Online Appendix

Racial Disparities in Voting Wait Times: Evidence from Smartphone Data

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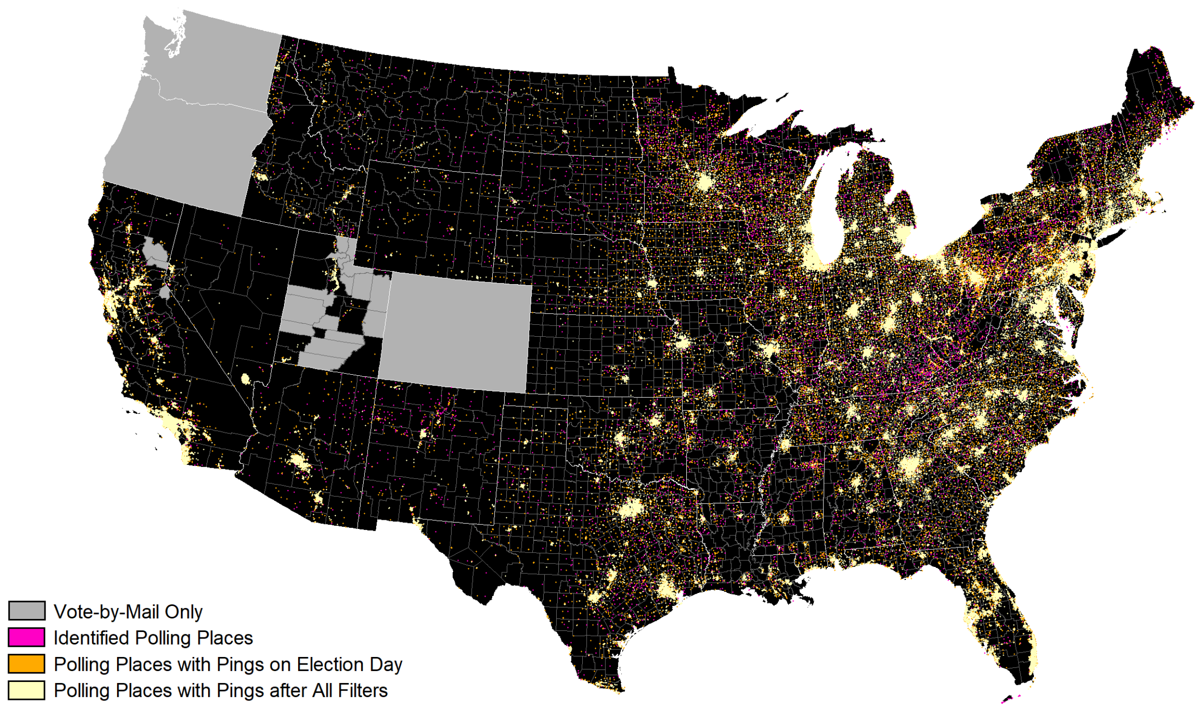
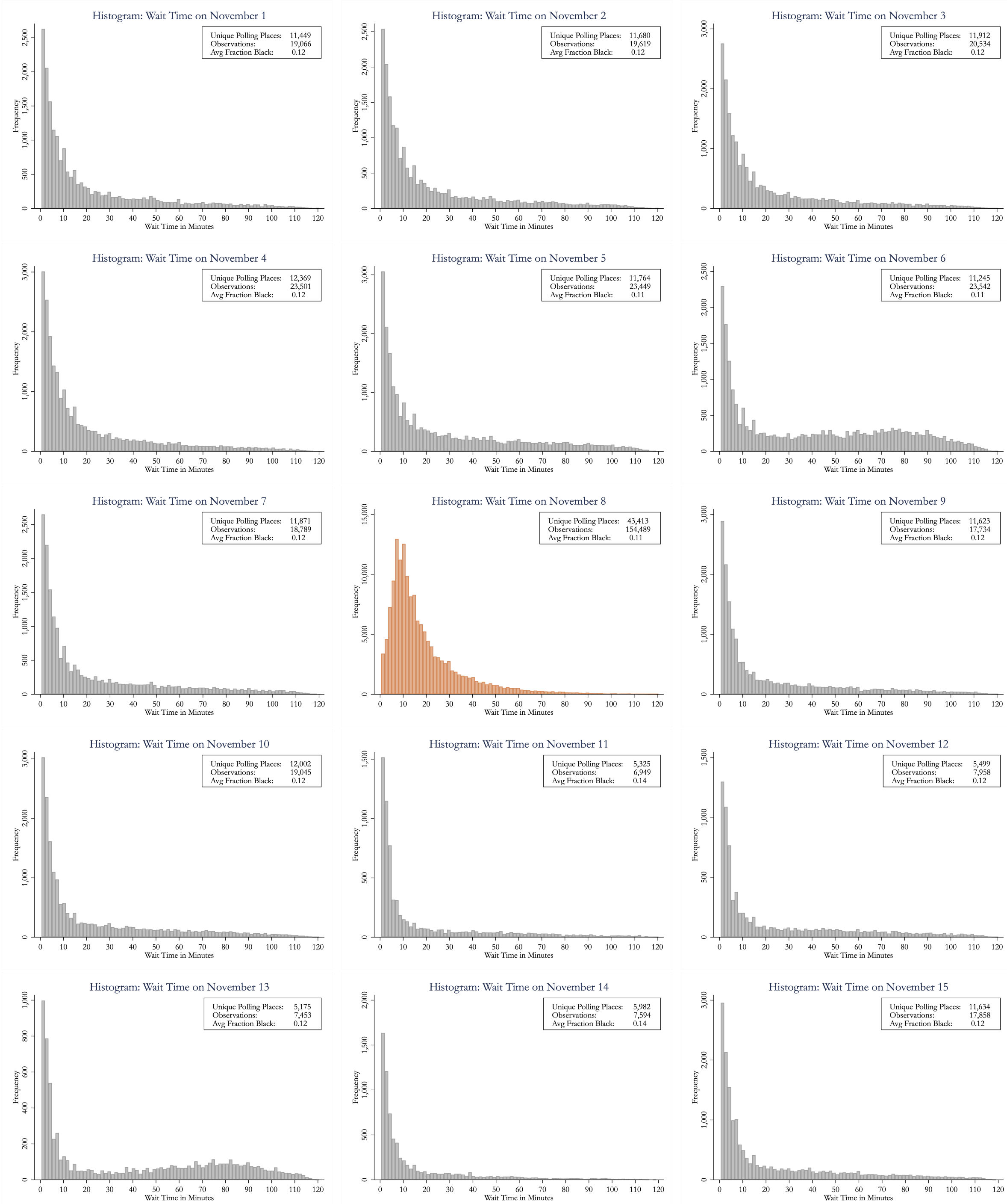
Appendix A: Figures and Tables

Figure A.1: Geographic Coverage



Notes: This figure shows polling place locations (overlaid on county shapes) colored by whether smartphone pings were observed.

Figure A.2: Placebo Day Wait Time Histograms



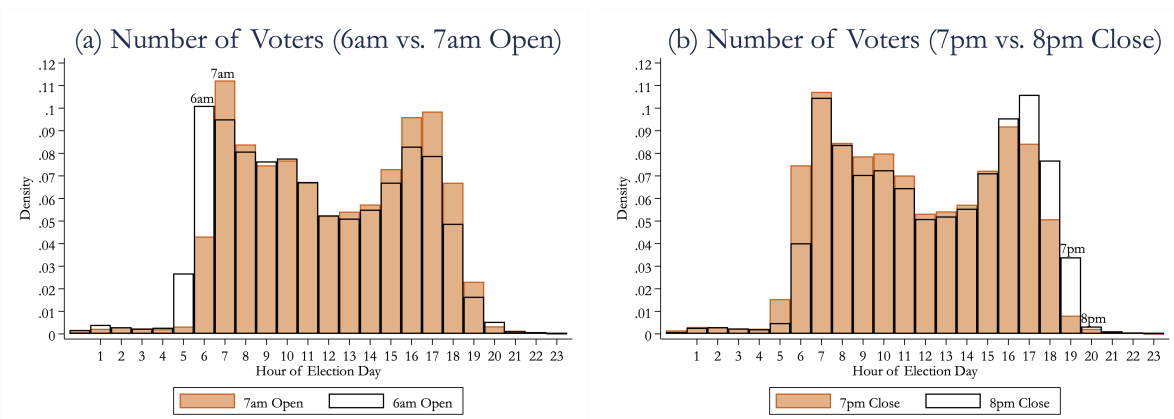
Notes: In this figure, we replicate our sample construction across 14 placebo days (i.e. we apply our filters to identifying a "likely voter" but replace the sample and the date used in each filter definition to the placebo date). The figure corresponding to Election Day (i.e. Figure 2 of the paper) is also shown, highlighted in orange. The figure illustrates that our filters identify a plausible distribution of wait times on Election Day, but that applying the same set of filters (with dates shifted accordingly) produces a very different distribution shape on other dates. Note that the Y-axes change across sub-figures.

