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EVIDENCE FROM SMARTPHONE DATA

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ABSTRACT

Equal access to voting is a core feature of democratic government. Using data from millions of smartphone users, we quantify a racial disparity in voting wait times across a nationwide sample of polling places during the 2016 U.S. presidential election. Relative to entirely-white neighborhoods, residents of entirely-black neighborhoods waited 29% longer to vote and were 74% more likely to spend more than 30 minutes at their polling place. This disparity holds when comparing predominantly white and black polling places within the same states and counties, and survives numerous robustness and placebo tests. We shed light on the mechanism for these results and discuss how geospatial data can be an effective tool to both measure and monitor these disparities going forward.

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Providing convenient and equal access to voting is a central component of democratic government. Among other important factors (e.g. barriers to registration, purges from voter rolls, travel times to polling places), long wait times on Election Day is a frequently discussed concern of voters. Long wait times have large opportunity costs (Stewart and Ansolabehere 2015), may lead to line abandonment by discouraged voters (Stein et al. 2019), and can undermine voters' confidence in the political process (Alvarez et al. 2008; Atkeson and Saunders 2007; Bowler et al. 2015). The topic of long wait times has reached the most prominent levels of media and policy attention, with President Obama discussing the issue in his 2012 election victory speech and appointing a presidential commission to investigate the issue. In their 2014 report, the Presidential Commission on Election Administration concluded that, "as a general rule, no voter should have to wait more than half an hour in order to have an opportunity to vote."

There have also been observations of worrying racial disparities in voter wait times. The Cooperative Congressional Election Study (CCES) finds that black voters report facing significantly longer lines than white voters (Pettigrew 2017; Alvarez et al. 2009; Stewart III 2013). While suggestive, the vast majority of prior work on racial disparities in wait times has been based on anecdotes and surveys, which face limits due to recall and reporting biases. For example, there is dramatic overreporting of voter turnout in the CCES. Enamorado and Imai (2019) further show that this reporting bias in turnout is correlated with a respondent's interest in politics, their race, and other characteristics.

In this paper, we use geospatial data generated by smartphones from an initial sample of over 10 million Americans to measure wait times during the 2016 election. For each cellphone user, we record "pings" based on the location of the cellphone throughout the day. These rich data allow us to document voter wait times across the entire country and also estimate how these wait times differ based on neighborhood racial composition.

We begin by restricting the set of smartphones to a sample that passes a series of filters that allow us to identify likely voters. This leaves us with a sample of just over 150,000 smartphone users who voted at one of more than 40,000 polling locations across 46 different states. Specifically, these individuals entered and spent at least one minute within a 60-meter radius of a polling location on Election Day and recorded at least one ping within the convex hull of the polling place building (based on building footprint shapefiles). We eliminate individuals who entered the same 60-meter radius in the week leading up to or the week after Election Day to avoid non-voters who happen to work at or otherwise frequently visit a polling place on non-election days.

We estimate that the median and average times spent at polling locations are 14 and 19 minutes, respectively, and 18% of individuals spent more than 30 minutes voting.[1] We provide descriptive data on how voting varies across the course of Election Day. As expected, voter volume is largest in the morning and in the evening, consistent with voting before and after the workday. We also find that average wait times are longest in the early morning hours of the day. Finally, as a validation of our approach, we show that people show up to the polls at times consistent with the opening and closing hours used in each state.

We next document geographic variation in average wait times using an empirical Bayes adjustment strategy. We find large differences across geographic units – for example, average wait times across congressional districts can vary by a factor of as much as four. We further validate our approach by merging in the CCES data, which elicits a coarse measure of wait time from respondents. Despite many reasons why one might discount the CCES measures (e.g. reporting bias and limited sample size), we find a remarkably high correlation with our own measures – a correlation of 0.86 in state-level averages and 0.73 in congressional-district-level averages. This concordance suggests that our wait time measures (and those elicited through the survey) have a high signal-to-noise ratio.

We next explore how wait times vary across areas with different racial compositions. We use Census data to generate race information for each each polling place's corresponding Census block group (as a proxy for its catchment area). We find that the average wait time in a Census block group composed entirely of black residents is approximately 5 minutes longer than average wait time in a block group that has no black residents. We also find longer wait times for areas with a high concentration of Hispanic residents, though this disparity is not as large as the one found for black residents. These racial disparities persist after controlling for population, density, poverty rates, and state fixed effects. We further decompose these effects into between- and within-county components, with the disparities remaining large even when including county fixed effects.

We perform a myriad of robustness checks and placebo specifications and find that the racial disparity exists independent of the many assumptions and restrictions that we have put on the data. We also correlate our measure of racial disparity in wait times at the state and congressional district level with the racial disparity in wait times reported in the CCES

[1]The time measure that we estimate in our paper is always a combination of wait time in addition to the time it took to cast a ballot. We frequently refer to this as just "wait time" in the paper. One may worry that the differences we find are not about wait times, but rather about differences in the amount of time spent casting a ballot. However, there is evidence to suggest this is not the case. For example, we find incredibly strong correlations between our wait time measures and survey responses that ask only about wait times as opposed to total voting time ("Approximately, how long did you have to wait in line to vote?").

survey as we did with the overall wait times. Once again we find a very strong relationship between states that we argue have a large racial disparity in wait times and the states shown to have large differences by survey participants (and a much more modest correlation at the congressional district level).

The final section of the paper attempts to better understand potential mechanisms driving the racial differences that we find. We begin by analyzing the possibility that black and white polling locations have equal resources and are both well-equipped to handle voters, but that areas with a high fraction of black voters experience surges in voters at specific times of day. For example, if black voters have less flexible jobs and must show up during certain hours, whereas white voters can spread out across the day, this could explain longer wait times for black voters. We find modest levels of bunching of this sort and thus rule out this mechanism as the primary explanation for the racial disparities that we find.

We next consider the possibility that wait times are longer in areas where Republicans make up a majority or control the office of chief election official. Given that black Americans voted overwhelmingly in favor of Democrats in 2016, there could be strategic or other reasons for Republican-controlled areas to try to increase wait times in black areas. We find no evidence that suggests that this is the case. If anything, we find larger disparities in areas that have a lower Republican vote share.

In addition to party affiliation, we investigate whether other characteristics of a county or state may correlate with having large racial disparities in wait times such as income inequality, racial segregation, and previously-documented levels of social mobility (Chetty and Hendren 2018). None of these measures is strongly correlated with voter wait time disparities and there is certainly not a consistent pattern that emerges.

We also check to see if racial disparities differ across states with different voting laws, specifically strict voter ID laws and early voting laws. Strict voter ID laws may lead to longer wait times for black voters if they are disproportionately delayed due to ID issues when they arrive at the polling locations. The hypothesized impact of early voting laws is less clear. Early voting may allow voters in relatively black areas who know they will face long lines to vote early, thereby reducing congestion and wait times for black voters on Election Day. However, it could also be that white voters are more likely to have access to early voting within a state (or be more likely to take advantage of it) and therefore white areas become even less congested, thereby increasing the black-white wait time gap. We find no correlation between wait time disparities and Strict ID or early voting laws. Failing to find an association is suggestive (but certainly not conclusive) that these state laws are not the primary mechanisms that explain the persistent black-white wait time gap that we document.

Lastly, we explore whether congestion at polling places could mediate the black-white wait time disparity. Using the number of registered voters assigned to a polling place as a proxy for congestion, we find that high-volume polling locations do indeed have longer average wait times. However, consistent with the lack of correlation between polling-place volume and black voters, this proxy for congestion is unable to explain the disparity. We do, however, show that there is a significant and robust interaction effect between congestion and black-white wait time differences. The racial disparity at high-volume polling locations is approximately twice as large as the disparity at low-volume polling locations. This suggests that whatever is driving the racial disparities is compounded by higher volume. For example, election officials may provide fewer or lower quality machines and/or poll workers to polling places in areas with more black residents, and further, they do not scale up those resources with congestion proportionately across black and white areas.

Overall, our results on mechanism suggest that the racial disparities that we find are widespread and unlikely to be caused by any one particular source or phenomenon. While our data do not allow us to conclusively pinpoint any precise mechanism, they do shed light on directions for future investigation that may be particularly fruitful.

Our paper is most closely related to work in political science that has examined determinants of wait times and also explored racial disparities. Some of the best work uses data from the CCES survey which provides a broad sample of survey responses on wait times (Pettigrew 2017; Alvarez et al. 2009; Stewart III 2013). For example, Pettigrew (2017) finds that black voters report waiting in line for twice as long as white voters and are three times more likely to wait for over 30 minutes to vote. Additional studies based on field observations may avoid issues that can arise from self-reported measures, but typically only cover small samples of polling places such as a single city or county (Highton 2006; Spencer and Markovits 2010; Herron and Smith 2016). Stein et al. (2019) collect the largest sample to date, using observers with stopwatches across a convenience sample of 528 polling locations in 19 states. Using a sample of 5,858 voters, they provide results from a regression of the number of people observed in line on an indicator that the polling place is in a majority-minority area. They find no significant effect – although they also control for arrival count in the regression. In a later regression, they find that being in a majority-minority polling location leads to a 12-second increase in the time it takes to check in to vote (although this regression includes a control for the number of poll workers per voter which may be a mechanism for racial disparities in voting times). Overall, we arrive at qualitatively similar results as the political science literature, but do so using much more comprehensive data that avoids the pitfalls of self-reports. Going forward, this approach could produce repeated measures across elections, which would facilitate a richer examination of the causal determinants of the disparities (e.g. difference-in-differences analysis of law changes).

Our paper also relates to the broader literature documenting that black individuals (and neighborhoods) are generally treated worse than white individuals and white neighborhoods (for reviews, see Altonji and Blank 1999, Charles and Guryan 2011, and Bertrand and Duflo 2017). Included in this literature is work showing evidence of racial discrimination by government officials. For example, Butler and Broockman (2011) find that legislators were less likely to respond to email requests from a black-sounding name, even when the email signaled shared partisanship in an attempt to rule out strategic motives. Similarly, White et al. (2015) find that election officials in the U.S. were less likely to respond and provided lower-quality responses to emails sent from constituents with Latino-sounding names. Racial bias has also been documented for public officials that are not part of the election process. For example, Giulietti et al. (2019) find that emails sent to local school districts and libraries asking for information were less likely to receive a response when signed with a black-sounding name relative to a white-sounding name. As one final example, several studies have documented racial bias by judges in criminal sentencing (Alesina and Ferrara 2014; Glaeser and Sacerdote 2003; Abrams et al. 2012).

This paper is organized as follows. Section 1 describes the data used in our paper. Section 2 presents the methodology. Section 3 presents results on the overall wait times. Section 4 focuses on racial disparities in wait times. Section 5 provides evidence and a discussion of possible mechanisms. Section 6 concludes. Supplementary results and details are provided in appendix tables and figures.

1 Data

The three primary datasets that we use in our paper include: (1) SafeGraph cell phone location records, (2) Polling locations, and (3) Census demographics.

We use anonymized location data for more than 10 million U.S. smartphones provided by SafeGraph, a firm that aggregates location data across a number of smartphone applications (Chen and Rohla 2018). These data cover the days between November 1st and 15th, 2016, and consist of "pings", which record a phone's location at a series of points in time. Pings are recorded anytime an application on a phone requests information about the phone's location. Depending on the application, this can happen when the application (e.g. a navigation or weather app) is being used, or can occur at regular intervals when the application is in the background. The modal time between pings in our sample for a given device is 5 minutes.

The geolocation data used in this paper is detailed and expansive, which allows us to estimate wait times around the entire United States. However, it also has its limitations. One key limitation is that the sample is an imperfect representation of the overall U.S. population. Given the nature of the data, our sample can by construction only be representative of the approximately 77% of U.S. adults who owned a smartphone in 2016. Additionally, we will be restricting our sample to phones that receive regular pings and thus will disproportionately remove individuals who turn off their phones for extended periods of time, do not allow location-tracking services on their phone, or live in areas with poor cell phone coverage. However, as shown in Chen and Pope (2019), the data are generally representative of the U.S. along several dimensions, with the primary exception being that our sample is skewed to be more wealthy. While the non-representative nature of our sample may reduce the number of observations for voting wait times at some polling locations, we argue that dropping some voters out of our sample is unlikely to cause bias in the estimates of voting wait times for the observations that we do have.

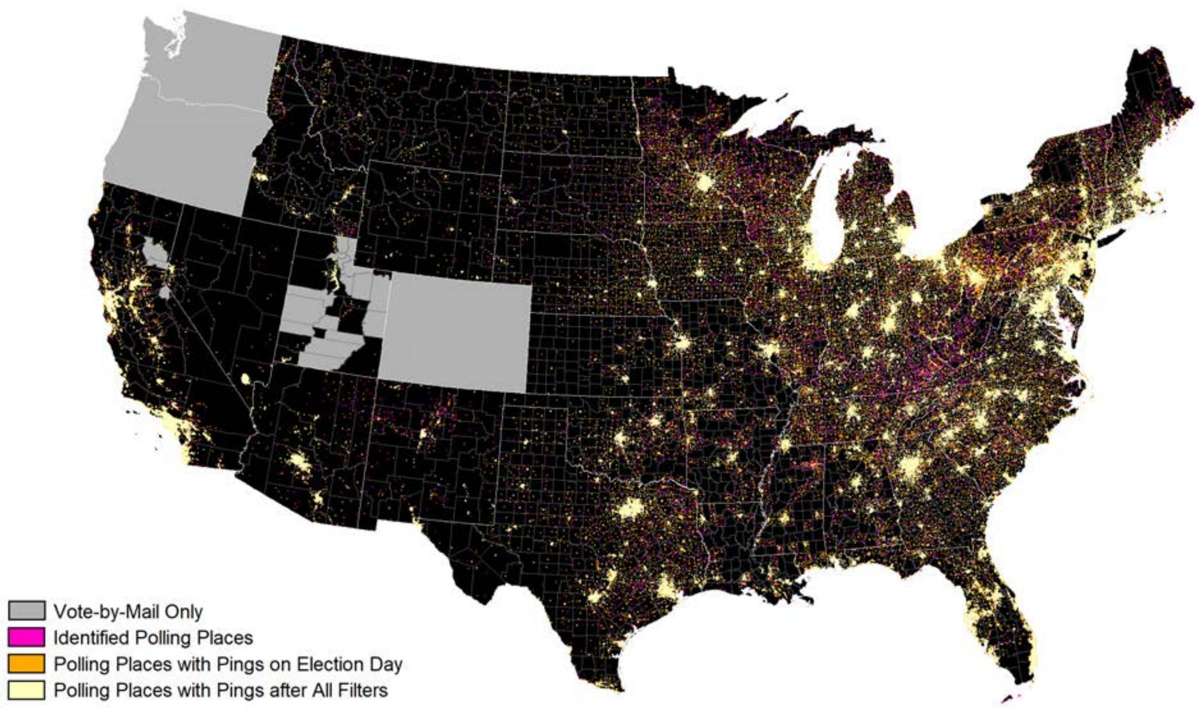
Polling place addresses for the 2016 General Election were collected by contacting state and county election authorities. However, when not available, locations were sourced from local newspapers, public notices, and state voter registration look-up webpages. State election authorities provided statewide locations for 32 states, five of which required supplemental county-level information to complete. Four states were completely collected on a county-by-county basis. In twelve states, not all county election authorities responded to inquiries. The largest counties by population not covered by the resultant dataset are Nassau County, New York; Westchester County, New York; Niagara County, New York; Chautauqua County, New York; Rapides Parish, Louisiana; St. Landry Parish, Louisiana; Iberia Parish, Louisiana; Lonoke County, Arkansas; Acadia Parish, Louisiana; Lowndes County, Mississippi; and Blount County, Alabama.

When complete addresses were provided, the polling locations were geocoded to coordinates using the Google Maps API. When partial or informal addresses were provided, buildings were manually assigned coordinates by identifying buildings through Google Street View, imagery, or local tax assessor maps as available. Additionally, Google Maps API geocodes are less accurate or incomplete in rural locations or areas of very recent development, and approximately 8% of Google geocodes were manually updated. Another 1% of coordinates were provided by the state or county directly; in the case of Michigan, these coordinates proved insufficiently precise and were updated by the same process used for other states.

Of the 116,990 national polling places reported in 2016 by the U.S. Election Assistance Commission, 93,658 polling places (80.1%) were identified and geocoded and comprise the initial sample of polling places that we use in this paper. Figure 1 illustrates the location of the 93,658 polling places and separately identifies polling places for which we identify likely voters on Election Day and pass various filters that we discuss and impose below.

Demographic characteristics were obtained using the 2017 American Community Survey's five-year estimates. Each polling place location was matched to a census block group. Census block groups were chosen as the level of aggregation given that the number of block groups is the census geography that most closely aligns with the number of polling places and because it contains the information of interest (racial characteristics, fraction below poverty line, population, and population density).

