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ABSTRACT

We estimate whether federal aid for state and local governments played a role in advancing population testing for COVID-19 and the administration of vaccines. To overcome biases that can result from the endogeneity of federal aid allocations, we use an instrumental-variables estimator reliant on the substantial variation in federal aid predicted by variation in states' congressional representation. We find that federal fiscal assistance dollars had a modest if any impact on the pace of vaccine rollouts, may have improved the equitability of vaccine administration, and had a substantial impact on the volume of tests administered. Regarding the total number of vaccines delivered, we estimate that an additional $1,000 in fiscal relief per resident, which would amount to $330 billion nationwide, translated into just under 1,200 extra doses of the vaccine being delivered per 100,000 people, with the upper bound of our confidence interval suggesting that we can rule out effects in excess of 7,030 extra doses per 100,000 people. We find that federal dollars predict a smaller gap between the vaccination rates of those with a college education relative to those with a high school education. Finally, our baseline estimate implies that each $1,000 in COVID-19 relief aid per capita generated 55,850 additional tests per 100,000 people.

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I Introduction

The COVID-19 pandemic confronted state and local governments with a unique set of pressures. As during more conventional periods of economic distress, tax revenues were threatened while strains on states' Medicaid programs and unemployment insurance systems were heightened (Clemens and Veuger, 2020a and 2020b; Clemens, Ippolito, and Veuger, 2021). Unlike conventional recessions, the pandemic introduced a new set of complications and demands pertaining to the delivery of public services. The new demands, which are the focus of this paper's analysis, stemmed from the role of both state and local governments in the delivery of COVID-19 tests and vaccines, as well as in the maintenance of the associated data and the promulgation and enforcement of pandemic-related regulations.

Our analysis focuses on the specific question of whether federal fiscal assistance to state and local governments played a role in advancing goals associated with population testing and the administration of vaccines. The outcomes we analyze include the total volume of tests and vaccines delivered. We also analyze a set of outcomes related to the equitability of vaccine delivery.

The key challenge to estimating the effects of federal fiscal assistance is a standard endogeneity concern: fiscal assistance may tend to be targeted at the geographic areas that were hardest hit by the pandemic, which may generate a spurious correlation between federal dollars and outcomes like the volume of testing.

We rely on an instrumental-variable estimator to overcome this and other potential sources of bias. In particular, we build on existing evidence showing that the overrepresentation of small states in the US Congress led federal legislation to send disproportionate relief to the state and local governments in those states (Clemens and Veuger, 2021a). Importantly, we confirm that variation induced by these predetermined, constitutionally anchored political factors was orthogonal to a rich set of measures of the COVID-19 crisis' direct impact on state-level public health and public finance.

In brief, our analysis finds that federal dollars had a modest if any impact on the pace of vaccine rollouts, had a substantial impact on the volume of tests administered, and may have improved the equitability of vaccine administration. Regarding the total number of vaccines delivered, we estimate a modestly positive but statistically insignificant relationship between federal dollars and vaccines distributed. Our point estimate suggests that, through March 2022, an additional $1,000 per resident translated into just under 1,200 extra doses of the vaccine being delivered per 100,000 people; the upper bound of our confidence interval suggests that we can rule out effects in excess of 7,030 extra doses per 100,000 people. Regarding tests, our baseline estimate implies that each $1,000 in COVID-19 relief aid per capita generated 55,850 additional tests per 100,000 people, or roughly one additional test for every two people. Here we can reject a null effect at the 95% confidence level.

Finally, we find that federal dollars predict smaller gaps between the vaccination rates of those with a college education and those with a high school education. An additional $1,000 in federal funding per resident reduced the disparity in vaccination rates between college and high school educated adults by a robust and statistically significant 5.4 percentage points.

Our analyses relate to several lines of thought regarding the role of state and local governments and both the structure and volume of federal fiscal assistance in response to economic and public health emergencies.

First, the federal government's unprecedented allocation of roughly $900 billion in fiscal assistance substantially overshot state and local governments' needs. This was due in part to the surprising resilience of state and local government tax revenues (Clemens and Veuger, 2021b; National Association of State Budget Officers, 2021). This raises the question of whether, in the end, federal fiscal assistance advanced outcomes of policy interest. Our findings suggest that the fiscal space created by federal fiscal assistance had a substantive impact on the delivery of COVID-19 tests and may also have improved the equitability of vaccine distribution.

Historically, federally funded vaccine programs have relied on state and local governments and the private sector to distribute and administer vaccinations. Research has linked this decentralized structure to variation across states in population vaccination percentages during various immunization campaigns (Neustadt and Fineberg, 1978; Orenstein, et al., 2005; Schwerzmann, et al., 2017; Kolbe, 2021). In general, vaccination efforts seem to face significant barriers. On the administrative side, these barriers include funding constraints, complexities of managing vaccination locations, training staff, providing accurate information to the public, and the logistics of transporting the vaccine itself (WHO, UNICEF, and World Bank, 2009; Penfold, et al., 2011; Kolbe, 2021).

Obstacles to take-up include geographical access, insurance coverage, job flexibility and childcare, dislike of receiving injections, and inaccurate information and perceptions about vaccine effectiveness and side effects (Alsan and Eichmeyer, 2021; Gonzales, et al., 2021).[2] Moreover, these individual barriers have been noted to interact with several dimensions of socioeconomic status and race both before and during the COVID-19 pandemic. Correlations between socioeconomic status and vaccination rates have been noted in early studies of COVID-19 vaccines (Biswas, et al., 2021) and a large prior literature on flu vaccination (Lucyk, et al., 2019). Additionally, Ali et al. (2021) find that wealthier individuals have higher perceived access to COVID-19 testing.

During the COVID-19 pandemic, several studies have found differences in vaccine hesitancy and take-up by race in addition to socioeconomic status (Padamsee, et al., 2022; Ndugga, et al., 2022). Historic experiences in the African-American and Hispanic communities with the US healthcare system have led to high levels of distrust in the government, the medical profession, and vaccines (Alsan and Wanamaker, 2018; Balasuriya et al., 2021). Perry et al. (2021) find that Black and Hispanic individuals are also more concerned with resource constraints when deciding to take a COVID-19 test.[3] However, there is some evidence that interventions can mitigate vaccine hesitancy and increase take-up by delivering information through individuals of similar socioeconomic backgrounds to the target population and by establishing state outreach efforts and clinics in hesitant communities (Alsan and Eichmeyer, 2021;

[2] In previous vaccination efforts, cost has operated as a significant deterrent to uptake (Walsh, Doherty, and O'Neill, 2016). Generous federal assistance throughout the pandemic has removed this constraint for most households; by May 2021, only 3 percent of surveyed unvaccinated individuals recorded cost as a reason for their hesitancy (US Census Bureau, 2022).

[3] See also Hendricks, et al. (2021); Jacobson, et al. (2021); and Dryden-Peterson, et al. (2021).

Gonzales, et al., 2021).[4] We contribute to the literature on vaccine uptake by shedding light on the extent to which gaps in vaccine receipt across socioeconomic groups were narrowed in states that had more resources available.

The paper is organized at follows. In Section II we introduce our data and sources. We turn to our empirical strategy in Section III. Sections IV presents our empirical results. We conclude with a discussion of our findings in Section V.

II Data

We analyze the fiscal assistance to state and local governments in four major pieces of legislation during the COVID-19 pandemic: the Families First Coronavirus Response Act (FFCRA), the CARES Act, the Response and Relief Act (RRA), and the American Rescue Plan Act (ARPA). Taken together, these packages provided almost $900 billion in funds to state and local governments. We focus on the impact of these funds on the expansion of COVID-19 vaccination and testing programs across the 50 states. Data from the Committee for a Responsible Federal Budget (CRFB, 2021) form the foundation for our fiscal assistance variables.[5]

While the total amount of aid is the most relevant indicator of a relieved budget constraint, each of the four bills mentioned above included specific provisions for testing and vaccination programs. The CARES Act established the Coronavirus Relief Fund, which designated $150 billion to cover public health expenses between March 1, 2020 and December 31, 2021 that included, but were not limited to, vaccines and testing (Coronavirus Relief Fund, 2021). Additional funding for CARES Act programs passed on April 24, 2020 included $11 billion for state, local, and tribal testing programs (Moss, 2020). The FFCRA included funding meant to ensure all individuals would have access to COVID testing that was free at the point of service (National Association of Counties, 2021a). The RRA allocated $22.4 billion for testing, contact tracing, and mitigation programs and $8.75 billion for broad-based local vaccination programs (Briggs, 2021). Vaccination and testing programs were also eligible for funding through ARPA's $350 billion State and Local Fiscal Recovery Funds (Coronavirus State and Local Fiscal Recovery Funds, 2022). ARPA independently distributed $55.3 billion in grants to states, localities, and tribes for testing and vaccines (National Association of Counties, 2021b). In all, the federal government provided at minimum $97.5 billion in targeted aid for these health programs alone.

On March 15, 2022, the White House released a statement outlining the risks associated with failing to pass further aid for combatting the pandemic (The White House, 2022). These include an insufficient supply of booster doses and variant-specific vaccines; reduced funding to cover the uninsured; limited supply of monoclonal antibodies; and scaling back domestic and international vaccination and testing efforts. Additional government funding for these purposes would thus need to come out of states' other

[4] Differences in vaccine hesitancy among Democrats and Republicans, where the latter group may be harder to convince that the vaccine is safe and effective, complicates the approach health officials must take to get widespread coverage (Khubchandani et al., 2021; Pink et al., 2021; Bolsen and Palm, 2022).

[5] We use data from the Committee for a Responsible Federal Budget's COVID-19 Money Tracker as of August 19th, 2021. We refer the reader to Clemens and Veuger (2021a) and Clemens, Hoxie, and Veuger (2022) for a more detailed discussion of the data and the legislative process.

funds, which raises the question of whether states that received more generous allocations of general fiscal assistance delivered more regular testing and either faster or more equitable vaccination rollouts.

Our main independent variable is the grand total of aid distributed to each state per resident in thousands of dollars. The distribution of money across states has not been equal, with smaller states receiving relatively more per person than larger states. As in Clemens, Hoxie, and Veuger (2022), we use a state's number of congressional representatives per million residents to instrument for federal aid per capita.

The main outcomes of interest in our analysis are the total number of COVID-19 tests and vaccinations administered throughout the pandemic. The number of tests given in each US state is accessed from the Johns Hopkins University Centers for Civic Impact (2022), which rely on data from the relevant state health agencies and the US Department of Health & Human Services. The number of vaccines administered in each US state is accessed directly from the US Centers for Disease Control and Prevention (2020). The CDC collect the number of vaccines distributed to and administered at "all vaccine partners including jurisdictional partner clinics, retail pharmacies, long-term care facilities, dialysis centers, Federal Emergency Management Agency and Health Resources and Services Administration partner sites, and federal entity facilities." Cumulative totals from March 2020 (December 2020) through March 2022 are scaled by population to estimate the total number of tests (vaccines) given per 100,000 people.

We additionally examine measures of distributional disparities during the pandemic. Since April 2020, the US Census Bureau (2022) has been publishing data from the Household Pulse Survey (HPS). The HPS "is a 20-minute online survey studying how the coronavirus pandemic is impacting (..) childcare, education, employment, energy use, food security, health, housing, household spending, Child Tax Credit payments, and intention to receive a COVID-19 vaccination." Vaccination questions have been included in the HPS since January 2021. We estimate the percentage of individuals by race, ethnicity, age, educational attainment and income who have received at least one dose of a COVID-19 vaccine from the pool of respondents to the vaccination section of the surveys.

Table 1 presents summary statistics on the full set of variables used in our analysis. Because some of the variables we use in our analyses are available for different time periods, not all variables have the same number of observations. Further details on the definitions of key variables can be found in Appendix Table 1.