Table A.1: Summary Statistics for Voter Wait Time Measures

	(1) N	(2) Mean	(3) SD	(4) Min	(5) p10	(6) Median	(7) p90	(8) Max
Wait Time Measures								
Primary Wait Time Measure (Midpoint)	154,489	19.13	16.89	0.51	5.02	13.57	40.83	119.50
Lower Bound Wait Time Measure	154,489	11.26	16.19	0.00	0.00	5.52	30.62	119.08
Upper Bound Wait Time Measure	154,489	27.00	20.33	1.02	9.28	20.30	54.52	119.98
Wait Time Is Over 30min	154,489	0.18	0.38	0.00	0.00	0.00	1.00	1.00
Race Fractions in Polling Area								
Fraction White	154,411	0.70	0.26	0.00	0.27	0.79	0.96	1.00
Fraction Black	154,411	0.11	0.18	0.00	0.00	0.03	0.31	1.00
Fraction Asian	154,411	0.05	0.09	0.00	0.00	0.02	0.14	0.96
Fraction Hispanic	154,411	0.11	0.17	0.00	0.00	0.05	0.31	1.00
Fraction Other Non-White	154,411	0.03	0.04	0.00	0.00	0.02	0.07	0.99
Other Demographics								
Fraction Below Poverty Line	154,260	0.11	0.12	0.00	0.01	0.07	0.26	1.00
Population (1000s)	154,489	2.12	1.87	0.00	0.84	1.71	3.56	51.87
Population Per Sq Mile (1000s)	154,489	3.81	9.44	0.00	0.20	1.99	7.04	338.94

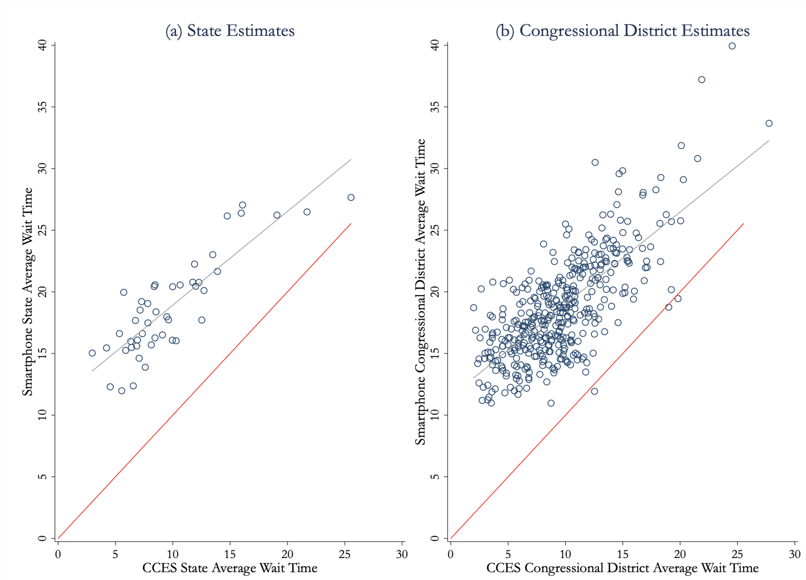
Notes: Race fractions and other demographics are defined at the Census block group of the associated polling place. These demographics correspond to the 2017 American Community Survey's five-year estimates.

Figure A.3: Voter Volume by Hour of Day (Early vs. Late Open and Close States)



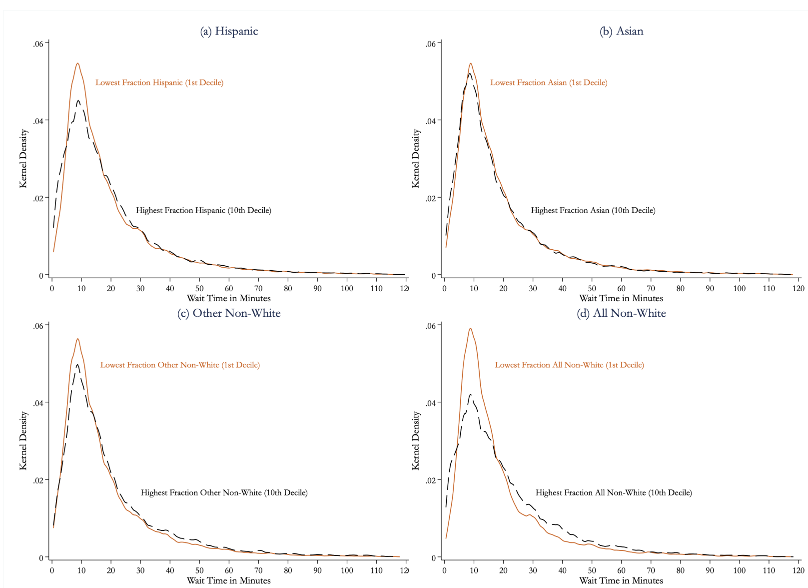
Notes: In this figure, we use state poll opening and close times to further validate our filters as identifying likely voters. Panel A separately plots the histogram for the 10 states where polls open at 6am and the 22 that open at 7am; Panel B plots the histograms for the 17 states that close at 7pm versus the 18 states that close at 8pm. We see relative spikes at 7am for the states that open at 7am (orange histogram), and that the number of voters falls substantially at 7pm for states that close at 7pm (orange histogram). [State open and close times are taken from: https://ballotpedia.org/State_Poll_Opening_and_Closing_Times_(2016)#table. We omit states which do not have standardized open (Panel A) or close times (Panel B) across the entire state.]

Figure A.4: Comparison with CCES Data



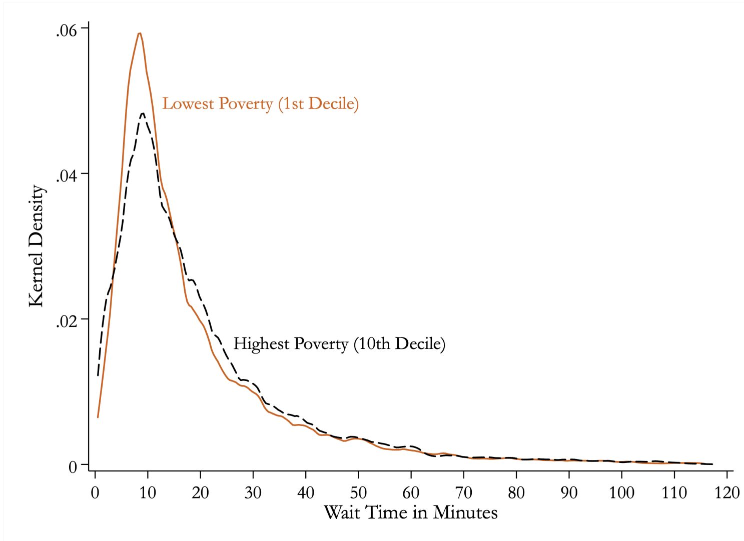
Notes: The red line corresponds to the 45 degree line (lining up would indicate equality between the two measures). The gray line is produced with `lfit` in Stata, giving the prediction of the Smartphone measure given the CCES measure. Both measures are first independently empirical-Bayes-adjusted to account for measurement error.

Figure A.5: Wait Time Disparities by Racial Categories



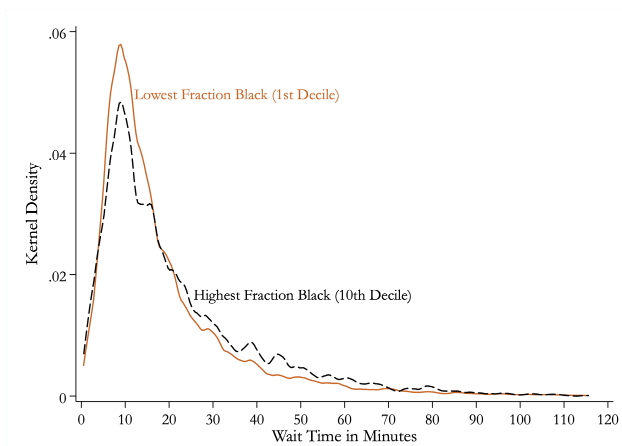
Notes: This figure repeats Figure 3 across other racial categories. We show the decile splits by Hispanic (Panel A), Asian (Panel B), and “Other Non-White” (Panel C), and then group these categories together with Black in Panel D. Note that “Asian” includes “Pacific Islander.” “Other Non-White” includes the “Other,” “Native American,” and “Multiracial” Census race categories. “All Non-White” includes Black, Hispanic, Asian, and Other Non-White.

