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Determinants of voluntary compliance: COVID-19 mitigation

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ABSTRACT

During the pre-vaccine period, the success of containing the spread of COVID-19 depends upon how communities respond to non-pharmaceutical mitigation policies such as social distancing, wearing of masks, retail and dining constraints, crowd limitation, and shelter-in-place orders. Of these policies, shelter-in-place and social distancing are of central importance. By using county-level mobility data as a measure of a community's voluntary compliance with social distancing policies, this study found that counties who received strong state social distancing policy directives and who had a high pro-social character showed lower mobility on retail and recreation mobility and grocery and pharmacy mobility (better social distancing) after states reopened from shelter-in-place orders. Counties that experienced a longer duration of shelter-in-place orders showed higher mobility (less social distancing), implying that the duration of the shelter-in-place order deteriorated social distancing response after reopening. This may be because reopening sent a "safe" signal to these counties or resulted in a response to the pent-up demand inducing higher mobility. The results indicate that implementing shelter-in-place and social distancing policies to slow down the transmission of COVID-19 were not necessarily effective in motivating a county to reduce mobility voluntarily. A county's pro-social character and the duration of shelter-in-place order should be considered when designing COVID-19 mitigation policies.

1. Introduction

In the first six months of 2020, the global outbreak of COVID-19 infected over 25 million people and caused 800,000 deaths. In the same period, the U.S. with 5.86 million infection cases had experienced 180,689 deaths which is the highest rate of fatalities anywhere in the world. (World Health Organization, 2020). Most state and local governments enforced various levels of restrictions to slow down the spread of the disease and ease the burden on healthcare systems (U.S. Department of Health & Human Services, 2022). The COVID-19 pandemic, however, raises concerns about government restriction ethics, as the public are posed with dilemmas related to the role of government in alleviating the discordance between individual freedom and collective action solutions (Lu et al., 2021; Rajkumar, 2021). Among those restriction strategies, the shelter-in-place mitigation order is demonstrated as the greatest effective measure in the fight against the spreading of the disease. Maintenance of physical distance (social distancing) between individuals, which reduces the number of times that individuals closely interact with each other, is of central importance in this highly contagious disease (Courtemanche et al., 2020; Gupta et al., 2021; Kraemer et al., 2020; Tian et al., 2020). In March and April 2020, forty U.S. state

governments issued varying levels of shelter-in-place orders to contain the spread of COVID-19. However, an effective shelter-in-place order does not necessarily lead to lasting social distancing practices after the order is lifted or eased. In fact, most states reported an increase in confirmed COVID-19 infections after the shelter-in-place order/directive was lifted. Some of the states even reported an increase in hospitalization rates and mortality levels (Zhou, 2020).

Is there a conflict between the public good of containing COVID-19 and the personal costs of practicing social distancing? If containing COVID-19 can maximize social welfare and public health goods, why do individuals not take actions to continually practice social distancing? On the one hand, voluntary compliance with social distancing policies relies upon the willingness of individuals in a community to sacrifice convenience and endure psychological distress and anxiety from increased social distancing behavior. If the cost of social distancing is higher than an individual's benefit expectation, the individual is likely to become a non-complier and not adhere to social distancing guides (Cato et al., 2020; Martela et al., 2021). On the other hand, current studies argue that community norms (e.g., pro-social behavior, altruism, civic capital, and/or social capital) can help a community overcome the non-complier problem and increase cooperative behavior leading to increased social

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Table 1
Descriptive analysis.

Variable	N	Mean	S.D.	Min	Max
Retail & recreation – first 1 week	1117	-11.06	14.80	-73.29	89.71
Retail & recreation – first 2 weeks	1117	-9.49	14.73	-71.71	104.64
Retail & recreation – first 3 weeks	1117	-7.89	14.96	-70.24	122.71
Grocery & pharmacy – first 1 week	1117	5.60	12.62	-54.00	89.71
Grocery & pharmacy – first 2 weeks	1117	5.97	12.32	-51.79	92.71
Grocery & pharmacy – first 3 weeks	1117	6.59	12.55	-49.81	102.33
Social distancing policies	1117	1.88	0.92	0.00	5.00
Pro-social character index	1117	0.10	0.32	-1.35	1.48
Nonprofit organization	1117	4.18	1.83	0.80	18.10
Days of shelter in place	1117	52.67	17.49	24.00	88.00
Female (%)	1117	50.58	1.39	42.27	54.21
Age under 17 (%)	1117	21.70	2.83	7.07	32.49
Age 65+ (%)	1117	18.00	4.28	6.97	57.59
Some college (%)	1117	56.21	10.09	27.80	86.00
Asian (%)	1117	2.32	3.29	0.19	42.95
Black (%)	1117	11.50	13.99	0.28	77.69
Hispanic (%)	1117	7.76	8.45	0.80	83.44
Household median income	1117	57766.22	15041.22	33159.00	140382.00
Population density	1117	580.97	2792.33	2.40	69468.40
Unemployment rate (%)	1117	4.06	1.12	1.70	17.00
Poverty (%)	1117	13.65	5.16	2.60	37.30
Rural	1117	3.16	1.91	1.00	9.00
Voted for Trump in 2016 (%)	1117	56.61	14.89	4.09	89.33
Cumulative confirmed cases (per 1000)	1117	3.24	5.98	0.00	127.98