III Empirical Strategy

We seek to identify the effect of COVID-19 relief funds to state and local governments on testing and vaccination programs. Equation (1) presents a "naïve" OLS model of the relationship between per capita aid and changes in the cumulative number of vaccinations or tests administered per 100,000 people:

$$\frac{V_{s,m,y}}{(Pop_{s,y_{2020}}/100{,}000)} = \alpha + \beta_1 \frac{TotalAid_s}{Pop_{s,y_{2020}}} + \beta_2 X_{s,m,y} + \varepsilon_{s,m,y}. \tag{1}$$

In equation (1) and the equations that follow, *m* and *y* iterate over the month-year pairs from March 2020 to March 2022. In the equation above, $\frac{V_{s,m,y}}{(Pop_{s,y_{2020}}/100{,}000)}$ is the cumulative number of COVID-19 vaccines or tests administered up to month *m* of year *y* scaled per 100,000 people residing in state *s*. We use vaccine data from Johns Hopkins University and testing data from the CDC (Johns Hopkins University Centers for Civic Impact, 2022; CDC, 2020). $\frac{TotalAid_s}{Pop_{s,y_{2020}}}$ is the total per capita funding (in thousands of dollars) to state and local governments in state *s* pooled across all four COVID-19 relief bills. This variable is time-invariant. $X_{s,m,y}$ is a vector of additional state-level demographic, economic, and political controls, which we discuss in greater detail below.

OLS estimates of β_1 from equation (1) are subject to potential biases linked to the endogeneity of fiscal assistance allocations. If policymakers allocated more money to states in which individuals were, all else equal, more likely to test or get vaccinated, then federal aid would be correlated with any variations in uptake that were driven by the severity of the pandemic, individual attitudes, or other factors. This would introduce upward bias as it would generate a spurious, positive correlation between aid dollars and our testing and vaccination-related outcomes. A more direct form of reverse causality may also arise if, for example, the capacity of state and local governments to design and promote testing and vaccination shaped federal aid allocations. In this case, early success in testing or vaccinating would determine the amount of aid given, creating a spurious negative relationship if more capable states were to receive less money.

We adopt an instrumental-variable approach to address these challenges. Specifically, we estimate the following set of equations:

$$\frac{TotalAid_s}{Pop_{s,y_{2020}}} = \alpha + \beta_1\, RepsPerMillion_s + \beta_2 X_{s,m,y} + \varepsilon_{s,m,y} \tag{2a}$$

$$\frac{V_{s,m,y}}{(Pop_{s,y_{2020}}/100{,}000)} = \alpha + \beta_1 \frac{\widehat{TotalAid_s}}{Pop_{s,y_{2020}}} + \beta_2 X_{s,m,y} + u_{s,m,y}. \tag{2b}$$

In the first-stage regression (2a), $\frac{TotalAid_s}{Pop_{s,y_{2020}}}$ is regressed on $RepsPerMillion_s$, the number of representatives and senators per million residents in 2020, and a set of additional controls $X_{s,m,y}$, the components of which we discuss below. Robust standard errors are clustered at the state level, and we weight observations by state population.[6] Fitted values from the first stage (2a) are used to estimate the second stage (2b).

The outcomes of interest include the cumulative number of tests or vaccines administered, as well as gaps in vaccination rates across population subgroups. Because the primary outcomes we analyze are cumulative, most of the regressions we present are estimated on a sample from March 2022, which is the last month for which we have compiled data on the full set of outcomes we analyze. We also

[6] Appendix Table 3 presents equally-weighted regressions of the specifications seen in Table 2. The coefficients are consistent across these results.

present estimates from sequences of regressions that trace out the accumulation of any impacts of federal dollars on testing and vaccination rates over time.

A valid instrument satisfies both the relevance and exogeneity (or exclusion) restrictions. To serve as a good instrument, congressional representation needs to be statistically related to the amount of aid disbursed by the federal government. If the relationship is not strong and the relevance restriction is failed, the fitted values will not pick up the exogenous variation needed to estimate a correctly specified second stage. As established by Clemens and Veuger (2021a) and Clemens, Hoxie, and Veuger (2022), the relationship between representatives per million and COVID-19 relief aid is very strong. On a per capita basis, small states received much more money than large states. The first-stage F-statistics in Table 2, which range from 75 to 109, illustrate the strength of this relationship.

The exogeneity restriction requires that, conditional on other independent variables, congressional representation be structurally unrelated to other factors that influence the expansion and success of testing and vaccine regimes. In our baseline specification, the vector $X_{s,m,y}$ includes the log of state *s*'s official 2020 Census population (the level of which is used to construct other variables that require population), the share of votes won by Donald Trump in the 2020 Presidential election in state *s* (MIT Election and Data Science Lab, 2017), the change in real GDP per capita from Q4 2018 to Q4 2019 in state *s* (US Bureau of Economic Analysis, 2022), and the number of cumulative and new COVID-19 cases and deaths per 100,000 people in state *s* measured during the previous month (Dong, Du, and Gardner, 2020). We will refer to these controls as the "baseline set." The rationale for this set of controls is to include proxies for attitudes towards the pandemic, pre-pandemic economic trends, and variations in demand for tests and vaccines driven by variations in the pandemic's severity. Recognizing potential concerns associated with the possibility of "endogenous controls," our robustness checks include a set of specifications with sparser control sets. Particularly relevant to the question of endogenous controls is our set of robustness checks in which we exclude all covariates associated with COVID-19 deaths and cases.

We use as additional robustness controls the share of each state's population that lives in an area eligible for financing through the Federal Reserve's Municipal Liquidity Facility (MLF); changes in state and local government employment per capita and private employment per capita between December 2018 and December 2019; the average of the Oxford Stringency Index (OSI), which is a measure of COVID-19 related restrictions, during March 2020 and during month *m* of year *y*; and finally, the change in retail mobility in the previous month (Google LLC, 2021). These covariates provide additional proxies for potentially relevant factors including states' pre-pandemic economic trends and their policy environments during the pandemic itself.

We advance several other arguments and pieces of evidence in support of the exogeneity restriction required for equation (2b) to yield a causal estimate of the effect of federal fiscal assistance.

First, we emphasize that our instrument's conditional exogeneity is plausible. Since representation imperfectly scales with population, some states will be relatively over-represented; for example, Montana's roughly 1 million residents enjoy three votes per million in Congress (2 senators and 1 representative) while 3 million Arkansans enjoy only 2 votes per million (2 senators and 4 representatives). Barring an unlikely epidemiological relationship between state population numbers and the spread and severity of the coronavirus, the number of congressional seats has no direct impact on vaccine and test distribution beyond its influence on the legislative priorities of Congress.

Furthermore, the data support the general argument that the degree of a state's over- or under-representation was largely unrelated to the needs it faced as a consequence of the pandemic. Clemens and Veuger's (2021a) analysis of the small-state advantage shows that it is more or less orthogonal to an extensive set of proxies for dimensions of such needs, including states' revenue shocks, economic shocks, the size of their public sector, and acreage of federal land.[7] They show further that the over-representation of small states is less correlated with political partisanship than is commonly assumed.

IV Results

In this section we use our instrumental-variable estimator to analyze the extent to which fiscal assistance to state and local governments helped to expand COVID-19 testing and vaccination programs through the crisis.

Federal COVID-19 Relief, Vaccination, and Testing

Table 2 presents our estimates of the effects of federal aid to state and local governments on state level vaccination and testing programs. Columns 3 and 7 present estimates of our baseline 2SLS specification using data from March 2022 for vaccines and tests, respectively.

In Column 3, the coefficient on total aid per capita implies that an additional $1,000 per resident translated into just under 1,200 extra doses of the vaccine being delivered per 100,000 people. This estimate is statistically indistinguishable from zero.[8] The result in Column 7 implies that by March 2022 residents had received 55,850 additional tests per 100,000 people for every additional $1,000 in COVID-19 relief aid, or roughly one additional test for every two people. This estimate is significant at the 95% confidence level.

Columns 1 and 5 of Table 2 present the OLS estimates of equation (1). The coefficient on aid per resident is substantially greater than the 2SLS estimate, indicating that the OLS estimate is biased in a positive direction. Columns 2 and 6 present the baseline first-stage estimates of equation (2a).

Our baseline estimates of equation (2b) may be biased if our instrument, representatives per million residents, is correlated with state characteristics that shaped states' budgetary positions or attitudes towards COVID-19 tests and vaccines. Potentially relevant characteristics might include access to

[7] See Appendix Table 4, largely mirroring results from Clemens, Hoxie, and Veuger (2022), for further exogeneity tests on our first stage.

[8] According to the New York Times (2022), by March 2022 30% of the US population was boosted, 36% was fully vaccinated, 11% was partially vaccinated, and 23% was not vaccinated. We assume that full vaccination was equivalent to two doses of the vaccine and that three doses were sufficient to be boosted. This would mean that the average American has received roughly 1.73 doses of the vaccine. Based on our point estimate, $1,000 in additional aid is thus associated with vaccinating 674 more people per 100,000 than otherwise would have been. Appendix Table 2 reports estimates in which the outcome variable is the percentage of the population fully vaccinated. As in Table 2, the estimates are statistically indistinguishable from 0.

financial markets, cultural attitudes towards the pandemic, or the stringency of government policies intended to help contain the spread of COVID-19. We present additional results to investigate whether our estimates are robust to the inclusion of controls for such factors.

Columns 4 and 8 of Table 2 show estimates with additional sets of controls to account for such variables as variations in voluntary and involuntary social distancing and eligibility for Federal Reserve lending.[9] For vaccinations, the point estimate is now negative, has become even smaller in absolute terms, and remains statistically indistinguishable from zero. Our estimate for the impact on the rollout of tests is very little affected and now implies that an increase in federal aid of $1,000 per resident translated into 57,722 additional tests per 100,000 people. We continue to be able to confidently reject the null hypothesis of no effect on tests.

We next consider estimates in which we do not weight states according to population. Weighted and unweighted specifications have different interpretations. Unweighted specifications are more appropriately interpreted as shedding light on the experience of a typical state, while population-weighted estimates are more appropriately interpreted as shedding light on the typical impact of each dollar spent. In a discussion of Chodorow-Reich's (2020) analyses of federal fiscal assistance from the ARRA, for example, Ramey (2019) notes that while unweighted regressions are satisfactory to analyze cross-state differences, weighted regressions are needed to comment on the overarching impact of federal stimulus. As shown in Appendix Table 3, unweighted regressions yield estimates that are qualitatively indistinguishable from weighted estimates in our setting. In the unweighted regressions, the coefficients for testing are estimated with substantially greater precision.

Federal COVID-19 Relief and Distributional Effects

Beyond vaccinating the general population, a secondary goal of federal COVID-19 relief aid was to ensure equitable access to medical care and vaccines for disadvantaged groups. The Federal Emergency Management Agency reiterated this commitment in March 2021 as access to vaccines expanded across the country (FEMA, 2021). Even if additional funding did not raise aggregate vaccination rates, it may still have helped meet policymakers' goals by closing racial and socioeconomic gaps in vaccination rates.

Table 3 presents estimates of the same baseline specification seen in Columns 3 and 7 of Table 2, but replaces the overall vaccination or testing rate with the difference in vaccination rates (in percentage points) between groups of different socioeconomic status in March 2022. For example, the dependent variable in Column 1 is calculated as the vaccination rate for white Americans in state s minus the vaccination rate for African-Americans. A negative coefficient on federal aid per capita represents an increase in the equitability of vaccine distribution.

We find potentially meaningful effects, with the sign intended by policymakers, on three of these seven disparities: the white-black gap, the old-young gap, and the college-high school gap. While the former two are only statistically significant at the 90% confidence level, the reduction in the college-high school gap is statistically significant at the 99% confidence level. The estimate suggests that an additional

[9] The additional sets of controls are described in detail in Appendix Table 1.

