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The influence of social norms varies with "others" groups: Evidence from COVID-19 vaccination intentions

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The theory that health behaviors spread through social groups implies that efforts to control COVID-19 through vaccination will succeed if people believe that others in their groups are getting vaccinated. But "others" can refer to many groups, including one's family, neighbors, fellow city or state dwellers, or copartisans. One challenge to examining these understudied distinctions is that many factors may confound observed relationships between perceived social norms (what people believe others do) and intended behaviors (what people themselves will do), as there are plausible common causes for both. We address these issues using survey data collected in the United States during late fall 2020 ($n = 824$) and spring 2021 ($n = 996$) and a matched design that approximates pair-randomized experiments. We find a strong relationship between perceived vaccination social norms and vaccination intentions when controlling for real risk factors (e.g., age), as well as dimensions known to predict COVID-19 preventive behaviors (e.g., trust in scientists). The strength of the relationship declines as the queried social group grows larger and more heterogeneous. The relationship for copartisans is second in magnitude to that of family and friends among Republicans but undetectable for Democrats. Sensitivity analysis shows that these relationships could be explained away only by an unmeasured variable with large effects (odds ratios between 2 and 15) on social norms perceptions and vaccination intentions. In addition, a prediction from the "false consensus" view that intentions cause perceived social norms is not supported. We discuss the implications for public health policy and understanding social norms.

social norms | COVID-19 | vaccination

Significance

Willingness to engage in COVID-related preventive behaviors including vaccination depends on the perceived extent to which others engage in them. But "others" can refer to groups of varying size, heterogeneity, and personal relevance. We find the strongest relationships between vaccination intentions and social norms for respondents' friends and family—and among Republicans, copartisans—and these relationships weaken as the reference group expands to people in one's neighborhood, city, and state. We see this pattern in two US studies, even in pairs of respondents identical in political party, gender, and race and highly similar on numerous possible confounds (e.g., age, ideology, trust in science). Public health efforts to increase vaccine uptake should seek ways to leverage social norms among close ties.

Beliefs about others' behavior—perceived social norms—influence people's own actions and intentions (1–4).* The idea that social norms drive health behaviors has guided research in public health generally (7–9) and on vaccination specifically (10, 11). Studies from COVID-19 find that people are more likely to vaccinate (12–14), wash their hands (15, 16), wear masks (17), stay at home (16), and social distance (15, 17–22, 23) the more they believe that other people engage in these preventive behaviors.

While the idea that what others do affects our own behaviors is well-established, there is less consensus about exactly who such others are (24). People belong to many partially overlapping groups that vary in size, homogeneity, and relevance (Fig. 1; see ref. 25 for a similar conception) and thus likely think about these groups differently. Yet a close read of COVID-19 social norms studies shows that "others" can refer to numerous different groups, from family and friends (15, 17, 19, 21) or close social ties (20, 22) to neighbors (14, 26), people in one's community (19), fellow survey respondents (11), people in one's country (12, 16, 18), people in general (13), or all of humankind (22). Ignoring this distinction has implications for social norms research—studies ostensibly on the same effect may be measuring very different instantiations—as well as for public health strategies hoping to harness the evident strength of social norms through messaging or other interventions.

We examine this issue in two studies comparing people's own vaccination intentions with their perceptions of others' intentions. Study 1 measured these perceptions among four groups of others: family and friends; neighbors; city residents; and state residents. Study 2 replicates the first and adds perceptions of vaccination intentions among co- and outpartisans, a dimension that to our knowledge has not been explored previously. We created homogeneous matched pairs to account for the fact that people in the same groups have many common characteristics that can explain away apparent social norms effects. For instance, an older adult may count more older than younger adults among

*Social norms are commonly divided into injunctive norms (what people think is right to do) and descriptive norms (what people in fact do) (5). Here, we focus on the latter to avoid introducing a moral dimension (6) that further complicates an already complex problem space. All references to social norms in our studies refer to descriptive norms.

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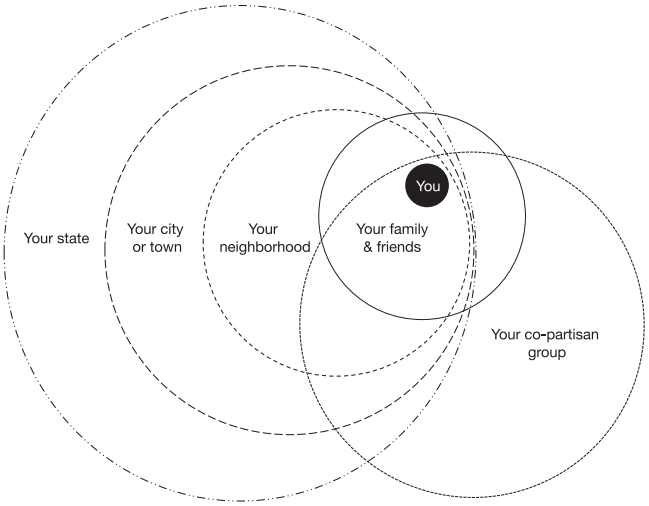