welfare (Barrios et al., 2021). Studies have discovered that community norms are the key factor in influencing voluntary compliance with social distancing behavior resulting in reduced transmission of COVID-19 (Bai et al., 2020; Barrios et al., 2021; Ding et al., 2020; Varshney and Socher, 2020). Barrios et al.'s (2021) study revealed that counties with high civic/social capital are more likely to maintain social distancing (measured by mobility) after state reopening. Nevertheless, most pro-social related studies typically deem a community's pro-social intention and a community's coordination/cooperation capacity as the same notion (Bai et al., 2020; Barrios et al., 2021; Ding et al., 2020; Varshney and Socher, 2020). They do not clearly distinguish the pro-social aspect of the community's coordination and cooperation capacity. Those studies pay little attention to the effects of policy learning and individual cognitive bias on such things as social distancing mitigation behavior. Strong social distancing policies as reflected in longer periods of shelter-in-place orders may shape an individual's voluntary compliance behavior in a community (Bai et al., 2020; Barrios et al., 2021; Ding et al., 2020; Varshney and Socher, 2020). However, it may also induce other individuals in a community to have an overly optimistic expectation after the order has ended. It is unclear what factor contributes more to the critical issue of voluntary compliance behavior in a community after the state reopened from the shelter-in-place order. Hence this study explores how a community's pro-social character, coordination capacity, policy learning and cognitive bias affects voluntary compliance behavior after the state's reopening decision.

1.1. Policy stringency and cognitive bias

State governments issued differential degrees of stringency and different periods related to mitigation (shelter-in-place and social distancing) measures. Strong shelter-in-place and social distancing measures inevitably involve more policy communication between governments and residents. It is thought that when state governments send more COVID-19 related messages to their residents, mitigation implementations might be internalized as social norms characterized by mutual understanding or shared belief systems within a community (Berman, 2001; Shachar and Nalebuff, 1999). However, shaping the new belief and related cooperative behavior in a community is very difficult and requires time to cultivate. Suppose a community has more people who previously performed pro-social behavior. In that case, it can be

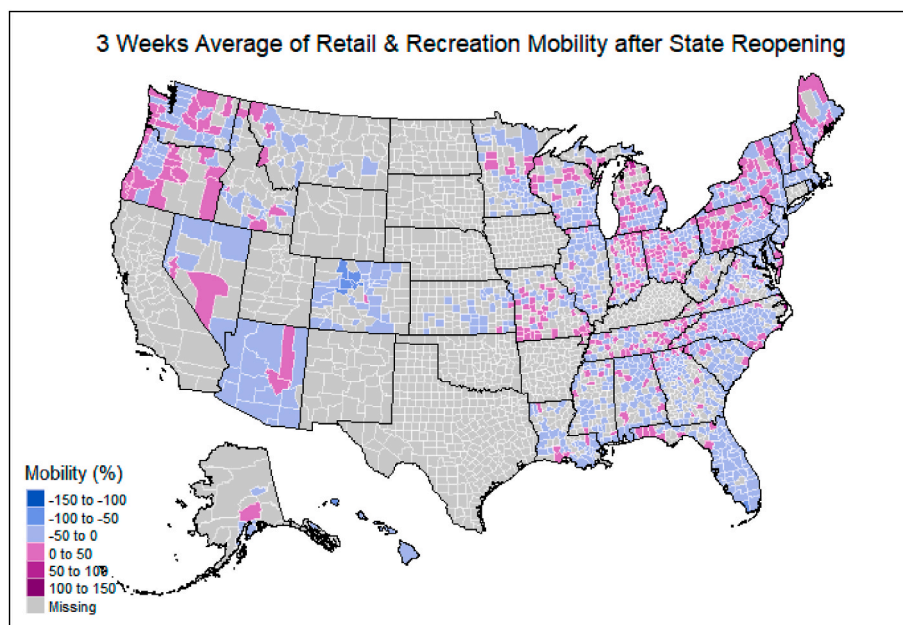


Fig. 1. 3 Weeks Average of Retail & Recreation Mobility after State Reopening.

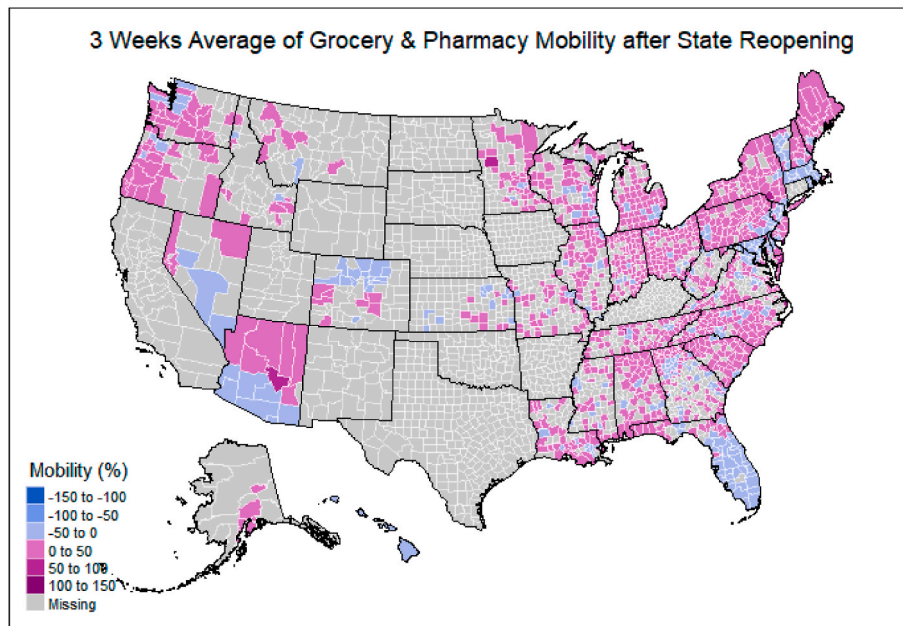


Fig. 2. 3 Weeks Average of Grocery & Pharmacy Mobility after State Reopening.