$1,000 in federal funding per resident reduced the disparity in vaccination rates between college- and high school-educated adults by 5.4 percentage points.

Additional Robustness Checks

We next subject estimates for our full set of outcomes to a set of robustness checks that gauges the potential relevance of the covariates we include, of the functional form in which we include those covariates, and the potential role of either the largest or smallest states in driving our results. In Appendix Table 5, we replace the log of states' populations with an indicator for whether a state was "small" in the sense that it benefited from the CARES Act's floor function. In Appendix Table 6 we drop the 3 (Panel A) or 5 (Panel B) most and least represented states from the sample. In Appendix Table 7 we augment the control set to include cubic polynomials in each of the covariates in the baseline control set other than the log of each state's population. In Appendix Tables 8 and 9 we present estimates in which we reduce the set of control variables. In Panel A of Appendix Table 8, the sole control variable is the log of each state's population. In Panel B of Table 8, the controls include the log of each state's population and Trump's vote share in the 2020 election. Finally, in Appendix Table 9 the controls include the log of each state's population, Trump's vote share, and our control for each state's pre-pandemic growth in per capita GDP. These last three sets of specifications exclude all COVID-19 case- and death-related variables, which is relevant for addressing any lingering concerns about biases due to the inclusion of potentially endogenous control variables.

Across this set of specifications, the estimated effect of federal aid on overall vaccine administration fluctuates non-trivially, but tends to remain statistically indistinguishable from zero. The point estimate is larger in specifications that exclude either the 3 or 5 least and most represented states from the sample, as well as in specifications that exclude the control for Trump's vote share in the 2020 election. We interpret this set of results as failing to detect systematic evidence of an effect of federal relief dollars on overall vaccination rates. A key caveat to this finding is that our robustness analysis reinforces the conclusion that we are unable to rule out non-trivial effects.

Throughout the analysis, our estimate of the effect of federal aid on COVID-19 testing rates is consistently our strongest finding. The estimated effect of federal aid on rates of testing is positive in all of our robustness checks, with an average point estimate that is modestly larger in magnitude than our baseline estimate. All but two of the estimated coefficients for the effect of federal aid on testing rates are statistically distinguishable from 0 at the 95% confidence level.

Across our analyses of various dimensions of inequity in vaccine distribution, we find consistent evidence that federal dollars reduced inequity with respect to education. Our estimate of the effect of federal aid on the difference between the vaccination rates of college-educated relative to high school-educated individuals is negative in all of our robustness checks and statistically distinguishable from 0 in all but one of them. The average coefficient across the robustness checks implies a modestly larger effect than our baseline estimate. Several estimates are suggestive of a reduction in the white-black vaccination gap, though this estimate is rarely statistically distinguishable from 0. For other dimensions of vaccine inequity, our point estimates tend to change sign across specifications and are rarely statistically distinguishable from 0.

Finally, we conduct a placebo test to provide additional evidence on the plausibility of the exclusion restriction. The last row of Table 2 shows the p-value for the coefficient on federal aid per capita from estimating equation (2b) with data on testing from March 2020 (our "pre-aid" period).[10] The insignificant pre-period coefficient suggests testing capacity was not strongly related with congressional representation prior to the arrival of federal fiscal assistance. A test of this sort is not possible in the case of vaccines since COVID-19 vaccines did not receive emergency use authorization until December 2020, well into our sample period.

Evolution of Public Health Effects over the Course of the Pandemic

Timely delivery of funds has been a central issue for the federal government's COVID-19 response. As there is a delay between the announcement of funding allocations, the disbursement to state treasuries, and the actual spending by state and local governments, it may be useful to examine the coefficient on federal aid per capita over the course of the pandemic in order to identify any trends over time. Further, initial advantages for some states may converge over time as strategies to handle the pandemic and personal attitudes evolve. These timing components are important aspects of the overall policy landscape.

Figure 1 presents the coefficient on total federal aid per capita in thousands of dollars, with equation (2b) estimated month by month. Panel A presents regressions using the cumulative number of vaccines administered per 100,000 people. Results for the months immediately following the authorization of the Pfizer and Moderna vaccines identify a small but significant channel from federal aid to vaccination progress. In this period, states prioritized highly-targeted programs towards healthcare professionals, essential workers, and the elderly. However, as vaccinations were made available to the general public, the effect plateaued and faded in significance, implying that there has been a convergence of vaccination rates across states that benefited from different levels of federal funding.

On the other hand, Panel B shows a steady expansion of the coefficient on federal aid for the cumulative number of tests administered. When tests were scarce in early 2020, additional aid had relatively little effect on testing capacity. As tests became more widely available and states established their testing regimes, these advantages, rooted in federal funding, grew.

V Discussion

Our analysis has assessed whether federal fiscal assistance played a role in advancing goals associated with population testing and the administration of vaccines. We find that federal dollars had a modest, if any, impact on the pace of vaccine rollouts, a substantial impact on the volume of tests administered, and may have improved the equitability of vaccine administration.

Our analysis provides one piece of the puzzle for assessing federal fiscal assistance. Other dimensions include the effects of fiscal assistance on economic activity, as well as the effects of aid on other more targeted goals like the opening of schools and the educational progress of children. In a complementary

[10] The FFCRA was not signed into law until March 18, while the Cares Act became law on March 27.

paper, Clemens, Hoxie, and Veuger (2022) consider the effects of fiscal assistance as stimulus and find that effect to be modest. The effects of fiscal assistance on education and law enforcement outcomes are important subjects for future work.

The context for our findings can help to shed additional light on their implications. A first point of interest is that, as discussed in Section II, federal assistance included substantial dollars targeted directly at the testing and vaccination outcomes we analyze. Our findings suggest that these targeted dollars may have been insufficient to meet demand for tests, as we estimate that general fiscal assistance dollars contributed substantially to the number of tests delivered.

The opposite is true for vaccines, for which we estimate that general fiscal assistance had little impact on total delivery, which suggests that the dollars earmarked towards the acquisition and delivery of vaccines, combined with private-sector efforts, may have been more than sufficient. While higher overall vaccination rates would certainly have been preferable from a public-health perspective, the evidence suggests that state and local government budgetary pressures were not a leading factor in holding back further progress towards this objective. On the other hand, our results on metrics related the equitability of vaccine distribution suggest that additional fiscal assistance dollars were useful for reaching populations with possible socioeconomic barriers to vaccine uptake.

As a concluding caveat, we emphasize that our results are more useful for shedding light on the question of how state and local governments have made use of their general fiscal assistance allocations than on the question of whether federal fiscal assistance had high or low value on the margin. A welfare evaluation is beyond the scope of our analysis. Instead, we are able to shed light on the extent to which federal fiscal assistance dollars moved metrics that have been targeted by policymakers over the course of the pandemic.

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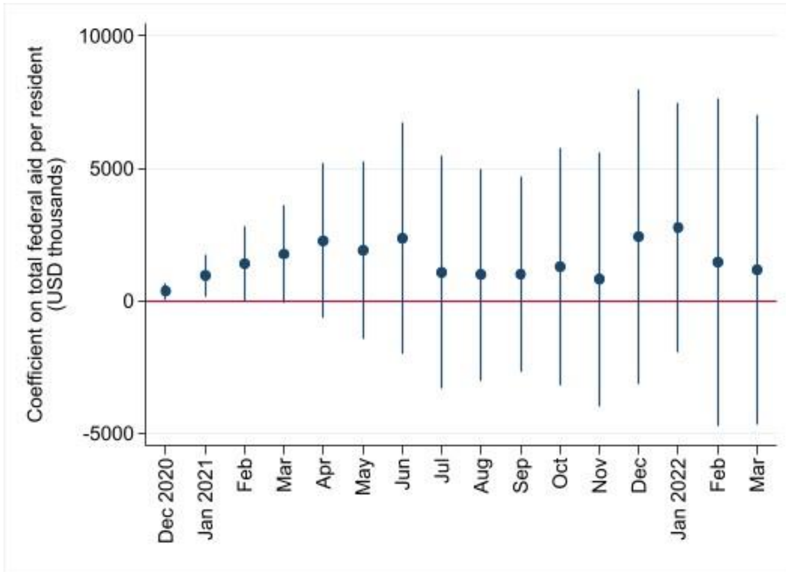
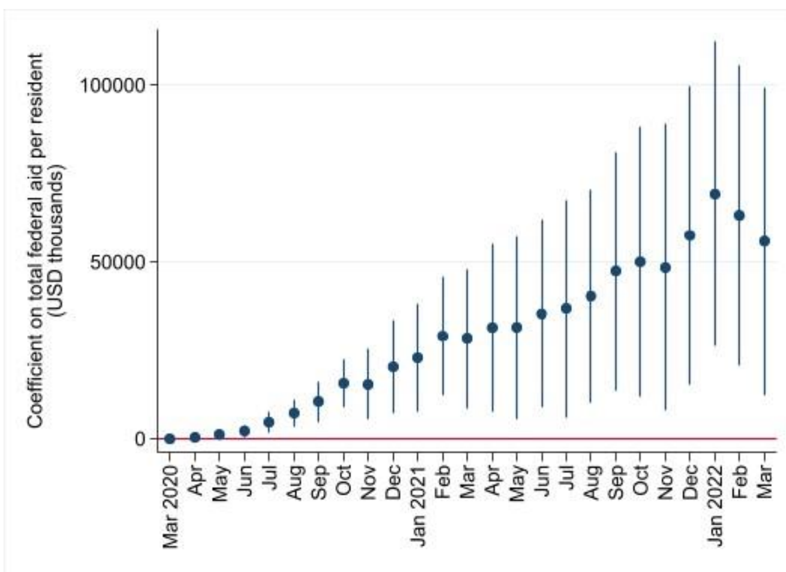
Figure 1: Local-Projection Impulse Response of Vaccinations and Testing to COVID-19 Relief Aid

Panel A: Total Federal Aid to State and Local Governments per Resident and Total Vaccinations Administered per 100,000



Panel B: Total Federal Aid to State and Local Governments per Resident and Total COVID-19 Tests Administered per 100,000



Note: This figure displays the coefficient (and the 95% confidence interval) on predicted total federal aid to state and local governments per resident (USD thousands) in the regression outlined in equation (2b):

$$\frac{V_{s,m,y}}{(Pop_{s,y_{2020}}/100{,}000)} = \alpha + \beta_1 \frac{\widehat{TotalAid}_s}{Pop_{s,y_{2020}}} + \beta_2 X_{s,m,y} + u_{s,m,y},$$

where *m* and *y* iterate over the month-year pairs from March 2020 through March 2022. $\frac{TotalAid_s}{Pop_{s,y_{2020}}}$ is the total amount of federal aid allocated to a state per resident in USD thousands since the pandemic began. $\frac{V_{s,m,y}}{(Pop_{s,y_{2020}}/100{,}000)}$ is the cumulative number of COVID-19 vaccines or tests administered up to month m of year y scaled per 100,000 people residing in state s. Included is a set of state-level controls $X_{s,m,y}$. This includes the log of 2020 official Census population, the share of votes won by Donald Trump in 2020, the change in state GDP per capita from Q4 2018 to Q4 2019, and the number of cumulative and new COVID-19 cases and deaths per 100,000 in the previous month. Observations are weighted by state population and standard errors (in parentheses) are clustered by state. Table 2 shows regressions run using data from March 2022. The figure uses data from the Committee for a Responsible Federal Budget (2021), US Federal Transit Administration (2021a, 2021b), US Census Bureau (2021), Chidambaram and Musumeci (2021), Medicaid and Chip Payment Access Commission (2021), US Office of Elementary and Secondary Education (2021), Lewis et al. (2021), Johns Hopkins University Centers for Civic Impact (2022), CDC (2020), MIT Election and Data Science Lab (2017), US Bureau of Economic Analysis (2022), Dong, Du, and Gardner (2020), and US Department of the Treasury (2021a).