Figure 1: Geographic Coverage



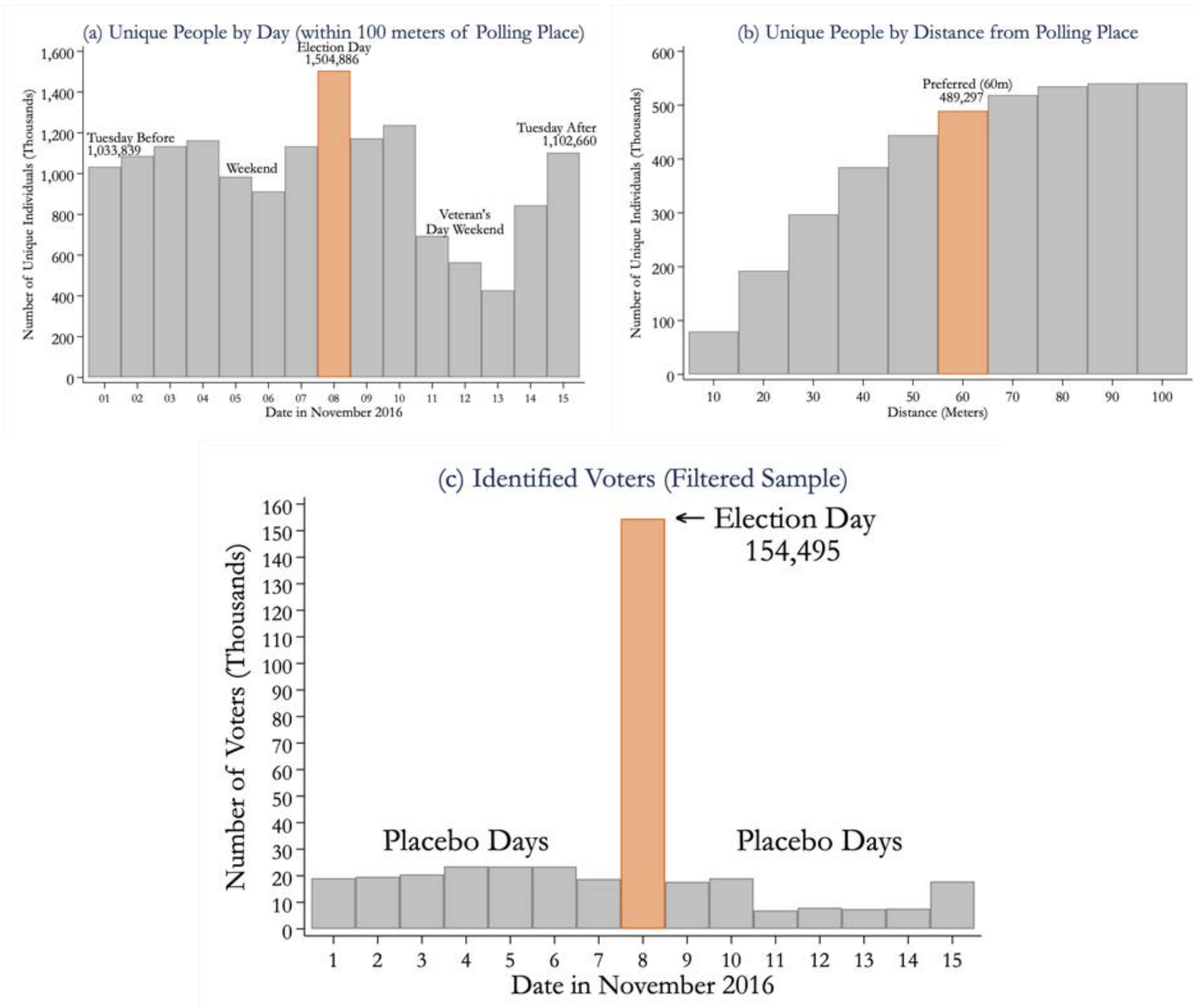
Notes: This figure shows polling place locations overlaid on county shapes colored by whether smartphone pings were observed.

2 Methods

In order to calculate voting wait times, we need to identify a set of individuals who we are reasonably confident actually voted at a polling place in the 2016 election. To do so, we restrict the cell phone data to cell phones that record a ping within a certain distance of a polling station on Election Day. This distance is governed by a trade-off – we want the radius of the circle around each polling station to be large enough to capture voters waiting in lines that may spill out of the polling place, but want the circle to be not so large that we introduce a significant number of false positive voters (people who came near a polling place, but did not actually vote).

We take a data-driven approach to determine what the optimal size of the radius should be. In Panel A of Figure 2, we examine whether there are more unique individuals who show up near a polling place on Election Day relative to the week before and the week after the election (using a 100-meter radius around a polling location). As can be seen, there appear to be more than 400k additional people on Election Day who come within 100 meters of a polling place relative to the weekdays before and after. In Panel B of Figure 2, we plot the difference in the number of people who show up within a particular radius of the polling place (10 meters to 100 meters) relative to the average across all other days. As we increase the size of the radius, we are able to identify more and more potential voters, but also start picking up more and more false positives. By around 60 meters, we are no longer identifying very many additional people on Election Day relative to non-election days, and yet are continuing to pick up false positives. Therefore, we choose 60 meters as the radius for our primary analysis. However, in our robustness section below, we demonstrate our effects for radii of other sizes.

Figure 2: Defining the Radius



Notes: The Y-axes change across subfigures. In 2016, Veteran's day was on Friday, November 11.

For each individual that comes within a 60-meter radius of a polling place, we would like to know the amount of time spent within that radius. Given that we do not receive location information for cell phones continuously (the modal time between pings is 5 minutes), we cannot obtain an exact length of time. Thus, we create upper and lower bounds for the amount of time spent voting by measuring the time between the last ping before entering and the first ping after exiting a polling-place circle (for an upper bound), and the first and last pings within the circle (for a lower bound). For example, pings may indicate a smartphone user was not at a polling location at 8:20am, but then was at the polling location at 8:23, 8:28, 8:29, and 8:37, followed by a ping outside of the polling area at 8:40am; translating to a lower bound of 14 minutes and an upper bound of 20 minutes. We use the midpoint of these bounds as our best guess of a voter's time at a polling place (e.g. 17 minutes in the aforementioned example). In the robustness section, we estimate our effects using values other than the midpoint.

Another important step in measuring voting times from pings is to isolate people who come within a 60-meter radius of a polling place that we think are likely voters and not simply passing by or people who live or work at a polling location. To avoid including people who are just passing by, we restrict the sample to individuals who spent at least one minute within a polling place circle and did so at only one polling place on Election Day. To avoid including people who live or work at the polling location, we exclude individuals who we observe spending time (more than 1 minute) at that location in the week before or the week after Election Day. To further help identify actual voters and reduce both noise and false positives, we restrict the sample to individuals who had at least one ping within the convex hull of the polling place building on Election Day (using Microsoft-OpenStreetMap building footprint shapefiles), logged a consistent set of pings on Election Day (posting at least 1 ping every hour for 12 hours), and spent no more than 2 hours at the polling location (to eliminate, for example, poll workers who spend all day at a polling place). In section 4.1, we provide evidence of robustness to these various sample restrictions.

After these data restrictions, our final sample consists of 154,495 individuals whom we identify as likely voters across 43,414 polling locations. Panel C in Figure 2 shows how many people pass our likely-voter filters on Election Day (154,495), and – as a placebo analysis – how many observations we would have on non-election ("placebo") days before and after the 2016 Election that would pass these same filters (modified to be centered around those placebo days). This analysis suggests that more than 87% of our sample are likely voters who would not have been picked up on days other than Election Day. In Appendix Figure A.1, we plot the distribution of wait times on each of these placebo non-election days. We find that the wait times of people who show up in our analysis on non-election days are shorter on average than those that show up on Election Day. Thus, to the degree that we can not completely eliminate false positives in our voter sample, we expect our overall voter wait times to be biased upward. We also would expect the noise introduced by non-voters to bias us towards not finding systematic disparities in wait times by race.

Table 1 provides summary statistics for our 154,495 likely voters. We find average voting wait times of just over 19 minutes when using our primary wait time measure (the midpoint between the lower and upper bound) and 18% of our sample waited more than 30 minutes to vote. Weighted by the number of voters in our sample, the racial composition of the polling place block groups is, on average, 70% white and 11% black.

Table 1: Summary Statistics for Voter Wait Time Measures

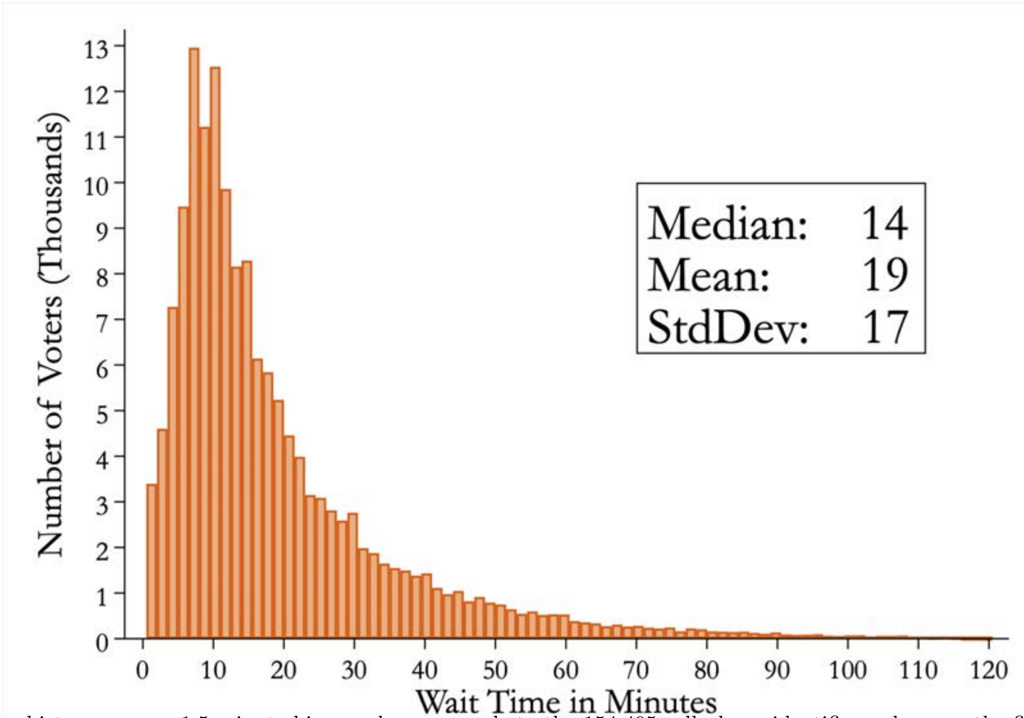
	(1) N	(2) Mean	(3) SD	(4) Min	(5) p10	(6) Median	(7) p90	(8) Max
Wait Time Measures								
Primary Wait Time Measure (Midpoint)	154,495	19.13	16.89	0.51	5.02	13.57	40.83	119.50
Lower Bound Wait Time Measure	154,495	27.00	20.33	1.02	9.28	20.30	54.52	119.98
Upper Bound Wait Time Measure	154,495	11.26	16.19	0.00	0.00	5.52	30.62	119.08
Wait Time Is Over 30min	154,495	0.18	0.38	0.00	0.00	0.00	1.00	1.00
Race Fractions in Polling Area								
Fraction White	154,417	0.70	0.26	0.00	0.27	0.79	0.96	1.00
Fraction Black	154,417	0.11	0.18	0.00	0.00	0.03	0.31	1.00
Fraction Asian	154,417	0.05	0.09	0.00	0.00	0.02	0.14	0.96
Fraction Hispanic	154,417	0.11	0.17	0.00	0.00	0.05	0.31	1.00
Fraction Other Non-White	154,417	0.03	0.04	0.00	0.00	0.02	0.07	0.99
Other Demographics								
Fraction Below Poverty Line	154,266	0.11	0.12	0.00	0.01	0.07	0.26	1.00
Population (1000s)	154,495	2.12	1.87	0.00	0.84	1.71	3.56	51.87
Population Per Sq Mile (1000s)	154,495	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.

3 Results: Overall Voter Wait Times

We plot the distribution of wait times in Figure 2. The median and average times spent at polling locations are 14 and 19 minutes, respectively, and 18% of individuals spent more than 30 minutes voting. As the figure illustrates, there is a non-negligible number of individuals who spent 1-5 minutes in the polling location (less time than one might imagine is needed to cast a ballot). These observations might be voters who abandoned after discovering a long wait time. Alternatively, they may be individuals who pass our screening as likely voters, but were not actually voting.

Figure 3: Wait Time Histogram



Notes: The histogram uses 1.5 minute bins, and corresponds to the 154,495 cell phone identifiers who pass the filters used to identify likely voters.

We explore the number of people who arrive to vote at the polling locations by time of day. This descriptive analysis of when people vote may be of interest in and of itself, but it also serves as a validation of whether people in our sample are indeed likely voters (e.g. if our sample consists primarily of people showing up at the polling locations at 3am, then one should worry about whether our sample is primarily composed of voters). Panel A of Figure 4 shows the distribution of arrival times where the "hour of day" is defined using the "hour of arrival" for a given wait time (i.e. the earliest ping within the polling place radius for a given wait time spell).[2] As expected, people are most likely to vote early in the morning or later in the evening (e.g. before or after work) with nearly twice as many people voting between 7 and 8am as between noon and 1pm. Panel B of Figure 4 plots the average wait time by time of arrival.

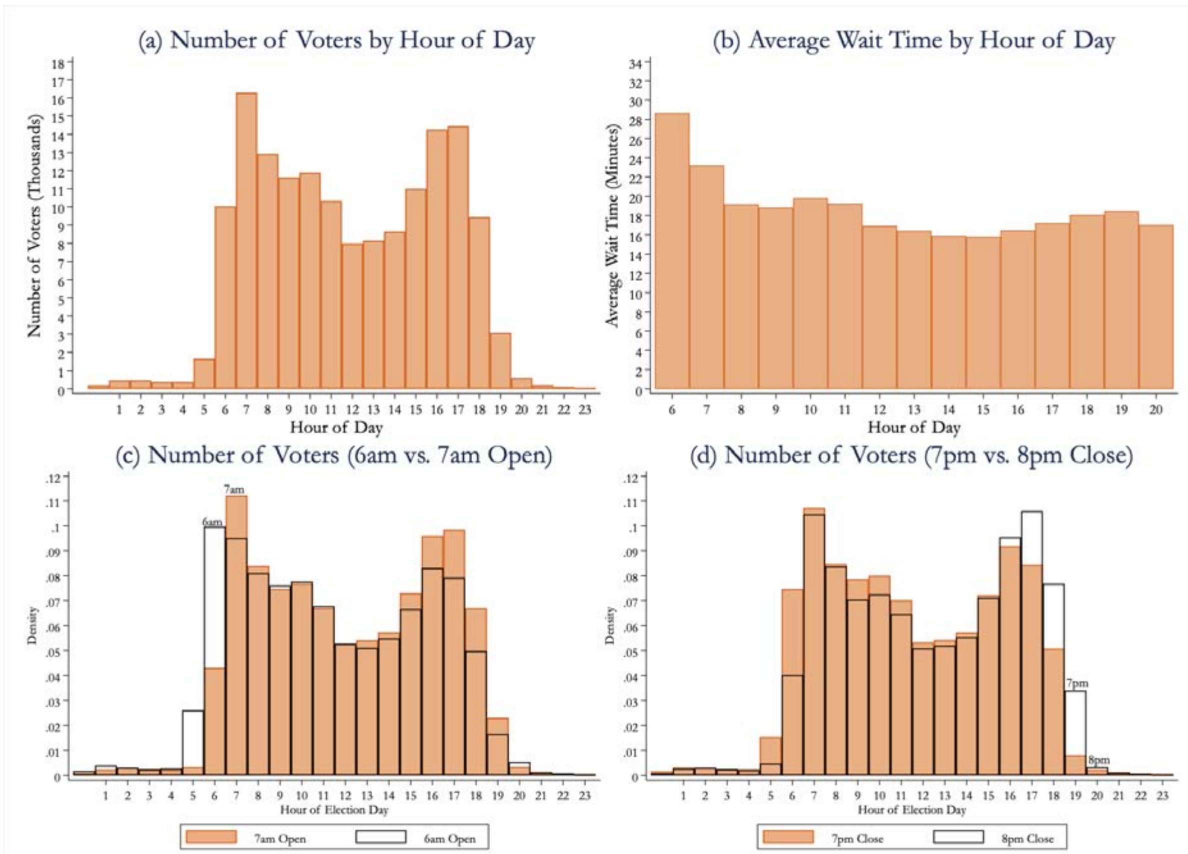
For additional validation, we compare the time of day of voting for people who reside in states with different poll opening and closing times.[3] In Panels C and D of Figure 4 we

[2]We adjusted the time of each ping to reflect the time zone associated with each respective state.

[3]State open and close times are taken from: https://ballotpedia.org/State_Poll_Opening_and_

show that volume patterns correspond to variation in poll opening and closing times at the state level. Panel C separately plots the histogram for the 10 states where polls open at 6am and the 22 that open at 7am; Panel D 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).

Figure 4: Voter Volume and Average Wait Time by Hour of Day



Notes: Panel A plots the total number of voters (volume) by hour of arrival. Panel B plots the average wait time for each hour of arrival. Panel C separately plots volume for the 10 states that open at 6am and the 22 that open at 7am, while Panel D plots these volumes for the 18 states that close at 7pm versus the 17 that close at 8pm.