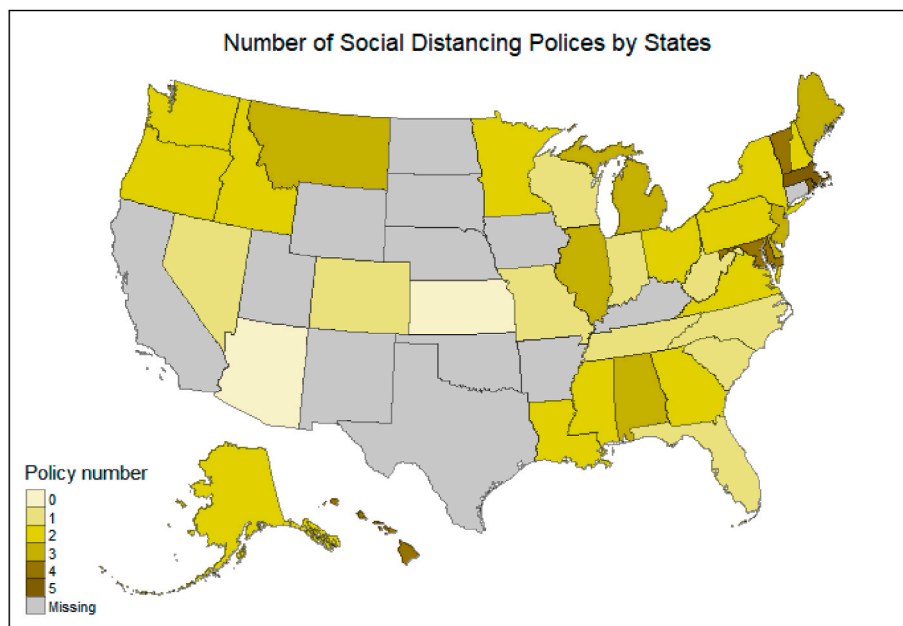


Fig. 3. Number of Social Distancing Policies by State.

expected that strong social distancing measures (a cooperative behavior) would be positively related to capturing the community’s attention and increase support to practice social distancing mitigation after state reopening. This study hypothesizes that a community with more people performing pro-social behavior will have a major effect on the voluntary COVID-19 compliance with respect to mitigation (social distancing) policies after state reopening. Further, the stringency of policy application is likely to impact the relationship after state reopening. Specifically, the stringency of policy may negatively moderate the effect of a community’s pro-social intention on mobility after state reopening (Hayes, 2017). Hence, our first hypothesis (H1) is that the stringency, reflected in the multiple mitigation rules put in place by the government, is likely to result in a negative relationship to the mitigation response even in a local pro-social environment.

However, cognitive biases may adversely affect individual mitigation/social distancing behavior (Gerber, 2007; Hagger et al., 2020; Lammers et al., 2020). Individuals tend to learn from short-term information and then extrapolate directly from the present situation to the future and underestimate uncertain future rewards compared to short-term costs. Therefore, when a state experienced substantial time in a shelter-in-place order, the residents may receive a strong “safe” signal when it ends and decide not to maintain social distancing after state reopening. Thus, this study expects that the longer the duration of the shelter-in-place order that a community has experienced, the higher the mobility response (i.e., lower social distancing) after state reopening. In economic behavior terms, the longer the duration of the shelter-in-place order, the greater the pent-up demand for externally supplied goods and services, and hence the greater the mobility following reopening

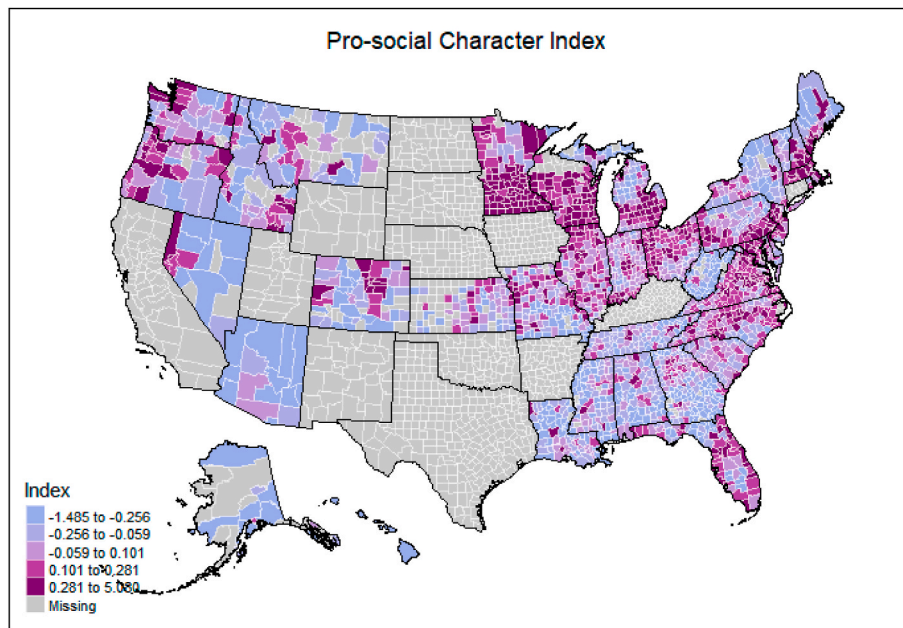


Fig. 4. Pro-social Character Index by County.