Table 1: Summary Statistics

	N	Mean	Std. Dev.	Min	Max
Total Aid to State and Local Governments per Resident (USD Thousands)	50	2.83	0.94	1.80	5.93
Senators and Representatives per Million Residents	50	2.14	0.893	1.30	5.19
Total Vaccinations per 100,000 (March 2022)	50	164,741	24,530	125,706	218,039
Total Tests Administered per 100,000 (March 2022)	48	267,034	13,700	60,476	695,553
Log of 2020 State Population	50	15.22	1.02	13.27	17.49
Share of Votes Won by Donald Trump in 2020 Election	50	0.50	0.10	0.30	0.70
Change in Real State GDP per Capita from 2018 to 2019	50	1,162.88	773.44	-768.45	2,812.25
New COVID-19 Deaths per 100,000 (February 2022)	50	18.78	6.74	9.02	37.22
Total COVID-19 Deaths per 100,000 (February 2022)	50	277.02	78.042	94.81	405.79
New COVID-19 Cases per 100,000 (February 2022)	50	1,380.63	662.97	411.32	3,845.90
Total COVID-19 Cases per 100,000 (February 2022)	50	24,310.94	3,863.75	16,360.44	33,669.15
Share of Population in City Eligible for Municipal Liquidity Facility	50	0.42	0.19	0.15	0.84
Change in State and Local Employment per Capita from Dec 2018 to Dec 2019 (QCEW)	50	0.00040	0.0005	-0.0008	0.002
Change in Private Employment per Capita from Dec 2018 to Dec 2019 (QCEW)	50	0.0039	0.0037	-0.007	0.01
March 2020 Average Oxford Stringency Index Level	50	0.43	0.05	0.32	0.55
March 2022 Oxford Stringency Index Level	50	0.32	0.06	0.25	0.57
Percent Change in Retail Mobility Relative to February 2020 Baseline (February 2022)	50	-10.39	5.22	-22.68	-1.25
White Minus Black Vaccination Rate (March 2022)	50	2.59	9.49	-12.50	38.02
White Minus Hispanic Vaccination Rate (March 2022)	50	1.08	8.24	-19.26	24.62
White Minus Asian Vaccination Rate (March 2022)	50	-9.32	10.33	-23.74	30.98
$200,000+ minus <$25,000 Household Income Vaccination Rate (March 2022)	50	13.12	7.78	-9.71	29.28
College Degree minus High School Degree Vaccination Rate (March 2022)	50	14.95	5.00	6.66	29.84
Aged 65+ minus 40-54 Vaccination Rate (March 2022)	50	11.51	5.53	0.98	28.16
Aged 65+ minus 18-24 Vaccination Rate (March 2022)	50	14.88	12.46	-6.94	56.07
Percentage of population fully vaccinated (March 2022)	50	64.03	8.874	50.7	81.6
Tax Shortfall per Capita	50	972.67	380.65	621.60	2,565.08
Average Q4 2020 Unemployment per Capita	50	0.03	0.01	0.02	0.06
Percent Change in Personal Income Q4 2019 to Q4 2020	50	4.66	1.93	-0.06	10.61

Total State and Local Spending per Capita	50	11,569.09	2,463.31	8,306.06	20,373.53
Acres of Federal Land per Capita	50	9.36	43.16	0.003	302.50
Log Population Density	50	4.56	1.40	0.25	7.14
Total COVID Cases per 100K (March 2020)	50	42.41	62.31	8.88	392.27
Total COVID Deaths per 100K (March 2020)	50	1.07	2.17	0	14.31

Note: This table uses data from the Committee for a Responsible Federal Budget (2021), US Federal Transit Administration (2021a, 2021b), US Census Bureau (2021, 2022), Chidambaram and Musumeci (2021), Medicaid and Chip Payment Access Commission (2021), US Office of Elementary and Secondary Education (2021), Lewis et al. (2021), US Bureau of Labor Statistics (2022a, 2022b), US Department of the Treasury (2021a, 2021b), Federal Reserve Board (2021), Hale et al. (2021), Google LLC (2021), MIT Election and Data Science Lab (2017, 2022), Dong, Du, and Gardner (2020), Johns Hopkins University Centers for Civic Impact (2022), CDC (2020), Whitaker (2020), National Association of State Budget Officers (2021), Vincent and Hanson (2020), and the US Bureau of Economic Analysis (2022).

Table 2: Vaccinations and Testing Impact of COVID-19 Relief Aid (March 2022)

	Total Vaccinations Administered per 100K				Total Tests Administered per 100K			
	OLS	First Stage	Baseline	Robust	OLS	First Stage	Baseline	Robust
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total Aid per Resident (USD thousands)	3,027		1,166	-995.8	81,028***		55,850**	57,722***
	(4,228)		(2,989)	(3,742)	(22,319)		(22,263)	(22,279)
Reps per million		1.217***				1.224***		
		(0.117)				(0.121)		
Log(Population)	-2,960	0.195***	-3,498	-4,303	11,426	0.202***	3,898	-8,013
	(2,599)	(0.0640)	(2,701)	(2,949)	(15,965)	(0.0692)	(15,903)	(11,611)
Trump vote share	-206,547***	-2.638***	-212,628***	-192,179***	-1.069e+06***	-2.645***	-1.15e+06***	-737,291***
	(24,636)	(0.489)	(21,574)	(29,769)	(215,991)	(0.496)	(216,966)	(226,934)
Change in Real GDP per Capita (2018 - 2019)	0.632	9.80e-05*	0.902	4.490	-24.31	9.17e-05	-20.33	-32.81
	(2.326)	(5.40e-05)	(2.142)	(3.624)	(14.93)	(5.85e-05)	(14.82)	(25.29)
New COVID-19 deaths per 100K, previous month	107.7	-0.0225**	31.03	378.7	-141.0	-0.0225**	-1,145	985.8
	(546.6)	(0.00863)	(534.9)	(533.7)	(2,209)	(0.00889)	(2,064)	(2,171)
Total COVID-19 deaths per 100K, previous month	-19.57	0.00466***	-9.556	-17.21	-205.3	0.00469***	-78.41	-153.7
	(48.46)	(0.00103)	(45.27)	(43.51)	(309.8)	(0.00113)	(317.6)	(286.7)
New COVID-19 cases per 100K, previous month	-2.690	5.59e-05	-2.125	-4.496	-6.225	5.66e-05	0.650	23.53
	(5.025)	(6.77e-05)	(4.470)	(4.842)	(21.91)	(7.11e-05)	(19.22)	(20.04)
Total COVID-19 cases per 100K, previous month	0.723	-1.81e-05	0.703	0.496	22.58***	-1.70e-05	22.34***	18.13***
	(0.752)	(1.47e-05)	(0.682)	(0.582)	(3.598)	(1.73e-05)	(3.133)	(3.517)
Robustness controls	N	N	N	Y	N	N	N	Y

Dep. Var Mean	164,741	2.83	164,741	165,521	267,034	2.85	267,034	270,056
Observations	50	50	50	48	48	48	48	46
R^2	0.775	0.815	0.774	0.835	0.792	0.813	0.787	0.848
First-Stage F-Statistic	N/A	N/A	108.78	84.05	N/A	N/A	102.44	75.18
P-value on Test for Pre-Period	-	-	-	-	0.201	-	0.608	0.165

Note: The table uses data from the Committee for a Responsible Federal Budget (2021), US Federal Transit Administration (2021a, 2021b), US Census Bureau (2021), Chidambaram and Musumeci (2021), Medicaid and Chip Payment Access Commission (2021), US Office of Elementary and Secondary Education (2021), Lewis et al. (2021), Johns Hopkins University Centers for Civic Impact (2022), CDC (2020), MIT Election and Data Science Lab (2017), US Bureau of Economic Analysis (2022), Dong, Du, and Gardner (2020), US Department of the Treasury (2021a, 2021b), Federal Reserve Board (2021), Google LLC (2021), US Bureau of Labor Statistics (2022b), and Hale et al. (2021) to estimate the following equations:

$$\frac{TotalAid_s}{Pop_{s,y_{2020}}} = \alpha + \beta_1\, RepsPerMillion_s + \beta_2 X_{s,m,y} + \varepsilon_{s,m,y}, \qquad (1)$$

$$\frac{V_{s,m,y}}{(Pop_{s,y_{2020}}/100{,}000)} = \alpha + \beta_1 \frac{\widehat{TotalAid_s}}{Pop_{s,y_{2020}}} + \beta_2 X_{s,m,y} + u_{s,m,y}. \qquad (2)$$

where regressions are estimated only for March 2022. $\frac{TotalAid_s}{Pop_{s,y_{2020}}}$ is the total amount of federal aid allocated to a state per resident in USD thousands since the pandemic began. $\frac{V_{s,m,y}}{(Pop_{s,y_{2020}}/100{,}000)}$ is the cumulative number of COVID-19 vaccines or tests administered up to month m of year y scaled per 100,000 people residing in state s. Included is a set of state-level controls $X_{s,m,y}$. This includes the log of 2020 official Census population, the share of votes won by Donald Trump in 2020, the change in state GDP per capita from Q4 2018 to Q4 2019, and the number of cumulative and new COVID-19 cases and deaths per 100,000 in the previous month. Observations are weighted by state population and standard errors (in parentheses) are clustered by state. Columns 1 and 5 present OLS results of equation (2); Columns 2 and 6 present the first-stage results of equation (1); Columns 3 and 7 present baseline second-stage results of equation (2); Columns 4 and 8 present equation (2) with added robustness controls. Robustness controls include the share of a state's population living in a town eligible for financing through the MLF, the change in state and local and private employment per capita (QCEW) between December 2018 and December 2019, the March 2020 and contemporaneous month averages of a state's Oxford Stringency Index, and the change in retail mobility in the previous month relative to pre-pandemic baseline. The p-value of the pre-pandemic (March 2020) trend coefficients on total aid per capita are presented as indicators of the robustness of the empirical strategy. Pre-period regressions are not available for vaccines as money had already been delivered to states prior to their introduction.

