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Introduction: In response to the COVID-19 pandemic, governments have implemented social distancing measures to slow viral transmission. This work aims to determine the extent to which socioeconomic and political conditions have shaped community-level distancing behaviors during the COVID-19 pandemic, especially how these dynamics have evolved over time.

Methods: This study used daily data on physical distancing from 15–17 million cell phone users in 3,037 U.S. counties. County-level changes in the average distance traveled per person were estimated relative to prepandemic weeks as a proxy for physical distancing. Pooled ordinary least squares regressions estimated the association between physical distancing and a variety of county-level demographic, socioeconomic, and political characteristics by week from March 9, 2020 to January 17, 2021. Data were collected until January 2021, at which point the analyses were finalized.

Results: Lower per capita income and greater Republican orientation were associated with significantly reduced physical distancing throughout nearly all the study period. These associations persisted after adjusting for a variety of county-level demographic and socioeconomic characteristics. Other county-level characteristics, such as the shares of Black and Hispanic residents, were associated with reduced distancing at various points during the study period.

Conclusions: These results highlight the importance of dynamic socioeconomic and political gradients in preventive behavior and imply the need for nimble policy responses.
Donald J. Trump were less likely to engage in social distancing.\textsuperscript{5,10,11}

However, most of these studies were conducted early in the COVID-19 pandemic. The associations between physical distancing and socioeconomic and political characteristics may have evolved owing to the changing geographic nature of the pandemic, the implementation of new mitigation strategies, and the politicization of these strategies.\textsuperscript{12} Evaluating the dynamics of physical distancing is critical for updating public health and social policy responses to respond to new patterns of transmission. Such analyses may also provide insight into how risk mitigation behaviors have shifted across population groups as the pandemic has drawn on. Therefore, this study examines the demographic, socioeconomic, and political determinants of physical distancing for the COVID-19 pandemic among U.S. counties from March 2020 through January 2021.

**METHODS**

**Study Sample and Measures**

Data for the main outcome (i.e., physical distancing) were obtained from Unacast.\textsuperscript{13} County-level averages of distance traveled per person were estimated using location data from 15 to 17 million anonymized cell phone users per day. A device was assigned to a county on a given day if a greater part of the day was spent in that county. Distance traveled was then summed and averaged across the total number of devices assigned to that county. Physical distancing was conceptualized as the percentage change in the average movement each day relative to the average movement for 4 pre-COVID-19 reference weeks. The reference period was defined as the average of 4 matched days between February 10, 2020 and March 8, 2020. For example, the distance traveled per device in Philadelphia County on Tuesday, April 7 was compared with the average movement in Philadelphia County across February 11, 2020; February 18, 2020; February 25, 2020; and March 3, 2020 (all Tuesdays). Similar physical distancing measures based on average movement have been used in other studies\textsuperscript{4,15} and been shown to predict case growth in the U.S.\textsuperscript{7,8} The validity of the measure is also supported by the sharp decline in movement after the declaration of a national emergency for COVID-19 on March 13, 2020 (Figure 1).

Data on the main exposures of county-level SES (operationalized as income per capita) and political orientation (operationalized as the 2016 vote share for President Trump) were obtained from the American Community Survey (5-year averages from 2014 to 2018) and MIT Election Data and Science Lab, respectively. Data on most county-level covariates (percentages of male, Black, Hispanic, and foreign-born residents; share of residents aged $\geq$65 years; and shares of the workforce in industries most affected by COVID-19 [i.e., retail; transportation; and health, educational, or social services]) were also obtained from the American Community Survey (5-year averages). Data on the county-level share of residential plots in rural areas were obtained from the 2010 Census. These county-level characteristics were chosen a priori on the basis of their expected contribution to a community’s ability to physically distance. Contemporaneous media reports suggested that structural barriers, work-related barriers (especially in specific industries), and political attitudes were shaping how communities responded to the pandemic.\textsuperscript{16–18} As such, covariates that reflected these barriers and attitudes at the county level were included in the models (Appendix Table 1, available online). Correlations between the county-level characteristics are shown in Appendix Figure 1 (available online).

**Statistical Analysis**

First, for each calendar day, bivariable associations between physical distancing and each county-level demographic, socioeconomic, and political characteristic were estimated using Pearson correlations with Bonferroni correction for multiple comparisons. Then, using data from the entire study period, a pooled multivariable ordinary least squares regression estimated the association between changes in average movement and each county-level characteristic, allowing the association to vary by week. For this model, distancing was averaged by week at the county level to produce 136,665 county-weeks. The aforementioned county-level characteristics were standardized using the

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**Figure 1.** The trajectory of county-level physical distancing.

Note: Physical distancing was operationalized as the percentage change in county-level average distance traveled from March 1, 2020 to January 17, 2021, relative to that in pre-COVID-19 reference weeks (average of matched days from February 10, 2020 to March 8, 2020). Negative values indicate greater physical distancing. Data are represented as notched boxplots; notches indicate 95% CIs of the median. Based on 15–17 million anonymized cell phone users per day. N=3,037 U.S. counties per day. Data were obtained from Unacast.