Figure A.6: Wait Time Disparities by Fraction Below Poverty Line



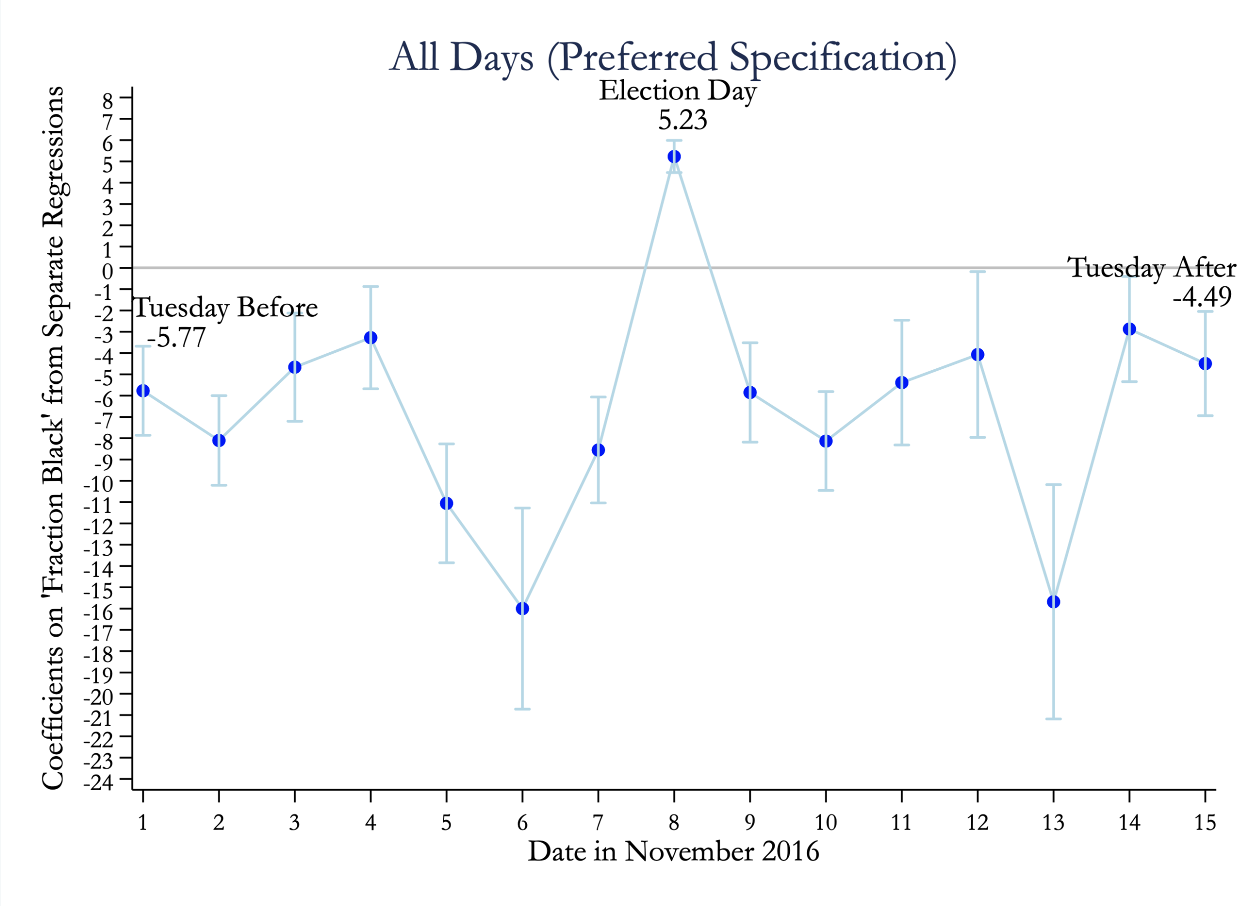
Notes: This figure repeats Figure 3 across the "Fraction Below Poverty Line" measure (top and bottom deciles).

Figure A.7: Wait Time Disparities: Stricter Likely Voter Filter



Notes: In this figure, we repeat Figure 3 with a sub-sample of voters. Specifically, we use a more conservative first filter for identifying "likely voters." Our primary analysis limited the sample to individuals who (a) spent at least one minute at a polling place, (b) did so at only one polling place on Election Day, and (c) did not spend more than one minute at that polling location in the week before or the week after Election Day. Here we make (c) stricter by dropping anyone who visited *any other polling place* on any day in the week before or after Election Day, e.g. we would thus exclude a person who only visited a school polling place on Election Day, but who visited a church (that later serves a polling place) on the prior Sunday. This drops our primary analysis sample from 154,489 voters down to 68,812 voters. Kernel densities are estimated using 1 minute half-widths. The 1st decile corresponds to the 15,402 voters across 6,576 polling places with the lowest percent of black residents (mean = 0%). The 10th decile corresponds to the 6,881 voters across the 3,229 polling places with the highest percent of black residents (mean = 54%).

Figure A.8: Main Specification Run on Placebo Days



Notes: In this figure, we replicate our sample construction for the 14 placebo days around Election Day, similar to A.2. We then repeat the regression used in Table 1, Panel A, Column 1 for each of these days. We find that none of these alternative dates produces a positive coefficient, suggesting that our approach likely identifies a lower bound on the racial gap in wait times. *Additional Notes:* Points correspond to coefficients on "Fraction Black" (+/- 1.96 standard errors) from separate regressions.

Table A.2: Fraction Black and Voter Wait Time: OLS

	(1)	(2)	(3)	(4)	(5)	(6)
Fraction Black	5.23***	5.22***	4.96***	4.84***	3.27***	3.10***
	(0.39)	(0.39)	(0.42)	(0.42)	(0.45)	(0.44)
Fraction Asian		-0.79	-2.48***	1.30*	-1.10	-0.66
		(0.72)	(0.74)	(0.76)	(0.81)	(0.81)
Fraction Hispanic		1.15***	0.43	3.90***	1.50***	1.72***
		(0.37)	(0.40)	(0.46)	(0.50)	(0.50)
Fraction Other Non-White		12.01***	11.76***	1.66	2.04	1.75
		(1.94)	(1.95)	(1.89)	(1.93)	(1.93)
Fraction Below Poverty Line			0.06	-2.03***	0.28	1.10
			(0.74)	(0.71)	(0.67)	(0.67)
Population (1000s)			0.43***	0.32***	0.28***	0.27***
			(0.06)	(0.05)	(0.05)	(0.05)
Population Per Sq Mile (1000s)			0.04***	0.07***	0.06***	0.06***
			(0.01)	(0.01)	(0.01)	(0.01)
Android (0 = iPhone)						0.38***
						(0.10)
N	154,411	154,411	154,260	154,260	154,260	154,260
R^2	0.00	0.00	0.01	0.06	0.13	0.17
DepVarMean	19.13	19.13	19.12	19.12	19.12	19.12
Polling Area Controls?	No	No	Yes	Yes	Yes	Yes
State FE?	No	No	No	Yes	Yes	Yes
County FE?	No	No	No	No	Yes	Yes
Hour of Day FE?	No	No	No	No	No	Yes

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: In this figure we repeat Table 1, Panel A, but display the coefficients on control variables (Fraction Below Poverty Line, Population, Population Per Sq Mile). We additionally add column 6 which adds two additional sets of control variables: fixed effects for each hour of the day (hour of arrival for a wait time) and whether the cellphone is Android (vs. iPhone). *Additional Notes:* Robust standard errors, clustered at the polling place level, are in parentheses. Unit of observation is a cellphone identifier on Election Day. *DepVarMean* is the mean of the dependent variable. *Polling Area Controls* includes the population, population per square mile, and fraction below poverty line for the block group of the polling station. “Asian” includes “Pacific Islander.” “Other Non-White” includes the “Other,” “Native American,” and “Multiracial” Census race categories. Column 6 adds an additional specification beyond Table 1; there we include fixed effects for the hour of arrival (i.e. the first ping of a waiting spell within the 60 meters of the polling place centroid) and a dummy variable for whether the observation corresponds to an Android phone.