Table 3: COVID-19 Relief Aid and Vaccine Disparities (March 2022)

	White minus Black Vaccination Rate (%)	White minus Hispanic Vaccination Rate (%)	White minus Asian Vaccination Rate (%)	$200,000+ minus <$25,000 Household Income Vaccination Rate (%)	College Degree minus High School Degree Vaccination Rate (%)	Aged 65+ minus 40-54 Vaccination Rate (%)	Aged 65+ minus 18-24 Vaccination Rate (%)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Total Aid per Capita (USD thousands)	-4.452*	-0.962	1.478	-0.941	-5.351***	-1.949	-7.246*
	(2.419)	(2.607)	(3.204)	(2.432)	(2.017)	(1.224)	(3.886)
Log(Population)	-2.687*	-2.215	-1.695	0.168	-2.571***	-2.327***	-3.059
	(1.447)	(1.659)	(1.230)	(1.211)	(0.856)	(0.590)	(2.645)
Share of 2020 votes cast for Donald Trump	-28.00	-5.311	-49.58***	20.90	-1.985	25.84***	29.68
	(17.19)	(31.25)	(18.53)	(15.62)	(12.09)	(6.853)	(29.88)
Change in Real GDP per Capita (2018 - 2019)	0.00211	0.000948	-0.000359	-0.00149	0.00109	0.000321	0.000915
	(0.00133)	(0.00206)	(0.00091)	(0.00124)	(0.00080)	(0.00084)	(0.00241)
New COVID-19 deaths per 100K, previous month	-0.620***	-0.577	0.416	0.245	-0.0767	0.0164	-0.364
	(0.235)	(0.376)	(0.308)	(0.228)	(0.168)	(0.126)	(0.373)
Total COVID-19 deaths per 100K, previous month	0.0659**	0.0286	-0.0307	-0.0277	0.0127	0.0241*	0.0690*
	(0.0280)	(0.0245)	(0.0261)	(0.0205)	(0.0196)	(0.0123)	(0.0391)
New COVID-19 cases per 100K, previous month	0.00538	0.00105	-0.00263	-0.00136	0.00168	0.000230	0.00303
	(0.00333)	(0.00273)	(0.00297)	(0.00201)	(0.00159)	(0.00106)	(0.00371)
Total COVID-19 cases per 100K, previous month	-0.000316	-0.000296	0.00109***	-0.000473	0.000153	-0.000114	-0.000631
	(0.00044)	(0.00058)	(0.00029)	(0.00037)	(0.00026)	(0.00016)	(0.00073)
Dep. Var Mean	2.59	1.08	-9.32	13.12	14.95	11.51	14.88
Observations	50	50	50	50	50	50	50
R^2	0.180	0.105	0.273	0.268	0.307	0.714	0.274
First-Stage F- Statistic	108.77	108.77	108.77	108.77	108.77	108.77	108.77

Note: The table uses data from the Committee for a Responsible Federal Budget (2021), US Federal Transit Administration (2021a, 2021b), US Census Bureau (2021, 2022), Chidambaram and Musumeci (2021), Medicaid and Chip Payment Access Commission (2021), US Office of Elementary and Secondary Education (2021), Lewis et al. (2021), MIT Election and Data Science Lab (2017), US Bureau of Economic Analysis (2022), Dong, Du, and Gardner (2020), and the US Department of the Treasury (2021a, 2021b) to estimate the following equations:

$$\frac{TotalAid_s}{Pop_{s,y_{2020}}} = \alpha + \beta_1\ RepsPerMillion_s + \beta_2 X_{s,m,y}\ + \varepsilon_{s,m,y} \tag{1}$$

$$V_{s,m,y} - W_{s,m,y} = \alpha + \beta_1 \frac{\widehat{TotalAid_s}}{Pop_{s,y_{2020}}} + \beta_2 X_{s,m,y} + u_{s,m,y}, \tag{2}$$

where regressions are estimated only for March 2022. $\frac{TotalAid_s}{Pop_{s,y_{2020}}}$ is the total amount of federal aid allocated to a state per resident in USD thousands since the pandemic began. $V_{s,m,y}$ and $W_{s,m,y}$ are the vaccination rates for high-socioeconomic status and low-socioeconomic status groups for a given category, respectively, in state s. Included is a set of state-level controls $X_{s,m,y}$. This includes the log of 2020 official Census population, the share of votes won by Donald Trump in 2020, the change in state GDP per capita from Q4 2018 to Q4 2019, and the number of cumulative and new COVID-19 cases and deaths per 100,000 in the previous month. Observations are weighted by state population and standard errors (in parentheses) are clustered by state. Columns 1 through 3 present the vaccination gaps between white Americans and Black, Hispanic, and Asian Americans; Column 4 presents the gap between individuals with a household income over $200,000 and less than $25,000; Column 5 presents the gap between those with a bachelor's degree or higher and those with only a high school diploma; Columns 6 and 7 present the gap between the elderly (65+) and the middle-aged (40-54) and young (18-24). Pre-period regressions are not available for vaccines as money had already been delivered to states prior their introduction.

Appendix Table 1: Variable Descriptions and Sets of Control Variables

Variable	Description	Source
Total Aid to State and Local Governments per Resident (USD Thousands)	Funds appropriated to each state by Congress in COVID-19 relief bills divided by the 2020 state population, in nominal USD thousands.	Committee for a Responsible Federal Budget (2021); US Federal Transit Administration (2021a, 2021b); US Census Bureau (2021); Chidambaram and Musumeci (2021); Medicaid and Chip Payment Access Commission (2021); US Department of the Treasury (2021a, 2021b); US Office of Elementary and Secondary Education (2021)
Senators and Representatives per Million Residents	Number of House plus the number of Senate seats per 1,000,000 people in each state, according to the 2020 estimate of population and Congressional seats.	US Census Bureau (2021); Lewis et al. (2021)
Total Vaccinations per 100,000	Total number of COVID-19 vaccines administered in the US per 100,000 people in each state.	CDC (2020)
Total Tests Administered per 100,000	Total number of COVID-19 tests administered in the US per 100,000 people in each state.	Johns Hopkins University Centers for Civic Impact (2022), US Census Bureau (2021)
Log of 2020 State Population	The natural logarithm of 2020 state population	US Census Bureau (2021)
Share of Votes Won by Donald Trump in 2020 Election	The percentage of votes cast in a state for Donald Trump in the 2020 US Presidential election. Proxy for attitudes toward COVID-19.	MIT Election and Data Science Lab (2017)
Change in Real State GDP per Capita from 2018 to 2019	The arithmetic change in real gross state product per capita from Q4 2018 to Q4 2019, in 2012 US dollars.	US Bureau of Economic Analysis (2022)
New COVID-19 Cases/Deaths per 100,000 (Previous Month)	The number of reported COVID-19 cases and deaths, divided by state population in hundred-thousands.	Dong, Du, and Gardner (2020)
Total COVID-19 Cases/Deaths per 100,000 (Previous Month)	The number of cumulative COVID-19 cases and deaths, divided by state population in hundred-thousands.	Dong, Du, and Gardner (2020)
Share of Population in City Eligible for Municipal Liquidity Facility	The share of a state's 2020 population living in a city or town deemed eligible for financing through the Federal Reserve's Municipal Liquidity Facility. Access to the Federal Reserve's MLF has been described as a major contributor to settling municipal bond markets during the coronavirus's initial outbreak (Haughwout, Hyman, and Shachar, 2021).	US Census Bureau (2021); Federal Reserve Board (2021)
Change in State and Local Employment per Capita from Dec 2018 to Dec 2019	The arithmetic difference in state and local government employment between December 2018 and December 2019, divided by the 2020 state population, as measured by the QCEW.	US Bureau of Labor Statistics (2022b); US Census Bureau (2021)
Change in Private Employment per	The arithmetic difference in private employment between December 2018 and 2019, divided by	US Bureau of Labor Statistics (2022b); US Census Bureau (2021)

Capita from Dec 2018 to Dec 2019	the 2020 state population, as measured by the QCEW.	
March 2020 Average Oxford Stringency Index Level	The monthly average level of a state's Oxford Stringency Index during March 2020, divided by 100. This variable ranges from 0 (no restrictions) to 100 (the highest possible level of restrictions across all eight dimensions). In all regressions, OSI is rescaled by dividing by 100 so that it ranges from 0 to 1.	Hale et al. (2021)
Contemporaneous Oxford Stringency Index Level	The monthly average level of a state's Oxford Stringency Index, divided by 100.	Hale et al. (2021)
Percent Change in Retail Mobility Relative to February 2020 Baseline (Previous Month)	Monthly-average percentage change in foot traffic in retail and recreation areas relative to the median level of traffic during the January 3, 2020 to February 6, 2020 baseline period.	Google LLC (2021)
White Minus Black Vaccination Rate (%)	Percentage of white survey respondents minus the percentage of Black respondents with at least one vaccination, as surveyed by the US Census Bureau.	US Census Bureau (2022)
White Minus Hispanic Vaccination Rate (%)	Percentage of white survey respondents minus the percentage of Hispanic respondents with at least one vaccination, as surveyed by the US Census Bureau.	US Census Bureau (2022)
White Minus Asian Vaccination Rate (March 2022)	Percentage of white survey respondents minus the percentage of Asian respondents with at least one vaccination, as surveyed by the US Census Bureau.	US Census Bureau (2022)
$200,000+ minus <$25,000 Household Income Vaccination Rate (March 2022)	Percentage of survey respondents with a household income of $200,000 or greater minus the percentage of respondents with a household income less than $25,000 with at least one vaccination, as surveyed by the US Census Bureau.	US Census Bureau (2022)
College Degree minus High School Degree Vaccination Rate (March 2022)	Percentage of survey respondents with a college degree or greater minus the percentage of respondents with only a high school degree with at least one vaccination, as measured by the US Census Bureau.	US Census Bureau (2022)
Aged 65+ minus 40-54 Vaccination Rate (March 2022)	Percentage of respondents aged 65 or older minus the percentage of respondents aged 40 through 54 with at least one vaccination, as measured by the US Census Bureau.	US Census Bureau (2022)
Aged 65+ minus 18-24 Vaccination Rate (March 2022)	Percentage of respondents aged 65 or older minus the percentage of respondents aged 18 through 24 with at least one vaccination, as measured by the US Census Bureau.	US Census Bureau (2022)
Percentage of population fully vaccinated (March 2022)	Percentage of US population that has received at least two doses of a Pfizer/Moderna COVID-19 vaccine or one dose of the Johnson and Johnson vaccine.	CDC (2020)

Tax Shortfall per Capita	Federal Reserve Bank of Cleveland estimates of state and local revenue shortfalls due to the pandemic, divided by 2020 state population.	Whitaker (2020); US Census Bureau (2021)
Average Q4 2020 Unemployment per Capita	Average number of unemployed persons during Q4 2020, divided by the 2020 state population.	US Bureau of Labor Statistics (2022a); US Census Bureau (2021)
Percent Change in Personal Income Q4 2019 to Q4 2020	Percent change in real personal income per capita from Q4 2019 to Q4 2020.	US Bureau of Economic Analysis (2022)
Total State and Local Spending per Capita	Total state and local government expenditures divided by 2020 state population.	National Association of State Budget Officers (2021); US Census Bureau (2021)
Acres of Federal Land per Capita	Acres of federally-owned land, divided by 2020 state population.	Vincent and Hanson (2020)
Log Population Density	2020 state population divided by land area (in square miles).	Vincent and Hanson (2020); US Census Bureau (2021)

Appendix Table 2: Vaccinations Impact of COVID-19 Relief Aid (March 2022)

	Percentage of Population Fully Vaccinated (%)			
	OLS	First Stage	Baseline	Robust
	(1)	(2)	(3)	(4)
Total Aid per Resident (USD thousands)	1.260		0.669	-0.558
	(1.584)		(1.167)	(1.432)
Reps per million		1.217***		
		(0.117)		
Log(Population)	-0.949	0.195***	-1.120	-1.691
	(0.969)	(0.0640)	(1.025)	(1.126)
Trump vote share (%)	-73.79***	-2.638***	-75.72***	-68.43***
	(9.083)	(0.489)	(7.920)	(10.88)
Change in Real GDP per Capita (2018 - 2019	0.000124	9.80e-05*	0.000210	0.00131
	(0.000837)	(5.40e-05)	(0.000786)	(0.00132)
New COVID-19 deaths per 100K, previous month	-0.0103	-0.0225**	-0.0346	0.103
	(0.214)	(0.00863)	(0.208)	(0.206)
Total COVID-19 deaths per 100K, previous month	-0.00580	0.00466***	-0.00262	-0.00488
	(0.0199)	(0.00103)	(0.0185)	(0.0181)
New COVID-19 cases per 100K, previous month	-0.000834	5.59e-05	-0.000655	-0.00138
	(0.00197)	(6.77e-05)	(0.00175)	(0.00189)
Total COVID-19 cases per 100K, previous month	0.000242	-1.81e-05	0.000236	0.000133
	(0.000286)	(1.47e-05)	(0.000260)	(0.000225)
Robustness controls	N	N	N	Y
Dep. Var. Mean	64.03	2.83	64.03	64.33
Observations	50	50	50	48
R^2	0.770	0.815	0.770	0.826
First-Stage F-Statistic	N/A	N/A	108.78	84.05
P-value on Test for Pre-Trends	-	-	-	-

