Relationship between mask wearing, testing, and vaccine willingness among Los Angeles County adults during the peak of the COVID-19 pandemic

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Abstract
Background: Mask wearing mitigates the spread of COVID-19; however, many individuals have not adopted the protective behavior. Purpose: We examine mask wearing behavior during the height of the pandemic in Los Angeles County, and its association with COVID-19 testing and willingness to get vaccinated. Methods: We conducted a cross-sectional survey using representative sampling between December 2020 and January 2021, through an online platform targeting Los Angeles County residents. Survey items include demographic characteristics, health conditions, access to health care, mask wearing, COVID-19 testing, exposure risk factors, and willingness to receive COVID-19 vaccine. We performed logistic regression models to examine factors associated with always mask wearing. Results: Of the analytic sample (n = 1,984), 75.3% reported always wearing a face mask when leaving home. Being a female, Asian or African American, or non-Republican resident, or having higher education, having poor or fair health, having a regular doctor, knowing someone hospitalized for COVID-19, and being willing to receive the COVID-19 vaccine were associated with always mask wearing. Conclusion: Mask wearing guidelines are easing; however, as vaccination rates plateau and new virus variants emerge, mask wearing remains an important tool to protect vulnerable populations. Encouraging protective measures among younger adults, those with less education, republicans, men, and White residents—groups that are least likely to be vaccinated or wear a mask—may be critical to reducing transmission.

Keywords
COVID-19, Mask wearing, Vaccination, Testing

INTRODUCTION
Due to the decline in new cases and deaths after COVID-19 vaccine rollout, most states have rescinded their protective measures against the spread of COVID-19 [1]. However, surge in hospitalizations and deaths from the delta variants among unvaccinated individuals has alarmed federal and state agencies to reinstate some mandates such as indoor mask wearing [2, 3]. As of early August, 49.7% of the United States is fully vaccinated [4]. Mask wearing and COVID-19 testing continue to be important public health strategies to protect all individuals.

In January 2021, Los Angeles County experienced the worst surge of COVID-19 with over 240 daily deaths [5]. Local efforts in boosting testing and vaccination have met with success, with 73.4% of Los Angeles County residents tested (16.5% test positive) [5], and 62.6% of the County’s 8.3 million eligible residents fully vaccinated [6]. However, due to the uncertainty of new variants, increased infection rates, the duration of antibody immunity, and risk of repeated infection, mask wearing remains crucial as the economy has reopened, while vaccination rate has plateaued [7]. Studying mask wearing behaviors and its association with testing and vaccination will help design targeted public health strategies and messaging to continue the fight against COVID-19.

Mask wearing, an effective approach to mitigate the spread of COVID-19 [8–11], was recommended by the CDC in April 2020 [12]. A study shows that eight states had reached 75% of state residents wearing mask after state mask mandates were in effect (California: 74.3% in July 2020) [13]. However, many states remained below that threshold. Observational studies from the pandemic’s early months suggest that older age, female, non-White, and urban region residents were more likely to report wearing a mask [14–18]. Greater belief in
science [17] and positive vaccine intentions [18] also predicted mask wearing. As suggested in the social identity theory, people who identify themselves in social categories would engage in certain normative behaviors [19]. Individuals who intend to get vaccinated may likely practice mask wearing given both are public preventive measures against COVID-19. This will serve as an underlying justification to test our study model. In addition, most studies of mask wearing were conducted during the early phase of the pandemic; few have examined mask wearing behavior when infection rates were peaking. Also, little is understood about how mask wearing relates to receipt of COVID-19 testing and willingness to get vaccinated. Previous studies suggest that most individuals who are hesitant to get the COVID-19 vaccine have concerns about vaccine side-effects and safety [18, 20]; however, a non-negligible contingent—up to 40% in a national trend—do not believe that they will get COVID-19 [21]. These individuals may be less inclined to also wear a mask.