Fig. 1. Groups to which an individual belongs form partially overlapping sets. Sizes of circles represent both the size of the set and the "closeness" of the group (personal relevance, homogeneity).

her friends. If she does, then her greater likelihood of vaccination could be due to a higher risk of poor COVID-19 outcomes (27) rather than beliefs about what her friends (who are also at higher risk) plan to do. Similarly, Democrats are likely to report higher vaccination intentions (28) and may perceive greater intentions among family and friends because they know more Democrats (29, 30). In both cases, people's beliefs about others' intentions and their own intentions have a common cause, rather than the beliefs causing the intentions. The pair-matched research design allows us to control for all of these confounds by comparing, say, two Democratic women who are within a few years of the same age and then asking whether the member of the pair who believes that more members of her family and friends group will get vaccinated also has higher intentions to be vaccinated herself.

We find that social norms perceptions predict vaccination intentions above and beyond numerous measured and plausible confounding influences, and that the strength of the relationship between descriptive social norms and vaccination intentions declines as groups become larger and more heterogeneous. We also find that among Republicans, perceptions of copartisans' intentions have the second-strongest relationship with one's own intentions, trailing only family and friends. To address two related threats to these inferences, we report 1) a formal sensitivity analysis showing that some unobserved variable driving the results would need to generate extremely large effects to change the interpretation, and 2) an additional result inconsistent with the "false consensus" interpretation (31) whereby people's own intentions drive their social norms perceptions rather than the other way around. We then discuss implications for public health and policy.

The Present Studies

A hypothetical experimental approach to the common cause problem would isolate differences in social norms perceptions by placing respondents into pairs that are highly similar on potentially confounding dimensions and then randomly assigning one member of each pair to perceive that more others will get vaccinated. We build on the intuitions from this idealized "pair-randomized" scenario in creating our own nonrandomized design since assigning perceptions to people would be difficult and would teach us more about the effects of assigning perceptions than about the perceptions themselves. Study 1 placed 824 survey respondents into 412 matched pairs[†] created to be highly similar on characteristics that either constitute risk factors or that have demonstrably predicted COVID-19 health behaviors even though they are not associated with risk. Study 2 placed 996 respondents into 498 pairs, similarly matched. For known risk factors, pairs were required to be identical on gender [female, male (33)] and race [White, Black, Latino, other (33–35)], and highly similar on age (27), education (36), and family income (34,37). For other dimensions associated with COVID-19 health behaviors, pairs were required to be identical on party ID [Democrat, Republican, other (28, 38)] and similar on political ideology [liberal, conservative (39)], trust in science (40, 41), trust in government (39, 42), religiosity (43), COVID-19 knowledge (44), and subjective assessments of that knowledge (45). The ensuing matched designs are conceptually equivalent to analyses using stratification, a method long used in the study of health behaviors (46); see Rosenbaum (47) for an overview of current techniques, and see *SI Appendix*, section S12 for further discussion.

Was this process successful? Hansen and Bowers (48) developed a single test of the null hypothesis of no differences between the members of a matched pair's covariate values taken all together. The result of this omnibus test for study 1 is χ^2 (7) = 5.1, P = 0.65; that is, the covariate-to-perceptions relationship in our nonrandomized paired design is consistent with what we would see in a pair-randomized experiment. Within pairs, the person who perceives more positive vaccination social norms is no more or less likely to have higher values on any of the matching variables than the person who perceives that fewer people intend to be vaccinated in their social context. The omnibus test for study 2 also indicated a design that compares favorably with a pair-randomized experiment, χ^2 (9) = 2.6, P = 0.98. Table 1 shows individual tests of the null hypothesis of no differences between higher and lower perceivers within pairs for all covariates. These tests produced no unadjusted P value less than 0.13; after adjusting for multiple testing using the Holm method, all P = 1. See *SI Appendix*, section S4 for details on the distribution of differences.

Results

For data and analysis code, see github.com/thepolicylab/COVID-VaccinesSocialNorms. The analysis is one of several questions from our broad preanalysis plan (osf.io/fqvp3); study 2 replicates the result from study 1 employing the same analysis strategy with the addition of perceived vaccination intentions among partisan groups. Deviations from preregistered analyses are explained in *SI Appendix*, section S1, and the other research questions are examined in *SI Appendix*, sections S5 and S10.

