937      |
| N (%)                 |       |           |           |           |

Participants in the reachable and endorser groups showed decreases in positive responses for knowledge about the virus between the two time points (-19% and -22%, respectively) (Table 5). the reachable group had large increases in positive responses for questions about vaccine knowledge (25% of vaccinated, 25% of unvaccinated), vaccine safety (10% of vaccinated, 34% of unvaccinated), and vaccine effectiveness (12% of vaccinated, 27% of unvaccinated).

### Change in vaccination status with change in KAP.

Amongst the overall sample, an increase of one point in response to the vaccine safety KAP corresponded with a 19 percent increase in the likelihood of becoming vaccinated. Each point-increase in belief in vaccine effectiveness resulted in a similarly strong increase in likelihood of vaccination (17% increase), with vaccine knowledge and trust in government showing moderate increases (11% and 9% respectively), and general knowledge of COVID-19 showing the smallest increase (2%). For all five, the effect was more pronounced in the endorser group than in the reluctant and reachable groups (Table 6).

### 4. Discussion

The HEROES-RECOVER prospective cohort provided a unique opportunity to examine COVID-19 vaccine knowledge, attitudes, and practices longitudinally in a large population of essential workers with high occupational COVID-19 exposure. The prospective design captured how vaccination intention, KAP, and vaccine uptake changed between December 2020 to May 2021, a critical time in COVID-19 vaccine roll-out in the United States.

First responders and participants with prior SARS-CoV-2 infection were more likely to be reluctant to receive the COVID-19 vaccine than other groups. First responders had the highest percentage of vaccine reluctant participants, especially the non-firefighter subcategory. Additionally, even first responders that were endorsers had low rates of vaccination.

Participants with prior SARS-CoV-2 infection were less likely to receive the COVID-19 vaccine and make up more than one-third of the vaccine reluctant group and one-quarter of the reachable group. Other studies have reported similar findings where previously infected were less concerned about reinfection and/or interest in vaccination [23], but better understanding why they report fewer positive attitudes toward vaccine effectiveness will be important in persuading them to get vaccinated. Additional studies highlighting the benefits of vaccination for those with prior infection may help to stress the importance of vaccination among this group [24].

Across vaccination intent, demographics, occupational, and prior SARS-CoV-2 infection groups, three KAP domains were con-
consistently correlated with intent to vaccinate and vaccine uptake: safety, effectiveness, and the chance of getting sick if not vaccinated. These indicators of vaccination continued to predict vaccination over time, with more favorable attitudes about vaccine safety and effectiveness substantially increasing the likelihood of vaccination.

Table 3
Difference in Knowledge, Attitude, and Practice (KAP) Questions Stratified by Vaccination Status, Intention Group, Occupation, and Prior SARS-CoV-2 Positivity in a Cohort of Essential Workers (N = 4803)