Note: The table uses data from the Committee for a Responsible Federal Budget (2021), US Federal Transit Administration (2021a, 2021b), US Census Bureau (2021), Chidambaram and Musumeci (2021), Medicaid and Chip Payment Access Commission (2021), US Office of Elementary and Secondary Education (2021), Lewis et al. (2021), CDC (2020), MIT Election and Data Science Lab (2017), US Bureau of Economic Analysis (2022), Dong, Du, and Gardner (2020), US Department of the Treasury (2021a, 2021b), Federal Reserve Board (2021), Google LLC (2021), US Bureau of Labor Statistics (2022b), and Hale et al. (2021) to estimate the following equations:

$$\frac{TotalAid_s}{Pop_{s,y_{2020}}} = \alpha + \beta_1\ RepsPerMillion_s + \beta_2 X_{s,m,y} + \varepsilon_{s,m,y} \qquad (1)$$

$$V_{s,m,y} = \alpha + \beta_1 \frac{\widehat{TotalAid_s}}{Pop_{s,y_{2020}}} + \beta_2 X_{s,m,y} + u_{s,m,y}, \tag{2}$$

where regressions are estimated only for March 2022. $\frac{TotalAid_s}{Pop_{s,y_{2020}}}$ is the total amount of federal aid allocated to a state per resident in USD thousands since the pandemic began. $V_{s,m,y}$ is the percentage of the population in state s that is fully vaccinated (two doses of Pfizer or Moderna, or one dose of Janssen). Included is a set of state-level controls $X_{s,m,y}$. This includes the log of 2020 official Census population, the share of votes won by Donald Trump in 2020, the change in state GDP per capita from Q4 2018 to Q4 2019, and the number of cumulative and new COVID-19 cases and deaths per 100,000 in the previous month. Observations are weighted by state population and standard errors (in parentheses) are clustered by state. Column 1 presents OLS results of equation (2); Column 2 presents the first-stage results of equation (1); Column 3 presents baseline second-stage results of equation (2); Column 4 presents equation (2) with added robustness controls. Robustness controls include the share of a state's population living in a town eligible for financing through the MLF, the change in state and local and private employment per capita (QCEW) between December 2018 and December 2019, and the March 2020 and contemporaneous month averages of a state's Oxford Stringency Index, and the change in retail mobility in the previous month relative to pre-pandemic baseline. Pre-period regressions are not available for vaccines as money had already been delivered to states prior their introduction.

Appendix Table 3: Vaccinations and Testing Impact of COVID-19 Relief Aid (March 2022), Unweighted

	Total Vaccinations Administered per 100K				Total Tests Administered per 100K			
	OLS	First Stage	Baseline	Robust	OLS	First Stage	Baseline	Robust
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total Aid per Resident (USD thousands)	-326.6		1,247	-1,539	61,621***		63,376***	44,402***
	(1,993)		(1,872)	(2,446)	(13,559)		(10,909)	(14,053)
Reps per million		1.363***				1.364***		
		(0.0687)				(0.0686)		
Robustness controls	N	N	N	Y	N	N	N	Y
Dep. Var Mean	164,741	2.83	164,741	165,521	267,034	2.85	267,034	270,056
Observations	50	50	50	48	48	48	48	46
R^2	0.817	0.914	0.816	0.869	0.754	0.913	0.754	0.808
First-Stage F-Statistic	N/A	N/A	393.77	241.14	N/A	N/A	394.88	213.84
P-value on Test for Pre-Trends	-	-	-	-	0.042	-	0.203	0.636

Note: The table uses data from the Committee for a Responsible Federal Budget (2021), US Federal Transit Administration (2021a, 2021b), US Census Bureau (2021), Chidambaram and Musumeci (2021), Medicaid and Chip Payment Access Commission (2021), US Office of Elementary and Secondary Education (2021), Lewis et al. (2021), Johns Hopkins University Centers for Civic Impact (2022), CDC (2020), MIT Election and Data Science Lab (2017), US Bureau of Economic Analysis (2022), Dong, Du, and Gardner (2020), US Department of the Treasury (2021a, 2021b), Federal Reserve Board (2021), Google LLC (2021), US Bureau of Labor Statistics (2022b), and Hale et al. (2021) to estimate the following equations:

$$\frac{TotalAid_s}{Pop_{s,y_{2020}}} = \alpha + \beta_1\, RepsPerMillion_s + \beta_2 X_{s,m,y} + \varepsilon_{s,m,y} \quad (1)$$

$$\frac{V_{s,m,y}}{(Pop_{s,y_{2020}}/100{,}000)} = \alpha + \beta_1 \frac{\widehat{TotalAid}_s}{Pop_{s,y_{2020}}} + \beta_2 X_{s,m,y} + u_{s,m,y}, \quad (2)$$

where regressions are estimated only for March 2022. $\frac{TotalAid_s}{Pop_{s,y_{2020}}}$ is the total amount of federal aid allocated to a state per resident in USD thousands since the pandemic began. $\frac{V_{s,m,y}}{(Pop_{s,y_{2020}}/100{,}000)}$ is the cumulative number of COVID-19 vaccines or tests administered up to month m of year y scaled per 100,000 people residing in state s. Included is a set of state-level controls $X_{s,m,y}$. This includes the log of 2020 official Census population, the share of votes won by Donald Trump in 2020, the change in state GDP per capita from Q4 2018 to Q4 2019, and the number of cumulative and new COVID-19 cases and deaths per 100,000 in the previous month. Observations are *not* weighted by state population and standard errors (in parentheses) are clustered by state. Columns 1 and 5 present OLS results of equation (2); Columns 2 and 6 present the first-stage results of equation (1); Columns 3 and 7 present baseline second-stage results of equation (2); Columns 4 and 8 present equation (2) with added robustness controls. Robustness controls include the share of a state's population living in a town eligible for financing through the MLF, the change in state and local and private employment per capita (QCEW) between December 2018 and December 2019, and the March 2020 and contemporaneous month averages of a state's Oxford Stringency Index, and the change in retail mobility in the previous month relative to pre-pandemic baseline. The p-value of the pre-pandemic (March 2020) trend coefficients on total aid per capita are presented as indicators of the robustness of the empirical strategy. Pre-period regressions are not available for vaccines as money had already been delivered to states prior their introduction.

Appendix Table 4: Estimates of the Relationship Between Total State and Local Funds per Resident and Congressional Representation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Representatives and Senators per Million Residents	1,334***	995.1***	1,105***	1,367***	902.0***	1,286***	1,417***	1,366***	1,332***	1,149***
	(114.8)	(181.3)	(134.7)	(137.3)	(159.3)	(116.7)	(138.1)	(89.19)	(94.05)	(117.9)
Log(Population)	419.5***	262.0***	165.1	443.6***	153.5	411.2***	366.8***	390.5***	375.0***	206.8***
	(91.99)	(96.93)	(101.9)	(116.0)	(107.9)	(92.96)	(68.11)	(53.29)	(54.04)	(64.42)
Tax Shortfall per Capita		0.853**								-0.345
		(0.356)								(0.267)
Average Q4 2020 Unemployment per Capita			37,186***							19,992***
			(10,768)							(6,202)
Percent Change in Personal Income Q4 2019 to Q4 2020				-42.48						-18.40
				(50.56)						(19.32)
Total State and Local Spending per Capita					0.104***					0.0494
					(0.0257)					(0.0330)
Acres of Federal Land per Capita						2.574***				2.153*
						(0.751)				(1.222)
Log Population Density							166.6**			8.691
							(67.34)			(46.35)
Total COVID Cases per 100K (March 2020)								3.063***		2.645**
								(0.243)		(1.027)
Total COVID Deaths per 100K (March 2020)									79.62***	-19.92
									(6.348)	(29.12)
Political and Mobility Controls	N	N	N	N	N	N	N	N	N	N
COVID-19 Controls	N	N	N	N	N	N	N	N	N	N
Economic Controls	N	N	N	N	N	N	N	N	N	N
Observations	50	50	50	50	50	50	50	50	50	50
R^2	0.496	0.635	0.709	0.518	0.758	0.501	0.572	0.838	0.797	0.916
First-Stage F-Statistic	135.18	30.14	67.20	99.24	32.07	121.31	105.31	234.71	200.44	95.04

Note: This table uses data from the Committee for a Responsible Federal Budget (2021), US Federal Transit Administration (2021a, 2021b), US Census Bureau (2021), Chidambaram and Musumeci (2021), Medicaid and Chip Payment Access Commission (2021), US Office of Elementary and Secondary Education (2021), Lewis et al. (2021), US Bureau of Labor Statistics (2022a), US Department of the Treasury (2021a, 2021b), Federal Reserve Board (2021), Dong, Du, and Gardner (2020), Whitaker (2020), National

Association of State Budget Officers (2021), Vincent and Hanson (2020), and the US Bureau of Economic Analysis (2022) to estimate an equation of the following form for all months pooled:

$$\frac{TotalAid_s}{Pop_{s,y_{2020}}} = \alpha + \beta_1\ RepsPerMillion_s + \beta_2 X_{s,m,y} + \varepsilon_{s,m,y},$$

where $TotalAid_s$ is the total federal aid per resident to state and local governments (USD) in state *s* pooled across all four bills. $\frac{TotalAid_s}{Pop_{s,y_{2020}}}$ is regressed on $RepsPerMillion_s$, the number of Representatives and Senators per million residents in 2020, according to equation (2a) in the text. Included is a set of state-level controls $X_{s,m,y}$. This includes the log of 2020 official Census population, the predicted tax shortfall for state and local governments divided by the state population, the average number of unemployed persons in the fourth quarter of 2020 per capita, the percent change in personal income between the fourth quarter of 2019 and the fourth quarter of 2020, the total direct expenditures of state and local governments per capita in 2019, the acres of federal lands per capita, the log of population density for state *s*, and the cumulative number of COVID-19 cases and deaths per 100,000 people through March 2020. This table largely mirrors Appendix Table 2 from Clemens, Hoxie, and Veuger (2022). Observations are weighted by state population and standard errors (in parentheses) are clustered by state.
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table 5: Impact of COVID-19 Relief Aid – Small State Indicator (March 2022)