Apr, April; Aug, August; Dec, December; Jan, January; Jul, July; Jun, June; Mar, March; Nov, November; Oct, October; Sep, September.
The estimating equation was as follows:

\[ y_i = \alpha_0 + \sum_{j=1}^{(j=45)} \beta_j(male\%)_i + \sum_{l=1}^{(l=45)} \gamma_l(Black\%)_i + \sum_{j=1}^{(j=45)} \beta_j(\text{Hispanic}\%)_i + \sum_{l=1}^{(l=45)} \gamma_l(elderly\%)_i + \sum_{j=1}^{(j=45)} \eta_j(f.born\%)_i + \sum_{l=1}^{(l=45)} \theta_l(\text{income}\%)_i + \sum_{j=1}^{(j=45)} \eta_j(rural\%)_i + \sum_{l=1}^{(l=45)} \kappa_l(\text{Trump}\%)_i + \sum_{j=1}^{(j=45)} \epsilon_j(\text{retail}\%)_i + \sum_{l=1}^{(l=45)} \mu_j(\text{transport.}\%)_i + \sum_{j=1}^{(j=45)} \nu_j(\text{health}\%)_i + \sum_{l=1}^{(l=45)} \sum_{l=1}^{(l=51)} \xi_{j,l} + \epsilon_i, \]

where \( j \) denotes the week, \( i \) denotes the county, and \( s \) denotes the state (including the District of Columbia) for a given county. SEs were clustered at the county level to account for temporal dependence in physical distancing.\(^{19} \) Analyses were not weighted by county population. All analyses were performed in R, version 3.6.3. Replication code is available at github.com/nolankav/social-distancing.

To test the possibility that any observed associations merely reflected rational responses to the local risk of infection, county COVID-19 case rates were added to the model as a sensitivity check. County-level cases per million residents reported over the previous week were obtained from The New York Times, standardized by week, and included as a proxy for the perceived local severity of the pandemic, relative to that of the rest of the country. The observed associations between the county-level characteristics and distancing were robust to their inclusion (Appendix Figure 3, available online). To ensure that the results were robust to alternative assumptions about independence between observations, SEs were clustered at the state level to account for any spatial dependence in physical distancing (e.g., state policy environments may have led to correlations in the main outcome). The alternative specification also provided support for the main findings (Appendix Figure 4, available online).

**RESULTS**

Descriptive analyses showed a sharp reduction in average movement among U.S. counties corresponding to the start of the COVID-19 pandemic and the declaration of a national emergency on March 13, 2020 (Figure 1). Physical distancing was most pronounced from late March to early June and returned close to pre–COVID-19 baseline levels by July 2020. Engagement in distancing then began to increase again in early September. However, even as the national trend evolved, there was substantial variability in physical distancing across counties.

Bivariable analyses showed that greater county-level income per capita was highly correlated with more physical distancing (i.e., decreased movement relative to that in other counties), whereas the county-level share of votes for President Trump in 2016 was highly correlated with less physical distancing (i.e., increased movement) (Appendix Figure 2, available online). Other county-level characteristics, including the shares of racial and ethnic minorities (Black and Hispanic), immigrants, rurality, and employment in transportation, were also correlated with changes in average movement on many days. Figure 2 plots the monthly trajectory of physical distancing by quintile of county income per capita (Figure 2A) and Republican political orientation (Figure 2B). Gradients in distancing by income and political orientation persisted throughout the study period.

A multivariable regression analysis emphasized the degree to which SES and political orientation were associated with physical distancing. The model adjusted for all specified county-level demographic, socioeconomic, and political characteristics. Figure 3 shows the adjusted estimates for the association between each county-level characteristic and physical distancing over time. All estimates were standardized on the basis of IQR to allow for meaningful comparisons of their magnitudes. Full summary statistics for the covariates are provided in Appendix Table 1 (available online). In line with the bivariable analyses, per capita income was the most consistent predictor of engagement in distancing over the study period, whereas support for President Trump was the most consistent predictor of a lack of engagement. For example, in May, increasing per capita income by the IQR (from $22,700 to $29,918) resulted in a 3.8–4.5 percentage-point decrease in average movement, depending on the week (\( p < 0.001 \) for all weeks). During the same month, an IQR increase in support for Trump (from 54.3% to 74.6% support) resulted in a 4.8–6.7 percentage-point increase in average movement (\( p < 0.001 \) for all weeks).

Other county-level characteristics varied over time in their degree of association with physical distancing. During the early months of the study period, counties with greater shares of Black and Hispanic residents were less likely to engage in distancing. These adjusted racial and ethnic differences closed during the summer months before reemerging in the fall. Similarly, rural counties were less likely to engage in distancing early on. This trend reversed during June and July, yet, by the end of the
summer, rurality became the strongest negative predictor of physical distancing. Some characteristics, such as the share of male residents and the share of employment in retail business, had little predictive value of physical distancing in the adjusted models. The observed associations were also robust to the inclusion of perceived pandemic severity, as measured by weekly COVID-19 cases per million county residents (Appendix Figure 3, available online).