|                  | Unadjusted |         | Adjusted |         |
|------------------|------------|---------|----------|---------|
|                  | OR 95% CI  |         | OR 95% CI|         |
| **Vaccinated during the study (not vaccinated is the reference group)** |            |         |          |         |
| Virus Knowledge  | 1.58       | 1.40 – 1.79 | 2.49     | 2.17 – 2.87 |
| Vaccine Knowledge| 9.81       | 8.42 – 11.44 | 8.29     | 7.10 – 9.67 |
| Vaccine Safety   | 4.40       | 3.87 – 5.00 | 4.15     | 3.58 – 4.81 |
| Vaccine Effectiveness |          |          |          |         |
| Trust in government |          |          |          |         |
| Chances of getting sick |          |          |          |         |
| **By Intention Group (Endorser is the reference Group)** |            |         |          |         |
| Reluctant Virus Knowledge | 0.53      | 0.45 – 0.62 | 0.30     | 0.26 – 0.35 |
| Vaccine Knowledge | 0.08       | 0.06 – 0.09 | 0.12     | 0.10 – 0.14 |
| Vaccine Safety   | 0.20       | 0.17 – 0.23 | 0.23     | 0.20 – 0.27 |
| Vaccine Effectiveness |          |          |          |         |
| Trust in government |          |          |          |         |
| Chances of getting sick |          |          |          |         |
| Reachable Virus Knowledge | 0.52      | 0.45 – 0.60 | 0.34     | 0.30 – 0.40 |
| Vaccine Knowledge | 0.33       | 0.28 – 0.38 | 0.40     | 0.35 – 0.47 |
| Vaccine Effectiveness |          |          |          |         |
| Trust in government |          |          |          |         |
| Chances of getting sick |          |          |          |         |
| **Occupation (HCP inpatient is the reference group)** |            |         |          |         |
| HCP other Virus Knowledge | 0.81      | 0.70 – 0.94 | 0.97     | 0.84 – 1.12 |
| Vaccine Knowledge | 0.91       | 0.79 – 1.06 | 1.02     | 0.87 – 1.18 |
| Vaccine Safety   | 0.98       | 0.85 – 1.13 | 0.89     | 0.77 – 1.03 |
| Vaccine Effectiveness |          |          |          |         |
| Trust in government |          |          |          |         |
| Chances of getting sick |          |          |          |         |
| First responder firefighter Virus Knowledge | 0.37      | 0.31 – 0.44 | 0.43     | 0.36 – 0.51 |
| Vaccine Knowledge | 0.43       | 0.36 – 0.51 | 0.43     | 0.36 – 0.51 |
| Vaccine Safety   | 0.41       | 0.34 – 0.49 | 0.41     | 0.34 – 0.49 |
| Vaccine Effectiveness |          |          |          |         |
| Trust in government |          |          |          |         |
| Chances of getting sick |          |          |          |         |
| First responder other Virus Knowledge | 0.20      | 0.15 – 0.25 | 0.19     | 0.15 – 0.25 |
| Vaccine Knowledge | 0.34       | 0.26 – 0.43 | 0.41     | 0.32 – 0.53 |
| Vaccine Safety   | 0.48       | 0.37 – 0.60 | 0.62     | 0.52 – 0.73 |
| Vaccine Effectiveness |          |          |          |         |
| Trust in government |          |          |          |         |
| Chances of getting sick |          |          |          |         |
| FW Public Virus Knowledge | 0.30      | 0.26 – 0.36 | 0.30     | 0.25 – 0.35 |
| Vaccine Knowledge | 0.65       | 0.55 – 0.76 | 0.75     | 0.64 – 0.88 |
| Vaccine Safety   | 0.95       | 0.82 – 1.11 | 0.94     | 0.81 – 1.10 |
| Vaccine Effectiveness |          |          |          |         |
| Trust in government |          |          |          |         |
| Chances of getting sick |          |          |          |         |
| FW other Virus Knowledge | 0.28      | 0.22 – 0.35 | 0.28     | 0.28 – 0.45 |
| Vaccine Knowledge | 0.59       | 0.47 – 0.75 | 0.59     | 0.47 – 0.75 |
| Vaccine Effectiveness | 0.72      | 0.56 – 0.91 | 0.72     | 0.56 – 0.91 |
| Trust in government | 0.86       | 0.68 – 1.08 | 0.86     | 0.68 – 1.08 |
| Chances of getting sick | 0.52      | 0.41 – 0.65 | 0.52     | 0.41 – 0.65 |
| **Prior SARS-CoV-2 Infection (No known prior infection as the reference group)** |            |         |          |         |
| Virus Knowledge  | 0.91       | 0.85 – 0.98 | 0.66     | 0.57 – 0.78 |
| Vaccine Knowledge | 0.48       | 0.44 – 0.52 | 0.51     | 0.47 – 0.55 |
| Vaccine Effectiveness |          |          |          |         |
| Trust in government |          |          |          |         |
| Chances of getting sick |          |          |          |         |

* P-values not reported due to inconsistencies that occur with multi-level categorical variables. Statistical significance based on 95% confidence intervals.

* Non-significant adjusted point estimates and confidence intervals not reported. Bonferroni corrections were used for each of vaccination status, intention group, occupation, and prior positivity. The model was adjusted for socio-demographics, occupation and occupational setting, vaccine intention, and prior positivity for SARS-CoV-2 infection.
We found knowledge about the SARS-CoV-2 virus, or the COVID-19 vaccine had no association with vaccine uptake. It is difficult to ascertain whether participants who perceive themselves to be knowledgeable are truly informed, but attitudes about vaccine safety and effectiveness appear to be more informative of individual intentions to vaccinate. Vaccination efforts that highlight vaccine safety and effectiveness may have a stronger influence on vaccination uptake than general or historical information. Utilizing KAP assessments to gauge a population’s intentions or concerns in advance of vaccination campaigns is critical to not only gauge intention to vaccinate, but also to guide the development of vaccination messaging.