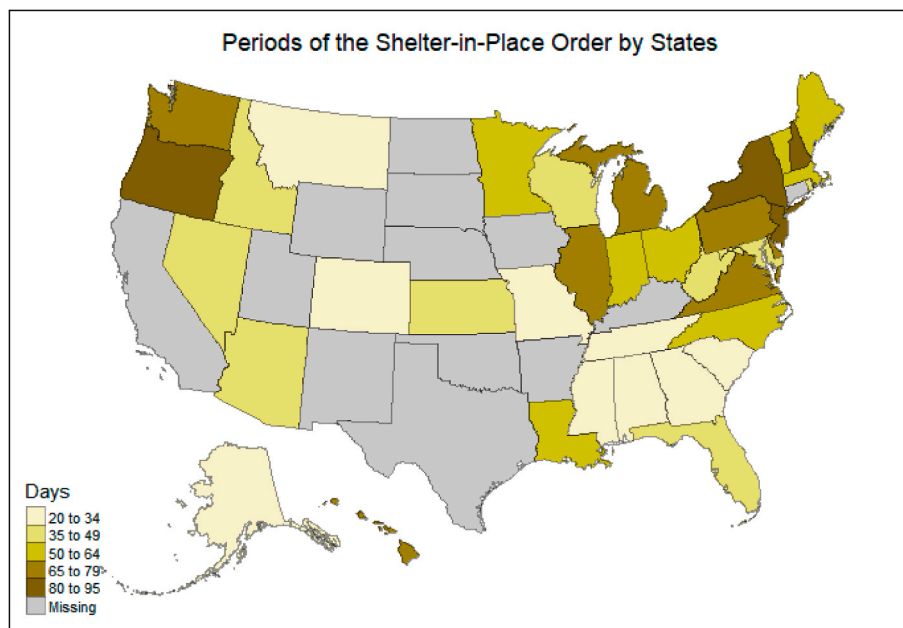


Fig. 5. Periods of the Shelter-in-Place Order by State.

(Donthu and Gustafsson, 2020). In both cases, the hypothesis (H2) is likely to result in a negative relationship between the duration of shelter-in-place and mobility following reopening.

1.2. Community coordination

Although a community’s pro-social character may have a negative relationship with mobility (social distancing compliance), it remains unclear what coordinates community members’ behavior to generate collective action. Simpson and Willer (2015) informed us that centralized leadership can monitor group members’ behavior and influence the effectiveness of collective action. In a community, local associations typically serve a coordination role to facilitate collective action and bring community members together for the common good (Bushouse,

2017; Putnam et al., 1993). For example, Solid Ground (Seattle, WA) recruited volunteers to make masks for vulnerable Solid Ground residents and staff who provide essential services to protect against COVID-19. However, some studies using the number of local associations as a measure of social or civic capital may be problematic because this community “capital” is not easily mobilized (Lin, 2001). Local associations are not necessarily interested in uniting community members to reduce the spread of COVID-19 or support personal protective equipment for essential workers. Local associations can benefit public health good only if they encourage community members to keep social distancing and reduce mobilization of individuals with the pro-social character. Their strategic planning principles are constrained by the community members’ intention of engaging in community activities (Vassalo, 2010; Villalonga-Olives and Kawachi, 2017). If the pro-social

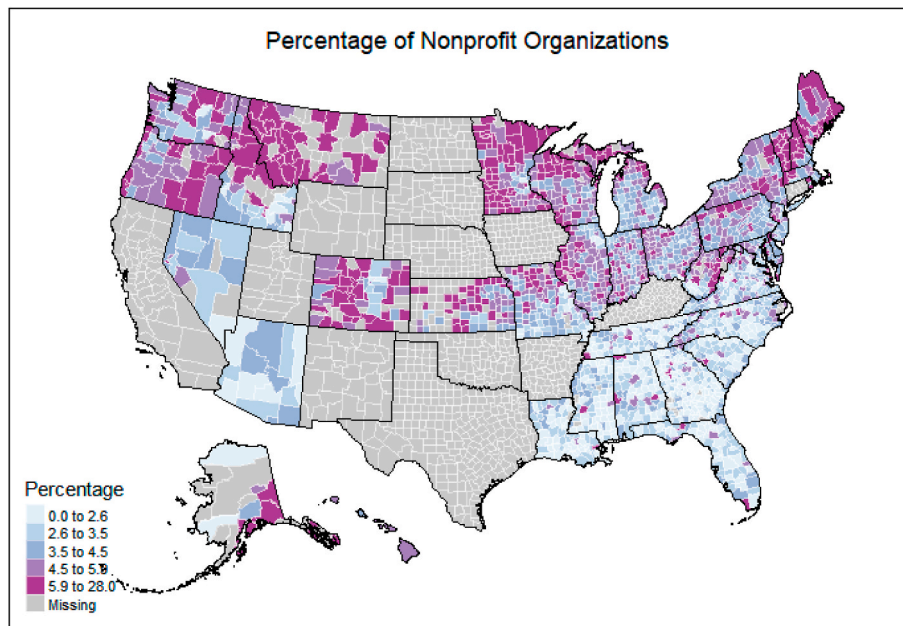


Fig. 6. Percentage of Nonprofit Organization by County.

character was uncommonly observed in a community, it would be challenging for the local associations to organize collective action in combating COVID-19 threats. Therefore, this study hypothesizes that local associations are negatively associated with the effect of a community's pro-social character on mobility after state reopening. This is our third hypothesis (H3).

Measurements.