Table A.3: Fraction Black and Voter Wait Time: LPM

	(1)	(2)	(3)	(4)	(5)	(6)
Fraction Black	0.12***	0.12***	0.11***	0.10***	0.07***	0.06***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Fraction Asian		-0.00	-0.04**	0.04**	-0.02	-0.01
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Fraction Hispanic		0.03***	0.01	0.08***	0.03***	0.04***
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Fraction Other Non-White		0.21***	0.21***	0.03	0.05	0.04
		(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Fraction Below Poverty Line			-0.02	-0.05***	0.01	0.03*
			(0.02)	(0.02)	(0.01)	(0.01)
Population (1000s)			0.01***	0.01***	0.01***	0.01***
			(0.00)	(0.00)	(0.00)	(0.00)
Population Per Sq Mile (1000s)			0.00***	0.00***	0.00***	0.00***
			(0.00)	(0.00)	(0.00)	(0.00)
Android (0 = iPhone)						0.01***
						(0.00)
N	154,411	154,411	154,260	154,260	154,260	154,260
R^2	0.00	0.00	0.01	0.04	0.10	0.14
DepVarMean	0.18	0.18	0.18	0.18	0.18	0.18
Polling Area Controls?	No	No	Yes	Yes	Yes	Yes
State FE?	No	No	No	Yes	Yes	Yes
County FE?	No	No	No	No	Yes	Yes
Hour of Day FE?	No	No	No	No	No	Yes

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: In this figure we repeat Table 1, Panel B, but display the coefficients on control variables (Fraction Below Poverty Line, Population, Population Per Sq Mile). We additionally add column 6 which adds two additional sets of control variables: fixed effects for each hour of the day (hour of arrival for a wait time) and whether the cellphone is Android (vs. iPhone). *Additional Notes:* Robust standard errors, clustered at the polling place level, are in parentheses. Unit of observation is a cellphone identifier on Election Day. *DepVarMean* is the mean of the dependent variable. The dependent variable is a binary variable equal to 1 if the wait time is greater than 30 minutes. *Polling Area Controls* includes the population, population per square mile, and fraction below poverty line for the block group of the polling station. “Asian” includes “Pacific Islander.” “Other Non-White” includes the “Other,” “Native American,” and “Multiracial” Census race categories. Column 6 adds an additional specification beyond Table 1; there we include fixed effects for the hour of arrival (i.e. the first ping of a waiting spell within the 60 meters of the polling place centroid) and a dummy variable for whether the observation corresponds to an Android phone.

Table A.4: Robustness: Regressions for Figure 4

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Panel A: Lower to Upper Bound Split (10% increments)											
	Lower	S1	S2	S3	S4	Midpoint	S6	S7	S8	S9	Upper
Fraction Black	4.71***	4.82***	4.92***	5.02***	5.13***	5.23***	5.33***	5.44***	5.54***	5.65***	5.75***
	(0.35)	(0.36)	(0.36)	(0.37)	(0.38)	(0.39)	(0.40)	(0.41)	(0.42)	(0.43)	(0.45)
N	154,411	154,411	154,411	154,411	154,411	154,411	154,411	154,411	154,411	154,411	154,411
R^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DepVarMean	11.26	12.83	14.40	15.98	17.55	19.13	20.70	22.28	23.85	25.42	27.00
Panel B: Reasonable Values (See Notes)											
	RV1	RV2	RV3	RV4	RV5	RV6	RV7	RV8	RV9	RV10	
Fraction Black	5.78***	5.33***	5.23***	5.23***	5.28***	5.37***	3.26***	3.32***	3.39***	3.56***	
	(0.54)	(0.49)	(0.45)	(0.39)	(0.39)	(0.39)	(0.23)	(0.23)	(0.23)	(0.23)	
N	159,046	158,167	156,937	154,411	154,014	153,433	141,170	140,470	139,788	138,452	
R^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
DepVarMean	22.92	21.79	20.63	19.13	19.17	19.24	15.64	15.71	15.78	15.91	
Panel C: Radius Around Building (10 to 100 meters)											
	Rad10	Rad20	Rad30	Rad40	Rad50	Rad60	Rad70	Rad80	Rad90	Rad100	
Fraction Black	1.43***	1.95***	2.86***	3.98***	4.53***	5.23***	5.68***	6.22***	6.72***	6.99***	
	(0.39)	(0.32)	(0.33)	(0.35)	(0.37)	(0.39)	(0.41)	(0.43)	(0.46)	(0.48)	
N	60,822	120,921	150,994	161,728	161,140	154,411	144,880	134,133	123,417	113,797	
R^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
DepVarMean	12.09	14.00	15.63	17.00	18.16	19.13	20.00	20.71	21.32	21.81	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Robust standard errors, clustered at the polling place level, are in parentheses. Unit of observation is a cellphone identifier on Election Day. *DepVarMean* is the mean of the dependent variable. All specifications are of the form used in Column 1 of Panel A, Table 1. See further notes on Figure 4.

Table A.5: Stricter Likely Voter Filter: Fraction Black and Voter Wait Time

	(1)	(2)	(3)	(4)	(5)
Panel A: Ordinary Least Squares (Y = Wait Time)					
Fraction Black	4.97***	4.93***	4.38***	4.31***	2.70***
	(0.53)	(0.53)	(0.56)	(0.57)	(0.63)
Fraction Asian		-1.98*	-3.80***	0.78	-2.21*
		(1.05)	(1.11)	(1.10)	(1.18)
Fraction Hispanic		1.21**	0.23	4.27***	2.10***
		(0.52)	(0.56)	(0.67)	(0.74)
Fraction Other Non-White		12.54***	11.86***	0.85	2.05
		(2.26)	(2.27)	(2.22)	(2.46)
N	68,811	68,811	68,724	68,724	68,724
R^2	0.00	0.00	0.01	0.06	0.14
DepVarMean	19.38	19.38	19.36	19.36	19.36
Polling Area Controls?	No	No	Yes	Yes	Yes
State FE?	No	No	No	Yes	Yes
County FE?	No	No	No	No	Yes
Panel B: Linear Probability Model (Y = Wait Time > 30min)					
Fraction Black	0.11***	0.11***	0.11***	0.09***	0.05***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Fraction Asian		-0.00	-0.04*	0.05*	-0.03
		(0.02)	(0.02)	(0.02)	(0.03)
Fraction Hispanic		0.03**	0.01	0.09***	0.04**
		(0.01)	(0.01)	(0.02)	(0.02)
Fraction Other Non-White		0.22***	0.21***	0.02	0.05
		(0.05)	(0.05)	(0.05)	(0.06)
N	68,811	68,811	68,724	68,724	68,724
R^2	0.00	0.00	0.01	0.05	0.12
DepVarMean	0.18	0.18	0.18	0.18	0.18
Polling Area Controls?	No	No	Yes	Yes	Yes
State FE?	No	No	No	Yes	Yes
County FE?	No	No	No	No	Yes

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Robust standard errors, clustered at the polling place level, are in parentheses. Unit of observation is a cellphone identifier on Election Day. *DepVarMean* is the mean of the dependent variable. The dependent variable in Panel B is a binary variable equal to 1 if the wait time is greater than 30 minutes. *Polling Area Controls* includes the population, population per square mile, and fraction below poverty line for the block group of the polling station. "Asian" includes "Pacific Islander." "Other Non-White" includes the "Other," "Native American," and "Multiracial" Census race categories. See further notes on Figure A.7.

Appendix B: Mechanisms

In Section 4 of the paper, we documented large and persistent differences in wait times for areas with a larger fraction of black residents relative to white residents. In this section, we explore potential explanations for these differences. This descriptive exercise is important as different mechanisms may imply different corrective policies. For example, if wait time disparities are driven by differential job flexibility (and thus bunching in busy arrival hours), the best policy response might be to create Federal holidays for elections (e.g. as proposed in "Democracy Day" legislation). By contrast, if the disparity is driven by inequalities in provided resources, the optimal policy response might be to set up systems to monitor and ensure equal resources per voter across the nation.

The nature of our data does not lend itself to a deep exploration of mechanism. A complete understanding of mechanism would likely need to include a large amount of investigative work including data for the quantity and quality of resources at the level of a polling place. There are also two measurement and identification issues to keep in mind. First, as noted in Section 3, our wait time measure may include voters who abandon the line after discovering a long wait time. Second, our estimates are conditional on a voter turning out. Each of the mechanisms below could affect either of these intermediate outcomes. For example, a Strict ID law could increase the amount of time it takes to process a single voter. However, it may also discourage potential voters from turning out to vote (decreasing the *actual queue length* for the marginal voter) and it could increase the likelihood that a voter who does turnout would leave the line early (decreasing the *average measured* time from our method). These two issues thus further caution against using this analysis in isolation to identify the causal effect of addressing these mechanisms. However, in our analysis below, we are able to cast doubt on a few potential mechanisms and draw some tentative conclusions that at the very least may help guide further work that attempts to pinpoint causal determinants of wait times.

B.1 Inflexible Arrival Times

One potential mechanism for the differences in wait times that we find is that areas differ in the intensity of voting that occurs at different times of day. For example, it is possible that polling stations in black and white areas are equally resourced and prepared to handle voters, but that voters in black areas are more likely to show up all at once. This could occur, for example, if black voters have less flexible jobs than white voters and therefore can only vote in the early morning or evening. This mechanism for differences in wait times is a bit more indirect than other potential mechanisms in that it is not driven by less attention or resources being devoted to black areas, but rather is a result of congestion caused by more general features of the economy (e.g. job flexibility).