Utilizing the prospective cohort, we were able to examine shifts in KAP over time, subgrouping vaccinated versus unvaccinated par-

### Table 4
Demographics of Vaccine Intention Groups, Stratified by Vaccination Status at Time of Follow-up Survey 2 in a Cohort of Essential Workers.

|               | Reluctant (N = 289) | Reachable (N = 94) | Endorser (N = 1232) |
|---------------|---------------------|--------------------|---------------------|
| **Gender**    |                     |                    |                     |
| Female        | 168 (58.1%)         | 58 (61.7%)         | 133 (54.1%)         |
| Male          | 121 (41.9%)         | 36 (38.3%)         | 112 (45.5%)         |
| **Age (years)** |                    |                    |                     |
| 18–24         | 11 (3.8%)           | 3 (3.2%)           | 10 (4.1%)           |
| 25–44         | 158 (54.7%)         | 44 (46.8%)         | 132 (53.7%)         |
| 45–64         | 111 (38.4%)         | 47 (50.0%)         | 99 (40.2%)          |
| 65+           | 9 (3.1%)            | 2 (2.1%)           | 5 (2.0%)            |
| **Race/Ethnicity** |                  |                    |                     |
| Non-Hispanic-White | 188 (65.1%) | 60 (63.8%) | 169 (68.7%) |
| African American  | 8 (2.8%)           | 3 (3.2%)           | 4 (1.6%)            |
| Asian American   | 6 (2.1%)           | 2 (2.1%)           | 4 (1.6%)            |
| Hispanic-White   | 54 (18.7%)         | 17 (17.0%)         | 48 (19.5%)          |
| Multi-Racial     | 13 (4.5%)          | 4 (4.3%)           | 8 (3.3%)            |
| **Education**   |                     |                    |                     |
| Less than High school | 0 (0%)               | 0 (0%)             | 0 (0%)             |
| HS diploma/GED  | 15 (5.2%)          | 6 (6.4%)           | 11 (4.5%)           |
| Some college    | 78 (27.0%)         | 25 (26.6%)         | 72 (29.7%)          |
| College degree/above | 187 (64.7%) | 60 (63.8%) | 172 (69.9%) |
| **Annual Income** |                    |                    |                     |
| < 50 k          | 63 (21.8%)         | 10 (10.6%)         | 46 (18.7%)          |
| 50 k-100 k      | 104 (36.0%)        | 40 (42.6%)         | 74 (30.3%)          |
| 100 k-150 k     | 62 (21.5%)         | 22 (23.4%)         | 62 (25.2%)          |
| 150 k-200 k     | 27 (9.3%)          | 8 (8.5%)           | 35 (14.2%)          |
| 200 k+          | 20 (6.9%)          | 9 (9.6%)           | 23 (9.3%)           |
| **Previously Tested Positive** | | | |< 0.001 |
| No             | 181 (62.6%)        | 64 (68.1%)         | 166 (67.5%)         |
| Yes            | 108 (37.4%)        | 30 (31.9%)         | 104 (32.5%)         |
| **Occupation**  |                     |                    |                     |
| HCP Inpatient   | 45 (15.6%)         | 17 (18.1%)         | 50 (20.3%)          |
| HCP Other       | 63 (21.8%)         | 16 (17.0%)         | 42 (17.1%)          |
| First responder firefighter | 55 (19.0%)   | 15 (16.0%)        | 62 (25.2%)          |
| First responder other | 29 (10.0%) | 9 (9.6%)          | 16 (6.5%)           |
| FW Public      | 67 (23.2%)         | 28 (29.8%)         | 40 (16.3%)          |
| FW other       | 22 (7.6%)          | 7 (7.4%)           | 23 (9.3%)           |
| **Asthma**     | 873 (87.6%)        | 141 (92.8%)        | 221 (89.8%)         |
| **Diabetes**   |                     |                    |                     |
| No             | 259 (89.6%)        | 85 (90.4%)         | 1091 (88.6%)        |
| Yes            | 22 (7.6%)          | 6 (6.4%)           | 122 (9.9%)          |
| **Hypertension** |                    |                    |                     |
| No             | 274 (94.8%)        | 87 (92.6%)         | 1167 (94.7%)        |
| Yes            | 7 (2.4%)           | 4 (4.3%)           | 46 (3.7%)           |
| **Table 5**    | Change in Positive Response to Knowledge, Attitude, and Practice (KAP) Questions by Intention and Actual Vaccination from Follow-up Survey 1 to Follow-up Survey 2. |