In addition to temporal variation in wait times, we can also explore how voting wait times vary geographically. Appendix Tables A.8 - A.10 report average wait times by state, congressional district, and the 100 most populous counties, along with accompanying stan-

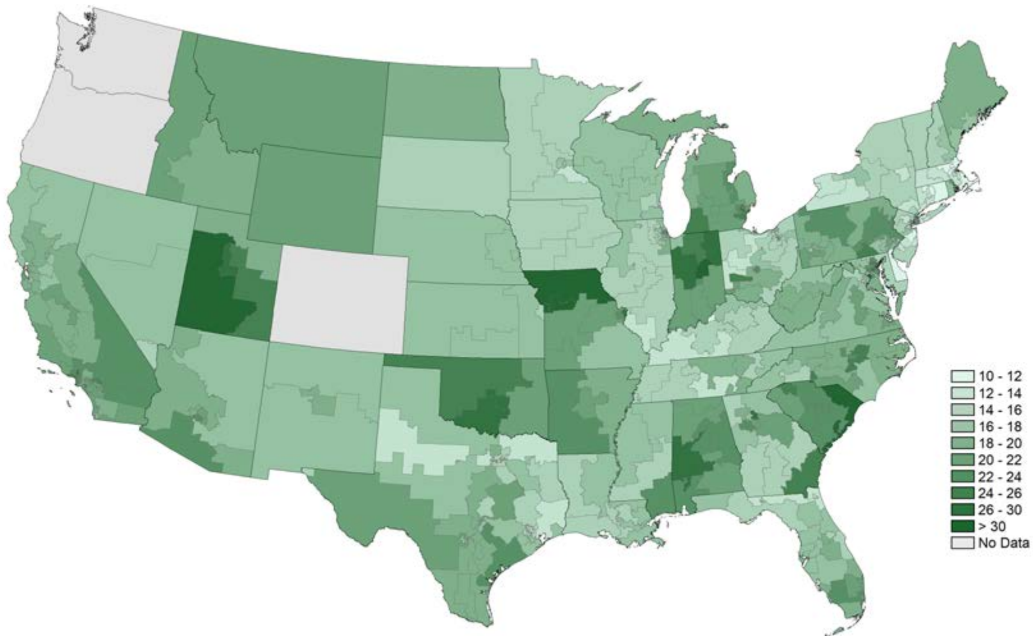
`Closing_Times_(2016)#table`. Panels C and D omit states which do not have standardized open (Panel C) or close times (Panel D) across the entire state.

dard deviations and observation counts, as well as an empirical-Bayes adjustment to account for measurement error.[4] Focusing on the empirical-Bayes adjusted estimates, the states with the longest average wait times are Utah and Indiana (28 and 27 minutes, respectively) and the states with the shortest average wait time are Delaware and Massachusetts (12 minutes each).

The map in Figure 5 illustrates the (empirical-Bayes-adjusted) average voting wait time for each congressional district across the United States. Average wait times vary from as low as $\sim$ 11 minutes in Massachusetts's Sixth and Connecticut's First Congressional District to as high as $\sim$ 40 minutes in Missouri's Fifth Congressional District. These geographic differences are not simply a result of a noisy measure, but contain actual signal value regarding which areas have longer wait time than others. Evidence for this can be seen by our next analysis which will correlate our wait time measures with those from a survey.

[4]Even if all states in the U.S. had the same voter wait time, we would find some dispersion in our measure due to sampling variation. Due to sample size, this measurement error in our estimates would result in the smallest states being the most likely to show evidence of having either very short or very long wait times. Thus, throughout the paper, whenever we discuss voter wait times or racial disparities that have been aggregated up to either the county, congressional district, or state level, we will report estimates that have been adjusted for measurement using a Bayesian shrinkage procedure. This iterative procedure (discussed in detail in Chandra et al. (2016) shrinks estimates toward the average of the true, underlying distribution. The amount of adjustment toward the mean is a function of how far the estimate for each state/county is from the mean and the precision of the estimate. The resulting adjusted estimate is our "best guess" (using Bayesian logic) as to what the actual wait time or disparity in wait time is for each geographic unit.

Figure 5: Geographic Variation in Average Wait Times



Notes: This figure shows variation in (empirical-Bayes-adjusted) average wait times by congressional district (115th Congress).

We correlate our average wait time measures at both the state and congressional district level with the average wait times reported by a national survey of voters from the 2016 Cooperative Congressional Election Study (CCES). The CCES is a large national online survey of over 50,000 people conducted before and after U.S. elections. The sample is meant to be representative of the U.S. as a whole.[5] There are several reasons one might be skeptical that the wait time estimates that we generate using smartphone-data will correlate closely with the wait times reported from the CCES survey. First, given sample sizes at the state and congressional district level, both our wait times and survey wait times may have a fair bit of sampling noise. Second, our wait time measures are a combination of waiting in line and casting a ballot whereas the survey only asks about wait times. Third, the question in the survey creates additional noise by only allowing respondents to answer the wait time question with one of five responses ("not at all", "less than 10 minutes", "10 to 30 minutes", "31 minutes to an hour", and "more than an hour").[6] Lastly, the survey does not necessarily

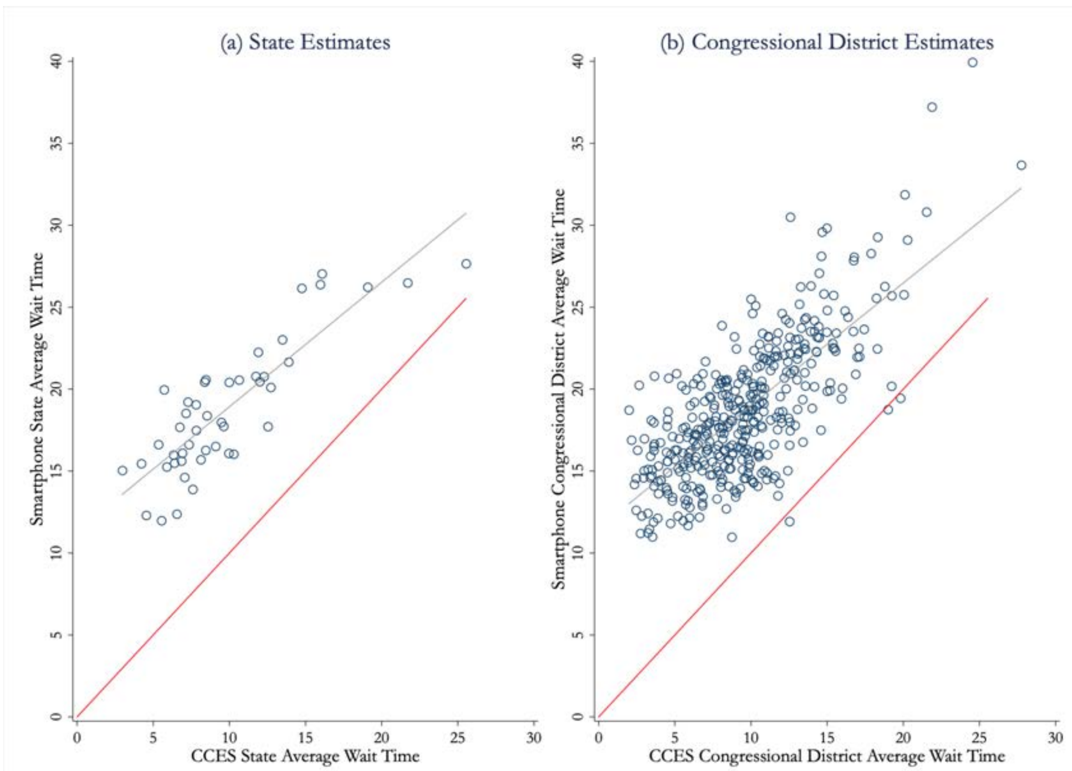
[5] https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi%3A10.7910/DVN/GDF6Z0

[6] There are 34,353 responses to the "wait time" question in the 2016 CCES. We restrict the sample of responses to just use individuals who voted in person on Election Day, leaving a sample of 24,378 individuals (we drop the 45 individuals who report "Don't Know" for this question). Following Pettigrew (2017), we translate the responses to minute values by using the midpoint of their response categories: 0 minutes ("not

represent truthful reporting. For example, while turnout in the U.S. has hovered between 50 and 60 percent, more than 80% of CCES respondents report voting.

Given these reasons for why our wait time results may not correlate well with the survey results, the findings presented in Panel A and B of Figure 6 are remarkable. Panel A provides a scatter plot at the state level with a fitted line and a 45-degree line, and uses empirical-Bayes adjusted estimates for both our wait times and those in the CCES. We find a strong correlation in wait times (correlation = 0.86). Panel B illustrates a similarly strong correlation at the congressional district level (correlation = 0.73). Our wait-time estimates are, on average, slightly longer than those in the survey (illustrated by most of the circles being above the 45-degree line), which is likely a reflection of the fact that our measure includes both wait time and ballot-casting time.

Figure 6: 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.

at all"), 5 minutes ("less than 10 minutes"), 20 minutes ("10 to 30 minutes") or 45 minutes ("31 minutes to an hour"). For the 421 individuals who responded as "more than an hour" we code them as waiting 90 minutes (by contrast, Pettigrew (2017) uses their open follow-up text responses.)

Overall, the strong correlations between the wait times we estimate and those from the CCES survey provide strong validation for our wait time measure (and validation for the survey responses and work that has been done primarily in political science using these surveys).

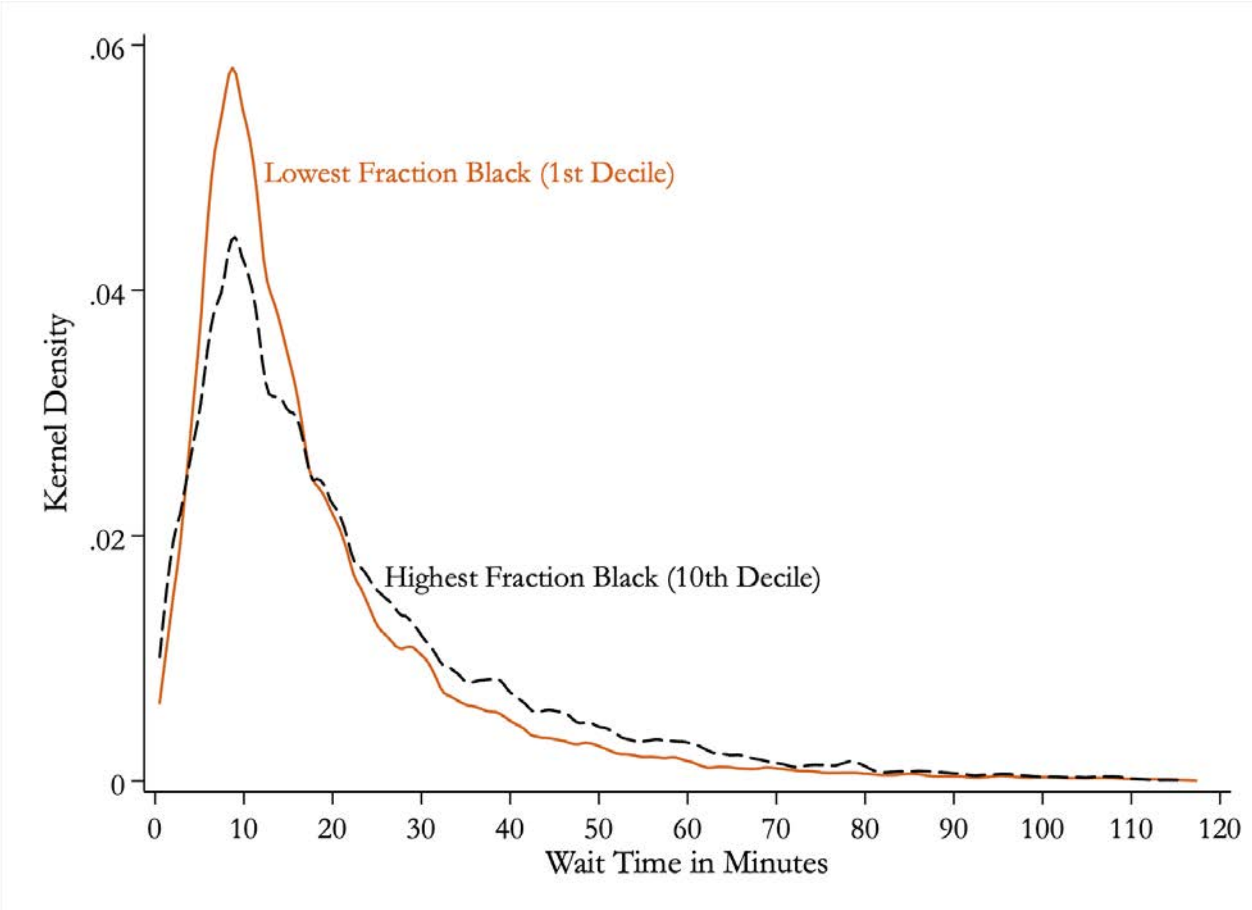
4 Results: Racial Disparities in Wait Times

Having documented overall voting wait time results, we now move to showing evidence that wait times are significantly different for areas with more black voters relative to white voters.

We begin with a simple visualization of wait times by race. Figure 7 plots the smoothed distribution of wait times (analogous to Figure 3) separately for polling places in the top and bottom deciles of the fraction-black distribution. These deciles average 58% and 0% black, respectively. Voters from areas in the top decile spent 19% more time at their polling locations than those in the bottom decile. Further, voters from the top decile were 49% more likely to spend over 30 minutes at their polling locations. Appendix Figures A.2 and A.3 provide similar density functions of wait-time comparisons for other demographic characteristics.

Of course, Figure 7 focuses just on polling places that are at the extremes of racial makeup. We provide a regression analysis in Table 2 in order to use all of the variation in a polling place's racial composition and to provide exact estimates and standard errors. Panel A uses wait time as the dependent variable. In column 1, we estimate the bivariate regression which shows that moving from a census block group with no black citizens to one that is entirely composed of black citizens is associated with a 5.23 minute longer wait time. In column 2, we broaden our focus by adding additional racial categories which reveals longer wait times for block groups with higher fractions of Hispanic and other non-white groups (Native American, other, multiracial). Column 3 examines whether these associations are robust to controlling for population, population density, and fraction below poverty line of the block group (see Appendix Tables A.1 and A.2 for the full set of omitted coefficients). The coefficient on fraction black is stable when adding in these additional covariates. Column 4 adds state fixed effects and the coefficient on fraction black only slightly decreases suggesting that racial disparities in voting wait times are just as strong within state as they are between state.

Figure 7: Wait Time: Fraction Black 1st vs. 10th Decile



Notes: Kernel density estimated using 1 minute half widths. The 1st decile corresponds to the 34,421 voters across 10,319 polling places with the lowest percent of black citizens (mean = 0%). The 10th decile corresponds to the 15,439 voters across the 5,262 polling places with the highest percent of black citizens (mean = 58%).

Table 2: Fraction Black and Voter Wait Time

	(1)	(2)	(3)	(4)	(5)
Panel A: Ordinary Least Squares (Y = Wait Time)					
Fraction Black	5.23***	5.22***	4.96***	4.84***	3.27***
	(0.39)	(0.39)	(0.42)	(0.42)	(0.45)
Fraction Asian		-0.79	-2.48***	1.30*	-1.14
		(0.72)	(0.74)	(0.76)	(0.81)
Fraction Hispanic		1.15***	0.43	3.90***	1.47***
		(0.37)	(0.40)	(0.46)	(0.50)
Fraction Other Non-White		12.01***	11.76***	1.67	2.02
		(1.94)	(1.95)	(1.89)	(1.94)
N	154,417	154,417	154,266	154,266	154,266
R^2	0.00	0.00	0.01	0.06	0.13
DepVarMean	19.13	19.13	19.12	19.12	19.12
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	0.12***	0.12***	0.11***	0.10***	0.07***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Fraction Asian		-0.00	-0.04**	0.04**	-0.02
		(0.02)	(0.02)	(0.02)	(0.02)
Fraction Hispanic		0.03***	0.01	0.08***	0.03***
		(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)
N	154,417	154,417	154,266	154,266	154,266
R^2	0.00	0.00	0.01	0.04	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.

In column 5, we present the results within county. We find that the disparity is mitigated within county, but it continues to be large and statistically significant. This suggests that there are racial disparities occurring both within and between county. Understanding the level at which discrimination occurs (state, county, within-county, etc.) is helpful when thinking about the mechanism in the next section. Further, the fact that we are finding evidence of racial disparities within county allows us to rule out what one may consider spurious explanations for our results such as differences in ballot length between counties – longer ballots may lead to longer wait times in the voting booth, and queuing theory suggests that could in turn lead to backlogs at other points of service (Pettigrew 2017; Edelstein and Edelstein 2010; Gross et al. 2013).