To test for evidence of this mechanism, Figure B.1 plots the density of arrival time for voters from the most black areas (highest decile) and from the the least black areas (lowest decile).[1] A visual inspection of Figure B.1 shows quite minor differences in bunching. Voters in black areas are slightly more likely to show up in the very early morning hours whereas voters in white areas are slightly more likely to show up in the evening.

Figure B.1 does not appear to make a particularly strong case for bunching in arrival times. However, as we showed in Panel B of Figure A.3, wait times are longer in the morning (when black voters are slightly more likely to show up). A simple test to see if these differences are large enough to explain the racial disparities we find is to include hour-of-the-day fixed effects in our main regression specification. These fixed effects account for any differences in wait times that are due to one group (e.g. voters from black areas) showing up disproportionately during hours that have longer wait times. We include hour-of-the-day fixed effects in Column 6 of Appendix Table A.2. The coefficient on fraction black drops from a disparity of 3.27 minutes to a disparity of 3.10 minutes, suggesting that hour-of-the-day differences are not a primary factor that contributes to the wait-time gap that we find.

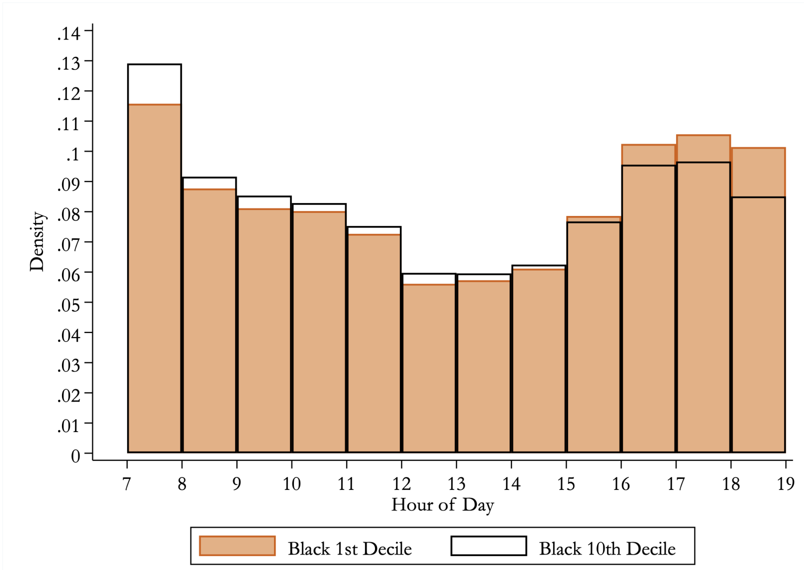
A different way to show that bunching in arrival times is not sufficient to explain our results is to restrict the sample to hours that don't include the early morning. In Appendix Table B.1, we replicate our main specification (Column 4 in Table 2), but only use data after 8am, 9am, and 10am. We continue to find strong evidence of a racial disparity in wait times despite the fact that this regression is including hours of the day (evening hours) when white areas may be more congested due to bunching. This table also provides estimates that exclude both morning and evening hours when there are differences in bunching by black and white areas and also restricts to just evening hours where white areas have higher relative volume in arrivals. Once again, we find strong black-white differences in voter wait times during these hours.

We conclude that the evidence does not support congestion at the polls due to bunching

[1]We restrict the sample to the 32 states that opened no later than 7am and closed no earlier than 7pm, and restrict the range to be from 7am to 7pm in order to avoid having attrition in the graph due to the opening and closing times of different states. We thus exclude the following states from this figure: Arkansas, Georgia, Idaho, Kansas, Kentucky, Maine, Massachusetts, Minnesota, Nebraska, New Hampshire, North Dakota, Tennessee, Vermont. Despite this sample restriction, we find a similar disparity estimate in this restricted sample (coefficient = 5.43; t = 13; N = 124,950) as in the full sample (coefficient = 5.23; t = 14; N = 154,411).

of arrival times as a primary mechanism explaining the racial disparity in wait times that we document.

Figure B.1: Density of Voters by Hour of Day by Fraction Black



Notes: Sample restricted to the 32 states that open no later than 7am and close no earlier than 7pm across all counties.

B.2 Partisan Bias

Another explanation for why voters in black areas may face longer wait times than voters in white areas is that election officials may provide fewer or lower quality resources to black areas. Using carefully-collected data by polling place across three states in the 2012 election (from Famighetti et al. 2014), Pettigrew (2017) finds evidence of exactly this – black areas were provided with fewer poll workers and machines than white areas. Thus, it seems likely that differential resources contribute to the effects that we find. An even deeper mechanism question though is why black areas might receive a lower quality or quantity of election resources. In this section, we explore whether partisanship is correlated with wait times.

At the state level, the individual charged with being the chief elections officer is the secretary of state (although in some states it is the lieutenant governor or secretary of the commonwealth). The secretary of state often oversees the distribution of resources to individual polling places, although the process can vary substantially from state to state and much of the responsibility is at times passed down to thousands of more local officials (Spencer and Markovitz 2010).[2]

[2]Spencer and Markovitz (2010) provide a useful summary of the problem of identifying precisely who is

It could be that state and county officials uniformly have a bias against allocating resources to black areas and this creates racial disparities in wait times across the U.S. as a whole. Alternatively, some election officials may be especially unequal in the resources they provide. An observable factor that could proxy for how unfair an election official may be in allocating resource is party affiliation. In 2016, black voters were far more likely to vote for the Democratic candidate than the Republican candidate.[3] Given this large difference in vote share, it is possible that Republican party control or overall Republican party membership of an area predicts a motivation (either strategic or based in prejudice) for limiting resources to polling places in black areas.

To test for evidence of a partisan bias, we plot empirical-Bayes-adjusted state-level racial disparities in wait times against the 2016 Republican vote share at both the state (panel A of Figure B.2) and county level (panel B of Figure B.2).[4] Panel A also color codes each state marker by the party affiliation of the chief elections officer in the state.[5] The fitted lines in both panels do not show evidence of positive correlation between Republican vote share and racial disparities in voter wait times. If anything we find larger disparities in areas that have

responsible for election administration in each of the 116,990 polling places spread over the country:

> One major reason why polling place inefficiency has yet to be adequately studied is that the administration of elections in the United States is extremely complicated. Each state creates its own rules, budgets its own money, and constructs its own election processes. In some states, such as Wisconsin and Michigan, local jurisdictions have primary autonomy over election administration. In others, such as Oklahoma and Delaware, all election officials are state employees. Still others share administrative duties between state and local election officials. For example, in California, counties have significant authority, yet they operate within a broad framework established by the Secretary of State. On the federal level, the United States Constitution preserves the right of Congress to supersede state laws regulating congressional elections. The result is a complex web of overlapping jurisdictions and 10,071 government units that administer elections. To complicate matters further, authority in all jurisdictions is ceded to two million poll workers who control the success or failure of each election.

[3]Exit polls suggested that 89% of black voters cast their ballot for the Democratic candidate in 2016 whereas only 8% voted for the Republican candidate (source: https://www.cnn.com/election/2016/results/exit-polls).

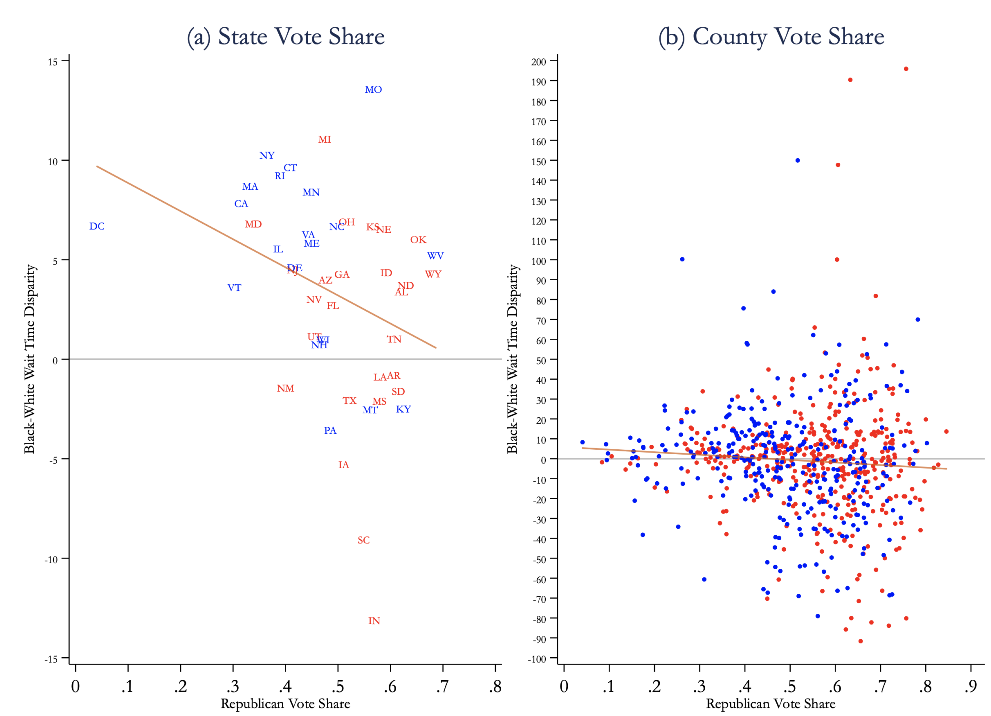
[4]The sample sizes for some counties are very small. Thus, we restrict the analysis to the 718 counties with at least 30 likely voters (and for which the disparity can be estimated) in order to avoid small-sample inference issues.