| Virus Knowledge | Vaccine Knowledge | Vaccine Safety | Vaccine Effectiveness | Trust in government |
|-----------------|-------------------|----------------|----------------------|---------------------|
| n(%)            | p-value           | n(%)           | p-value              | n(%)               | p-value   |
| Reluctant       |                   |                |                      |                     |
| Never Vaccinated| -26 (-9.0%)       | 0.044          | 58 (20.0%)           | <0.001              | 13 (4.5%) | 0.170 |
| Vaccinated      | -8 (-8.5%)        | 0.305          | 20 (21.2%)           | 0.02                | 25 (26.6%)| <0.001 |
| Reachable       |                   |                |                      |                     |
| Never Vaccinated| -29 (-19.0%)      | 0.001          | 38 (25.0%)           | <0.001              | 15 (9.9%) | 0.044 |
| Vaccinated      | 2 (1.0%)          | 0.876          | 49 (25.2%)           | <0.001              | 67 (34.7%)| <0.001 |
| Endorser        |                   |                |                      |                     |
| Never Vaccinated| -53 (-21.3%)      | <0.001         | 53 (21.3%)           | <0.001              | 8 (3.2%)  | 0.476 |
| Vaccinated      | 13 (1.1%)         | 0.596          | 235 (19.1%)          | <0.001              | 147 (11.9%)| <0.001 |

We found knowledge about the SARS-CoV-2 virus, or the COVID-19 vaccine had no association with vaccine uptake. It is difficult to ascertain whether participants who perceive themselves to be knowledgeable are truly informed, but attitudes about vaccine safety and effectiveness appear to be more informative of individual intentions to vaccinate. Vaccination efforts that highlight vaccine safety and effectiveness may have a stronger influence on vaccination uptake than general or historical information. Utilizing KAP assessments to gauge a population’s intentions or concerns in advance of vaccination campaigns is critical to not only gauge intention to vaccinate, but also to guide the development of vaccination messaging.

Utilizing the prospective cohort, we were able to examine shifts in KAP over time, subgrouping vaccinated versus unvaccinated par-
Change in Likelihood of Vaccination Status at Follow-up Survey 2 Compared to Follow-up Survey 1, by Change in Knowledge, Attitude, and Practice Questions in a Cohort of Essential Workers.

|                          | Overall (n = 1983) | Endorser (n = 1262) | Reluctant & Reachable (n = 721) |
|--------------------------|--------------------|--------------------|---------------------------------|
| Virus Knowledge          | 2.2*** (0.00839)   | 1.5 (0.0115)       | -0.2 (0.0107)                   |
| Vaccine Knowledge        | 11.2*** (0.00782)  | 11.2*** (0.0108)   | 5.6*** (0.0105)                 |
| Vaccine Safety           | 18.7*** (0.00720)  | 18.0*** (0.0105)   | 13.6*** (0.0108)                |
| Vaccine Effectiveness    | 17.2*** (0.00779)  | 16.1*** (0.0113)   | 11.7*** (0.0111)                |
| Trust in government      | 9.4*** (0.00546)   | 8.1*** (0.00748)   | 6.3*** (0.00815)                |

*** p < 0.01, ** p < 0.05, * p < 0.1.

participants. The KAP factors that were most connected to vaccination remained influential over time. Our findings indicate that positive changes in individuals’ perceptions of vaccine safety and efficacy were associated with the receipt of vaccination. These findings indicate that these KAPs are important for understanding differences in vaccination status not only across individuals, but also for understanding correlates with within-person changes in vaccination status.

Our findings are consistent with other studies conducted prior to COVID-19 vaccine authorization and availability [13,15]. While vaccine intent was assessed in our study after the FDA granted EUA, our findings capture an initial uncertainty that was seemingly overcome with time and positive findings for vaccine safety and effectiveness [11].