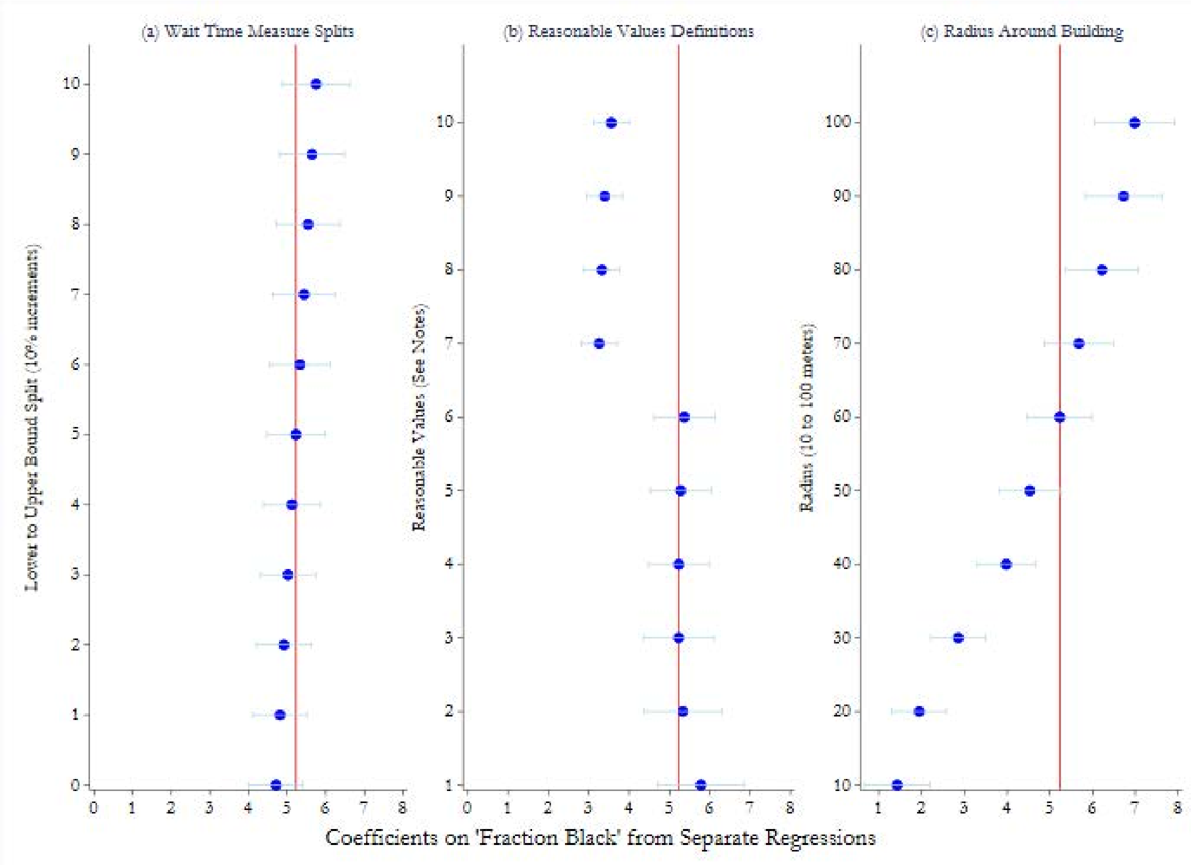
Panel B of Table 2 is analogous to Panel A, but changes the outcome to a binary variable indicating a wait time longer than 30 minutes. We choose to report a threshold of 30 minutes as this was the standard used by the Presidential Commission on Election Administration in their 2014 report, which concluded that, "as a general rule, no voter should have to wait more than half an hour in order to have an opportunity to vote" (Bauer et al. 2014). The bivariate regression shows that entirely black areas are 12 percentage points more likely to wait more than 30 minutes than entirely white areas, a 74% increase in that likelihood. This remains at 10 percentage points with polling-area controls and 7 percentage points within county.

4.1 Robustness

We have made several data restrictions and assumptions throughout the analysis. In this section, we show our main effect of longer wait times for areas with a higher fraction of black voters using alternative restrictions and assumptions.

In our primary analysis we use the midpoint between the lower and upper bound of time spent near the polling location as the primary measure of wait time. In Panel A of Figure 8, we vary the wait time measure from the lower bound to the upper bound in 10 percent increments, finding that it has little impact on the significance or magnitude of our estimates. We further vary the wait time trimming thresholds in Panel B and the radius around a building centroid used to identify the polling location in Panel C. While these do move the average wait times around, and the corresponding differences, we find that the difference remains significant even across fairly implausible adjustments (e.g. a tight radius of 20 meters around a polling place centroid). We show the associated regression output for this figure in Appendix Table A.3.

Figure 8: Robustness to Different Data Construction Choices



Notes: Points correspond to coefficients on "Fraction Black" from separate regressions (+/- 1.96 robust standard errors, clustered at the polling place level). Unit of observation is a cellphone identifier on Election Day. All specifications are of the form used in Column 1 of Panel A, Table 1. Panel A varies the dependent variable across splits between the lower and upper bounds for our wait time measure (as described in Data and Methods); the first point (y = 0) corresponds to the lower bound, the last point (y = 10) corresponds to the upper bound measure, and all other points are intermediate deciles of the split (e.g. y = 5 corresponds to the midpoint of the two measures). Panel B varies the "reasonable values" (RV) filter, as follows: [RV1] Upper Bound under 5 hours (N = 159,052; Mean of Dependent Variable = 22.92) [RV2] Upper Bound under 4 hours (N = 158,172; Mean = 21.79) [RV3] Upper Bound under 3 hours (N = 156,943; Mean = 20.63) [RV4] Upper Bound under 2 hours (N = 154,417; Mean = 19.13) [RV5] Upper Bound under 2 hours and over 1.5 minutes (N = 154,020; Mean = 19.17) [RV6] Upper Bound under 2 hours and over 2 minutes (N = 153,439; Mean = 19.24) [RV7] Upper Bound under 1 hour and over 2 minutes (N = 141,176; Mean = 15.64) [RV8] Upper Bound under 1 hour and over 2.5 minutes (N = 140,476; Mean = 15.71) [RV9] Upper Bound under 1 hour and over 3 minutes (N = 139,794; Mean = 15.78) [RV10] Upper Bound under 1 hour and over 4 minutes (N = 138,458; Mean = 15.91). Panel C varies the bounding radius around the polling station centroid from 10 meters (N = 60,822; Mean = 12.09) up to 100 meters (N = 113,802; Mean = 21.81). The red line on each figure corresponds to the coefficient from the choice we use in our primary analysis, i.e. the midpoint wait time measure (Panel A), a filter of upper bounds under 2 hours (Panel B), and a radius of 60 meters (Panel C).

Another assumption that we made in our data construction was that we 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. As a robustness check, 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 154,495 voters down to 66,690 voters, but arguably does a better job of eliminating false positives. In Appendix Table A.4 and Appendix Figure A.4 we replicate our primary analysis using this more restricted sample and find results that are very similar to our preferred estimates.

As a placebo check, we perform our primary regression analysis using the same sample construction methods on the non-election days leading up to and after the actual Election Day. Specifically, we repeat the regression used in Table 2, Panel A, Column 1 for each of these days. Appendix Figure A.5 shows the coefficients for each date. 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.

As a final robustness/validation, we correlate the racial disparities in wait times that identify using the smartphone data with the racial disparities in wait times found using the CCES survey (discussed in the previous section). As we found when correlating our overall wait time measure with the CCES, there is a strong correlation at the state level (0.72). The correlation at the congressional district level is much more modest (0.07).

5 Mechanism

In the previous section, 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. 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 nail down causal determinants of wait times.

5.1 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 not as nefarious as 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 9 plots the density of arrival time for voters from the most black areas (highest decile) and from the the least black areas (lowest decile).[7] A visual inspection of Figure 9 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 9 does not appear to make a particularly strong case for bunching in arrival times. However, as we showed in Panel B of Figure 4, 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.1. 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 is not a primary factor that contributes to the wait-time gap that we find.

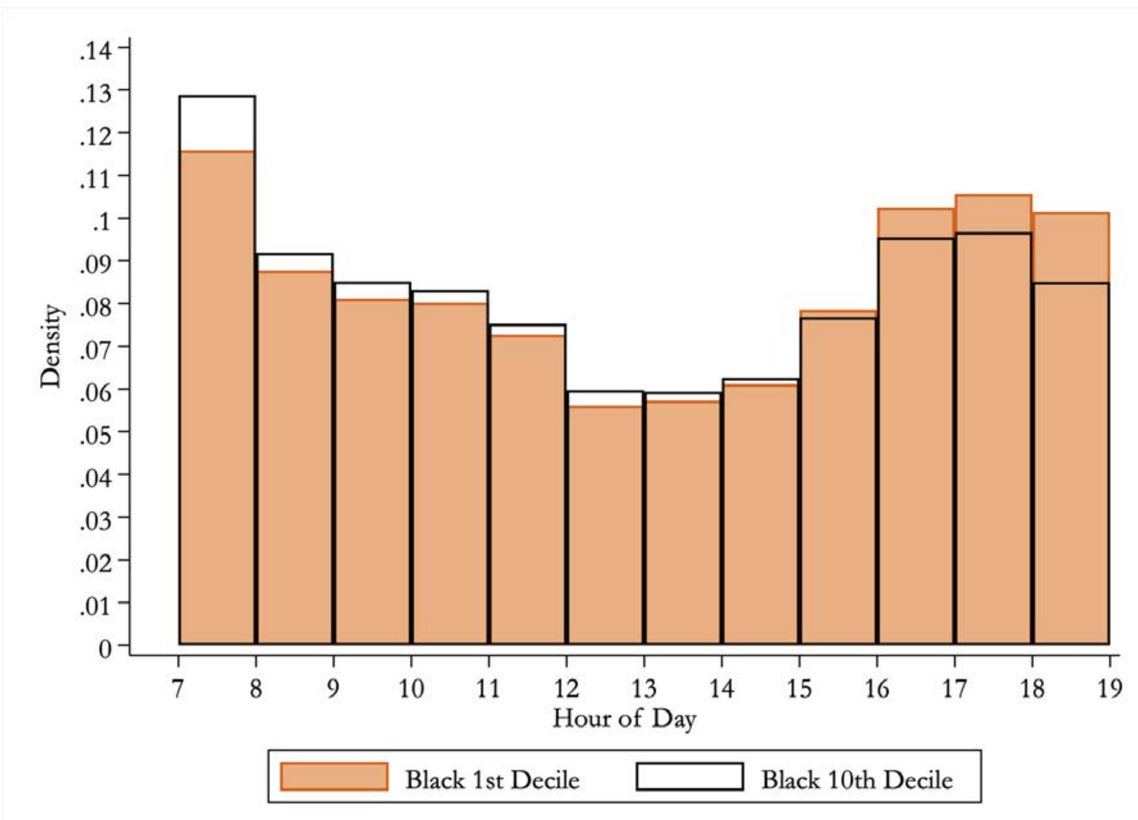
A different way to show that bunching in arrival times is not sufficient to explain our

[7] 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 = 124,952) as in the full sample (coefficient = 5.23; t = 14; N = 154,417).

results is to restrict the sample to hours that don't include the early morning. In Appendix Table A.5, 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 of arrival times as a primary mechanism explaining the racial disparity in wait times that we document.

Figure 9: 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.

5.2 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 Markovits 2010).[8]

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.[9] Given this large difference in vote

[8]Spencer and Markovits (2010) provide a useful summary of the problem of identifying precisely who is 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.

[9]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).

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.

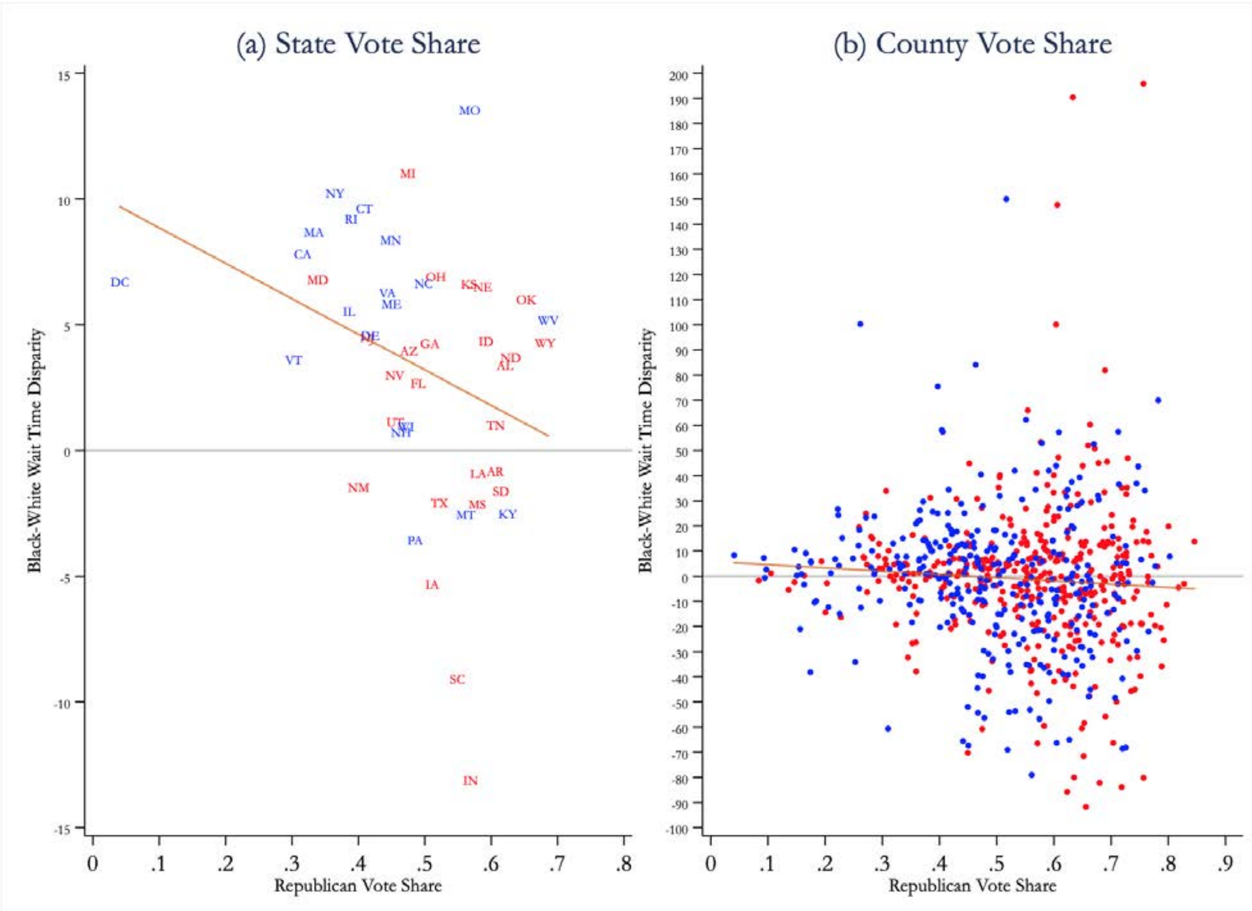
To test for evidence of a partisan bias, we plot empirical-Bayes-adjusted state-level racial disparities in wait times against the 2016 Republican vote share at both the state (panel A of Figure 10) and county level (panel B of Figure 10).[10] Panel A also color codes each state marker by the party affiliation of the chief elections officer in the state.[11] 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 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.

[10] 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.

[11] 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`

Figure 10: 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*.

5.3 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 11, 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.[12] 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.

5.4 State Voting Laws

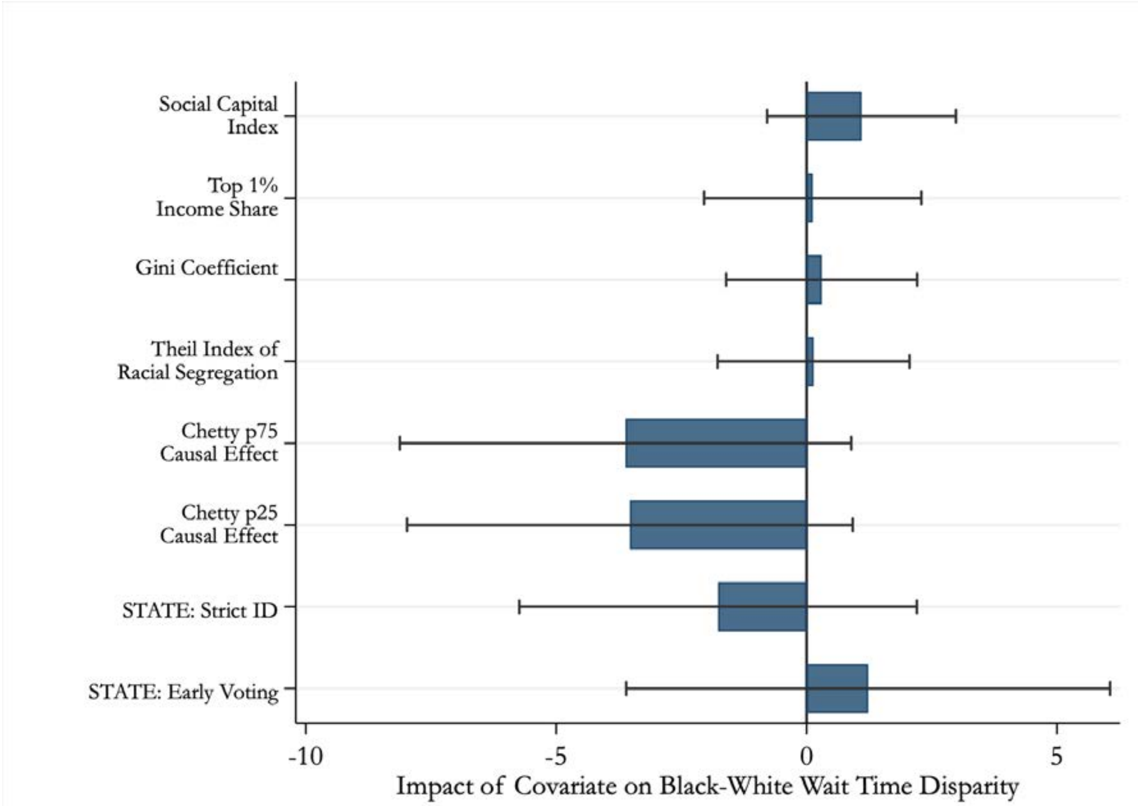
A large recent discussion has emerged regarding the impact of Strict ID laws (Cantoni and Pons 2019b; Grimmer and Yoder 2019) and unequal access to early voting (Kaplan and Yuan 2019; Herron and Smith 2014) on the voting process. Both of these types of laws have the potential to produce racial inequalities 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 11 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).[13] 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.