[5]State and county Republican vote shares are taken from the MIT Election Data and Science Lab's County Presidential Election Returns 2000-2016 (https://dataverse.harvard.edu/file.xhtml?persistentId=doi:10.7910/DVN/VOQCHQ/FQ9NBF&version=5.0). We compute the Republican vote share as the number of votes cast at the County (or State) level divided by the total number of votes cast in that election, and thus states with a Republican vote share under 50% may still have more votes for Trump over Clinton (e.g. Utah). The partisan affiliation of the chief elections officer in the state is taken from: https://en.wikipedia.org/w/index.php?title=Secretary_of_state_(U.S._state_government)&oldid=746677873

a lower Republican vote share.

While this analysis is correlational in nature, it suggests that racial disparities in wait times are not primarily driven by how Republican the state/county is. Rather, both red and blue states and counties are susceptible to generating conditions that lead to black voters spending more time at the polls than their white counterparts.

Figure B.2: Republican Vote Share and Racial Gaps



Notes: Panel A shows a scatter plot of empirical-Bayes-adjusted state-level wait time disparities (i.e. the adjusted coefficient from a regression of wait time on "Fraction Black", with standard errors clustered at the polling place level) against the 2016 Republican vote share for that state. Panel B shows the same relationship for county-level measures. Points are colored by the partisan affiliation of the chief elections officer in that State (Red = Republican). The fit lines are produced using lfit in *Stata*.

B.3 County-Level Correlates

We do not find evidence of a correlation between party affiliation at the county level and racial disparities in wait times. However, there may be other characteristics of counties that correlate with our measure of racial disparities. In Figure B.3, we show estimates of a regression of our measure of racial disparities at the county-level (empirical-Bayes adjusted and limited to those counties with more than 30 observations) against a Social Capital Index, Top 1% Income Share, Gini Coefficient, Theil Index of Racial Segregation, and two measures of social mobility from Chetty and Hendren (2018). Each of these variables is taken from

Figure 5 of Chetty and Hendren (2018), corresponds to the 2000 Census, and has been standardized.[6] We find little evidence that voter wait time disparities are correlated with these additional measures. Overall, we argue that a clear pattern does not emerge where counties of a particular type are experiencing the largest disparities in voter wait time.

B.4 State Voting Laws

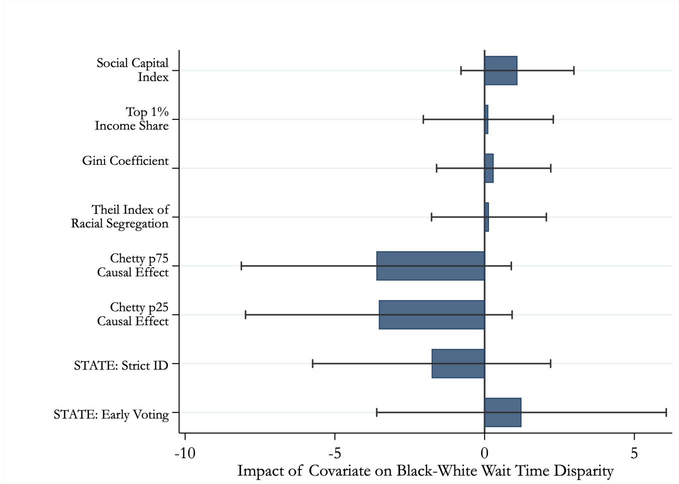
A large recent discussion has emerged regarding the impact of Strict ID laws (Cantoni and Pons 2019b; Grimmer and Yoder 2019) and unequal access to early voting (Kaplan and Yuan 2019; Herron and Smith 2014) on the voting process. Both of these types of laws have the potential to produce racial inequalities in wait times. For example, Strict ID laws may disproportionately cause delays at polling places in minority areas. The effect of early voting laws is less clear. It is possible that early voting allows voters who would have otherwise faced long lines to take advantage of the early voting process and therefore release some of the pressure at the polling places with the longest waits. However, it is also possible that white voters are more likely to learn about and take advantage of early voting (or that early voting is more likely to be available in white areas within a State that has early voting) which could lead to even longer disparities in wait times if election officials don't adjust polling place resources to accommodate the new equilibrium.

The final two bars in Figure B.3 show how our measure of racial disparity at the state level interacts with states with early voting laws (N = 34) and states with Strict ID laws (N = 10).[7] As can be seen in the figure, we do not find evidence that the variation in wait time disparities is being explained in a substantial way by these laws.

[6]We source these variables from: `https://opportunityinsights.org/wp-content/uploads/2018/04/online_table4-2.dta` and merge on the Census County FIPS (taken from the 2000 Census in the Chetty and Hendren (2018) data and from the 2017 ACS in our data.

[7]Following Cantoni and Pons (2019a), we source both of these measures from the National Conference of State Legislatures. We use Internet Archive snapshots from just before the 2016 Election to obtain measures relevant for that time period (e.g. for Strict ID laws we use the following link: `https://web.archive.org/web/20161113113845/http://www.ncsl.org/research/elections-and-campaigns/voter-id.aspx`). For the early-voting measure we define it as any state that has same-day voter registration, automatic voter registration, no-excuse absentee voting, or early voting (Cantoni and Pons (2019a) study multiple elections, and thus define this measure as the share of elections over which one of these was offered). States identified as having strict voter ID laws in 2016 are: Arizona, Georgia, Indiana, Kansas, Mississippi, North Dakota, Ohio, Tennessee, Virginia, and Wisconsin. States identified as *not* having any type of early voting in 2016 are: Alabama, Delaware, Indiana, Kentucky, Michigan, Mississippi, Missouri, New York, Pennsylvania, Rhode Island, South Carolina, Virginia.

Figure B.3: County Characteristics, State Laws, and Racial Disparities



Notes: Each row reports the coefficient from a bivariate regression of a county-level (empirical-Bayes-adjusted) wait time average on a county-level measure (rows 1-8) or of a state-level (empirical-Bayes-adjusted) wait time average on a state-level measure. See footnote 9 for further details on the county-level measures taken from Chetty and Hendren (2018). States identified as having strict voter ID laws in 2016 are: Arizona, Georgia, Indiana, Kansas, Mississippi, North Dakota, Ohio, Tennessee, Virginia, and Wisconsin. States identified as *not* having any type of early voting in 2016 are: Alabama, Delaware, Indiana, Kentucky, Michigan, Mississippi, Missouri, New York, Pennsylvania, Rhode Island, South Carolina, Virginia.

B.5 Congestion

A final mechanism that we explore is congestion due to fewer or lower quality resources per voter at a polling place. Congestion may cause longer wait times and be more likely to be a factor at polling places with more black voters. We do not have a direct measure of resources or overall congestion at the polling place level, but a potential proxy for congestion is the number of registered voters who are assigned to each polling place. We use data from L2's 2016 General Election national voter file. These data allow us to determine the total number of registered voters who are assigned to vote at each polling place and also the number of actual votes cast. For most voters, their polling place was determined by the name of their assigned precinct; precincts were assigned to one or more polling places by their local election authority. In the rare case where voters were allowed their choice from multiple polling places, the polling place closest to their home address was used. Registered voters and votes cast by polling place are highly correlated (correlation = 0.96) and the analysis below is unchanged independent of what measure we use. We will therefore focus on the number of registered voters for each polling place.

It is not obvious that polling places with more voters should have longer overall wait times. In a carefully-resourced system in equilibrium, high-volume polling places should have more machines and polling workers and therefore be set up to handle the higher number of voters. However, it is possible that the quality and quantity of polling resources is out of equilibrium and does not compensate for the higher volume. For example, polling-place closures or residential construction may increase the number of registered voters assigned to a given polling place and polling resources may not adjust fast enough to catch up to the changing volume. Alternatively, even if variable resource are in equilibrium, there may be fixed differences that lead to longer wait times in high volume areas (e.g. constrained building sizes leading to slower throughput, or a higher risk of technical issues).[8]

Following our baseline specifications, we regress voting wait time for each individual in our sample on the number of registered voters assigned to the polling place where they voted. These results can be found in Appendix Table B.3. We do indeed find a positive relationship across specifications with varied fixed effects suggesting that congestion may be an issue in high-volume polling locations.