1.3. Dependent variables

The dependent variables in this study measure the level of voluntary compliance with social distancing (mobility) by county after shelter-in-place orders ended. Mobility is an ideal variable to measure whether a population continued to reduce outdoor activities and maintain social distancing behavior after shelter-in-place orders ended (Borkowski et al., 2021; Noland, 2021; Nouvellet et al., 2021). Both Google and Apple companies released mobility data collected from their mobile device users. Apple provides the data based on how Apple users travel (i. e., driving, public transport, and walking) in a limited number of counties, whereas Google offers the data based on Google users' trip destinations in most counties. Thus, Google's mobility data is a better representative sample at the county level. The mobility data is the percent change in the length of stay after shelter-in-place orders ended, compared to a baseline between January 3 and February 6. Specifically, each county has six mobility percent change scores reflecting six categories of places: grocery and pharmacy, parks, transit stations, retail and recreation, residential, and workplaces (Aktay et al., 2020). However, this study only used the "retail and recreation" and "grocery and pharmacy" categories as dependent variables of risk. The rest of the categories of places may not be suitable to serve as the mobility measure. We described their potential limitations below:

1. Research has indicated that there are potential positive and negative correlations between frequency of park visits and health outcomes during the COVID-19 pandemic. Thus, it is uncertain whether frequent visits to parks are the risky behavior of COVID-19 or beneficial for health (Heckert and Bristowe, 2021).
2. Public transit infrastructure and access vary greatly by county, and some counties do not have sufficient budgets or/and demand to

establish public transit, which may mislead the mobility measure (Nichols and Taylor, 2018).

3. Residential locations could refer to mobile phone users' homes or those of users' friends; hence it is unclear whether the residential mobility score measures the users staying at home or visiting friends.
4. Workplace mobility scores are restricted by occupation characteristics and employers' policies because some occupations or companies allow employees to work remotely, but some are unlikely to be able to do so (Kramer and Kramer, 2020).

Thus, to understand why some counties have lower voluntary compliance with social distancing than others after state reopening, the percentage changes in the length of stay at "retail and recreation" locations as well as "groceries and pharmacies" are the most suitable measures (Varshney and Socher, 2020).

The secondary data indicated that the retail and recreation places consist of restaurants, cafes, shopping centers, theme parks, museums, libraries, and movie theaters. The secondary data also indicated that the grocery and pharmacy places consist of grocery markets, food warehouses, farmers' markets, specialty food shops, drug stores, and pharmacies. The mobility scores were then estimated using the multiple linear regression analysis. State dummies were specified in each model to control for the unmeasured variations of states, e.g., temperature (Gupta et al., 2020) or the intensity of governors' COVID-19 communications (Grossman et al., 2020). To ensure the robust estimate of mobility, this study calculated the average mobility scores for one week, two weeks and three weeks (after state reopening). Due to missing data as well as unspecified start and end dates of stay at home orders per county, this study analyzed 1117 counties drawn from 38 states (Table 1). The examples of county distributions of the two categories of location mobility scores are displayed below (Figs. 1 and 2).

1.4. Independent variables

1. Policy Stringency: policy stringency is a measure of the sum of state-level social distancing dummy measures during stay-at-home restrictions including closing daycare locations, banning nursing home visitors, limiting religious gatherings exempted with mandates, mandating face mask use in all public spaces, and mandating quarantine for all individuals entering the state from another state (Fig. 3).

Table 2
Average length of visit to retail & recreation locations after reopening.

	M1	M2	M3	M4	M5	M6
	One week	One week	Two weeks	Two weeks	Three weeks	Three weeks
Policy Stringency						
Social distancing policies	19.3113*** (3.5589)	16.5470*** (3.6576)	23.4547*** (3.4543)	20.6793*** (3.6220)	23.7178*** (3.6405)	20.9501*** (3.7662)
Pro-social character index	-4.8469* (2.1539)	-.7504 (3.9122)	-6.2245** (2.2314)	-2.7385 (4.0031)	-6.9532** (2.2867)	-3.4991 (4.0637)
Social distancing policies x Pro-social character index		-3.8249* (1.7583)		-3.8059* (1.8262)		-3.7940* (1.8717)
Cognitive Bias						
Days of shelter-in-place	1.6113*** (.3404)	1.3402*** (.3612)	2.2846*** (.3361)	2.0169*** (.3633)	2.3661*** (.3476)	2.0993*** (.3707)
Community Coordination						
Nonprofit organization	-.1358 (.2445)	-.2671 (.2961)	-.0519 (.2435)	-.2112 (.2987)	-.0015 (.2485)	-.1613 (.3056)
Nonprofit organization x Pro-social character index		.5050 (.4667)		.6215 (.4864)		.6239 (.4960)
Control						
Female	-.0676 (.2971)	-.1161 (.3164)	.0652 (.3024)	.0283 (.3223)	.1122 (.3061)	.0758 (.3256)
Age under 17	.9513*** (.2380)	.9870*** (.2379)	.8881*** (.2430)	.9196*** (.2436)	.8457*** (.2452)	.8769*** (.2466)
Age 65+	.4388* (.2147)	.4712* (.2112)	.4535* (.2231)	.4865* (.2196)	.4788* (.2344)	.5117* (.2312)
Some college	-.1996** (.0677)	-.1982** (.0679)	-.1922** (.0693)	-.1889** (.0694)	-.1548* (.0732)	-.1515* (.0731)
Asian	-.6595*** (.1648)	-.6664*** (.1678)	-.7015*** (.1716)	-.7115*** (.1740)	-.7241*** (.1793)	-.7342*** (.1812)
Black	-.0286 (.0649)	-.0204 (.0636)	-.0325 (.0660)	-.0229 (.0648)	-.0408 (.0665)	-.0312 (.0654)
Hispanic	-.3837*** (.0800)	-.3962*** (.0782)	-.3706*** (.0833)	-.3834*** (.0818)	-.3541*** (.0839)	-.3669*** (.0826)
Household median income	-.0001* (.0000)	-.0001* (.0000)	-.0001 (.0000)	-.0001 (.0000)	-.0001 (.0000)	-.0001 (.0000)
Population density	-.0001 (.0001)	-.0001 (.0001)	-.0001 (.0001)	-.0001 (.0001)	-.0001 (.0001)	-.0001 (.0001)
Unemployment rate	3.0985* (1.3536)	2.9664* (1.3140)	3.1768* (1.4488)	3.0441* (1.4091)	3.4607* (1.5760)	3.3283* (1.5360)
Poverty	-.4875** (.1723)	-.4644** (.1660)	-.5335** (.1777)	-.5152** (.1705)	-.6190** (.1879)	-.6009** (.1805)
Rural index	.4135 (.2367)	.4156 (.2351)	.3619 (.2375)	.3681 (.2356)	.4086 (.2431)	.4149 (.2411)
Voted for Trump in 2016	.1698* (.0683)	.1680* (.0677)	.1621* (.0695)	.1610* (.0690)	.1550* (.0697)	.1540* (.0693)
Cumulative confirmed cases	-.1382* (.0639)	-.1246 (.0645)	-.1245 (.0664)	-.1084 (.0665)	-.1194 (.0708)	-.1033 (.0706)
Constant	-132.9113*** (27.7817)	-117.3409*** (29.1757)	-168.3799*** (27.6227)	-153.4062*** (29.3439)	-172.8292*** (28.3428)	-157.9207*** (29.7680)
N	1117	1117	1117	1117	1117	1117
R ²	.633	.636	.626	.629	.612	.615
Adjusted. R ²	.614	.617	.607	.610	.593	.595