In this study, we examine mask wearing during the height of COVID-19 pandemic in Los Angeles County. We test two constructs in the Health Belief Model [22], perceived susceptibility to disease and benefits of preventative action, measured by COVID-19 testing and willingness to get vaccinated; to assess their associations with the mask wearing behavior. We hypothesize that mask wearing is associated with higher testing rates and higher vaccination willingness. Using weighted measures we also quantify the number of individuals in Los Angeles County who are unwilling to receive the vaccine and wear a mask and thus remain more susceptible to COVID-19. Our study can help inform strategies to mitigate the spread of COVID-19 through mask wearing and vaccination.

METHODS

We conducted a cross-sectional survey using Qualtrics Panels, an online survey platform, from December 5, 2020 to January 9, 2021. Using online panels is a way to rapidly recruit a large sample of study participants using a prescreened pool of individuals who have agreed to participate in survey research [23–25]. Qualtrics sent email recruitment notices to individuals on its member platform, and those who provided consent became participants. We sampled adults who lived in Los Angeles County, those who provided consent became participants. Of the 6,686 invitations sent via the survey platform, 2,087 (31.2%) responses met the inclusion criteria. The analysis used 1,984 responses after data quality check, including ZIP codes verification and detecting repeating response patterns. The analytic sample matched the recruitment quota on gender (male: 45.9%, female: 53.3%, transgender: 0.8%), income (<$20,000: 14.9%, $20,000–$49,999: 22.9%,
Our findings are consistent with previous studies showing that being older age, female, more highly educated, non-White resident, non-Republican, poor/fair health, and having regular access to healthcare is associated with always wearing a mask [14–18]. In addition to these existing findings, our results show that participants with the highest risk health conditions are less likely to always wear a mask. Among the highest risk group, only 50% of those with heart disease, cancer, or COPD reported always wearing a mask. It is possible that some of these high-risk conditions may have prevented or complicated individuals use of mask. Further research to understand mask wearing behaviors among those with chronic health conditions and potential barriers to mask wearing is warranted.

As hypothesized, mask wearing is associated with willingness to receive COVID-19 vaccine. This supports the benefits of preventative action construct in the Health Belief Model, as vaccine willingness relate to actual vaccination uptake and mask wearing. These normative behaviors are public preventive measures, manifested among individuals who engage in similar activities that are consistent with COVID-19 prevention according to the social identity theory [19]. However, mask wearing’s negative association with COVID-19 testing was unexpected. The association between always mask wearing and willingness to receive the COVID-19 vaccine can be explained by consistent, protective measure individuals take against the pandemic, as recommended by public health authorities [12]. It is unclear why increased testing is inversely related to mask wearing. One possibility is that people who always wear masks may not perceive the need to get tested given their lower exposure risk. Those who do not wear mask may get sick and experience flu-like symptoms more often and, as a result, are more likely to get tested for...
Table 1 | Participant characteristics and factors associated with always mask wearing (N = 1,984)