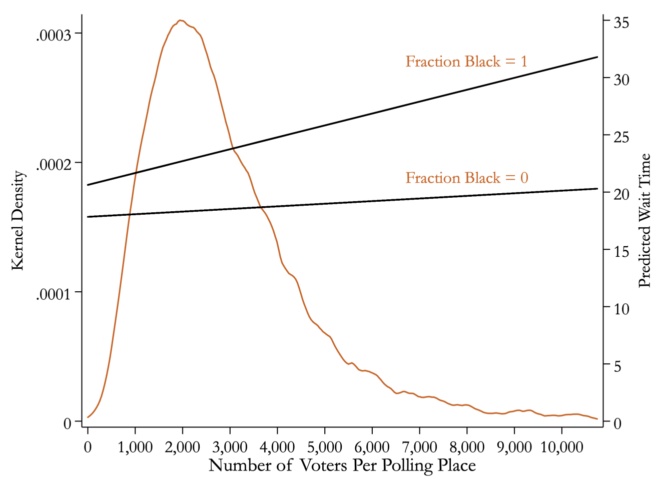
Given the above association, if polling places with a large fraction of black voters are also more likely to be high volume, this could help explain the black-white disparity in wait times that we have documented. The data, however, do not bear this out. There is not a strong correlation between volume and the fraction of black residents at a polling place (correlation = .03). One way to see this is we run our baseline regressions, but include the number of registered voters in each polling place as a control. The table indicates that this new control does not significantly diminish the racial disparity in wait times and if anything may cause the disparity to become a bit larger in some specifications.

Lastly, we explore whether or not the racial disparity in voter wait times that we document interacts with our proxy for congestion. Is the racial gap in wait times larger or smaller in high-volume polling places? In Appendix Table B.4 we run our baseline regressions and include the number of registered voters in each polling place and also an interaction between registered voters and the fraction of black residents. Across all specifications, we find a significant and robust interaction effect indicating larger racial disparities at higher volume polling places. Figure B.4 helps put this interaction effect in perspective. In this figure, we plot the density function for the number of voters registered in each individual's polling place

[8]In Appendix Table B.2, we investigate these potential fixed building type differences directly by matching polling place buildings to information on size and types from Microsoft OpenStreetMap. We group building types into 6 categories (Commercial, Medical, Private, Public, Religious, School) and 76 sub-categories (e.g. Commercial is divided into Gym, Hotel, Shopping Center, and 7 other sub-categories). We show in Panel C that building categories and building size are only weakly predictive of fraction black. Panels A and B in turn show that controlling for a second-order polynomial in building size (Column 2), category fixed effects (Column 3), and sub-category fixed effects (Column 4) has little effect on estimates of the racial disparities. This analysis suggests that at least these coarse building characteristics, on their own, do not seem to mediate the relationship. Moreover, this analysis provides some reassurance that the rules for cleaning data—which may differentially affect different building types—do not skew our estimates of the racial disparities.

in our data (labeled on the left y-axis). We also plot the predicted wait time for an area composed entirely of black residents (fraction black = 1) as well as an area with no black residents (fraction black = 0) by the number of registered voters at the polling place (labeled on the right y-axis). The predicted lines indicate that the black-white disparity in wait times for individuals who vote at a low-volume polling location (10th percentile = 1,150 registered voters) is 3.7 minutes whereas the disparity in high-volume polling locations (90th percentile = 5,242 registered voters) is almost twice as large at 7 minutes.

Figure B.4: Congestion and Wait Times by Fraction Black



Notes: The left y-axis corresponds to the kernel density (estimated using 100 person half-widths) of the Number of Registered Voters per Polling Place (after first dropping the top 1% of observations, i.e. voters in polling places with more than 10,746 registered individuals). The right y-axis corresponds to the two regression lines (estimated on the full sample) – both lines correspond to a voter (i.e. cellphone identifier)-level regression of wait time on "Fraction Black", the "Number of Registered Voters Per Polling Place", and the interaction. The top line reports the predicted regression line for "Fraction Black" = 1, while the bottom line reports this for "Fraction Black" = 0.

Thus, we find that the largest racial disparities in voter wait times are in the highest volume polling places. This finding is consistent with several possible stories. For example, this pattern may reflect another dimension of the aforementioned inequality in polling machines, workers, and other support. Black areas may face persistent under-resourcing and these resourcing constraints may be especially harmful at higher volumes of voters. Relatedly, election officials may respond less quickly to adjustments in volume (e.g. caused by polling closures or changes in voter-age population) in areas with higher concentrations of black residents. This off-equilibrium response may lead to the differential gradient we find in volume between black and white areas. Our analysis is correlational and thus does not allow us to make conclusive statements about the exact underlying mechanism. On the other hand, this descriptive exercise can provide guidance on potential sources for the disparity that are worthy of further exploration.

Table B.1: Fraction Black and Voter Wait Time (Restricting Hour of Arrival Windows)

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Ordinary Least Squares (Y = Wait Time)						
Fraction Black	4.84***	2.90***	2.21***	1.85***	1.71***	1.92***
	(0.42)	(0.43)	(0.43)	(0.44)	(0.54)	(0.51)
Fraction Asian	1.30*	0.20	-0.14	-0.41	0.57	-1.08
	(0.76)	(0.77)	(0.79)	(0.80)	(1.01)	(0.98)
Fraction Hispanic	3.90***	3.23***	3.22***	3.26***	0.84	5.25***
	(0.46)	(0.48)	(0.50)	(0.51)	(0.62)	(0.63)
Fraction Other Non-White	1.66	1.14	1.40	2.20	0.53	3.02
	(1.89)	(1.92)	(2.00)	(2.06)	(2.44)	(2.55)
N	154,260	124,367	111,480	99,858	57,863	52,995
R^2	0.06	0.04	0.04	0.04	0.04	0.04
DepVarMean	19.12	17.67	17.50	17.34	17.47	16.88
Sample?	Full	$\geq 8am$	$\geq 9am$	$\geq 10am$	10am-3pm	$\geq 3pm$
Panel B: LPM (Y = Wait Time > 30min)						
Fraction Black	0.10***	0.06***	0.04***	0.03***	0.03**	0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Fraction Asian	0.04**	0.02	0.01	0.01	0.02	0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Fraction Hispanic	0.08***	0.06***	0.06***	0.07***	0.01	0.11***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Fraction Other Non-White	0.03	0.01	0.03	0.05	0.02	0.04
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.06)
N	154,260	124,367	111,480	99,858	57,863	52,995
R^2	0.04	0.03	0.03	0.03	0.03	0.03
DepVarMean	0.18	0.14	0.14	0.14	0.14	0.13
Sample?	Full	$\geq 8am$	$\geq 9am$	$\geq 10am$	10am-3pm	$\geq 3pm$

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Robust standard errors, clustered at the polling place level, are in parentheses. Unit of observation is a cellphone identifier on Election Day. *DepVarMean* is the mean of the dependent variable. Specifications match those of Table 1, Column 4. The dependent variable in Panel B is a binary variable equal to 1 if the wait time is greater than 30 minutes. All columns include state fixed effects and *polling area controls* (includes the population, population per square mile, and fraction below poverty line for the block group of the polling station. "Asian" includes "Pacific Islander." "Other Non-White" includes the "Other," "Native American," and "Multiracial" Census race categories).