*p < 0.1, **p < 0.05, ***p < 0.01; Robust standard errors are in parenthesis; State dummies are omitted from the table.

2. Pro-social character index: the pro-social character of a county is a composite index constructed from the number of organ donations per 1000 population between 2014 and 2018, the average participation in presidential elections as reflected in voting rates in 2012 and 2016, as well as the census participation rates (i.e., the mail-back rate) in the 2010 census (Arbesman and Christakis, 2011). A factor analysis was applied to calculate those three items' factor scores and generate a pro-social character index (Fig. 4).

3. Cognitive bias: cognitive bias is measured by the number of days between the start and end dates of the shelter-in-place order (Fig. 5). A longer period of the shelter-in-place order usually implies that the state has had increasing confirmed cases of COVID-19 and that government has had more time to communicate with residents about COVID-19 during that period. Once the shelter-in-place order has ended, residents may misinterpret the ending as a strong safety signal and immediately start increasing external (non-mitigation) activities reflected in increased mobility (Soud et al., 2009).

4. Nonprofit organization: the nonprofit organization reflects a

community's coordination capacity and measures the number of non-religious and non-profit organizations per 1000 population (Fig. 6).

1.5. Control variables

We identified the following variables as control variables in the model: gender (female), age (those < 17 years old and those > 65 years old), highest level of education (percentage of those who at least attended some college), minority population (Asian, Black, and Hispanic), household income (median), population density (population/mi²), unemployment rate, poverty rate (household income below 100% of the Federal poverty line), rural area, Trump voter rate in the 2016 election, and cumulative confirmed COVID-19 cases per 1000 population on the state reopening day (Bonaccorsi et al., 2020; Lin et al., 2021; Nivette et al., 2021; Motie and Biolsi, 2020).

Table 3
Average length of visit to grocery & pharmacy locations after reopening.