	Total Vaccinations Administered per 100K	Total Tests Administered per 100K	White minus Black Vaccination Rate (%)	White minus Hispanic Vaccination Rate (%)	White minus Asian Vaccination Rate (%)	$200,000+ minus <$25,000 Household Income Vaccination Rate (%)	College Degree minus High School Degree Vaccination Rate (%)	Aged 65+ minus 40-54 Vaccination Rate (%)	Aged 65+ minus 18-24 Vaccination Rate (%)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Total Aid per Resident (USD thousands)	6,679	86,158***	-1.834	1.664	3.502	-4.270**	-1.412	1.467	-3.827
	(4,337)	(18,055)	(2.182)	(2.893)	(3.910)	(1.998)	(1.539)	(1.359)	(4.623)
=1 if 'small state'	234.5	-59,217**	2.810	1.555	1.168	4.972*	0.355	0.566	2.486
	(4,313)	(24,043)	(3.362)	(3.620)	(4.775)	(2.714)	(1.624)	(2.334)	(6.310)
Share of 2020 votes cast for Donald Trump	-189,418***	-1.06e+06***	-15.24	6.678	-40.36*	10.19	14.72	40.49***	45.58
	(29,761)	(145,268)	(13.02)	(28.50)	(20.60)	(14.27)	(11.33)	(9.056)	(31.13)
Change Real Person Income per Capita (2018 – 2019)	-0.967	-21.00**	0.000811	-0.000162	-0.00121	-0.00114	-0.000278	-0.000901	-0.000602
	(1.903)	(10.61)	(0.000923)	(0.00203)	(0.000761)	(0.00119)	(0.000878)	(0.000784)	(0.00209)
New COVID-19 deaths per 100K, previous month	263.7	-228.2	-0.493*	-0.457	0.508	0.137	0.0907	0.163	-0.205
	(496.9)	(2,093)	(0.260)	(0.403)	(0.342)	(0.243)	(0.182)	(0.145)	(0.389)
Total COVID-19 deaths per 100K, previous month	-46.69	-192.2	0.0440*	0.00861	-0.0461	-0.0133	-0.0141	0.000426	0.0423
	(39.41)	(253.3)	(0.0238)	(0.0270)	(0.0287)	(0.0228)	(0.0182)	(0.0115)	(0.0346)
New COVID-19 cases per 100K, previous month	-3.650	3.743	0.00413	4.06e-05	-0.00340	-0.00144	0.000550	-0.000797	0.00162
	(4.870)	(19.61)	(0.00320)	(0.00246)	(0.00284)	(0.00221)	(0.00162)	(0.00114)	(0.00366)
Total COVID-19 cases per 100K, previous month	0.789	22.00***	-0.000242	-0.000237	0.00114***	-0.000461	0.000217	-5.54e-05	-0.000548
	(0.669)	(3.198)	(0.000430)	(0.000624)	(0.000306)	(0.000374)	(0.000284)	(0.000174)	(0.000767)
Dep. Var. Mean	164,741	267,034	2.59	1.08	-9.32	13.12	14.95	11.51	14.88
Observations	50	48	50	50	50	50	50	50	50
R^2	0.767	0.805	0.142	0.096	0.260	0.295	0.289	0.669	0.247
First-Stage F-Statistic	75.00	76.52	75.00	75.00	75.00	75.00	75.00	75.00	75.00
P-value on Test for Pre-Trends	-	0.153	-	-	-	-	-	-	-

Note: The table uses data from the Committee for a Responsible Federal Budget (2021), US Federal Transit Administration (2021a, 2021b), US Census Bureau (2021, 2022), Chidambaram and Musumeci (2021), Medicaid and Chip Payment Access Commission (2021), US Office of Elementary and Secondary Education (2021), MIT Election and Data

Science Lab (2017), US Bureau of Economic Analysis (2022), Dong, Du, and Gardner (2020), CDC (2020), Johns Hopkins University Centers for Civic Impact (2022), and the US Department of the Treasury (2021a, 2021b) to estimate the following equations:

$$\frac{TotalAid_s}{Pop_{s,y_{2020}}} = \alpha + \beta_1\ RepsPerMillion_s + \beta_2 X_{s,m,y} + \varepsilon_{s,m,y} \tag{1}$$

$$V_{s,m,y} = \alpha + \beta_1 \frac{\widehat{TotalAid_s}}{Pop_{s,y_{2020}}} + \beta_2 X_{s,m,y} + u_{s,m,y}, \tag{2}$$

where regressions are estimated only for March 2022. $\frac{TotalAid_s}{Pop_{s,y_{2020}}}$ is the total amount of federal aid allocated to a state per resident in USD thousands since the pandemic began. $V_{s,m,y}$ is either the cumulative number of COVID-19 vaccines (Column 1) or tests administered (Column 2) up to month m of year y scaled per 100,000 people residing in state s or the vaccination rate gap between high and low socioeconomic status groups (Columns 3 through 9) in percentage points, as noted by the column headings. Included is a set of state-level controls $X_{s,m,y}$. This includes an indicator for if state *s* is considered a 'small state,' the share of votes won by Donald Trump in 2020, the change in state GDP per capita from Q4 2018 to Q4 2019, and the number of cumulative and new COVID-19 cases and deaths per 100,000 in the previous month. Observations are weighted by state population and standard errors (in parentheses) are clustered by state. Columns 3 through 5 present the vaccination gaps between white Americans and Black, Hispanic, and Asian Americans; Column 6 presents the gap between individuals with a household income over $200,000 and less than $25,000; Column 7 presents the gap between those with a bachelor's degree or higher and those with only a high school diploma; Columns 8 and 9 present the gap between the elderly (65+) and the middle-aged (40-54) and young (18-24).

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

Appendix Table 6: Impact of COVID-19 Relief Aid – Drop Most- & Least-Represented States (March 2022)

	Total Vaccinations Administered per 100K (March 2022)	Total Tests Administered per 100K (March 2022)	White minus Black Vaccination Rate (%)	White minus Hispanic Vaccination Rate (%)	White minus Asian Vaccination Rate (%)	$200,000+ minus <$25,000 Household Income Vaccination Rate (%)	College Degree minus High School Degree Vaccination Rate (%)	Aged 65+ minus 40-54 Vaccination Rate (%)	Aged 65+ minus 18-24 Vaccination Rate (%)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Drop 3 Most- & Least-Represented States									
Total Aid per Resident (USD thousands)	9,433	87,887*	-14.86***	3.392	-5.736**	2.363	-4.796**	-3.477*	-3.769
	(6,045)	(49,933)	(3.801)	(4.502)	(2.558)	(3.583)	(2.080)	(1.895)	(7.166)
Dep. Var. Mean	164,290	254,054	2.20	1.04	-10.08	13.85	15.18	11.56	15.53
Observations	44	42	44	44	44	44	44	44	44
R^2	0.826	0.751	0.159	0.150	0.174	0.215	0.339	0.578	0.176
First-Stage F-Statistic	35.71	34.70	35.71	35.71	35.71	35.71	35.71	35.71	35.71
P-value on Test for Pre-Trends	-	0.002	-	-	-	-	-	-	-
Panel B: Drop 5 Most- & Least-Represented States									
Total Aid per Resident (USD thousands)	8,597	48,587	-16.87***	4.251	-11.66**	-0.706	-8.695***	-6.404**	-10.56
	(10,271)	(54,639)	(6.341)	(8.931)	(5.149)	(5.753)	(3.250)	(2.681)	(11.72)
Dep. Var. Mean	163,306	235,491	2.58	0.56	-10.31	13.80	15.24	11.59	15.11
Observations	40	38	40	40	40	40	40	40	40
R^2	0.797	0.607	0.136	0.122	0.185	0.208	0.330	0.573	0.221
First-Stage F-Statistic	22.78	21.60	22.78	22.78	22.78	22.78	22.78	22.78	22.78
P-value on Test for Pre-Trends	-	0.550	-	-	-	-	-	-	-

Committee for a Responsible Federal Budget (2021), US Federal Transit Administration (2021a, 2021b), US Census Bureau (2021, 2022), Chidambaram and Musumeci (2021), Medicaid and Chip Payment Access Commission (2021), US Office of Elementary and Secondary Education (2021), Lewis et al. (2021), Johns Hopkins University Centers for Civic Impact (2022), CDC (2020), MIT Election and Data Science Lab (2017), US Bureau of Economic Analysis (2022), Dong, Du, and Gardner (2020), and the US Department of the Treasury (2021a, 2021b) to estimate the following equations:

$$\frac{TotalAid_s}{Pop_{s,y_{2020}}} = \alpha + \beta_1\ RepsPerMillion_s + \beta_2 X_{s,m,y} + \varepsilon_{s,m,y} \qquad (1)$$

$$V_{s,m,y} = \alpha + \beta_1 \frac{\widehat{TotalAid_s}}{Pop_{s,y_{2020}}} + \beta_2 X_{s,m,y} + u_{s,m,y}, \tag{2}$$

where regressions are estimated only for March 2022. $\frac{TotalAid_s}{Pop_{s,y_{2020}}}$ is the total amount of federal aid allocated to a state per resident in USD thousands since the pandemic began. $V_{s,m,y}$ is either the cumulative number of COVID-19 vaccines (Column 1) or tests administered (Column 2) up to month m of year y scaled per 100,000 people residing in state s or the vaccination rate gap between high and low socioeconomic status groups (Columns 3 through 9) in percentage points, as noted by the column headings. Included is a set of state-level controls $X_{s,m,y}$. This includes the log of 2020 official Census population, the share of votes won by Donald Trump in 2020, the change in state GDP per capita from Q4 2018 to Q4 2019, and the number of cumulative and new COVID-19 cases and deaths per 100,000 in the previous month. Observations are weighted by state population and standard errors (in parentheses) are clustered by state. Columns 3 through 5 present the vaccination gaps between White Americans and Black, Hispanic, and Asian Americans; Column 6 presents the gap between individuals with a household income over $200,000 and less than $25,000; Column 7 presents the gap between those with a bachelor's degree or higher and those with only a high school diploma; Columns 8 and 9 present the gap between the elderly (65+) and the middle-aged (40-54) and young (18-24). Panel A excludes observations for the three most over-represented and under-represented states (Wyoming, Vermont, Alaska; Texas, Florida, California), while Panel B excludes the five most over- and under-represented states (Wyoming, Vermont, Alaska, North Dakota, Rhode Island; Texas, Florida, California, New York, North Carolina).

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

Appendix Table 7: Impact of COVID-19 Relief Aid – Saturated Specifications (March 2022)

	Total Vaccinations Administered per 100K	Total Tests Administered per 100K	White minus Black Vaccination Rate (%)	White minus Hispanic Vaccination Rate (%)	White minus Asian Vaccination Rate (%)	$200,000+ minus <$25,000 Household Income Vaccination Rate (%)	College Degree minus High School Degree Vaccination Rate (%)	Aged 65+ minus 40-54 Vaccination Rate (%)	Aged 65+ minus 18-24 Vaccination Rate (%)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Total Aid per Resident (USD thousands)	-2,496	11,436	-4.240	0.244	1.324	-1.072	-3.304*	-0.705	-6.263
	(4,738)	(27,663)	(2.867)	(3.319)	(2.897)	(3.806)	(1.722)	(1.620)	(4.654)
Log(Population)	-870.7	736.8	-4.482***	-0.752	-0.233	0.351	-2.254***	-2.104***	-1.574
	(2,253)	(12,442)	(1.303)	(1.422)	(0.763)	(1.134)	(0.730)	(0.558)	(2.382)
Share of 2020 votes cast for Donald Trump	2.95e+06***	-8.212e+06	-693.7	51.45	1,091	398.1	659.2	-590.1**	-411.6
	(984,421)	(9.387e+06)	(572.4)	(754.3)	(666.4)	(729.1)	(418.8)	(282.0)	(902.2)
Change Real Person Income per Capita (2018 – 2019)	4.761	-137.1***	0.00556	0.00894	0.00710	-0.00786	0.00654**	0.00329**	0.00847
	(6.934)	(45.86)	(0.00418)	(0.00794)	(0.00484)	(0.00514)	(0.00264)	(0.00162)	(0.00758)
New COVID-19 deaths per 100K, previous month	3,582	-29,769	6.190*	-2.918	8.493***	10.19***	2.797	3.767**	14.91**
	(5,168)	(66,273)	(3.662)	(5.578)	(2.694)	(3.623)	(3.021)	(1.843)	(7.478)
Total COVID-19 deaths per 100K, previous month	-1,093*	-4,080	0.0242	-0.144	0.717*	0.570	-0.0780	-0.240	-1.168*
	(562.1)	(5,044)	(0.446)	(0.484)	(0.410)	(0.365)	(0.213)	(0.182)	(0.677)
New COVID-19 cases per 100K, previous month	-2.576	319.2	-0.00944	-0.0131	0.0335**	-0.0189	-0.00894	-0.0127*	-0.0331
	(27.88)	(276.4)	(0.0173)	(0.0243)	(0.0165)	(0.0180)	(0.0119)	(0.00681)	(0.0353)
Total COVID-19 cases per 100K, previous month	-22.04	62.82	0.00290	0.0316	-0.0205	-0.0121	-0.0202	0.00374	-0.00896
	(38.60)	(207.2)	(0.0203)	(0.0264)	(0.0150)	(0.0194)	(0.0125)	(0.00834)	(0.0468)
Dep. Var. Mean	164,741	267,034	2.59	1.08	-9.32	13.12	14.95	11.51	14.88
Observations	50	48	50	50	50	50	50	50	50
R^2	0.837	0.847	0.379	0.296	0.687	0.512	0.484	0.825	0.434
First-Stage F-Statistic	78.69	61.35	78.69	78.69	78.69	78.69	78.69	78.69	78.69
P-value on Test for Pre-Trends	-	0.087	-	-	-	-	-	-	-