|                          | Descriptive statistics | Unadjusted odds ratio | Adjusted odds ratio |
|--------------------------|------------------------|-----------------------|---------------------|
|                          | n | %   | OR (95% CI) | p-value | AOR (95% CI) | p-value |
| Mask wearing             |   |     |             |         |             |         |
| Always                   | 1,494 | 75.3% | 0.4 (0.2, 0.7) | 0.001 | 0.5 (0.2, 0.8) | 0.012 |
| Most of the time         | 305 | 15.4% | 0.4 (0.2, 0.7) | <0.001 | 0.4 (0.2, 0.8) | <0.001 |
| Rarely                   | 51 | 2.6% | 0.4 (0.2, 0.7) | 0.001 | 0.4 (0.2, 0.8) | <0.001 |
| Never                    | 137 | 6.9% | 0.4 (0.2, 0.7) | 0.001 | 0.4 (0.2, 0.8) | <0.001 |
| Age                      |   |     |             |         |             |         |
| 18–29                    | 652 | 32.9% | 0.4 (0.2, 0.7) | 0.001 | 0.5 (0.2, 0.8) | 0.012 |
| 30–39                    | 571 | 28.8% | 0.4 (0.2, 0.7) | 0.001 | 0.4 (0.2, 0.8) | 0.009 |
| 40–64                    | 634 | 32.0% | 0.6 (0.4, 1.1) | 0.083 | 0.7 (0.4, 1.3) | 0.292 |
| 65 and up                | 127 | 6.4% | Ref         |         | Ref         |         |
| Gender                   |   |     |             |         |             |         |
| Male                     | 910 | 45.9% | Ref         |         | Ref         |         |
| Female                   | 1,058 | 53.3% | 1.6 (1.3, 1.9) | <0.001 | 1.6 (1.3, 2.0) | <0.001 |
| Transgender              | 16 | 0.8% | 1.8 (0.5, 6.4) | 0.362 | 1.9 (0.5, 7.1) | 0.358 |
| Education                |   |     |             |         |             |         |
| High school or less      | 484 | 24.4% | Ref         |         | Ref         |         |
| Some college             | 481 | 24.2% | 1.8 (1.4, 2.4) | <0.001 | 1.6 (1.2, 2.3) | 0.002 |
| Bachelor or higher       | 1,019 | 51.4% | 1.7 (1.3, 2.1) | <0.001 | 1.5 (1.1, 2.1) | 0.008 |
| Race and ethnicity       |   |     |             |         |             |         |
| Asian                    | 298 | 15.0% | 2.7 (1.8, 4.0) | <0.001 | 2.9 (1.8, 4.4) | <0.001 |
| African American         | 339 | 17.1% | 1.3 (0.9, 1.8) | 0.108 | 1.5 (1.0, 2.3) | 0.028 |
| Hispanic                 | 922 | 46.5% | 1.1 (0.8, 1.4) | 0.654 | 1.3 (0.9, 1.9) | 0.075 |
| Other                    | 29 | 1.5% | 0.8 (3.4, 1.7) | 0.497 | 0.8 (0.4, 2.0) | 0.7 |
| White                    | 396 | 20.0% | Ref         |         | Ref         |         |
| Income, annual           |   |     |             |         |             |         |
| <$20,000                 | 295 | 14.9% | 0.7 (0.5, 0.9) | 0.046 | 0.9 (1.6, 2.9) | 0.687 |
| $20,000–$49,999          | 455 | 22.9% | 1.3 (1.0, 1.8) | 0.067 | 1.5 (1.1, 2.2) | 0.019 |
| $50,000–$99,999          | 682 | 34.4% | 1.4 (1.1, 1.8) | 0.019 | 1.2 (0.9, 1.7) | 0.168 |
| ≥$100,000                | 552 | 27.8% | Ref         |         | Ref         |         |
| Political party          |   |     |             |         |             |         |
| Democrat                 | 1,052 | 53.0% | 2.3 (1.8, 3.1) | <0.001 | 2.1 (1.6, 2.9) | <0.001 |
| Independent              | 390 | 19.7% | 1.6 (1.2, 2.2) | 0.004 | 1.5 (1.0, 2.1) | 0.033 |
| None of these            | 240 | 12.1% | 1.9 (1.3, 2.7) | 0.001 | 2.2 (1.5, 3.4) | <0.001 |
| Republican               | 302 | 15.2% | Ref         |         | Ref         |         |
| General health           |   |     |             |         |             |         |
| Good, very well, excellent | 1,735 | 87.4% | Ref         |         | Ref         |         |
| Poor, fair               | 249 | 12.6% | 1.3 (0.9, 1.8) | 0.089 | 1.5 (1.1, 2.2) | 0.021 |
| High-risk conditions     |   |     |             |         |             |         |
| No high-risk condition   | 942 | 47.5% | Ref         |         | Ref         |         |
| Possible higher risk only | 528 | 26.6% | 0.9 (0.7, 1.1) | 0.327 | 0.8 (0.6, 1.1) | 0.118 |
| Any highest risk         | 514 | 25.9% | 0.7 (0.5, 0.8) | 0.001 | 0.6 (0.5, 0.8) | 0.001 |
| Insurance                |   |     |             |         |             |         |
| Private                  | 810 | 40.8% | Ref         |         | Ref         |         |
| Public                   | 1,019 | 51.4% | 0.8 (0.6, 0.9) | 0.035 | 0.9 (0.7, 1.2) | 0.417 |
| Uninsured                | 155 | 7.8% | 0.7 (0.5, 1.1) | 0.136 | 1.2 (0.7, 1.9) | 0.483 |
| Have a regular doctor    |   |     |             |         |             |         |
| Yes                      | 1,561 | 78.7% | 0.8 (0.6, 0.9) | 0.034 | 1.8 (1.4, 2.4) | <0.001 |
| No                       | 423 | 21.3% | Ref         |         | Ref         |         |