Study 1. We regress respondents' reported intentions on their perceptions of social norms for each of the groups of interest, conditional on pair. This is conceptually equivalent to comparing the intentions of the higher with the lower perceiver within-pair and taking the average across all of the pair differences. Perceptions were recoded to run from 0 = none to 6 = all group members will definitely vaccinate. Vaccination intentions were coded 1 to 5 (M = 3.76, $SD_{unadjusted}$ = 1.31). The coefficients in Fig. 2 (*Left*) represent average differences in vaccination intention associated with a one-unit

[†]We used a nonbipartite matching algorithm (32) to create the pairs. Details and code are available at https://github.com/thepolicylab/COVID-VaccinesSocialNorms.

Table 1. Tests of mean differences between rank-ordered higher and lower perceivers of social norms for continuous variables used to match respondents in study 1 and study 2

Variable	Mean lower perceiver	Mean higher perceiver	Difference	Standardized difference	P	$P_{adj.}$
Study 1						
Liberal/conservative ideology	3.02913	3.03641	0.007282	0.005408	0.8877	1
Age	48.89563	48.71845	−0.177184	−0.010232	0.5336	1
Family income	6.28155	6.32039	0.038835	0.012427	0.6716	1
Education	3.67718	3.73301	0.055825	0.038231	0.1319	1
Trust in science	3.90655	3.90655	0.000000	0.000000	1.0000	1
COVID-19 knowledge	0.76335	0.77063	0.007282	0.052088	0.3883	1
Subjective COVID-19 knowledge	3.97573	3.97573	0.000000	0.000000	1.0000	1
Religiosity	0.32949	0.33568	0.006189	0.033275	0.5565	1
Family income missingness	0.07767	0.06553	−0.012136	−0.047026	0.2971	1
COVID-19 knowledge missingness	0.06068	0.06068	0.000000	0.000000	1.0000	1
Subjective COVID-19 knowledge missingness	0.93932	0.93932	0.000000	0.000000	1.0000	1
Study 2						
Liberal/conservative ideology	3.0843	3.1064	0.0220884	0.0155571	0.4875	1
Age	50.2952	50.4137	0.1184739	0.0069468	0.5349	1
Family income	6.1265	6.1245	−0.0020080	−0.0006334	0.9802	1
Education	3.7048	3.6827	−0.0220884	−0.0151481	0.6692	1
Trust in government	2.2533	2.2537	0.0003347	0.0005367	0.9880	1
Trust in science	3.8996	3.9217	0.0220884	0.0221226	0.3447	1
Subjective COVID-19 knowledge	3.4920	3.4679	−0.0240964	−0.0260201	0.6534	1
Religiosity	0.5030	0.5068	0.0037830	0.0128432	0.8171	1
Family income missingness	0.1145	0.1225	0.0080321	0.0248313	0.5791	1

difference in perceptions of others' intentions. Fig. 2 (*Right*) shows the strong relationships between perceptions and intentions: A difference of even one point in perceptions of family/friends' intentions produces, on average, a difference of 0.35 points in intentions, which is roughly equal to 1/4 SD difference in the outcome.

The relationships decline in strength for perceptions of norms in larger and more heterogeneous groups, and we can easily reject the null of no average effect for all of them (all P values < 0.001, two-tailed). The vaccination intention difference related to a one-point difference between perceived social norms is 0.24 at the state level, 0.28 at the city level, 0.30 among neighbors, and 0.35 among family and friends. To interpret these coefficients, consider the difference of one scale point—the change, for instance, in believing that "about three quarters" as opposed to "about half" of one's family and friends will get vaccinated. Given that the mean vaccination intention was 3.76 (between "not sure" and "maybe will"), even a one-point difference in perceived social norms can push intentions from this mean to "maybe will." Comparing the coefficients, we can reject the hypothesis that the differences associated with family/friends are the same as the differences associated with the other levels considered all together with $P = 0.045$ [seemingly unrelated regression framework for testing linear hypotheses across equations (49)]. However, we do not have strong evidence that the neighborhood perceptions are more powerful than even larger groups (city and state perceptions combined, $P = 0.39$) or that the city effect differs from the state effect ($P = 0.35$).

Fig. 2 also shows that the family and friends group effect size is consistent with results from the most directly comparable prior study: Tunçgenç et al. (22) also controlled for demographics including partisan identity and reported coefficients for perceived social norms/own behavior relationships of 0.42 and 0.416. These values are similar to the relationship we observed in the unmatched population (0.44) and the matched design (0.35).