[12] 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.

[13] 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 11: 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.

5.5 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 (corr = 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.

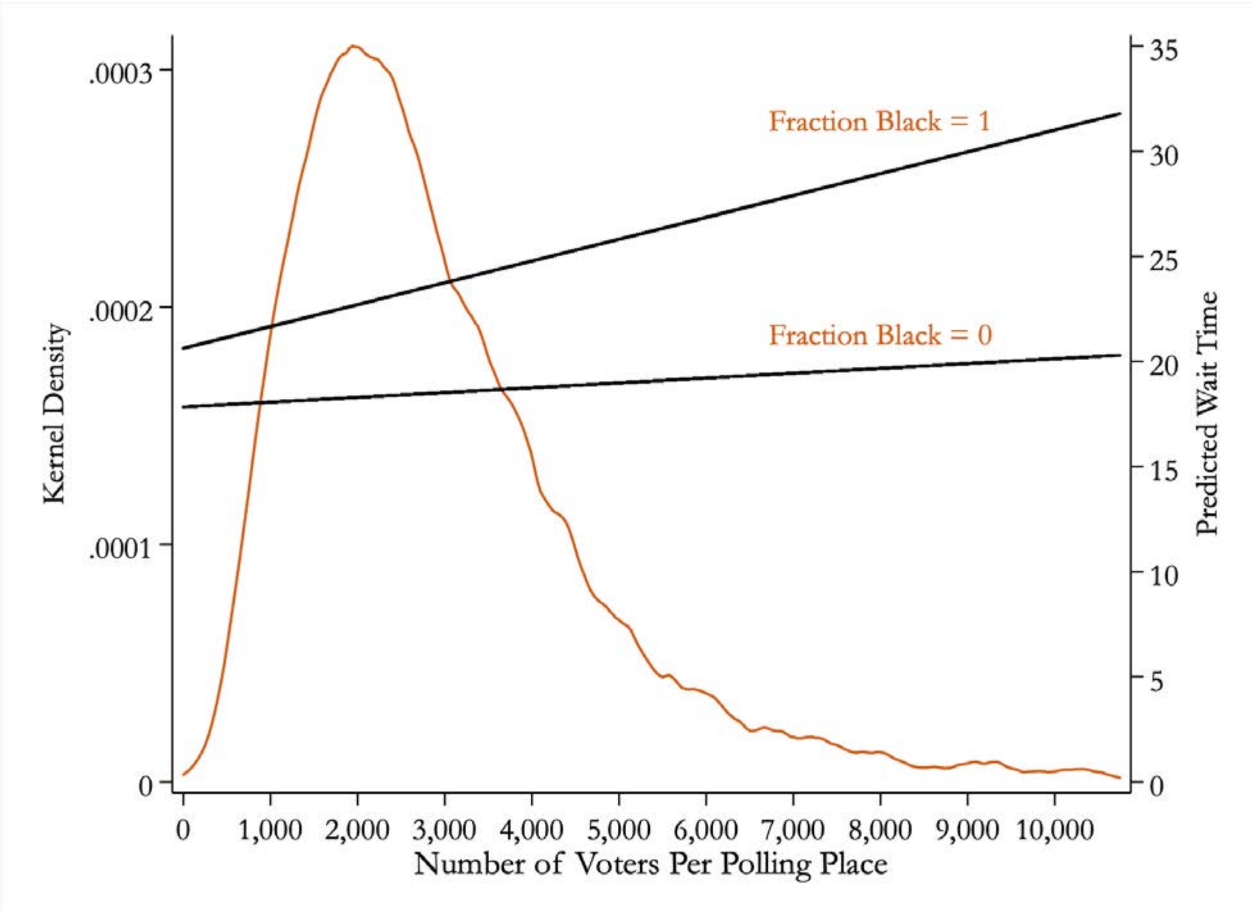
It is not obvious that polling places with more voters should have longer overall wait times. In a carefully-resourced system in equilibrium, high-volume polling places should have more machines and polling workers and therefore be set up to handle the higher number of voters. However, it is possible 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).

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 A.6. 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 (corr = .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 A.7 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 12 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 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 12: 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.

6 Discussion and Conclusion

Exploiting a large geospatial dataset, we provide new, nationwide estimates for the wait times of voters during the 2016 U.S. presidential election. In addition to describing wait times overall, we document a persistent racial disparity in voter wait times: areas with a higher proportion of black (and to a lesser extent Hispanic) residents are more likely to face long wait times than areas that are predominantly white. These effects survive a host of robustness and placebo tests and are also validated by being strongly correlated with survey data on voter wait times.

While the primary contribution of our paper is to carefully document voter wait times and disparities at the national level, it is natural to ask why these disparities exist. We explore the mechanism and do not find conclusive evidence in favor of arrival bunching, partisan bias, early voting, or strict ID laws. We find suggestive evidence that the effects could be driven by fewer resources that leads to congestion especially in high-volume polling places. We are left with the fact that these racial disparities are not limited to just a few states or areas with particular laws or party affiliations that might reflect strategic motivations. Rather, there is work to be done in a diverse set of areas to correct these inequities. A simple explanation is that law makers in general tend to focus more attention on areas with white voters at the expense of those with black constituents. For example, this could be due to politicians being more responsive to white voters' complaints about voting administration than those from black voters (and relatedly, white voters lodging more complaints), in line with prior work demonstrating lower responsiveness to black constituents across a variety of policy dimensions (e.g. Butler and Broockman (2011); Giulietti et al. (2019); White et al. (2015)).

Our results also demonstrate that smartphone data may be a relatively cheap and effective way to monitor and measure progress in both overall wait times and racial disparities in wait times across various geographic areas. The analysis that we conduct in this paper can be easily replicated after the 2020 election and thereby generate a panel dataset of wait times across areas. Creating a panel data across the country may be useful to help pin down the mechanism for disparities (e.g. using difference-in-differences designs to test if disparities in voter wait times change when different laws or election officials take over in a state). We hope that future work can build on the results in this paper to provide even greater understanding and context.

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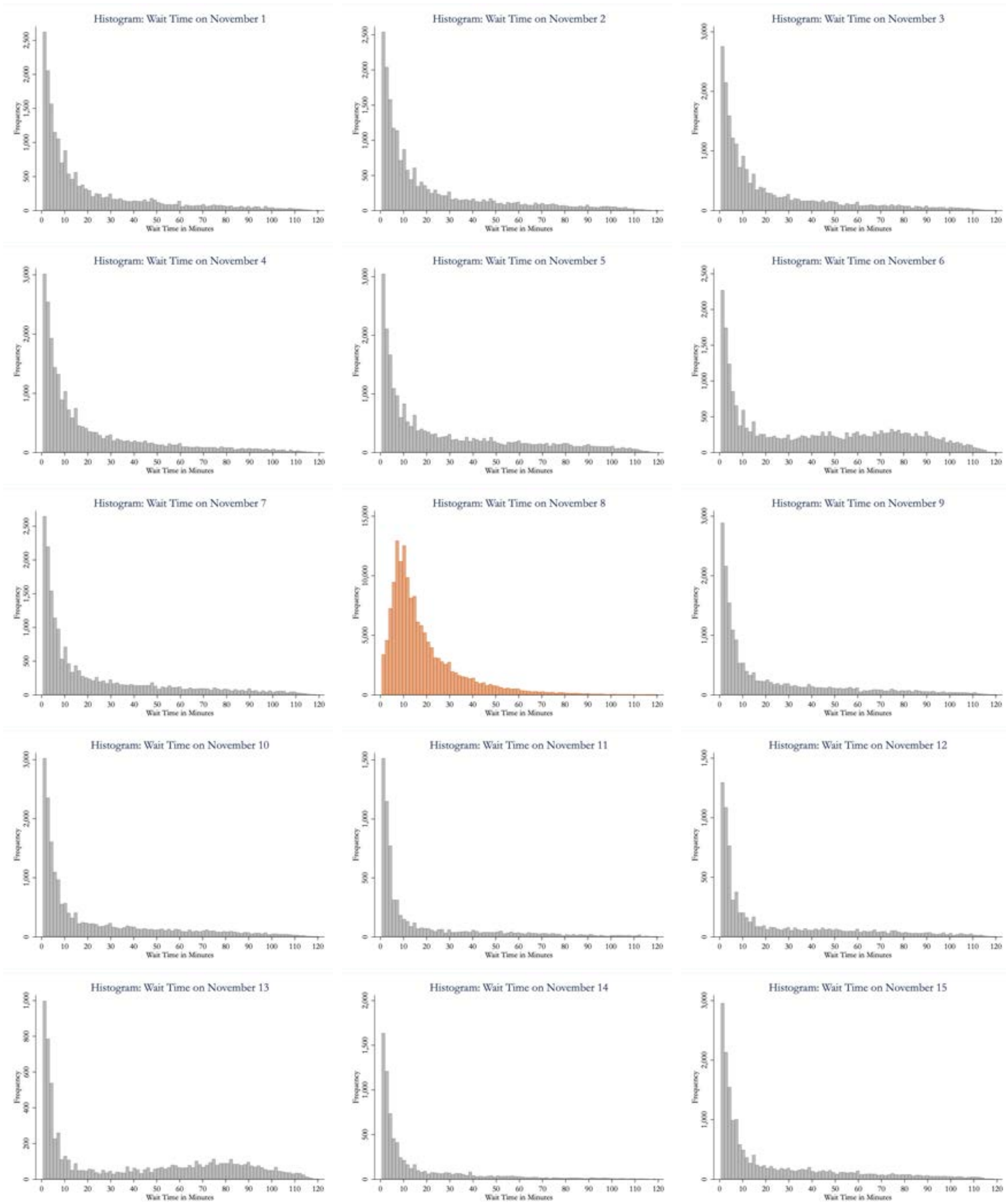
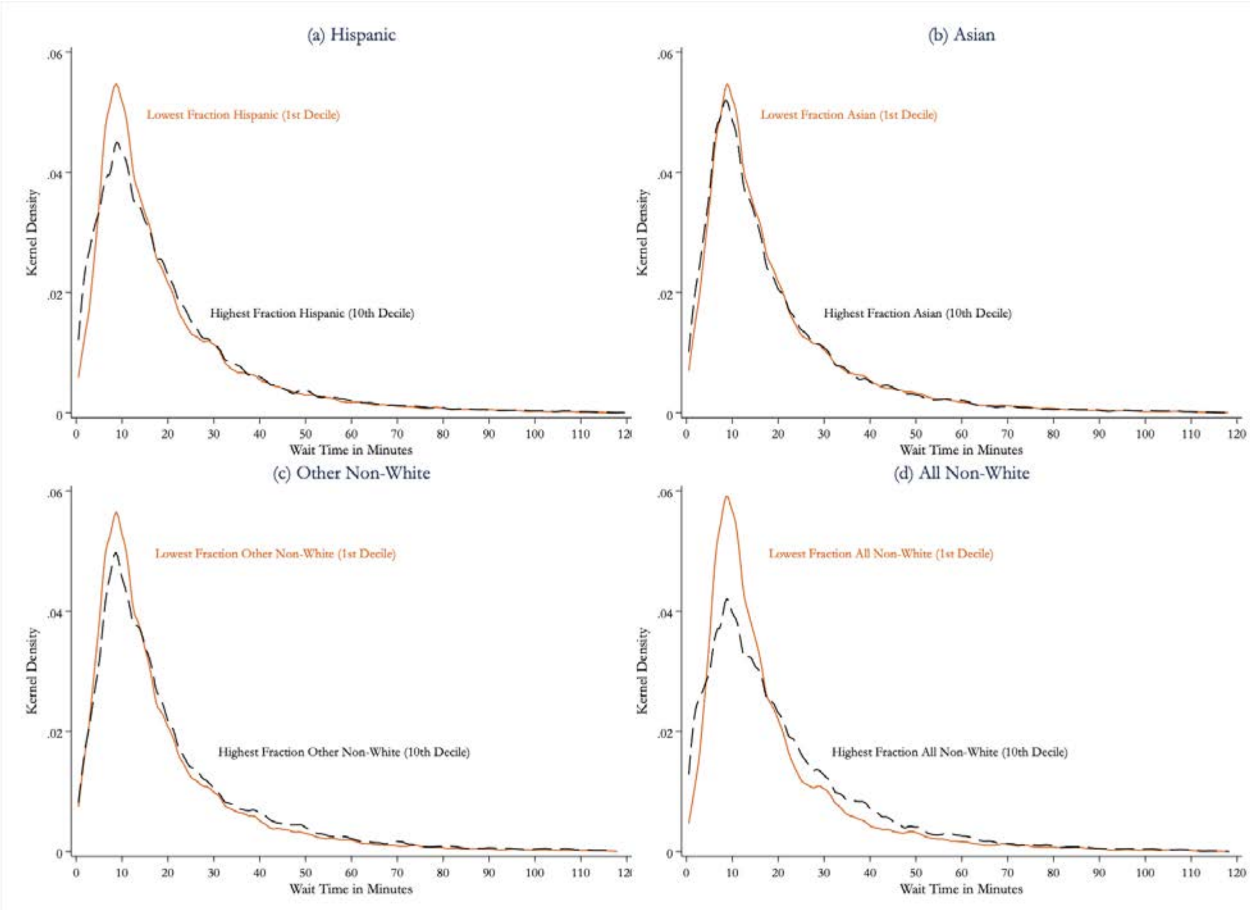
Appendix Figures and Tables

Figure A.1: Placebo Day Wait Time Histograms



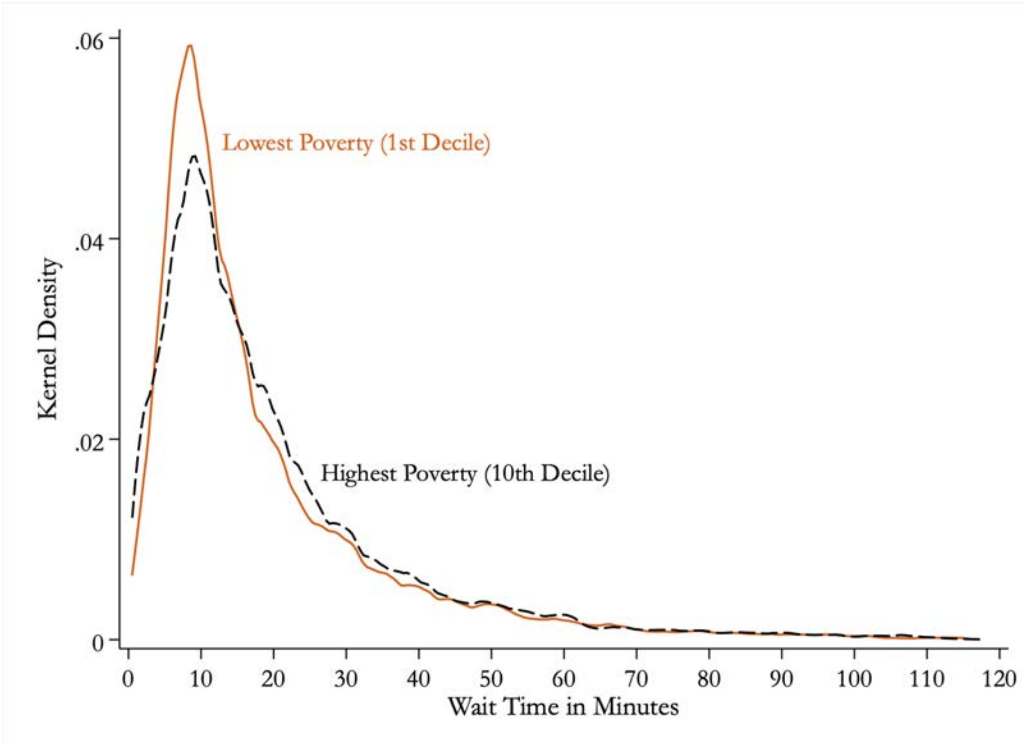
Notes: In this figure, we replicate our sample construction across 14 placebo days (i.e. we apply our filters to identifying a "likely voter" but replace the sample and the date used in each filter definition to the placebo date). The figure corresponding to Election Day (i.e. Figure 2 of the paper) 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.