5. Limitations

This study is subject to several limitations. First, the follow-up surveys were spread out over about six weeks due to site’s individual IRB timelines. As the level of information available evolved quickly during the study period, participants at sites where the follow-up surveys were administered later may have had access to a meaningfully different amount, or quality, of information. Secondly, all KAPs are self-reported and there may be a disconnect between perceived knowledge and actual level of knowledge. Next, while we are confident KAPs are successfully captured in our cohorts at the time of administration, due to the novelty of the COVID-19 vaccine, KAPs will likely continue to change and evolve past this analysis period. Finally, the mechanism prompting change in KAPs is not captured, so it is difficult to know why certain KAPs changed as they did over time; e.g., the change in certain KAPs between the two follow-up surveys may have been due to increased numbers of participants receiving the vaccine with few documented serious adverse event rates, increased access to information leading to more disease/vaccine literacy, changes in national and local COVID-19 incidence, etc. The demographic characteristics of the group that answered Follow-up 2 differed slightly from those that completed Follow-up 1, as there were more female participants (64% vs 60%), older participants (45% 40–65 years of age compared to 36%), and a different breakdown of occupations (FW 36% vs 20% and HCP 44% vs 58%). Race/ethnicity, education, and income were similar between the two groups. Finally, we did not differentiate between individual COVID-19 vaccine products in this analysis. In the first-differences analyses, other time-varying factors that may impact KAPs and vaccination status, such as changes in local policies, were unable to be accounted for in the model.

6. Public health implication

The HEROES-RECOVER cohort provides valuable insight into the perceptions and intentions of essential workers receiving the COVID-19 vaccine. With the current increase in cases, encouraging high-risk occupational groups to receive the COVID-19 vaccine is a critical next step. Our findings indicate that perceptions of the COVID-19 vaccine can shift over time and suggest that focusing on clear messages about the vaccine’s safety and effectiveness in reducing SARS-CoV-2 virus infection and illness severity may increase vaccine uptake for reluctant and reachable participants. Targeted messaging by key stakeholders and healthcare providers for participants with prior infection and in occupations with low vaccine coverage and low trust in the government (like first responders) would be especially useful.

7. Disclosures

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

8. Statement of Contributions

K Lutrick, H Groom, A Fowlkes, K Groover, P Rivers, K Nguyen, M Herring, J Mayo Lamberte, K Prather, and S Yoon conceptualized the study and drafted the manuscript with the help of Z Baccam. J Parker, P Rivers, and K Groover conducted the statistical analysis. M Gaglani, A Naleway, K Dunnigan, A Phillips, M Thiese, and H Tyner were responsible for review and revision of the manuscript. All authors read and approved of the final manuscript.

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. Allison L. Naleway reported funding from Pfizer for a meningococcal B vaccine study unrelated to the submitted work.

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References

[1] Centers for Disease Control and Prevention. COVID-19. https://www.cdc.gov/coronavirus/2019-ncov/index.html. Accessed May 25, 2021.

[2] US Food & Drug Administration. Pfizer-BioNTech COVID-19 Vaccine. https://www.fda.gov/emergency-preparedness-and-response/coronavirus-disease-2019-covid-19/pfizer-biontech-covid-19-vaccine. Accessed May 25, 2021.

[3] Chen J, Eustace V-C, Wong S-C, Yuen KC. Development of the Hong Kong Coronavirus Disease 2019 Infection Risk in Health Care Workers. JAMA Netw Open 2020;3(5):e209687. https://doi.org/10.1001/jamanetworkopen.2020.9687.

[4] Nguyen LH, Drew DA, Caban-Martinez AJ, et al. Risk of COVID-19 among front-line health-care workers and the general community: a prospective cohort study. Lancet Public Health 2020;5(9):e475–83.

[5] Centers for Disease Control and Prevention. Interim List of Categories of Essential Workers Mapped to Standardized Industry Codes and Titles. https://www.cdc.gov/coronavirus/2019-covid-19/categories-essential-workers.html. Accessed June 1, 2021.

[6] Centers for Disease Control and Prevention. COVID data tracker: COVID-19 vaccinations. https://covid.cdc.gov/covid-data-tracker/#vaccinations. Published 2020. Accessed May 10, 2021.