(Continued)
COVID-19. Conversely, people who have a negative COVID-19 test may believe that they do not need to wear a mask as their risk of transmission is low. Lastly, those who had previously tested positive for COVID-19 may consider themselves immune and thus not feel the need to wear a mask. These are possible alternative explanations to the observed relation between perceived susceptibility to disease measured by COVID-19 testing with mask wearing behavior, which warrant further research.

This study has several limitations. First, surveys using an internet-based sample inherently exclude those without digital access; however, a recent PEW report estimated that in 2020, 93% of Americans had internet access. While internet surveys can introduce self-selection and nonresponse biases, and can have a lower response rate than traditional survey methods, this methodology can reach a niche population quickly, and is suitable for research during this pandemic, when guidelines are rapidly changing and in-person recruitment is less safe.

Our response rate (31%) also met the average online survey rate (33%) from meta-analyses data[31]. Second, although we included sampling quotas on sex, income, and race and ethnicity to represent the adult population in Los Angeles County, and our political affiliation matched closely with the voter data (82% non-Republican), we did not reach an adequate sample size of individuals who spoke Spanish as their primary language, and our survey was only offered in Spanish and English. Third, the survey was conducted around the first COVID-19 vaccine emergency use authorization in the U.S. Participant’s attitude and behavior toward the pandemic could have shifted since then. Lastly, over-reporting of mask wearing might exist, given the literature shows inconsistency between mask wearing beliefs and actual behaviors.[32]. However, reasons for mask and non-mask wearing were not included in the data collection, which limits our ability to verify the potential self-reporting bias. Lastly, the survey focused on Los Angeles County, which limits the generalizability but with the advantage of demonstrating a diverse demographic composition.

Although policies governing mask wearing have been confusing and controversial, mask wearing...
remains important for several reasons. There is uncertainty as to how long immunity would last after vaccination or natural infection; vaccines may not fully protect against new variants, and more virulent strains of COVID-19 are emerging and vaccination rates are declining. Additionally, 50% of the country remains unvaccinated, including children [4]. We estimate that there are 0.7 million adults in Los Angeles County who have never tested positive for COVID-19, who do not always wear a mask and who are unwilling to get vaccinated. Public health efforts to target these individuals—who tend to be younger adults, men, White residents, with less education, republicans, and have poor healthcare access—may be the key to reducing COVID-19 transmission and bringing an end to the pandemic.

**SUPPLEMENTARY MATERIAL**

Supplementary data are available at Translational Behavioral Medicine online.

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**Compliance with Ethical Standards**

**Conflicts of Interest:** Chun Nok Lam, Cameron Kaplan, and Sonali Saluja declare that they have no conflicts of interest.

**Human Rights:** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed Consent:** Informed consent was obtained from all individual participants included in the study.

**Study Registration:** This study was not formally registered.

**Analytic Plan Pre-registration:** The analysis plan was not formally preregistered.

**Data Availability**

De-identified data from this study are not available in an public archive. De-identified data from this study will be made available (as allowable according to institutional IRB standards) by emailing the corresponding author.

**Analytic Code Availability:** Analytic code used to conduct the analyses presented in this study are not available in a public archive. They may be available by emailing the corresponding author.

**Material Availability:** Materials used to conduct the study are not publically available.

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