Study 2. Since study 2 happened after some respondents were eligible for vaccines, intentions to vaccinate were only asked of people who did not report having started vaccination. The outcome variable used here is coded 1 if a person had already begun vaccinations or responded that they "definitely will" get vaccinated and 0 otherwise; 66% of the population met this criterion. For intentions among the subset who had not yet been vaccinated, $M = 3.5$, $SD_{unadjusted} = 1.54$, and there was no indication of a ceiling effect, as just 43% of those who had not been vaccinated (or 25.7% of the whole group) responded that they "definitely will" as soon as they are eligible. Fig. 3 shows the same pattern seen in study 1—perceptions of others' vaccination intentions predict own vaccination intention or behavior—with the exception that here the state effect was indistinguishable from zero (family and friends, $P < 0.001$; neighbors, $P < 0.001$; city, $P = 0.03$; state, $P = 0.17$). For example, a difference of one unit in perceptions of vaccination intentions among family members produces a 0.09 percentage point difference in the outcome; a six-unit difference, the maximum difference between any two people in a pair, would increase the proportion of people who definitely would vaccinate or already have by 6*0.09 = 0.54 if all perception differences were this large. The pattern of decreasing yet still strong relationships also appears. Note that effect sizes are not directly comparable to those in study 1 because the outcome measure here is dichotomous rather than continuous.

Fig. 3 also shows that among Republicans, the social norms–intentions relationship for copartisans is similar to other close groups.[‡] Overall, the effect of beliefs about

[‡]Independents were excluded from the party ID analysis for conceptual and methodological reasons. Conceptually, self-assignment to this group implies a desire to stand apart from a bipolar conception of political identity, so it is ambiguous whether Independents count as outpartisans to Democrats or Republicans. But sidestepping this issue by including them in both outpartisan groups yields an analysis where individuals are counted twice.

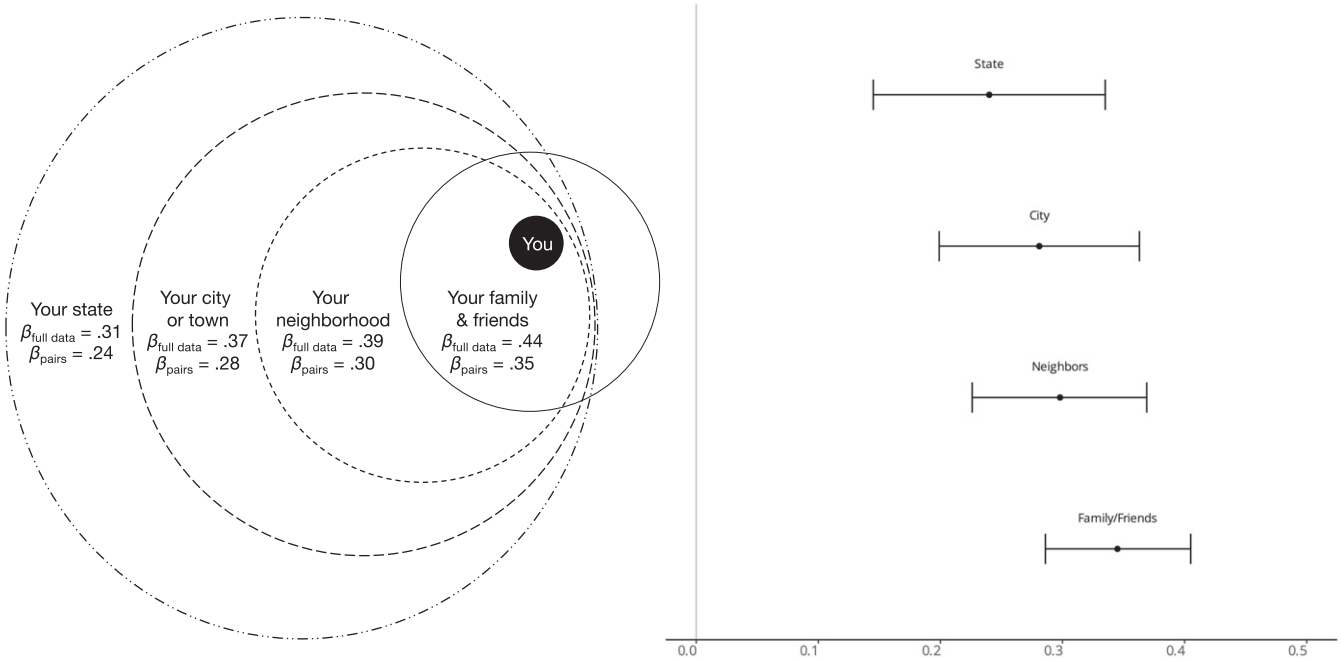

Fig. 2. (*Left*) Study 1 average relationships within-pair between a one-unit difference in perceptions of vaccination intentions of others (0 = no one in the group will definitely vaccinate to 6 = all people in the group definitely will vaccinate) on own intention (1 = definitely won't vaccinate to 5 = definitely will vaccinate) for the pair-matched design (n = 824) and the full valid data (n = 1,992). (*Right*) Point estimates from the paired design plus 95% CIs created with heteroskedasticity-consistent (HC2) SEs. All P values for the null hypothesis of no effects <0.001, two-tailed.