Note: The table uses data from the Committee for a Responsible Federal Budget (2021), US Federal Transit Administration (2021a, 2021b), US Census Bureau (2021, 2022), Chidambaram and Musumeci (2021), Medicaid and Chip Payment Access Commission (2021), US Office of Elementary and Secondary Education (2021), Lewis et al. (2021), US Census Bureau (2022), CDC (2020), Johns Hopkins University Centers for Civic Impact (2022), MIT Election and Data Science Lab (2017), US Bureau of Economic Analysis (2022), Dong, Du, and Gardner (2020), and the US Department of the Treasury (2021a, 2021b) to estimate the following equations:

$$\frac{TotalAid_s}{Pop_{s,y_{2020}}} = \alpha + \beta_1\ RepsPerMillion_s + \beta_2 X_{s,m,y} + \beta_3 X_{s,m,y}^2 + \beta_4 X_{s,m,y}^3 + \varepsilon_{s,m,y} \tag{1}$$

$$V_{s,m,y} = \alpha + \beta_1 \frac{\widehat{TotalAid_s}}{Pop_{s,y_{2020}}} + \beta_2 X_{s,m,y} + \beta_3 X_{s,m,y}^2 + \beta_4 X_{s,m,y}^3 + u_{s,m,y}, \tag{2}$$

where regressions are estimated only for March 2022. $\frac{TotalAid_s}{Pop_{s,y_{2020}}}$ is the total amount of federal aid allocated to a state per resident in USD thousands since the pandemic began. $V_{s,m,y}$ is either the cumulative number of COVID-19 vaccines (Column 1) or tests administered (Column 2) up to month m of year y scaled per 100,000 people residing in state s or the vaccination rate gap between high and low socioeconomic status groups (Columns 3 through 9) in percentage points, as noted by the column headings. Included is a set of state-level controls $X_{s,m,y}$. This includes This includes the log of 2020 official Census population, the share of votes won by Donald Trump in 2020, the change in state GDP per capita from Q4 2018 to Q4 2019, and the number of cumulative and new COVID-19 cases and deaths per 100,000 in the previous month. $X_{s,m,y}^2\ and\ X_{s,m,y}^3$ denote the squared and cubed terms of the variables contained in $X_{s,m,y}$. Observations are weighted by state population and standard errors (in parentheses) are clustered by state. Columns 3 through 5 present the vaccination gaps between White Americans and Black, Hispanic, and Asian Americans; Column 6 presents the gap between individuals with a household income over $200,000 and less than $25,000; Column 7 presents the gap between those with a bachelor's degree or higher and those with only a high school diploma; Columns 8 and 9 present the gap between the elderly (65+) and the middle-aged (40-54) and young (18-24).

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

Appendix Table 8: Impact of COVID-19 Relief Aid – Simple Specifications (March 2022)

	Total Vaccinations Administered per 100K	Total Tests Administered per 100K	White minus Black Vaccination Rate (%)	White minus Hispanic Vaccination Rate (%)	White minus Asian Vaccination Rate (%)	$200,000+ minus <$25,000 Household Income Vaccination Rate (%)	College Degree minus High School Degree Vaccination Rate (%)	Aged 65+ minus 40-54 Vaccination Rate (%)	Aged 65+ minus 18-24 Vaccination Rate (%)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Log of Population									
Total Aid per Resident (USD thousands)	10,739*	121,736***	-0.643	1.201	2.765	-3.297	-4.283***	-3.857**	-8.585**
	(6,497)	(36,398)	(2.008)	(1.793)	(2.912)	(2.008)	(1.393)	(1.767)	(3.826)
Dep. Var. Mean	164,741	267,035	2.59	1.08	-9.32	13.12	14.95	11.51	14.88
Observations	50	48	50	50	50	50	50	50	50
R^2	0.227	0.432	0.027	0.027	0.065	0.162	0.264	0.391	0.168
First-Stage F-Statistic	135.18	132.63	135.18	135.18	135.18	135.18	135.18	135.18	135.18
P-value on Test for Pre-Trends	-	0.702	-	-	-	-	-	-	-
Panel B: Log of Population and Trump Vote Share									
Total Aid per Resident (USD thousands)	1,871	83,576**	-1.466	0.443	1.403	-2.967	-4.003***	-2.491**	-7.076**
	(3,516)	(32,563)	(2.085)	(2.005)	(2.980)	(2.347)	(1.510)	(1.169)	(3.412)
Dep. Var. Mean	164,741	267,034	2.59	1.08	-9.32	13.12	14.95	11.51	14.88
Observations	50	48	50	50	50	50	50	50	50
R^2	0.768	0.630	0.027	0.046	0.169	0.166	0.285	0.643	0.225
First-Stage F-Statistic	81.27	74.54	81.27	81.27	81.27	81.27	81.27	81.27	81.27
P-value on Test for Pre-Trends	-	0.564	-	-	-	-	-	-	-

Committee for a Responsible Federal Budget (2021), US Federal Transit Administration (2021a, 2021b), US Census Bureau (2021, 2022), Chidambaram and Musumeci (2021), Medicaid and Chip Payment Access Commission (2021), US Office of Elementary and Secondary Education (2021), Lewis et al. (2021), Johns Hopkins University Centers for Civic Impact (2022), CDC (2020), MIT Election and Data Science Lab (2017), and the US Department of the Treasury (2021a, 2021b) to estimate the following equations:

$$\frac{TotalAid_s}{Pop_{s,y_{2020}}} = \alpha + \beta_1\ RepsPerMillion_s + \beta_2 X_{s,m,y} + \varepsilon_{s,m,y} \tag{1}$$

$$V_{s,m,y} = \alpha + \beta_1 \frac{\widehat{TotalAid_s}}{Pop_{s,y_{2020}}} + \beta_2 X_{s,m,y} + u_{s,m,y}, \tag{2}$$

where regressions are estimated only for March 2022. $\frac{TotalAid_s}{Pop_{s,y_{2020}}}$ is the total amount of federal aid allocated to a state per resident in USD thousands since the pandemic began. $V_{s,m,y}$ is either the cumulative number of COVID-19 vaccines (Column 1) or tests administered (Column 2) up to month m of year y scaled per 100,000 people residing in state s or the vaccination rate gap between high and low socioeconomic status groups (Columns 3 through 9) in percentage points, as noted by the column headings. Included is a set of state-level controls $X_{s,m,y}$. This includes the log of 2020 official Census population (Panel A), plus the share of votes won by Donald Trump in 2020 (in Panel B). Observations are weighted by state population and standard errors (in parentheses) are clustered by state. Columns 3 through 5 present the vaccination gaps between White Americans and Black, Hispanic, and Asian Americans; Column 6 presents the gap between individuals with a household income over $200,000 and less than $25,000; Column 7 presents the gap between those with a bachelor’s degree or higher and those with only a high school diploma; Columns 8 and 9 present the gap between the elderly (65+) and the middle-aged (40-54) and young (18-24).

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

Appendix Table 9: Impact of COVID-19 Relief Aid – Dropping COVID-19 Variables (March 2022)

	Total Vaccinations Administered per 100K	Total Tests Administered per 100K	White minus Black Vaccination Rate (%)	White minus Hispanic Vaccination Rate (%)	White minus Asian Vaccination Rate (%)	$200,000+ minus <$25,000 Household Income Vaccination Rate (%)	College Degree minus High School Degree Vaccination Rate (%)	Aged 65+ minus 40-54 Vaccination Rate (%)	Aged 65+ minus 18-24 Vaccination Rate (%)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Total Aid per Resident (USD thousands)	1,521	88,994**	-2.142	0.155	1.481	-2.483	-4.455***	-2.392*	-7.015**
	(3,621)	(35,516)	(2.230)	(2.044)	(2.960)	(2.264)	(1.491)	(1.221)	(3.553)
Log(Population)	-3,251	9,348	-1.590	-1.750	-1.709	-0.649	-2.272***	-1.882***	-1.999
	(2,490)	(21,456)	(1.289)	(1.556)	(1.088)	(1.269)	(0.754)	(0.648)	(2.332)
Share of 2020 votes cast for Donald Trump	-206,733***	-787,570***	-17.98	-17.21	-32.02**	6.809	7.391	31.78***	35.17**
	(18,637)	(238,735)	(11.16)	(16.05)	(13.30)	(14.30)	(8.226)	(5.817)	(17.78)
Change Real Person Income per Capita (2018 – 2019)	0.816	-10.10	0.00158	0.000671	-0.000182	-0.00113	0.00105	-0.000230	-0.000144
	(1.878)	(21.56)	(0.00119)	(0.00196)	(0.000777)	(0.00142)	(0.000703)	(0.000894)	(0.00228)
Dep. Var. Mean	164,741	267,034	2.59	1.08	-9.32	13.12	14.95	11.51	14.88
Observations	50	48	50	50	50	50	50	50	50
R^2	0.769	0.635	0.043	0.046	0.169	0.174	0.296	0.647	0.226
First-Stage F-Statistic	82.75	70.28	82.75	82.75	82.75	82.75	82.75	82.75	82.75
P-value on Test for Pre-Trends	-	0.440	-	-	-	-	-	-	-

Note: The table uses data from the Committee for a Responsible Federal Budget (2021), US Federal Transit Administration (2021a, 2021b), US Census Bureau (2021, 2022), Chidambaram and Musumeci (2021), Medicaid and Chip Payment Access Commission (2021), US Office of Elementary and Secondary Education (2021), Lewis et al. (2021), MIT Election and Data Science Lab (2017), US Bureau of Economic Analysis (2022), and the US Department of the Treasury (2021a, 2021b) to estimate the following equations for Columns 1 and 2:

$$\frac{TotalAid_s}{Pop_{s,y_{2020}}} = \alpha + \beta_1 \, RepsPerMillion_s + \beta_2 X_{s,m,y} + \varepsilon_{s,m,y} \tag{1}$$

$$V_{s,m,y} = \alpha + \beta_1 \frac{\widehat{TotalAid_s}}{Pop_{s,y_{2020}}} + \beta_2 X_{s,m,y} + u_{s,m,y}, \tag{2}$$

where regressions are estimated only for March 2022. $\frac{TotalAid_s}{Pop_{s,y_{2020}}}$ is the total amount of federal aid allocated to a state per resident in USD thousands since the pandemic began. $V_{s,m,y}$ is either the cumulative number of COVID-19 vaccines (Column 1) or tests administered (Column 2) up to month m of year y scaled per 100,000 people residing in state s or the vaccination rate gap between high and low socioeconomic status groups (Columns 3 through 9) in percentage points, as noted by the column headings. Included is a set of state-level controls $X_{s,m,y}$. This includes the log of population, the share of votes won by Donald Trump in 2020, and the change in state GDP per capita from Q4 2018 to Q4 2019. Observations are weighted by state population and standard errors (in parentheses) are clustered by state. Columns 3 through 5 present the vaccination gaps between White Americans and Black, Hispanic, and Asian Americans; Column 6 presents the gap between individuals with a household income over $200,000 and less than $25,000; Column 7 presents the gap between those with a bachelor's degree or higher and those with only a high school diploma; Columns 8 and 9 present the gap between the elderly (65+) and the middle-aged (40-54) and young (18-24).

*** $p<0.01$, ** $p<0.05$, * $p<0.1$