	M1	M2	M3	M4	M5	M6
	One week	One week	Two weeks	Two weeks	Three weeks	Three weeks
Policy Stringency						
Social distancing policies	10.9557** (3.8729)	6.7038 (3.8980)	15.4846*** (3.9680)	11.4607** (4.0808)	14.9524*** (4.0174)	10.9943** (4.1539)
Pro-social character index	-4.4185 (2.3130)	4.5264 (3.8648)	-5.4632* (2.3463)	2.4689 (3.9330)	-6.1140* (2.3721)	2.3831 (3.9671)
Social distancing policies x Pro-social character index		-6.0283*** (1.7945)		-5.6758** (1.8002)		-5.6211** (1.8223)
Cognitive Bias						
Days of shelter in place	.7169 (.3668)	.2811 (.3868)	1.3742*** (.3810)	.9656* (.4047)	1.4356*** (.3845)	1.0288* (.4084)
Community Coordination						
Nonprofit organization	.1246 (.2293)	.0382 (.2964)	.2391 (.2272)	.1341 (.2902)	.2321 (.2302)	.1591 (.2911)
Nonprofit organization x Pro-social character index		.2940 (.5305)		.3756 (.5145)		.2426 (.4972)
Control						
Female	-.1040 (.3291)	-.2281 (.3317)	-.0253 (.3293)	-.1327 (.3344)	-.1355 (.3250)	-.2542 (.3295)
Age under 17	.7307** (.2318)	.8043*** (.2353)	.7740** (.2348)	.8399*** (.2400)	.7404** (.2338)	.8102*** (.2393)
Age 65+	.3022 (.2000)	.3500 (.1912)	.3102 (.2059)	.3559 (.1969)	.3261 (.2112)	.3705 (.2024)
Some college	-.0950 (.0693)	-.1009 (.0693)	-.0564 (.0692)	-.0604 (.0692)	-.0044 (.0716)	-.0103 (.0712)
Asian	-.4303** (.1535)	-.4282** (.1586)	-.4663** (.1605)	-.4668** (.1641)	-.4915** (.1649)	-.4887** (.1682)
Black	-.0150 (.0589)	-.0080 (.0589)	-.0262 (.0592)	-.0184 (.0594)	-.0334 (.0590)	-.0273 (.0589)
Hispanic	-.2470*** (.0634)	-.2655*** (.0618)	-.2382*** (.0664)	-.2559*** (.0652)	-.2291*** (.0674)	-.2463*** (.0664)
Household median income	-.0001* (.0000)	-.0001* (.0000)	-.0001* (.0000)	-.0001 (.0000)	-.0001** (.0000)	-.0001* (.0000)
Population density	-.0001 (.0001)	-.0001 (.0001)	-.0001 (.0001)	-.0002 (.0001)	-.0002 (.0001)	-.0002 (.0001)
Unemployment rate	1.3976 (1.1702)	1.1949 (1.0966)	1.4387 (1.2234)	1.2468 (1.1512)	1.6588 (1.3002)	1.4702 (1.2275)
Poverty	-.3327* (.1632)	-.2762 (.1564)	-.3238 (.1660)	-.2746 (.1590)	-.3628* (.1718)	-.3089 (.1646)
Rural index	.5428* (.2649)	.5288* (.2609)	.4407 (.2623)	.4309 (.2592)	.4525 (.2580)	.4384 (.2553)
Voted for Trump in 2016	.1026 (.0633)	.0967 (.0629)	.1148 (.0644)	.1098 (.0644)	.1105 (.0641)	.1048 (.0640)
Cumulative confirmed cases	-.0430 (.0542)	-.0322 (.0533)	-.0324 (.0564)	-.0201 (.0556)	-.0261 (.0599)	-.0167 (.0594)
Constant	-52.7595 (30.1255)	-26.0301 (30.7970)	-92.4151** (30.6832)	-67.6796* (31.6369)	-89.3709** (30.6306)	-64.3094* (31.5801)
N	1117	1117	1117	1117	1117	1117
R ²	.471	.482	.460	.470	.468	.477
Adjusted R ²	.445	.455	.433	.443	.441	.450

*p < 0.1, **p < 0.05, ***p < 0.01; Robust standard errors are in parenthesis; State dummies are omitted from the table.

2. Results

Tables 2 and 3 show the estimated determinants of retail and recreation mobility as well as grocery and pharmacy mobility. In both Tables, M1 and M2 are the estimates of the average mobility in the first week after state reopening. M3 and M4 are the estimates of the average mobility in the first two weeks after state reopening. M5 and M6 are the estimates of the average mobility in the first three weeks after state reopening. M1, M3 and M5 include all the independent and control variables before adding any interaction/moderation effects. Hypotheses one and three indicate that there is a need to examine how mitigation (social distancing) policy stringency and local associations moderate the effect of a community’s pro-social character on mobility. M2, M4 and M6 are full models including the moderation effects of interest.

For retail and recreation mobility, the results are robust across all time periods and models. M1, M3 and M5 indicate that strong mitigation/social distancing policies tend to increase retail and recreation mobility after state reopening. Using M5 as an example, a one-unit

change in social distancing policies increases retail and recreation mobility by 23.72%. The pro-social character index is negatively associated with retail and recreation mobility. For every unit change in the pro-social index, there is a 6.95% decrease in retail and recreation mobility. Days of shelter-in-place have a positive effect on retail and recreation mobility. One day increase in shelter-in-place leads to a 2.37% increase in retail and recreation mobility.

Taking the moderation/interaction effect into account (M2, M4 and M6), social distancing policies are likely to negatively moderate the effect of the pro-social character index on retail and recreation mobility after state reopening. Strong social distancing policies coupled with a high pro-social character index are negatively associated with retail and recreation mobility (Fig. 7; plotted based on M6). Hypothesis one (H1) is supported. As for hypothesis two (H2), the results show that days of shelter in place have a positive effect on retail and recreation mobility, implying that a greater cognitive bias in a county tends to lead to higher mobility after state reopening. Hypothesis two is supported. However, hypothesis three (H3) is not supported. This study expects that the

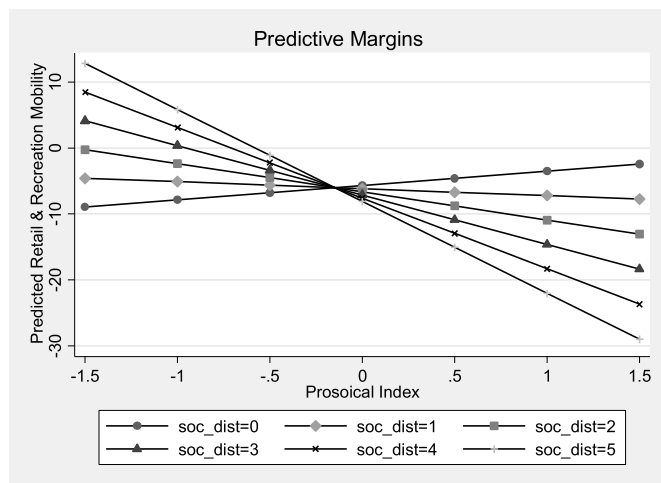


Fig. 7. Interaction effect between social distancing policies and pro-social character index on retail and recreation mobility.