[7] Centers for Disease Control and Prevention. COVID-19 Vaccination Intent, Perceptions, and Reasons for Not Vaccinating Among Groups Prioritized for Early Vaccination – United States, September and December 2020. MMWR Morb Mortal Wkly Rep 2021;70(6):217–22.

[8] Ruiz JB, Bell RA. Predictors of intention to vaccinate against COVID-19: Results of a nationwide survey. Vaccine 2021;39(7):1080–6.

[9] Caban-Martinez AJ, Silbera CA, Santiago KM, et al. COVID-19 Vaccine Acceptability Among US Firefighters and Emergency Medical Services Workers: A Cross-Sectional Study. Journal of occupational and environmental medicine. 2021;63(5):369.

[10] Pogue K, Jensen JL, Stancil CK, Ferguson DG, Hughes SJ, Mello EJ, et al. Influences on attitudes regarding potential COVID-19 vaccination in the United States. Vaccines 2020;8(4):582. https://doi.org/10.3390/vaccines8040582.

[11] Biswas N, Mustapha T, Khubchandani J, Price JH. The Nature and Extent of COVID-19 Vaccination Hesitancy in Healthcare Workers. J Community Health 2021;46(6):1244–51.

[12] Shu J, Stewart T, Anderson KR, et al. Assessment of US health care personnel (HCP) attitudes towards COVID-19 vaccination in a large university health care system. Clinical Infectious Diseases: An Official Publication of the Infectious Diseases Society of America. 2021.

[13] Centers for Disease Control and Prevention. COVID-19 data tracker: COVID-19 vaccinations in the United States. https://covid.cdc.gov/covid-data-tracker/#/vaccinations. Published 2021. Accessed May 10, 2021.

[14] Meyer MN, Gjorgjieva T, Santiago KM, et al. COVID-19 Vaccine Acceptability Among US Firefighters and Emergency Medical Services Workers: A Cross-Sectional Study. JAMA network open. 2021;4(3):e213544-e213544.

[15] Halbrook M, Gadoth A, Martin-Blais R, et al. Longitudinal assessment of COVID-19 vaccine acceptance and uptake among frontline medical workers in Los Angeles, California. Clin. Infect Dis. 2021.

[16] Akarsu B, Canbay Ozdemir D, Ayhan Baser D, Aksoy H, Fidancı I, Cankurtaran M, et al. Antibody responses in seropositive persons after a single dose of SARS-CoV-2 mRNA vaccine. N Engl J Med 2021;384(14):1372–4.

[17] Centers for Disease Control and Prevention. Interim List of Categories of Essential Workers Mapped to Standardized Industry Codes and Titles. https://www.cdc.gov/coronavirus/2019-covid-19/categories-essential-workers.html. Accessed June 1, 2021.

[18] Centers for Disease Control and Prevention. COVID-19 Vaccination Hesitancy in Healthcare Workers. JAMA Netw Open 2020;3(5):e209687. https://doi.org/10.1001/jamanetworkopen.2020.9687.

[19] Centers for Disease Control and Prevention. Interim List of Categories of Essential Workers Mapped to Standardized Industry Codes and Titles. https://www.cdc.gov/coronavirus/2019-covid-19/categories-essential-workers.html. Accessed May 25, 2021.

[20] Centers for Disease Control and Prevention. COVID-19 Vaccination Hesitancy in Healthcare Workers. JAMA Netw Open 2020;3(5):e209687. https://doi.org/10.1001/jamanetworkopen.2020.9687.

[21] Centers for Disease Control and Prevention. COVID-19 Vaccination Hesitancy in Healthcare Workers. JAMA Netw Open 2020;3(5):e209687. https://doi.org/10.1001/jamanetworkopen.2020.9687.

[22] Centers for Disease Control and Prevention. COVID-19 Vaccination Hesitancy in Healthcare Workers. JAMA Netw Open 2020;3(5):e209687. https://doi.org/10.1001/jamanetworkopen.2020.9687.

[23] Centers for Disease Control and Prevention. COVID-19 Vaccination Hesitancy in Healthcare Workers. JAMA Netw Open 2020;3(5):e209687. https://doi.org/10.1001/jamanetworkopen.2020.9687.

[24] Centers for Disease Control and Prevention. COVID-19 Vaccination Hesitancy in Healthcare Workers. JAMA Netw Open 2020;3(5):e209687. https://doi.org/10.1001/jamanetworkopen.2020.9687.