Republican copartisans is second in magnitude behind that of family and friends ($P = 0.045$). The same pattern does not hold among Democrats ($P = 0.551$). Perceptions of the intentions of outpartisan others also show no discernible effect: The Republican within the Republican pair who thinks that Democrats are more likely to be vaccinated is no more or less likely to report that she will be vaccinated than the Republican who thinks that Democrats are not likely to be vaccinated ($P = 0.942$), and vice versa for Democrats ($P = 0.871$).

Sensitivity to Hidden Bias. Both studies showed relationships between perceived social norms and vaccination intentions increasing in strength as the norm holders grow closer or more personally relevant to the individual. The relationship between perceptions and confounding common causes was consistent with that of a randomized experiment, thus minimizing the likelihood that measured factors explain away social norms effects. Of course, we did not randomly place perceptions of social norms into people's heads, and the possibility that some unmeasured factor causes both different vaccination intentions and different beliefs about others' intentions remains.

While we cannot name or measure this potential variable, we can assess how strong its relationship with perceived social norms and vaccination intentions would have to be to qualitatively change our results (i.e., to make the social norms–intentions relationship indistinguishable from zero in our hypothesis tests). Rosenbaum and Silber (50) use Δ to reflect how an unobserved covariate might increase the odds of a positive difference in outcome within-pair and Λ to reflect the same for treatment within-pair. For the present purposes, Δ is the odds that the person with higher vaccination intentions has them because of an unobserved covariate, and is the odds that the person with higher social norms perceptions has them because of this unobserved covariate. The family/friends perceptions relationship was most resistant to hidden bias in both studies ($\Lambda = 4.5$, $\Delta = 14.7$ in study 1; $\Lambda = 3.1$, $\Delta = 5.9$ in study 2). Thus, in study 1, only a hidden factor that increases the odds of being the higher perceiver by 4.5 times and of being more likely to vaccinate by 14.7 times would change the observed P value from <0.0000001 to 0.051.[§] Across all perceived social norms variables for which the strength of the relationships was detectably different from zero, even the weakest relationships would need an unobserved covariate with at least $\Lambda = 2.5$ and $\Delta = 2.4$ (perceptions of state-level norms in study 1) and at least $\Lambda = 2.1$ and $\Delta = 1.5$ (perceptions of city-level norms in study 2).

To put this result in perspective, we examined a variable that was not included in the pair-matched design but could account for differences in both vaccination intentions and perceived social norms: risk perception (51). We calculated the odds of reporting greater social norms perceptions and vaccination intentions given higher perceptions of the risk of becoming infected with COVID-19 over the next month (0 to 100% chance) or of experiencing severe side effects from the COVID-19 vaccine (agreement on a 1 to 5 scale that "getting vaccinated would put me at risk for vaccine side effects"). These odds ratios can then be directly compared with the values that would change the results from significant to nonsignificant (Δ and Λ) and hence provide evidence that risk perception explains away the results. Among all odds ratios capturing relationships between risk perception and either vaccination intention or social norms perceptions, the largest was 1.88, yet the smallest required by the sensitivity analysis was 2.2. Thus, differences in risk perception within-pair do not seem to threaten our interpretation (*SI Appendix*, section S8).

[§]This is equivalent to a value of $\Gamma = 3.5$ for Rosenbaum's sensitivity parameter, using the Rosenbaum and Silber (50) approach to decompose Γ into two parts: an effect on treatment or selection (here, perception rank within-pair) and outcome (here, outcome rank within-pair).