Figure A.2: Wait Time Disparities by Racial Categories



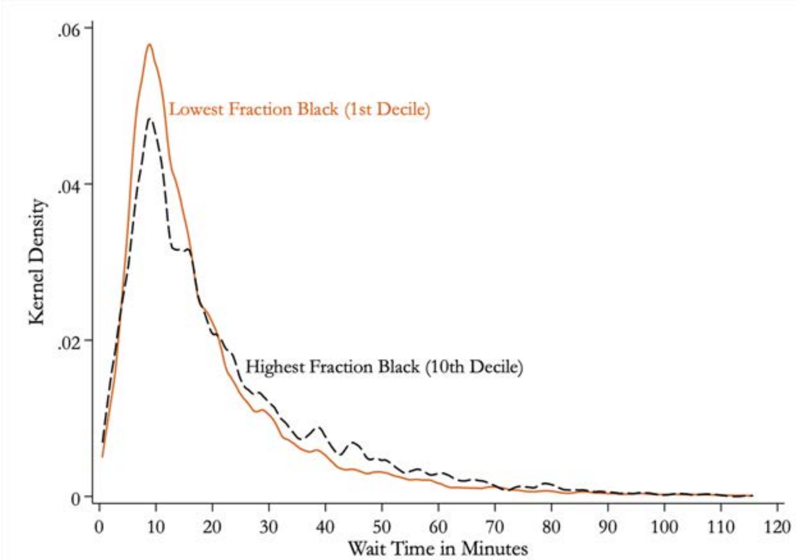
Notes: This figure repeats Figure 7 across other racial categories. We show the decile splits by Hispanic (Panel A), Asian (Panel B), and "Other Non-White" (Panel C), and then group these categories together with Black in Panel D. Note that "Asian" includes "Pacific Islander." "Other Non-White" includes the "Other," "Native American," and "Multiracial" Census race categories. "All Non-White" includes Black, Hispanic, Asian, and Other Non-White.

Figure A.3: Wait Time Disparities by Fraction Below Poverty Line



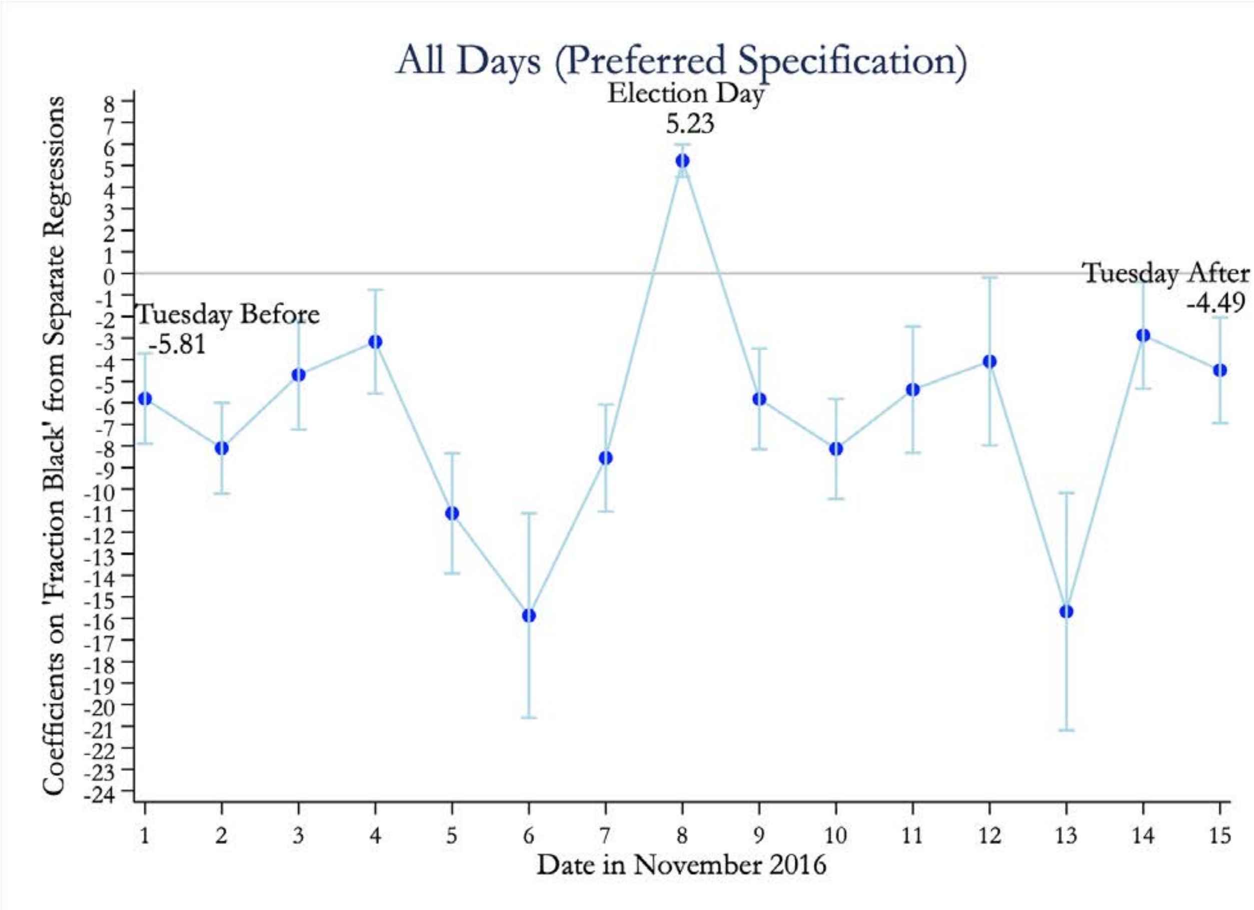
Notes: This figure repeats Figure 7 across the "Fraction Below Poverty Line" measure (top and bottom deciles).

Figure A.4: Wait Time Disparities: Stricter Likely Voter Filter



Notes: In this figure, we repeat Figure 7 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 147,907 voters down to 66,690 voters. *Additional Notes:* Kernel density estimated using 1 minute half widths. The 1st decile corresponds to the 15,405 voters across 6,577 polling places with the lowest percent of black citizens (mean = 0%). The 10th decile corresponds to the 6,880 voters across the 3,228 polling places with the highest percent of black citizens (mean = 54%).

Figure A.5: 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.1. We then repeat the regression used in Table 2, 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.1: 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*	-1.14	-0.69
		(0.72)	(0.74)	(0.76)	(0.81)	(0.81)
Fraction Hispanic		1.15***	0.43	3.90***	1.47***	1.69***
		(0.37)	(0.40)	(0.46)	(0.50)	(0.50)
Fraction Other Non-White		12.01***	11.76***	1.67	2.02	1.76
		(1.94)	(1.95)	(1.89)	(1.94)	(1.93)
Fraction Below Poverty Line			0.06	-2.03***	0.29	1.11*
			(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	154,417	154,417	154,266	154,266	154,266	154,266
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 2, 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.2: 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	154,417	154,417	154,266	154,266	154,266	154,266
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 2, 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.3: Robustness: Regressions for Figure 8

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	
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	154,417	154,417	154,417	154,417	154,417	154,417	154,417	154,417	154,417	154,417	154,417
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	159,052	158,172	156,943	154,417	154,020	153,439	141,176	140,476	139,794	138,458	
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	120,927	151,000	161,733	161,144	154,417	144,885	134,139	123,420	113,802	
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 8.

Table A.4: 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***	2.68***
	(0.53)	(0.53)	(0.56)	(0.57)	(0.63)
Fraction Asian		-1.97*	-3.79***	0.78	-2.24*
		(1.05)	(1.11)	(1.11)	(1.19)
Fraction Hispanic		1.21**	0.22	4.26***	2.07***
		(0.52)	(0.56)	(0.67)	(0.74)
Fraction Other Non-White		12.55***	11.86***	0.85	2.07
		(2.26)	(2.27)	(2.22)	(2.46)
N	68,816	68,816	68,729	68,729	68,729
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	68,816	68,816	68,729	68,729	68,729
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.4.

Table A.5: 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***	2.89***	2.21***	1.86***	1.74***	1.93***
	(0.42)	(0.43)	(0.43)	(0.44)	(0.54)	(0.51)
Fraction Asian	1.30*	0.19	-0.13	-0.42	0.55	-1.08
	(0.76)	(0.77)	(0.79)	(0.80)	(1.01)	(0.98)
Fraction Hispanic	3.90***	3.23***	3.23***	3.26***	0.85	5.24***
	(0.46)	(0.48)	(0.50)	(0.51)	(0.62)	(0.63)
Fraction Other Non-White	1.67	1.15	1.42	2.18	0.49	3.13
	(1.89)	(1.92)	(2.00)	(2.06)	(2.44)	(2.55)
N	154,266	124,466	111,564	99,956	57,878	53,058
R^2	0.06	0.04	0.04	0.04	0.04	0.04
DepVarMean	19.12	17.67	17.50	17.34	17.48	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***	0.05***	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	154,266	124,466	111,564	99,956	57,878	53,058
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 2, 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 A.6: 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	-2.52***	-2.34***	1.25	1.04	-1.17	-1.21
			(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***	1.51***	1.64***
			(0.37)	(0.37)	(0.40)	(0.40)	(0.46)	(0.47)	(0.50)	(0.51)
Fraction Other Non-White			12.49***	12.98***	12.32***	12.68***	1.97	2.27	1.93	1.86
			(1.96)	(1.97)	(1.97)	(1.98)	(1.90)	(1.89)	(1.95)	(1.95)
N	152,323	152,323	152,323	152,323	152,173	152,173	152,173	152,173	152,173	152,173
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	152,323	152,323	152,323	152,323	152,173	152,173	152,173	152,173	152,173	152,173
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 A.7: 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***	0.24***	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**	0.79***	0.76***
	(0.27)	(0.27)	(0.27)	(0.23)	(0.22)
Fraction Asian		-0.88	-2.32***	1.09	-1.07
		(0.71)	(0.74)	(0.75)	(0.80)
Fraction Hispanic		0.93**	0.29	3.86***	1.65***
		(0.37)	(0.40)	(0.46)	(0.51)
Fraction Other Non-White		12.95***	12.63***	2.18	1.85
		(1.97)	(1.98)	(1.89)	(1.95)
N	152,323	152,323	152,173	152,173	152,173
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***	0.02
	(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	152,323	152,323	152,173	152,173	152,173
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.

Table A.8: State-Level Measures of Wait Time and Disparities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Unadjusted		**Bayesian**	**Unadjusted**		**Bayesian**
State	**N**	**Mean**	**Std Dev**	**Adjusted Mean**	**Disparity**	**Std Error**	**Adjusted Disparity**
Alabama	4,410	23.04	17.25	23.03	3.46	1.86	3.46
Arizona	2,069	20.80	18.75	20.78	4.67	6.56	4.05
Arkansas	907	21.73	18.27	21.67	-1.84	3.36	-0.74
California	11,744	20.43	17.37	20.43	8.33	2.04	7.89
Connecticut	2,722	12.37	12.51	12.39	11.70	3.69	9.71
Delaware	688	11.91	11.68	11.99	4.85	2.50	4.67
DistrictofColumbia	179	27.49	22.94	26.24	8.38	4.56	6.77
Florida	7,173	17.98	15.52	17.99	2.73	1.42	2.76
Georgia	5,058	20.12	18.14	20.12	4.38	1.54	4.33
Idaho	1,274	19.23	14.99	19.22	13.12	25.23	4.41
Illinois	6,213	15.99	13.69	15.99	5.68	1.19	5.61
Indiana	4,289	27.11	23.08	27.05	-15.90	2.73	-13.04
Iowa	1,667	15.44	13.17	15.46	-9.66	4.72	-5.23
Kansas	1,488	16.08	13.78	16.10	8.20	4.43	6.71
Kentucky	3,167	14.62	12.63	14.63	-2.99	2.00	-2.44
Louisiana	2,403	16.08	14.30	16.09	-0.96	1.13	-0.83
Maine	463	17.66	15.13	17.69	27.35	24.83	5.90
Maryland	4,949	20.48	16.97	20.47	7.03	1.41	6.87
Massachusetts	2,655	12.29	10.94	12.31	9.75	2.82	8.76
Michigan	9,776	22.27	16.44	22.26	11.48	1.42	11.12
Minnesota	4,526	15.26	12.52	15.27	10.11	3.75	8.46
Mississippi	999	17.73	15.87	17.74	-3.26	3.08	-2.05
Missouri	6,231	26.20	20.70	26.17	15.00	2.40	13.63
Montana	307	20.53	16.56	20.45	-117.11	92.15	-2.48
Nebraska	1,355	16.60	16.02	16.63	13.22	9.91	6.60
Nevada	976	15.67	14.15	15.71	2.57	8.31	3.08
NewHampshire	1,325	15.48	12.10	15.50	-4.98	10.24	0.81
NewJersey	4,446	13.89	13.24	13.90	4.64	1.58	4.57
NewMexico	484	18.53	14.48	18.54	-35.21	21.06	-1.39
NewYork	7,892	16.51	14.66	16.52	10.50	1.08	10.31
NorthCarolina	4,061	20.58	16.81	20.57	6.99	1.78	6.74
NorthDakota	424	20.03	17.76	19.97	8.97	42.73	3.79
Ohio	8,343	17.49	14.27	17.49	7.10	1.22	6.98
Oklahoma	3,445	26.45	20.96	26.39	7.29	4.41	6.09
Pennsylvania	6,227	20.80	18.50	20.79	-4.34	2.29	-3.49
RhodeIsland	785	19.07	15.77	19.07	35.78	15.56	9.30
SouthCarolina	4,141	26.55	22.12	26.49	-11.68	3.03	-9.01
SouthDakota	429	15.55	12.81	15.62	-12.56	10.26	-1.54
Tennessee	2,418	16.27	15.40	16.28	0.94	1.60	1.09
Texas	7,377	16.04	16.51	16.05	-2.25	1.38	-2.01
Utah	1,201	27.89	22.96	27.67	-34.32	51.98	1.21
Vermont	165	14.83	13.09	15.05	6.78	33.00	3.69
Virginia	9,030	17.73	15.09	17.73	6.53	1.71	6.34
WestVirginia	600	18.38	13.69	18.39	7.29	6.96	5.28
Wisconsin	3,728	16.62	13.80	16.63	0.83	1.99	1.05
Wyoming	286	20.65	13.15	20.59	17.90	44.06	4.35

Notes: Columns 5-7 (*Disparity*) correspond to the coefficients on the interaction between a state fixed effect and the "Fraction Black" variable from the voter-level regression of wait time on the full set of state fixed effects and the interaction of those fixed effects with "Fraction Black", omitting the constant and clustering standard errors at the polling place level. Column 7 provides empirical-Bayes-adjusted estimates of these state-level disparities to account for measurement error. Similarly, Column 4 provides empirical-Bayes-adjusted estimates of the unadjusted state-level means shown in Column 2.

Table A.9: Congressional District-Level Measures of Wait Time and Disparities (1)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Unadjusted		**Bayesian**	**Unadjusted**		**Bayesian**
State & District	**N**	**Mean**	**Std Dev**	**Adjusted Mean**	**Disparity**	**Std Error**	**Adjusted Disparity**
Alabama 01	518	22.38	16.63	22.28	-4.95	5.06	-3.40
Alabama 02	689	21.76	15.48	21.70	-4.26	6.77	-2.14
Alabama 03	468	22.66	17.40	22.53	10.10	8.05	6.66
Alabama 04	272	21.06	15.10	20.95	-1.92	8.59	-0.16
Alabama 05	956	22.05	17.49	21.99	13.94	5.80	10.64
Alabama 06	1,061	23.91	17.42	23.83	4.86	5.08	4.20
Alabama 07	446	27.49	19.78	27.09	-0.86	5.06	-0.23
Arizona 01	192	16.16	14.06	16.30	-10.97	13.22	-2.41
Arizona 02	193	20.02	20.16	19.88	54.76	59.49	3.49
Arizona 03	150	23.88	19.66	23.24	-75.87	39.55	-2.55
Arizona 04	226	18.28	15.76	18.30	-28.90	28.87	-1.13
Arizona 05	375	21.59	19.48	21.44	-14.55	68.23	1.57
Arizona 06	252	21.37	19.95	21.16	76.05	39.51	6.25
Arizona 07	133	23.03	18.27	22.50	9.03	5.27	7.34
Arizona 08	334	19.98	18.04	19.92	-6.32	16.88	-0.03
Arizona 09	214	23.97	20.95	23.44	-36.35	24.47	-3.12
Arkansas 01	127	19.85	16.68	19.72	-2.12	8.10	-0.39
Arkansas 02	415	20.80	17.22	20.72	1.72	3.43	1.75
Arkansas 03	234	23.63	20.17	23.20	14.72	47.25	2.50
Arkansas 04	131	23.13	19.22	22.54	-5.72	11.96	-0.99
California 01	220	16.17	13.87	16.28	5.56	83.94	2.02
California 02	125	16.96	15.52	17.12	-53.21	35.46	-1.90
California 03	264	19.31	14.91	19.28	0.84	8.83	1.36
California 04	290	18.73	18.47	18.73	-31.90	69.72	1.19
California 05	184	18.76	16.51	18.75	16.49	4.45	13.84
California 06	205	18.03	15.69	18.07	2.43	10.04	2.18
California 07	287	17.66	15.64	17.70	-2.79	12.09	0.16
California 08	164	23.89	21.22	23.21	51.09	34.65	5.53
California 09	257	16.83	14.00	16.90	18.14	11.60	8.40
California 10	247	16.91	14.61	16.99	27.82	28.69	4.57
California 11	274	18.64	15.72	18.64	6.48	7.40	4.75
California 12	145	17.46	20.08	17.62	17.74	29.13	3.51
California 13	133	21.35	20.38	20.96	7.39	8.95	4.81
California 14	174	21.43	18.91	21.15	-32.29	39.81	-0.00
California 15	253	18.08	15.41	18.11	2.37	11.02	2.13
California 16	175	20.32	18.58	20.16	36.56	16.42	10.59
California 17	219	17.76	16.05	17.81	7.62	35.34	2.35
California 18	220	19.29	16.45	19.25	-35.51	33.45	-0.95
California 19	205	17.95	16.88	18.00	-17.27	36.32	0.67
California 20	112	19.68	18.48	19.54	89.54	19.14	19.26
California 21	74	17.97	14.37	18.06	-6.19	16.92	0.01

Notes: Columns 5-7 (*Disparity*) correspond to the coefficients on the interaction between a congressional district fixed effect and the "Fraction Black" variable from the voter-level regression of wait time on the full set of congressional district fixed effects and the interaction of those fixed effects with "Fraction Black", omitting the constant and clustering standard errors at the polling place level. Column 7 provides empirical-Bayes-adjusted estimates of these congressional-district-level disparities to account for measurement error. Similarly, Column 4 provides empirical-Bayes-adjusted estimates of the unadjusted congressional-district-level means shown in Column 2.