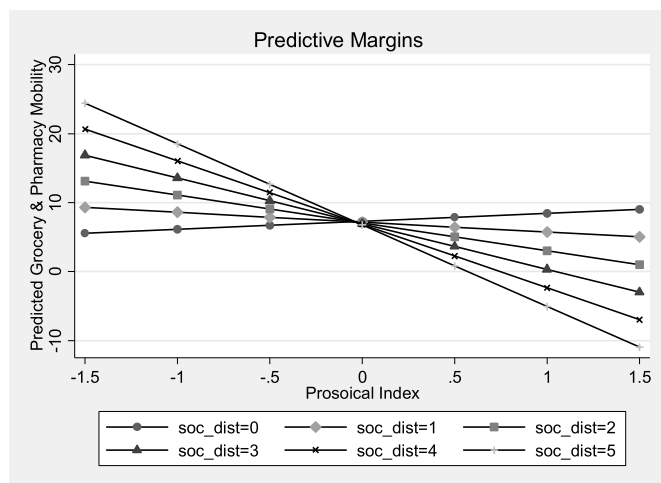


Fig. 8. Interaction effect between social distancing policies and pro-social character index on grocery and pharmacy mobility.

nonprofit organizations would coordinate community members to comply with social distancing, while the findings reveal that nonprofit organizations do not significantly moderate (or contribute to) the effect of a pro-social character index on retail and recreation mobility after state reopening.

In terms of the determinants of grocery and pharmacy mobility, the findings are similar to the determinants of retail and recreation mobility, except for the first week (Table 3). The effect of days of shelter in place on grocery and pharmacy mobility is not significant in the first week but is positively associated with grocery and pharmacy mobility in the first two and three weeks after state reopening. Hypothesis two is partially supported. Fig. 8 (plotted based on M6) reveals that hypothesis one (H1) is supported. A county with strong mitigation/social distancing policies and a high pro-social character index is likely to decrease grocery and pharmacy mobility after state opening. Similar to the determinants of retail and recreation mobility, the third hypothesis (H3) is not supported here. The results also show that nonprofit organizations do not significantly moderate the effect of the pro-social character index on grocery and pharmacy mobility after state reopening.

3. Conclusion

Results indicated without controlling for the interaction term of a

county’s pro-social character index and mitigation policies, a positive relationship was observed between mitigation policies and mobility. However, results indicated with controlling for the interaction term of a county’s pro-social character index and mitigation policies, a negative relationship between mitigation policies and mobility was observed. These results imply that the mitigation policies “activate” a county’s pro-social character that leads to residents to voluntarily comply with mitigation policies and reduce mobility activities pertaining to retail, recreation, grocery, and pharmacy locations after state reopening (Berman, 2001; Shachar and Nalebuff, 1999). The top five counties with the highest pro-social character indexes and mitigation policies consist of Montour County (PA), Charlottesville (VA), Peoria County (IL), Barnstable County (MA), and Olmsted County (MI).

The findings also revealed that a county experiencing a longer duration of shelter-in-place order typically showed higher mobility response in retail, recreation, grocery and pharmacy locations. This may be explained by human cognition limitations that indicated that a longer duration of shelter-in-place order should be sufficient to take us back to regular life after state reopening even though the COVID-19 pandemic has not yet ended (Gerber, 2007). Another alternative explanation is that a longer duration of shelter-in-place order increased the pent-up demand, leading to a higher mobility response. If this is a case, we should observe that the high demand frequently occurs in grocery and pharmacy locations but are less likely to occur in retail and recreation locations. However, the results show that the longer duration of shelter-in-place order is associated with higher mobility in all locations. The duration of the shelter-in-place order has a larger effect (higher coefficients) on retail and recreation locations than grocery and pharmacy locations. The effect remains continuous as two-week or three-week average mobility is considered. Hence, human cognition bias or limitations would be a better explanation to interpret the higher mobility response after a longer duration of shelter-in-place order than the pent-up demand.

Additionally, this study expects that local nonprofit organizations would encourage community members to comply with social distancing practices, but the empirical results did not support the hypothesis. Part of the reason is that this study assumes that nonprofit organizations would organize local promotions or activities related to voluntary compliance with social distancing practices. Yet, our present variable (number of nonprofit organizations) is an indirect measure of the coordination actions and might not reflect whether those organizations have played the role in coordinating COVID-19 mitigation activities in the community. Future research should consider collecting a direct measure of whether local nonprofit organizations are involved in such coordination activities.

3.1. Policy implications

This study illustrates two important implications for individual ethical decision making and social distancing policies after states reopened from shelter-in-place orders. First, most U.S. states have implemented shelter-in-place orders to contain the spread of COVID-19, but a stringent order does not necessarily lead to lasting social distancing practices after the order is eased. This study shows that pro-social behavior is an important determinant of voluntary social distancing practices. For counties with different pro-social characters, implementing a same social distancing policy could cause their various degrees of voluntary social distancing practices. Thus, it suggests that public health officials should consider devising county-level strategies to enhance pro-social behavior and moral obligations in a more nuanced manner (Baumsteiger, 2019). Second, individual cognitive bias may be used to elucidate the negative association between the duration of the shelter-in-place and voluntary compliance with COVID-19 mitigation. It suggests that public health officials should cautiously formulate reopening phases to reduce residents’ over-optimistic perception resulting from the reopening order and wisely choose neutral words to

communicate with residents.

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Credit author statement

Meng-Hao Li: Conceptualization, Data Cleaning, Methodology, Visualization, Analysis and Writing. Kingsley E. Haynes: Conceptualization, Methodology, Supervision, Writing and Funding Acquisition. Rajendra G. Kulkarni: Conceptualization and Data Cleaning, Methodology and Writing. Abu Bakkar Siddique: Conceptualization, Data Cleaning, Methodology and Writing.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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