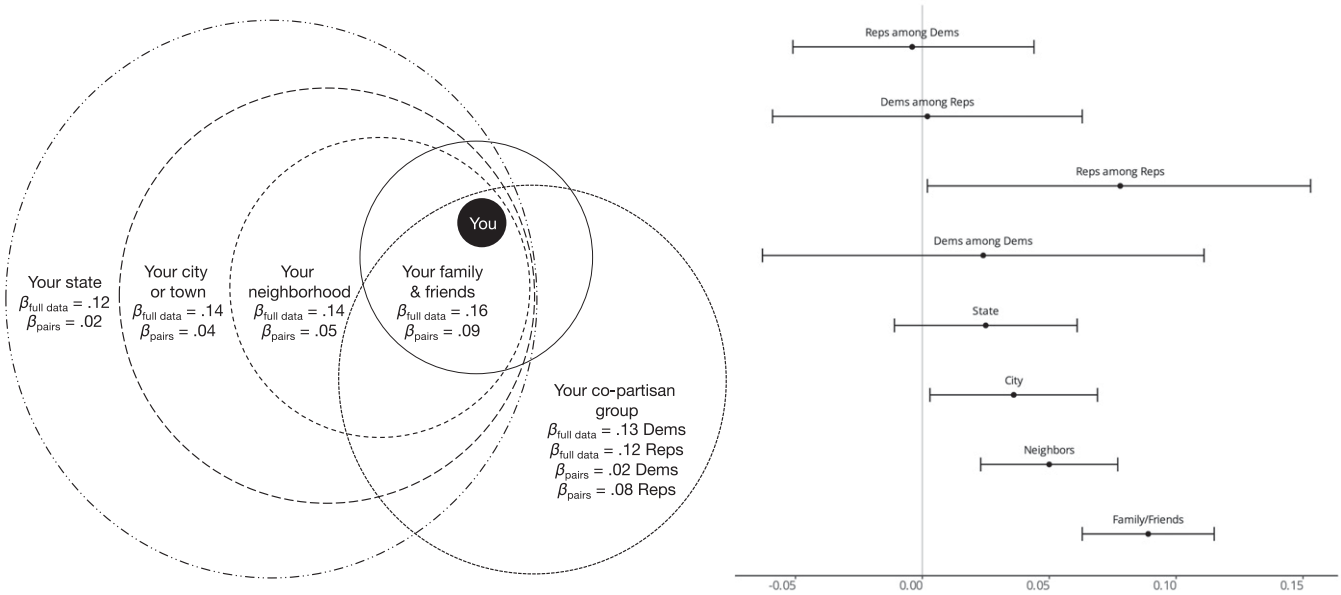

Fig. 3. (*Left*) Study 2 average relationships within-pair between a one-unit difference in perceptions of vaccination intentions of others (0 = no one in the group will definitely vaccinate to 6 = all people in the group definitely will vaccinate) on own intention or behavior (1 = definitely will vaccinate/has already vaccinated, 0 = otherwise) for the pair-matched design (n = 996) and the full valid data (n = 1,497). (*Right*) Point estimates from the paired design plus 95% CIs created with HC2 SEs. Note that coefficient magnitudes reflect the dichotomous outcome measure, in contrast to the continuous measure in study 1.

False Consensus and Directionality. Another possibility is that the results could be wholly or partly due to false consensus effects (31). In this view, social norms are not driving health behaviors; rather, people believe that others do what they themselves plan to do and respond to our questions by inferring from their own intentions. Although we cannot definitely settle questions of directionality in these cross-sectional studies, the false consensus hypothesis makes a prediction that we can investigate using our data. If perceptions of others are dictated by people's own intentions, then we would expect respondents with the most extreme intentions to have the least accurate perceptions because they systematically over- or underestimate others' intentions. To test this, we calculated accuracy scores for the population from which respondents were drawn for study 2 by comparing respondents' estimates of how many people in a group would get vaccinated with independent estimates of the vaccination intentions for these same groups; this was only possible at the state level, as no independent survey data were available for cities, neighborhoods, or families and friends groups. Respondents received a 1 if their estimates of how many people in their state intended to get vaccinated were close to independent, contemporaneous survey estimates and a 0 if not (*SI Appendix*, section S5). Accuracy was operationalized as choosing the response option closest to the independent survey estimate on either side; in other words, if the true state-level estimate at the time was 63% (as it was for Alabama), then either "about half" or "about three quarters" would count as correct. We then created a variable dividing the sample into one group consisting of those who gave the most extreme responses regarding their own intentions (5 = definitely will and 1 = definitely won't) and another consisting of people with moderate ratings (2, 3, or 4). Against the prediction from false consensus, people with the strongest pro- or antivaccination intentions were not more likely to provide incorrect state-level estimates (in either direction) than people with moderate intentions, χ^2 (1) = 2.15, P = 0.14. The direction of these weak differences was inconsistent with the false consensus hypothesis: More people in the "extreme" categories for own vaccination (64.8%) than people with moderate views (60%) gave accurate estimates.

Discussion

Using a quasiexperimental design with surveys conducted at different points in the COVID-19 pandemic and vaccine rollout, we find that beliefs about others' intentions to get vaccinated predict people's own intentions even when holding constant demographic variables that reflect risk of poor COVID-19 outcomes [gender (33), race (33–35), age (27), education (36), and family income (34, 37)] as well as variables that have been shown to predict COVID-19 health behaviors even though they are not associated with differential risk [partisan identity (28, 38), political ideology (39), trust in science (40, 41), trust in government (39, 42), religiosity (39), COVID-19 knowledge (44), and subjective assessments of that knowledge (45)]. Moreover, who those others are—one's friends and family, neighbors, or city or state coresidents—dictates the strength of the relationship, which declines as the groups get larger and more diffuse. This pattern is consistent with some existing health behavior models—the theory of planned behavior, for instance, predicts that social norms will factor into decision making to the extent they are associated with personally significant referents (52), while the theory of normative social behavior (53) similarly expects group identification to modulate effects of descriptive norms on behaviors—and has been observed in a social norms study on energy consumption (54) (as reported in ref. 55). Among Republicans, beliefs about copartisans' intentions predicted people's own intentions with magnitudes between the "friends or family" and "neighbors" relationships. Beliefs about outpartisans appeared irrelevant to vaccination intentions for Democrats and Republicans. A sensitivity analysis shows that if both perceived social norms and vaccination intentions were caused by some unmeasurable variable, the effect of this variable would have to be extremely large to change the interpretation. And a