Table A.9: Congressional District-Level Measures of Wait Time and Disparities (2)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Unadjusted		**Bayesian**	**Unadjusted**		**Bayesian**
State & District	**N**	**Mean**	**Std Dev**	**Adjusted Mean**	**Disparity**	**Std Error**	**Adjusted Disparity**
California 22	285	21.97	18.49	21.77	-63.14	24.93	-6.39
California 23	268	18.79	13.90	18.79	7.52	14.14	3.67
California 24	171	20.40	16.93	20.25	122.44	73.82	4.45
California 25	348	22.55	17.37	22.37	31.20	12.57	12.50
California 26	275	20.32	18.65	20.21	-7.38	22.44	0.53
California 27	214	19.71	15.37	19.65	17.63	11.57	8.22
California 28	189	22.92	19.69	22.49	-3.66	52.23	1.75
California 29	161	27.40	21.16	26.25	4.99	47.28	2.08
California 30	271	22.53	17.21	22.31	22.10	27.85	4.10
California 31	78	26.65	22.08	24.63	43.66	47.82	3.70
California 32	196	21.07	16.94	20.89	7.75	30.66	2.48
California 33	234	24.59	20.65	24.06	-39.32	28.35	-2.30
California 34	121	23.55	19.86	22.81	9.87	38.17	2.44
California 35	259	22.50	17.19	22.28	1.54	40.33	1.93
California 36	250	23.53	18.64	23.19	27.06	16.95	7.93
California 37	162	24.20	20.23	23.54	7.83	6.36	5.99
California 38	188	19.75	16.63	19.67	23.97	46.88	2.91
California 39	286	20.45	16.40	20.36	-61.49	31.34	-3.54
California 40	129	21.28	16.00	21.02	-42.47	23.12	-4.51
California 41	308	20.42	15.64	20.35	24.92	14.17	9.03
California 42	496	21.04	17.86	20.96	27.76	27.67	4.73
California 43	177	23.39	18.27	22.95	0.99	5.21	1.22
California 44	119	24.61	19.30	23.75	-20.00	6.73	-12.58
California 45	378	20.62	15.45	20.55	-26.77	22.53	-2.41
California 46	154	26.46	24.46	25.10	51.88	125.13	2.48
California 47	208	18.78	14.73	18.78	1.43	10.22	1.71
California 48	277	21.19	15.79	21.07	-47.61	40.00	-0.86
California 49	292	21.06	17.09	20.93	-12.81	67.88	1.61
California 50	357	18.31	15.20	18.32	51.96	34.81	5.57
California 51	141	22.20	19.01	21.77	0.06	9.88	1.05
California 52	286	20.97	19.78	20.81	103.50	55.78	5.23
California 53	239	17.21	14.28	17.28	20.12	19.98	5.31
Connecticut 01	590	10.91	10.57	10.99	4.77	2.59	4.57
Connecticut 02	529	11.38	10.97	11.47	-4.51	5.84	-2.72
Connecticut 03	508	12.60	13.40	12.71	18.98	7.79	12.06
Connecticut 04	545	13.67	12.75	13.75	16.69	6.49	11.94
Connecticut 05	550	13.37	14.39	13.48	20.93	9.29	11.58
Delaware 01	688	11.91	11.68	11.98	4.85	2.51	4.66
DistrictofColumbia 01	179	27.49	22.94	26.27	8.38	4.57	7.15
Florida 01	321	16.25	13.98	16.33	8.88	4.62	7.53
Florida 02	173	14.52	12.70	14.72	3.44	5.89	3.02

Notes: Columns 5-7 (*Disparity*) correspond to the coefficients on the interaction between a congressional district fixed effect and the "Fraction Black" variable from the voter-level regression of wait time on the full set of congressional district fixed effects and the interaction of those fixed effects with "Fraction Black", omitting the constant and clustering standard errors at the polling place level. Column 7 provides empirical-Bayes-adjusted estimates of these congressional-district-level disparities to account for measurement error. Similarly, Column 4 provides empirical-Bayes-adjusted estimates of the unadjusted congressional-district-level means shown in Column 2

Table A.9: Congressional District-Level Measures of Wait Time and Disparities (3)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Unadjusted		**Bayesian**	**Unadjusted**		**Bayesian**
State & District	**N**	**Mean**	**Std Dev**	**Adjusted Mean**	**Disparity**	**Std Error**	**Adjusted Disparity**
Florida 03	288	17.20	15.61	17.27	0.10	11.53	1.21
Florida 04	285	13.07	10.86	13.20	-0.64	9.89	0.72
Florida 05	170	13.69	13.61	13.96	0.13	5.41	0.58
Florida 06	299	17.94	15.36	17.97	8.52	7.08	6.15
Florida 07	277	15.61	13.57	15.72	-3.66	12.73	-0.04
Florida 08	341	15.50	14.66	15.60	0.95	4.51	1.14
Florida 09	293	18.23	15.31	18.24	-19.45	7.97	-10.51
Florida 10	249	19.59	15.15	19.55	-5.24	4.70	-3.80
Florida 11	300	16.23	12.74	16.30	-8.30	8.83	-3.51
Florida 12	499	17.85	13.74	17.87	-1.81	16.83	1.05
Florida 13	261	18.75	15.52	18.75	5.58	5.05	4.76
Florida 14	215	17.35	13.36	17.40	-0.79	4.16	-0.34
Florida 15	397	17.41	13.34	17.44	-0.17	8.50	0.79
Florida 16	346	17.68	14.68	17.71	20.91	14.74	7.48
Florida 17	261	16.23	14.24	16.33	18.88	15.56	6.53
Florida 18	304	19.42	17.48	19.38	-3.28	11.49	-0.15
Florida 19	215	18.26	16.86	18.28	22.18	15.83	7.29
Florida 20	152	20.92	18.13	20.68	-6.21	6.94	-3.34
Florida 21	348	20.65	17.86	20.56	-5.90	5.20	-4.06
Florida 22	305	20.27	17.63	20.18	9.94	9.64	5.86
Florida 23	248	23.11	19.70	22.76	6.53	13.91	3.40
Florida 24	120	21.20	16.45	20.92	6.95	6.19	5.44
Florida 25	193	22.54	18.68	22.19	-30.83	36.47	-0.23
Florida 26	173	18.64	14.80	18.65	21.82	8.50	12.91
Florida 27	138	22.97	20.99	22.33	12.87	15.71	4.86
Georgia 01	291	25.32	20.86	24.82	8.96	6.85	6.53
Georgia 02	255	15.21	12.71	15.32	5.79	3.11	5.41
Georgia 03	385	16.06	14.22	16.13	-3.36	3.20	-2.81
Georgia 04	294	20.11	18.03	20.03	-0.85	3.78	-0.46
Georgia 05	273	23.84	19.13	23.49	-11.33	3.36	-9.83
Georgia 06	644	17.45	15.59	17.48	3.30	5.60	2.95
Georgia 07	676	28.59	24.64	28.12	31.24	9.64	16.27
Georgia 08	207	15.55	11.80	15.66	-9.62	5.87	-6.38
Georgia 09	324	16.29	12.35	16.35	-1.94	11.15	0.33
Georgia 10	316	21.63	20.05	21.44	10.10	10.72	5.51
Georgia 11	655	18.85	15.42	18.84	14.01	4.98	11.37
Georgia 12	199	14.38	13.10	14.57	2.04	3.00	2.03
Georgia 13	310	23.77	20.21	23.43	6.10	7.85	4.40
Georgia 14	229	15.10	12.00	15.22	2.32	7.38	2.18
Idaho 01	665	20.07	14.84	20.04	-15.27	23.49	-0.49
Idaho 02	609	18.31	15.11	18.32	51.18	57.40	3.47

Notes: Columns 5-7 (*Disparity*) correspond to the coefficients on the interaction between a congressional district fixed effect and the "Fraction Black" variable from the voter-level regression of wait time on the full set of congressional district fixed effects and the interaction of those fixed effects with "Fraction Black", omitting the constant and clustering standard errors at the polling place level. Column 7 provides empirical-Bayes-adjusted estimates of these congressional-district-level disparities to account for measurement error. Similarly, Column 4 provides empirical-Bayes-adjusted estimates of the unadjusted congressional-district-level means shown in Column 2

Table A.9: Congressional District-Level Measures of Wait Time and Disparities (4)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Unadjusted		**Bayesian**	**Unadjusted**		**Bayesian**
State & District	**N**	**Mean**	**Std Dev**	**Adjusted Mean**	**Disparity**	**Std Error**	**Adjusted Disparity**
Illinois 01	295	17.07	14.99	17.14	6.56	2.83	6.17
Illinois 02	224	18.22	14.32	18.24	4.82	2.60	4.61
Illinois 03	272	18.10	13.38	18.12	11.08	11.55	5.61
Illinois 04	113	20.94	17.38	20.65	-48.99	23.93	-5.04
Illinois 05	183	22.94	20.49	22.47	32.84	69.70	2.65
Illinois 06	546	15.67	14.82	15.73	66.64	41.00	5.47
Illinois 07	174	22.46	20.80	22.01	1.61	5.42	1.69
Illinois 08	412	16.28	11.54	16.32	-17.80	8.66	-8.75
Illinois 09	270	17.33	13.99	17.38	-5.20	11.30	-0.98
Illinois 10	416	16.49	13.66	16.54	19.07	14.37	7.13
Illinois 11	588	14.74	11.43	14.79	7.47	7.64	5.28
Illinois 12	366	13.75	11.24	13.84	7.27	3.51	6.62
Illinois 13	403	15.10	13.22	15.18	-5.28	4.02	-4.16
Illinois 14	669	14.04	11.85	14.09	-0.57	12.51	1.04
Illinois 15	222	14.04	12.16	14.20	2.33	4.75	2.26
Illinois 16	361	14.90	13.19	14.99	19.88	7.84	12.54
Illinois 17	210	16.57	14.09	16.67	10.21	9.22	6.17
Illinois 18	488	14.03	11.03	14.10	5.18	9.26	3.59
Indiana 01	291	16.09	15.26	16.20	2.55	3.81	2.46
Indiana 02	484	26.12	19.25	25.82	-25.16	7.96	-13.86
Indiana 03	588	29.81	23.12	29.29	-24.60	11.62	-8.59
Indiana 04	412	30.73	24.71	29.83	-10.91	25.30	0.35
Indiana 05	823	38.27	29.21	37.23	-65.07	10.93	-26.65
Indiana 06	329	22.17	17.77	22.00	6.34	16.75	3.02
Indiana 07	532	23.76	21.34	23.53	-14.32	9.25	-6.34
Indiana 08	325	22.00	16.61	21.85	3.16	4.34	2.95
Indiana 09	505	20.12	16.81	20.08	-14.71	19.85	-1.15
Iowa 01	368	14.52	13.46	14.62	-18.53	6.90	-11.37
Iowa 02	374	15.60	13.09	15.67	-17.36	9.45	-7.68
Iowa 03	610	15.89	12.45	15.92	-6.02	7.23	-3.06
Iowa 04	315	15.49	14.22	15.60	34.82	28.39	5.33
Kansas 01	220	15.96	13.53	16.08	-34.21	26.88	-2.12
Kansas 02	305	16.43	14.54	16.51	-0.77	9.67	0.63
Kansas 03	582	14.85	14.88	14.92	11.41	8.84	6.98
Kansas 04	381	17.76	11.17	17.78	9.70	4.91	8.04
Kentucky 01	278	12.70	9.33	12.80	2.75	4.87	2.58
Kentucky 02	627	15.25	13.04	15.30	21.00	20.37	5.36
Kentucky 03	775	11.65	9.17	11.69	1.08	1.73	1.11
Kentucky 04	720	17.54	14.65	17.55	5.64	16.91	2.84
Kentucky 05	170	15.06	15.60	15.32	-6.24	30.51	1.21
Kentucky 06	597	15.04	12.94	15.09	1.07	6.59	1.36

Notes: Columns 5-7 (*Disparity*) correspond to the coefficients on the interaction between a congressional district fixed effect and the "Fraction Black" variable from the voter-level regression of wait time on the full set of congressional district fixed effects and the interaction of those fixed effects with "Fraction Black", omitting the constant and clustering standard errors at the polling place level. Column 7 provides empirical-Bayes-adjusted estimates of these congressional-district-level disparities to account for measurement error. Similarly, Column 4 provides empirical-Bayes-adjusted estimates of the unadjusted congressional-district-level means shown in Column 2

Table A.9: Congressional District-Level Measures of Wait Time and Disparities (5)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Unadjusted		**Bayesian**	**Unadjusted**		**Bayesian**
State & District	**N**	**Mean**	**Std Dev**	**Adjusted Mean**	**Disparity**	**Std Error**	**Adjusted Disparity**
Louisiana 01	547	16.39	15.97	16.45	9.22	7.71	6.30
Louisiana 02	350	17.31	15.47	17.35	1.29	3.86	1.39
Louisiana 03	506	15.84	13.13	15.89	-5.65	2.82	-5.03
Louisiana 04	370	15.92	14.27	15.99	-4.23	1.97	-3.97
Louisiana 05	148	17.86	15.38	17.92	-5.16	3.66	-4.22
Louisiana 06	482	14.66	12.05	14.72	-1.84	3.65	-1.35
Maine 01	334	17.49	13.91	17.53	16.58	20.95	4.46
Maine 02	129	18.09	17.96	18.16	142.74	176.10	3.04
Maryland 01	705	15.88	13.13	15.91	4.40	5.27	3.82
Maryland 02	674	26.57	20.54	26.31	5.70	4.31	5.05
Maryland 03	672	24.44	19.76	24.26	-4.15	9.02	-1.23
Maryland 04	555	23.69	17.87	23.54	-1.60	3.78	-1.11
Maryland 05	583	18.00	14.15	18.01	0.32	2.70	0.44
Maryland 06	695	16.30	12.97	16.33	9.31	6.14	7.11
Maryland 07	445	22.49	18.25	22.34	9.23	3.78	8.22
Maryland 08	620	17.48	13.89	17.50	13.27	6.79	9.39
Massachusetts 01	270	12.42	13.01	12.62	9.62	13.56	4.46
Massachusetts 02	376	12.07	9.65	12.16	2.97	7.51	2.57
Massachusetts 03	355	11.78	10.83	11.90	13.01	14.38	5.29
Massachusetts 04	278	12.33	9.45	12.44	3.45	9.43	2.70
Massachusetts 05	241	11.70	8.88	11.82	6.74	4.49	5.85
Massachusetts 06	336	10.89	9.33	11.00	22.43	12.30	9.54
Massachusetts 07	179	18.02	15.84	18.07	-4.32	4.49	-3.15
Massachusetts 08	331	12.77	11.77	12.90	10.33	9.15	6.26
Massachusetts 09	289	11.09	9.32	11.21	49.75	26.89	7.35
Michigan 01	316	19.24	15.51	19.22	-18.95	25.02	-0.71
Michigan 02	777	19.66	13.62	19.65	2.35	8.66	2.17
Michigan 03	667	21.97	15.90	21.90	5.80	6.72	4.50
Michigan 04	450	20.28	15.21	20.23	-13.66	7.45	-7.65
Michigan 05	589	23.29	17.00	23.17	7.51	3.78	6.73
Michigan 06	559	24.80	17.53	24.62	3.54	6.79	3.00
Michigan 07	603	20.62	14.20	20.59	11.11	8.62	6.94
Michigan 08	1,022	21.62	16.50	21.58	-2.36	8.49	-0.42
Michigan 09	874	20.22	14.19	20.20	2.14	5.99	2.09
Michigan 10	854	18.98	13.54	18.98	8.32	7.08	6.02
Michigan 11	1,154	23.13	16.65	23.07	20.40	11.38	9.47
Michigan 12	722	24.32	17.89	24.19	18.07	11.31	8.57
Michigan 13	538	26.03	20.30	25.73	13.96	3.30	12.64
Michigan 14	651	28.15	19.34	27.86	6.67	3.30	6.16
Minnesota 01	347	14.31	10.08	14.38	-2.88	8.75	-0.64
Minnesota 02	903	13.60	10.42	13.63	14.82	10.52	7.69