**DISCUSSION**

In this national study using county-level data, lower SES and greater Republican orientation were strongly associated with reduced physical distancing throughout the COVID-19 pandemic to date. These patterns persisted over a period during which geographic patterns in transmission risk and policy responses shifted rapidly. County-level shares of racial and ethnic minorities as well as that of rurality were also associated with reduced physical distancing at various times, although these associations did not persist throughout the study period.

These findings suggest that income-related barriers could lead to significant socioeconomic gradients in COVID-19, similar to those for other health conditions. The associations may implicate a number of potential underlying factors. For example, lower-income or gig jobs may necessitate continued work and be incompatible with working from home, raising the movement profile of a low-income community. Moreover, lower-income households may not have the necessary liquidity or savings to purchase essential goods in bulk, requiring more trips to businesses and other vendors. These factors are consistent with previous studies showing that lower-income communities often struggle to engage in social distancing. A study of the 2009 H1N1 influenza epidemic using TV ratings data suggested that higher-SES groups were better able to engage in behavioral responses (i.e., home TV viewing) that were associated with social distancing. Studies of COVID-19 have demonstrated that social distancing responses to emergency declarations were strongly differentiated by income and that differences in mobility between low- and high-income neighborhoods have been driven by work-related needs.

In addition to work-related barriers, communities of lower SES have also faced less access to health care during the pandemic. A recent study showed extreme disparities in access to critical care services, with 49% of the lowest-income communities having no available intensive care unit beds—compared with only 3% of the highest-income communities. Such areas are acutely vulnerable to COVID-19. Lower-income communities also have a greater burden of comorbidities that predispose to severe disease. In these ways, structural barriers have led to inequitable burdens in COVID-19 mortality, and the inability of lower-income communities to fully
engage in physical distancing may deepen the existing inequities affecting these populations.

At various points during the study period, communities with greater shares of Black and Hispanic residents were less likely to engage in physical distancing. In the U.S., race and ethnicity intersect with many structural barriers, including income, access to health care, and the burden of chronic health conditions. These barriers are then compounded by racial bias within governmental and healthcare institutions. As a result, racial and ethnic minorities have experienced inequitably higher rates of cases, hospitalizations, and deaths owing to COVID-19. In the context of this study, it is likely that the county-level associations between race, ethnicity, and physical distancing primarily reflect the uncontrolled confounding of structural barriers and the influence of racial bias rather than any cultural differences between racial and ethnic groups.

Throughout the majority of the study period, greater Republican orientation was associated with reduced engagement in physical distancing. Partisanship has dramatically shaped the government and public’s responses to COVID-19 in the U.S. Political leaders have been polarized in their handling of the pandemic, and some have even spread misinformation about the virus, treatments, and policy responses. Public polls have shown divergent attitudes about the severity of the pandemic on the basis of political affiliation, and political messaging appears to partly explain variation in prevention behaviors, cases, and deaths. For example, a recent study suggested that Democratic-leaning counties were more likely to reduce their mobility in response to governors’ recommendations to stay home. Another study showed that partisan differences in distancing partly explain the disparities in case and fatality growth across U.S. counties.

Building on these findings, this study shows that political differences have continued to shape physical distancing behavior, months into the pandemic. Early on, largely Democratic cities were most burdened by...
COVID-19 and consequently engaged in more distancing. However, even as cases and deaths have risen in rural Republican areas, support for Trump has continued to predict less distancing, albeit at a lower magnitude. These partisan influences have persisted beyond the 2020 general election and were robust to the inclusion of local COVID-19 case rates in the model. Such differences are concerning during a pandemic that requires a coordinated public health response. That they persist even in the face of a rapidly evolving pandemic is more concerning still. Other health conditions disparately impact Republican communities,\textsuperscript{15,36} and gradients in social distancing could result in the same for COVID-19.

Limitations
This study has several limitations. First, even though physical movement predicts case growth at the community level,\textsuperscript{7,8} it is one of many social distancing behaviors that also include limiting visits to nonessential businesses, maintaining physical space from other people, and working from home. Moreover, the risk of transmission due to mobility may depend on local social and geographic contexts; that is, a given percentage-point change in distance traveled in 1 county may not translate to the same risk of transmission as in another county. Thus, the proxy metric used in this study may not fully capture the degree of the risk faced by different demographic, socioeconomic, and political groups. Second, physical distancing may have been measured with error, given that the data did not sample all cell phone users and did not reflect nonusers. Third, this study has the potential for omitted-variable and ecological biases owing to aggregated, cross-sectional data. Finally, although a pooled regression with errors clustered at the county level accounts for some temporal dependence in the measurement of physical distancing,\textsuperscript{19} some dependence may remain and bias the inferences in the analysis. The literature on confidence bands may offer more advanced corrections for multiple comparisons and temporal dependence in future studies.\textsuperscript{37,38}

CONCLUSIONS
This study underscores the heterogeneity of communities’ engagement in public health responses to COVID-19. It documents gradients by socioeconomic and political conditions that may partly explain the inequities in COVID-19 cases and mortality. These patterns may also help policymakers and health professionals to identify the communities that are most vulnerable to transmission and to direct resources and communications accordingly.

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SUPPLEMENTAL MATERIAL
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