prediction from the false consensus hypothesis (i.e., that intentions cause social norms perceptions rather than the other way around) was not supported.

One limitation of our studies is that they cannot speak to mechanisms. It is unknown whether people's vaccination intentions are influenced by perceived social norms due to a desire for reward or fear of sanction from one's community, to social learning, or to some other mechanism. Another limitation is that our measures do not distinguish family from friends; it is possible that the two groups' intentions would show different relationships with people's own intentions. In addition, our sample after matching was whiter than the US population as a whole and all participants were US residents. While the demographics of our matched sample are a limitation, Bogart and colleagues (56) report a similar relationship among Black Americans. Finally, our study measured intentions to get vaccinated rather than actual vaccinations. The gap between intentions and behaviors has been substantial in other vaccination contexts like seasonal flu (57) or H1N1 (58). However, recent results suggest this gap is much smaller for COVID-19. A study from Sweden linking survey responses with subsequent vaccination records found a roughly 10 percentage point discrepancy between intentions and actions (59). Comparisons of self-reported vaccination status with previously measured intentions show a very similar correspondence in US samples (60, 61) but a larger gap in China (62). Thus, while people's stated intentions almost certainly overestimate subsequent behaviors to some extent, in the case of COVID-19, the extent does not render them uninformative.

These results have implications for both social norms research and public health policy. Although studies have shown effects of perceived others' beliefs on people's own COVID-related behaviors, the means of operationalizing others have run the gamut from family or friends (15) to fellow nationals (18) to all of humankind (22). We find that these distinctions matter for vaccination, the most critical COVID-related health behavior. Researchers studying social norms and public health should measure perceived social norms of multiple groups and consider how the characteristics of the respondent match those of the groups.

Policy implications are more complex. Most straightforwardly, public health communications that use social norms information cannot treat various groups as interchangeable. Messages reporting how many people in one's country have been vaccinated may show less influence than those reporting numbers at the state level, which in turn may show less influence than those reporting city numbers. A similar distinction among reference groups is seen in COVID-related messages using imperatives [e.g., "do it for your community" versus "do it for your family" (63, 64)].

The social norms–vaccination relationship was unequivocally strongest for the friends and family group in both studies, and convergent survey evidence is consistent with this finding. In April 2021, the Kaiser Family Foundation COVID-19 Vaccine Monitor found that among 18- to 29-y-olds, 68% of those who reported that more than half of their friends had been vaccinated were themselves vaccinated, while the number was just 19% for people reporting less than half of their friends had been vaccinated (65). Similarly, in June 2021, 77% of vaccinated adults said that everyone in their household had been vaccinated, while 75% of unvaccinated adults said that no one in their household had been vaccinated (66). Public health authorities hoping to employ social norms in messaging therefore face a problematic choice between making implausible claims about people's close social ties (how could a health department official know what my family did?) and making plausible but weaker claims about larger, more diffuse groups. Indeed, assertions about social norms in larger groups have fared poorly in the literature. Moehring and colleagues (13) presented a large, multinational sample (n = 437,236) with percentages in people's regions that intended to get vaccinated against COVID-19 as estimated on a prior survey. This information yielded a small increase in stated vaccination intentions, but the gains were driven by less than half of the countries, the United States not among them. Sinclair and Agerström (14) manipulated rather than reported the proportions (85 versus 45%) of "people in general" or people in respondents' age groups intending to get vaccinated; neither stated proportion increased intentions relative to control in a UK sample. Using a similar manipulation, Sasaki et al. (67) find no effect among Japanese respondents. Directly informing people of the vaccination status of their close ties, as Gerber et al. (68) did with past voting behavior, is not possible given the medically sensitive nature of the information. And since we find no evidence that misperceived social norms are associated with intentions, interventions that have targeted other risky behaviors [e.g., excessive drinking (69)] by correcting perceptions may yield little return for vaccination (although future work should test this assumption about people's closest ties, for instance by using snowball sampling).