Table B.2: Controlling for Building Type and Size

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Ordinary Least Squares (Y = Wait Time)										
Fraction Black	5.23***	5.41***	5.69***	5.55***	7.57	10.60	4.10***	4.54***	5.62***	6.36***
	(0.39)	(0.39)	(0.38)	(0.38)	(6.11)	(6.44)	(1.57)	(0.83)	(0.87)	(0.52)
N	154,411	154,411	154,411	153,937	2,259	474	10,514	37,243	44,823	59,098
R^2	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.01
DepVarMean	19.13	19.13	19.13	19.12	19.60	20.18	19.35	19.42	20.33	17.96
PollingPlaces	43,385	43,385	43,385	43,220	628	165	3,962	12,630	12,173	13,827
Category FE?	No	No	Yes	No	No	No	No	No	No	No
Subcategory FE?	No	No	No	Yes	No	No	No	No	No	No
Subsample?	All	All	All	All	Com	Med	Pri	Pub	Rel	Sch
Panel B: Linear Probability Model (Y = Wait Time > 30min)										
Fraction Black	0.12***	0.12***	0.12***	0.12***	0.15	0.17	0.09***	0.10***	0.12***	0.14***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.12)	(0.14)	(0.03)	(0.02)	(0.02)	(0.01)
N	154,411	154,411	154,411	153,937	2,259	474	10,514	37,243	44,823	59,098
R^2	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.01
DepVarMean	0.18	0.18	0.18	0.18	0.20	0.19	0.18	0.18	0.20	0.16
PollingPlaces	43,385	43,385	43,385	43,220	628	165	3,962	12,630	12,173	13,827
Category FE?	No	No	Yes	No	No	No	No	No	No	No
Subcategory FE?	No	No	No	Yes	No	No	No	No	No	No
Subsample?	All	All	All	All	Com	Med	Pri	Pub	Rel	Sch
Panel C: Do Building Characteristics Predict Race? (Y = Fraction Black)										
Poll: Medical	0.03									
	(0.02)									
Poll: Private	0.00									
	(0.01)									
Poll: Public	-0.00									
	(0.01)									
Poll: Religious	0.00									
	(0.01)									
Poll: School	0.03***									
	(0.01)									
Poll: Building Area		0.01***								
		(0.00)								
N	154,411	154,411								
R^2	0.01	0.00								
DepVarMean	19.13	19.13								
PollingPlaces	43,385	43,385								

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Robust standard errors, clustered at the polling place level, are in parentheses. Unit of observation is a cellphone identifier on Election Day. *DepVarMean* is the mean of the dependent variable. The dependent variable in Panel B is a binary variable equal to 1 if the wait time is greater than 30 minutes. Column 1 of Panels A and B present the baseline specification shown in Column 1, Panel A, Table 1 in the text. Column 2 includes a second-order polynomial in building area, where building area is in 5,000 square meters units (close to the standard deviation of building area in our sample), Columns 3 includes building category (Commercial, Medical, Private, Religious, Public, School) fixed effects, and Column 4 includes building sub-category (76) fixed effects. Columns 5-10 show sub-sample estimates across the 6 building categories.The dependent variable in Panel C is "Fraction Black," and the omitted category is "Poll: Commercial".

Table B.3: Congestion (Table 2 with added Volume Controls)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Ordinary Least Squares (Y = Wait Time)										
Fraction Black	5.20***	5.21***	5.18***	5.18***	4.97***	4.96***	4.80***	4.82***	3.32***	3.36***
	(0.38)	(0.38)	(0.39)	(0.38)	(0.42)	(0.41)	(0.42)	(0.41)	(0.45)	(0.44)
Voters Per Polling Place		0.29***		0.30***		0.25***		0.51***		0.61***
		(0.07)		(0.07)		(0.07)		(0.06)		(0.05)
Fraction Asian			-0.80	-0.81	-2.51***	-2.34***	1.25*	1.04	-1.13	-1.18
			(0.72)	(0.71)	(0.75)	(0.74)	(0.76)	(0.75)	(0.81)	(0.80)
Fraction Hispanic			1.01***	0.95**	0.31	0.30	3.81***	3.85***	1.53***	1.67***
			(0.37)	(0.37)	(0.40)	(0.40)	(0.46)	(0.47)	(0.50)	(0.51)
Fraction Other Non-White			12.49***	12.97***	12.32***	12.67***	1.96	2.26	1.95	1.90
			(1.96)	(1.97)	(1.97)	(1.98)	(1.90)	(1.89)	(1.95)	(1.95)
N	152,317	152,317	152,317	152,317	152,167	152,167	152,167	152,167	152,167	152,167
R^2	0.00	0.00	0.00	0.01	0.01	0.01	0.06	0.06	0.13	0.13
DepVarMean	19.10	19.10	19.10	19.10	19.09	19.09	19.09	19.09	19.09	19.09
Polling Area Controls?	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
State FE?	No	No	No	No	No	No	Yes	Yes	Yes	Yes
County FE?	No	No	No	No	No	No	No	No	Yes	Yes
Panel B: Linear Probability Model (Y = Wait Time > 30min)										
Fraction Black	0.12***	0.12***	0.12***	0.12***	0.11***	0.11***	0.10***	0.10***	0.07***	0.07***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Voters Per Polling Place		0.01***		0.01***		0.01***		0.01***		0.01***
		(0.00)		(0.00)		(0.00)		(0.00)		(0.00)
Fraction Asian			-0.00	-0.00	-0.04**	-0.04**	0.04**	0.03**	-0.02	-0.02
			(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Fraction Hispanic			0.02***	0.02**	0.01	0.01	0.08***	0.08***	0.03***	0.04***
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Fraction Other Non-White			0.22***	0.23***	0.22***	0.23***	0.03	0.04	0.04	0.04
			(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
N	152,317	152,317	152,317	152,317	152,167	152,167	152,167	152,167	152,167	152,167
R^2	0.00	0.00	0.00	0.00	0.01	0.01	0.05	0.05	0.10	0.10
DepVarMean	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Polling Area Controls?	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
State FE?	No	No	No	No	No	No	Yes	Yes	Yes	Yes
County FE?	No	No	No	No	No	No	No	No	Yes	Yes

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Robust standard errors, clustered at the polling place level, are in parentheses. Unit of observation is a cellphone identifier on Election Day. *DepVarMean* is the mean of the dependent variable. The dependent variable in Panel B is a binary variable equal to 1 if the wait time is greater than 30 minutes. *Polling Area Controls* includes the population, population per square mile, and fraction below poverty line for the block group of the polling station. "Asian" includes "Pacific Islander." "Other Non-White" includes the "Other," "Native American," and "Multiracial" Census race categories. "Voters per Polling Place" is the number of registered individuals for that polling place in the National voterfile.

Table B.4: Congestion Heterogeneity (Table 2 with added Volume Interactions)

	(1)	(2)	(3)	(4)	(5)
Panel A: Ordinary Least Squares (Y = Wait Time)					
Fraction Black	2.79***	2.79***	3.01***	2.45***	1.08
	(0.79)	(0.78)	(0.82)	(0.75)	(0.74)
Voters Per Polling Place	0.23***	0.23***	0.20**	0.45***	0.54***
	(0.08)	(0.08)	(0.08)	(0.06)	(0.05)
Interaction: Black X VotersPerPoll	0.81***	0.80***	0.65**	0.80***	0.76***
	(0.27)	(0.27)	(0.27)	(0.23)	(0.22)
Fraction Asian		-0.88	-2.32***	1.10	-1.04
		(0.71)	(0.74)	(0.75)	(0.80)
Fraction Hispanic		0.93**	0.29	3.86***	1.68***
		(0.37)	(0.40)	(0.46)	(0.51)
Fraction Other Non-White		12.94***	12.62***	2.17	1.88
		(1.97)	(1.98)	(1.89)	(1.95)
N	152,317	152,317	152,167	152,167	152,167
R^2	0.00	0.01	0.01	0.06	0.13
DepVarMean	19.10	19.10	19.09	19.09	19.09
Polling Area Controls?	No	No	Yes	Yes	Yes
State FE?	No	No	No	Yes	Yes
County FE?	No	No	No	No	Yes
Panel B: Linear Probability Model (Y = Wait Time > 30min)					
Fraction Black	0.07***	0.07***	0.08***	0.06***	0.03
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Voters Per Polling Place	0.01***	0.01***	0.00***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Interaction: Black X VotersPerPoll	0.01**	0.01**	0.01*	0.01***	0.01***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Fraction Asian		-0.00	-0.04**	0.03**	-0.02
		(0.02)	(0.02)	(0.02)	(0.02)
Fraction Hispanic		0.02**	0.01	0.08***	0.04***
		(0.01)	(0.01)	(0.01)	(0.01)
Fraction Other Non-White		0.23***	0.23***	0.04	0.04
		(0.04)	(0.04)	(0.04)	(0.04)
N	152,317	152,317	152,167	152,167	152,167
R^2	0.00	0.01	0.01	0.05	0.10
DepVarMean	0.18	0.18	0.18	0.18	0.18
Polling Area Controls?	No	No	Yes	Yes	Yes
State FE?	No	No	No	Yes	Yes
County FE?	No	No	No	No	Yes

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Robust standard errors, clustered at the polling place level, are in parentheses. Unit of observation is a cellphone identifier on Election Day. *DepVarMean* is the mean of the dependent variable. The dependent variable in Panel B is a binary variable equal to 1 if the wait time is greater than 30 minutes. *Polling Area Controls* includes the population, population per square mile, and fraction below poverty line for the block group of the polling station. "Asian" includes "Pacific Islander." "Other Non-White" includes the "Other," "Native American," and "Multiracial" Census race categories. "Voters per Polling Place" is the number of registered individuals for that polling place in the National voterfile.