However, evidence from non-COVID vaccine studies suggests that demonstrating social proof at the individual level, rather than asserting it in blanket messaging about groups, could be effective. Badges indicating who had been vaccinated against seasonal flu increase vaccine uptake among healthcare workers (70, 71); notably, blanket messages in letters mailed to healthcare workers did not (72). Conceptually similar interventions have been effective at increasing voter turnout. People who saw that a number of their Facebook friends had voted were in turn more likely to vote (73). Note, however, that refs. 70 and 71 did not test social proof in perfect isolation, as the interventions contained several features (e.g., healthcare workers who did not get vaccinated were required to wear masks). And elections are discrete events but vaccination campaigns are ongoing, so stronger and less transient interventions than, for example, "I got vaccinated" stickers distributed at vaccination sites are probably required. Researchers might look to more elaborate interventions exploiting first-degree ties from other domains. For instance, Paluck et al. (74) found that conducting conflict-reduction workshops with adolescent students but allowing the students to develop their own peer-facing strategies and materials reduced the frequency of fights recorded by school administrations. The context-specific nature of such approaches is appealing given the dynamic nature of social norms (75). Interventions that exploit the structure of norm holders' networks may also be fruitful (76); see, for instance, ref. 77.

The strong relationship between beliefs about copartisans' behaviors and people's own intentions among Republicans, a group that has been consistently less likely to vaccinate against COVID-19 (28), suggests that explicit partisan appeals could increase uptake. But it is unclear whether the sort of "elite cues" (i.e., messages from leaders) that have shown promise in survey experiments (78, 79) would fulfill this function. Recall that we asked about vaccination intentions of Democrats, Republicans, and Independents generally, not the intentions of group leaders. We doubt that provaccination messages from delegates of groups more often associated with antivaccination attitudes

would hurt campaigns to encourage vaccination. But the most promising interventions are those that harness the power of social proof demonstrated by the copartisans that people are most likely to trust: their family and friends.

Materials and Methods

Populations, COVID-19 Context, and Data Sources. Data for study 1 come from surveys fielded by YouGov for The Policy Lab and Rhode Island Department of Health, 10 to 17 November and 11 to 20 December 2020. The November survey included 500 Rhode Island (RI) residents and 1,000 non-RI US residents; the December survey included 500 RI residents only. Because the behavior of 18- to 29-y-olds was a policy concern at the time, we also oversampled young adults through outreach to colleges and universities; 694 respondents voluntarily completed an identical Qualtrics survey. The first COVID-19 vaccine was approved 11 December 2020 and became available to healthcare workers and select others shortly after. Data for study 2 come from a similar survey also fielded by YouGov and conducted 18 to 31 March 2021, with 500 RI residents and 1,000 non-RI US residents. At this time, older residents and those with underlying conditions had become eligible for vaccination. This research was classified as public health surveillance by the Brown University Institutional Review Board and thus was exempt from review.

Measures. We measured perceived social norms in study 1 by asking respondents four questions: "How many people in _____ do you believe will definitely get vaccinated? (Give your best estimate)" with the blank filled by "your network of family and friends," "your neighborhood," "your city or town," and "your state" on a 1 to 7 scale (1 = none, 2 = a few [less than a quarter], 3 = about a quarter, 4 = about half, 5 = about three quarters, 6 = most [more than three quarters], 7 = all). Study 2 included these questions and added perceptions of three partisan groups ("How many Republicans/Democrats/Independents do you believe will definitely get vaccinated?").

Because data for study 1 were collected before COVID-19 vaccines were approved, we measured respondents' own vaccine intentions by asking, "If and when a coronavirus vaccine becomes available, will you get vaccinated?" (1 = definitely won't, 2 = maybe won't, 3 = not sure, 4 = maybe will, 5 = definitely will). Since vaccines were available to some groups at the time of study 2, vaccine intentions were measured by creating a composite variable with value 1 if a respondent either reported having begun vaccination or responded "definitely will" when asked "Are you going to get vaccinated for coronavirus as soon as it's possible to do so?" (same scale as study 1), and value 0 otherwise. See *SI Appendix*, section S2 for an analysis using the continuous rather than dichotomous composite variable; results do not differ.

Trust in science was captured by calculating the average across two questions (trust in information from public health scientists, how much scientists understand COVID-19). Trust in government was measured by averaging across trust in federal, state, and local government. COVID-19 knowledge was measured using an eight-item true/false knowledge battery, while subjective assessments of knowledge came from a single question asking how much respondents understand COVID-19 (study 1) or COVID-19 vaccines (study 2). See *SI Appendix*, section S3 for question wordings and https://osf.io/8dnjs/ for complete survey instruments.

Data Availability. Data and analysis code reported in this article have been deposited in the GitHub repository (https://github.com/thepolicylab/COVID-VaccinesSocialNorms) (80) .

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