Notes: Columns 5-7 (*Disparity*) correspond to the coefficients on the interaction between a congressional district fixed effect and the "Fraction Black" variable from the voter-level regression of wait time on the full set of congressional district fixed effects and the interaction of those fixed effects with "Fraction Black", omitting the constant and clustering standard errors at the polling place level. Column 7 provides empirical-Bayes-adjusted estimates of these congressional-district-level disparities to account for measurement error. Similarly, Column 4 provides empirical-Bayes-adjusted estimates of the unadjusted congressional-district-level means shown in Column 2

Table A.9: Congressional District-Level Measures of Wait Time and Disparities (6)

State & District	(1) N	(2) Unadjusted Mean	(3) Unadjusted Std Dev	(4) Bayesian Adjusted Mean	(5) Unadjusted Disparity	(6) Unadjusted Std Error	(7) Bayesian Adjusted Disparity
Minnesota 03	874	16.80	13.69	16.82	24.64	12.34	10.33
Minnesota 04	642	16.19	13.73	16.23	-0.06	4.62	0.33
Minnesota 05	384	17.50	16.45	17.54	-0.72	6.16	0.08
Minnesota 06	855	14.43	11.08	14.47	-1.96	8.82	-0.13
Minnesota 07	235	14.44	13.34	14.60	20.56	38.51	3.08
Minnesota 08	286	15.02	10.84	15.10	63.07	24.95	9.78
Mississippi 01	332	16.95	13.65	17.00	-8.22	6.37	-5.03
Mississippi 02	153	16.29	15.70	16.48	8.30	5.66	6.61
Mississippi 03	248	14.71	13.86	14.87	-6.50	3.49	-5.47
Mississippi 04	266	22.34	19.06	22.08	-4.54	5.30	-2.98
Missouri 01	634	29.49	20.63	29.11	10.67	3.11	9.81
Missouri 02	1,408	22.82	16.61	22.78	2.38	13.41	2.10
Missouri 03	814	20.43	16.33	20.40	18.00	14.16	6.90
Missouri 04	422	20.65	17.37	20.57	31.80	20.47	7.25
Missouri 05	830	40.97	27.05	39.95	-2.95	6.50	-1.36
Missouri 06	980	30.85	23.01	30.51	26.29	28.53	4.44
Missouri 07	906	20.72	14.54	20.70	75.62	32.40	7.98
Missouri 08	237	17.03	12.86	17.09	-13.13	10.37	-4.87
Montana 01	307	20.53	16.56	20.45	-117.11	92.37	0.16
Nebraska 01	485	17.52	17.83	17.56	78.02	34.86	7.43
Nebraska 02	615	16.06	15.14	16.11	8.69	10.25	5.05
Nebraska 03	255	16.17	14.35	16.27	-10.56	22.53	0.06
Nevada 01	163	15.01	12.14	15.18	-13.11	10.09	-5.06
Nevada 02	291	16.06	14.62	16.16	-2.79	19.71	1.06
Nevada 03	294	14.15	11.79	14.26	-5.37	14.39	-0.25
Nevada 04	228	17.62	17.18	17.69	3.20	12.74	2.40
NewHampshire 01	755	16.16	12.77	16.19	-3.35	11.18	-0.25
NewHampshire 02	570	14.58	11.09	14.62	-8.54	21.88	0.28
NewJersey 01	432	12.18	10.03	12.26	3.56	3.71	3.34
NewJersey 02	324	14.45	12.68	14.56	12.78	7.42	8.64
NewJersey 03	411	13.06	14.13	13.21	-3.95	2.49	-3.56
NewJersey 04	458	11.17	9.65	11.25	-3.30	5.38	-2.01
NewJersey 05	415	13.93	13.78	14.04	-7.09	9.67	-2.45
NewJersey 06	426	13.98	13.25	14.09	13.04	9.82	7.27
NewJersey 07	566	14.28	13.59	14.35	12.02	11.34	6.07
NewJersey 08	64	21.06	21.45	20.39	9.94	10.50	5.52
NewJersey 09	252	13.16	11.61	13.32	16.17	5.74	12.31
NewJersey 10	194	18.30	14.51	18.32	-5.83	4.06	-4.60
NewJersey 11	447	12.84	14.02	12.98	51.94	20.36	10.90
NewJersey 12	457	16.47	14.40	16.53	-9.00	3.25	-7.83
NewMexico 01	171	19.62	14.14	19.57	-43.72	29.29	-2.49

Notes: Columns 5-7 (*Disparity*) correspond to the coefficients on the interaction between a congressional district fixed effect and the "Fraction Black" variable from the voter-level regression of wait time on the full set of congressional district fixed effects and the interaction of those fixed effects with "Fraction Black", omitting the constant and clustering standard errors at the polling place level. Column 7 provides empirical-Bayes-adjusted estimates of these congressional-district-level disparities to account for measurement error. Similarly, Column 4 provides empirical-Bayes-adjusted estimates of the unadjusted congressional-district-level means shown in Column 2

Table A.9: Congressional District-Level Measures of Wait Time and Disparities (7)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Unadjusted		**Bayesian**	**Unadjusted**		**Bayesian**
State & District	**N**	**Mean**	**Std Dev**	**Adjusted Mean**	**Disparity**	**Std Error**	**Adjusted Disparity**
NewMexico 02	160	17.94	14.56	17.99	-35.96	32.87	-1.07
NewMexico 03	153	17.93	14.79	17.98	4.21	69.60	2.01
NewYork 01	743	14.97	13.46	15.02	15.31	20.04	4.41
NewYork 02	615	13.90	11.93	13.95	17.19	4.66	14.19
NewYork 03	469	13.35	10.60	13.41	22.03	9.53	11.88
NewYork 05	379	25.07	18.19	24.78	2.50	3.10	2.45
NewYork 06	327	18.98	14.34	18.97	24.18	12.33	10.17
NewYork 07	147	19.50	16.49	19.43	17.89	20.99	4.67
NewYork 08	260	20.29	15.11	20.21	4.75	3.28	4.45
NewYork 09	218	22.81	17.72	22.50	4.34	3.09	4.11
NewYork 10	236	19.51	15.92	19.46	-24.72	22.98	-1.97
NewYork 11	413	14.70	11.88	14.77	-0.13	1.87	-0.05
NewYork 12	277	20.29	18.41	20.19	-19.39	7.52	-11.07
NewYork 13	145	22.41	18.98	21.97	6.72	6.31	5.24
NewYork 14	205	22.52	19.45	22.17	-3.87	16.19	0.47
NewYork 15	174	20.66	16.69	20.50	-0.55	7.67	0.45
NewYork 16	73	21.98	17.93	21.34	-9.23	8.91	-3.95
NewYork 17	159	14.83	13.00	15.04	-5.32	10.97	-1.14
NewYork 18	402	13.87	11.36	13.95	3.31	4.08	3.10
NewYork 19	216	14.32	11.77	14.46	10.70	12.73	5.06
NewYork 20	291	11.98	11.19	12.14	5.93	11.29	3.59
NewYork 21	141	14.79	15.69	15.12	-8.80	16.68	-0.67
NewYork 22	255	14.41	13.42	14.57	-8.62	16.68	-0.62
NewYork 23	135	12.04	9.72	12.28	38.25	22.84	7.34
NewYork 24	535	16.70	14.23	16.74	11.57	4.89	9.52
NewYork 25	545	15.25	15.10	15.32	0.59	6.17	1.00
NewYork 26	253	13.08	13.02	13.28	6.15	5.45	5.10
NewYork 27	279	13.50	11.90	13.63	44.88	36.55	4.80
NorthCarolina 01	178	19.49	15.17	19.44	-4.35	5.10	-2.92
NorthCarolina 02	558	24.58	19.29	24.37	-0.10	7.07	0.64
NorthCarolina 03	168	19.24	16.62	19.19	-8.91	7.76	-4.52
NorthCarolina 04	418	22.62	18.38	22.45	19.61	7.05	13.27
NorthCarolina 05	263	18.70	16.35	18.70	15.29	8.64	9.20
NorthCarolina 06	306	18.30	13.12	18.31	3.74	5.27	3.31
NorthCarolina 07	239	17.63	13.44	17.67	3.19	6.32	2.81
NorthCarolina 08	381	19.74	15.93	19.70	0.04	7.30	0.76
NorthCarolina 09	372	20.20	15.74	20.15	4.74	6.73	3.80
NorthCarolina 10	256	15.44	12.51	15.54	11.24	12.18	5.44
NorthCarolina 11	176	17.66	16.80	17.74	-31.10	19.22	-4.53
NorthCarolina 12	405	25.52	19.28	25.19	3.11	5.23	2.84
NorthCarolina 13	341	19.15	15.76	19.13	-3.33	3.56	-2.67

Notes: Columns 5-7 (*Disparity*) correspond to the coefficients on the interaction between a congressional district fixed effect and the "Fraction Black" variable from the voter-level regression of wait time on the full set of congressional district fixed effects and the interaction of those fixed effects with "Fraction Black", omitting the constant and clustering standard errors at the polling place level. Column 7 provides empirical-Bayes-adjusted estimates of these congressional-district-level disparities to account for measurement error. Similarly, Column 4 provides empirical-Bayes-adjusted estimates of the unadjusted congressional-district-level means shown in Column 2

Table A.9: Congressional District-Level Measures of Wait Time and Disparities (8)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Unadjusted		**Bayesian**	**Unadjusted**		**Bayesian**
State & District	**N**	**Mean**	**Std Dev**	**Adjusted Mean**	**Disparity**	**Std Error**	**Adjusted Disparity**
NorthDakota 01	424	20.03	17.76	19.97	8.97	42.83	2.31
Ohio 01	672	20.96	14.85	20.92	11.17	3.15	10.24
Ohio 02	589	18.73	14.07	18.73	6.73	6.18	5.29
Ohio 03	542	22.11	15.98	22.02	1.51	3.70	1.57
Ohio 04	310	12.09	9.82	12.20	-8.88	3.50	-7.57
Ohio 05	575	15.42	13.03	15.47	7.90	9.38	4.94
Ohio 06	260	15.19	11.01	15.27	35.86	21.81	7.39
Ohio 07	368	15.30	13.41	15.39	-13.77	7.85	-7.33
Ohio 08	669	13.78	11.89	13.84	-8.52	3.29	-7.37
Ohio 09	383	16.21	10.98	16.26	8.64	2.74	8.12
Ohio 10	563	24.47	19.55	24.26	-13.94	3.89	-11.62
Ohio 11	331	19.02	14.19	19.01	4.47	2.56	4.30
Ohio 12	774	16.74	14.03	16.77	18.83	13.19	7.67
Ohio 13	456	16.07	12.94	16.12	17.79	6.04	13.17
Ohio 14	507	14.42	11.07	14.48	-11.11	6.59	-6.82
Ohio 15	701	19.05	15.20	19.04	19.26	15.02	6.87
Ohio 16	643	15.83	13.34	15.87	11.80	14.78	4.82
Oklahoma 01	968	24.53	19.67	24.41	1.42	8.22	1.65
Oklahoma 02	192	20.49	17.37	20.34	32.36	12.17	13.38
Oklahoma 03	591	25.77	20.51	25.51	11.18	29.58	2.84
Oklahoma 04	728	28.65	22.58	28.29	-0.68	14.28	1.15
Oklahoma 05	966	28.31	21.48	28.07	4.67	5.89	3.91
Pennsylvania 01	132	16.60	17.65	16.83	11.11	4.88	9.17
Pennsylvania 02	141	18.99	20.51	18.95	-0.32	4.89	0.16
Pennsylvania 03	292	19.04	17.57	19.02	-34.09	14.26	-9.05
Pennsylvania 04	479	26.11	22.47	25.71	-3.17	19.10	0.94
Pennsylvania 05	209	24.52	21.54	23.89	118.97	40.17	8.55
Pennsylvania 06	571	21.79	19.16	21.68	0.05	18.90	1.57
Pennsylvania 07	512	17.64	17.11	17.67	-14.90	7.70	-8.14
Pennsylvania 08	821	22.55	18.29	22.47	-27.55	11.57	-9.83
Pennsylvania 09	173	18.31	14.70	18.34	-18.23	16.57	-3.01
Pennsylvania 10	214	19.63	16.74	19.57	3.65	25.74	2.16
Pennsylvania 11	279	23.60	22.15	23.17	-15.56	18.16	-1.80
Pennsylvania 12	339	19.01	17.50	18.99	6.13	30.83	2.33
Pennsylvania 13	326	17.68	17.50	17.73	1.25	6.56	1.48
Pennsylvania 14	179	16.09	13.24	16.22	7.10	4.97	5.98
Pennsylvania 15	469	23.32	18.29	23.15	-44.29	19.63	-6.82
Pennsylvania 16	405	17.49	14.55	17.52	8.14	15.10	3.70
Pennsylvania 17	263	22.21	16.99	22.01	-10.02	8.06	-4.96
Pennsylvania 18	423	20.23	17.95	20.16	-20.47	24.44	-1.02
RhodeIsland 01	354	21.33	18.65	21.19	37.64	21.09	7.99

Notes: Columns 5-7 (*Disparity*) correspond to the coefficients on the interaction between a congressional district fixed effect and the "Fraction Black" variable from the voter-level regression of wait time on the full set of congressional district fixed effects and the interaction of those fixed effects with "Fraction Black", omitting the constant and clustering standard errors at the polling place level. Column 7 provides empirical-Bayes-adjusted estimates of these congressional-district-level disparities to account for measurement error. Similarly, Column 4 provides empirical-Bayes-adjusted estimates of the unadjusted congressional-district-level means shown in Column 2

Table A.9: Congressional District-Level Measures of Wait Time and Disparities (9)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Unadjusted		**Bayesian**	**Unadjusted**		**Bayesian**
State & District	**N**	**Mean**	**Std Dev**	**Adjusted Mean**	**Disparity**	**Std Error**	**Adjusted Disparity**
RhodeIsland 02	431	17.22	12.66	17.25	9.56	14.58	4.21
SouthCarolina 01	715	34.44	25.83	33.68	-26.27	12.07	-8.76
SouthCarolina 02	737	23.82	20.64	23.66	-6.41	6.24	-3.86
SouthCarolina 03	449	20.12	17.60	20.06	-12.50	8.35	-6.14
SouthCarolina 04	749	25.99	20.53	25.77	-2.18	8.35	-0.36
SouthCarolina 05	588	22.77	19.20	22.63	-16.31	7.17	-9.61
SouthCarolina 06	315	23.37	21.02	23.04	3.53	8.24	2.85
SouthCarolina 07	588	31.46	23.78	30.82	-31.43	7.45	-18.57
SouthDakota 01	429	15.55	12.81	15.62	-12.56	10.28	-4.67
Tennessee 01	286	17.26	15.53	17.32	-18.24	23.23	-0.96
Tennessee 02	279	15.30	14.64	15.43	8.72	9.45	5.33
Tennessee 03	344	19.39	15.95	19.36	5.48	6.74	4.29
Tennessee 04	264	13.85	12.34	13.99	-3.60	9.93	-0.68
Tennessee 05	287	15.01	14.75	15.15	4.55	3.88	4.17
Tennessee 06	301	18.68	18.16	18.67	28.58	7.90	17.59
Tennessee 07	242	14.65	12.59	14.78	2.04	6.05	2.01
Tennessee 08	241	15.66	17.61	15.86	4.04	5.98	3.44
Tennessee 09	174	14.68	14.20	14.91	1.92	3.37	1.93
Texas 01	114	13.75	12.06	14.07	1.53	10.89	1.77
Texas 02	228	14.21	17.46	14.51	14.14	14.17	5.71
Texas 03	355	14.12	16.41	14.29	8.47	11.24	4.65
Texas 04	160	12.83	11.02	13.06	-8.24	6.64	-4.85
Texas 05	162	16.39	19.22	16.64	-3.67	10.71	-0.50
Texas 06	285	14.22	12.10	14.34	0.09	4.40	0.42
Texas 07	246	13.22	15.83	13.51	-14.29	8.87	-6.65
Texas 08	270	15.85	16.40	16.00	-11.01	16.76	-1.18
Texas 09	134	16.33	17.47	16.59	-1.14	7.46	0.05
Texas 10	203	16.50	18.06	16.67	-0.80	8.69	0.46
Texas 11	156	15.75	17.36	16.02	12.40	27.92	3.06
Texas 12	246	13.24	13.18	13.44	6.08	11.82	3.56
Texas 13	164	16.22	18.19	16.47	-5.93	29.13	1.18
Texas 14	181	16.33	17.49	16.52	7.57	7.36	5.44
Texas 15	135	19.37	19.61	19.27	-48.73	17.28	-9.76
Texas 16	176	15.01	14.51	15.23	46.67	46.53	3.91
Texas 17	261	20.43	17.08	20.33	3.11	13.38	2.34
Texas 18	184	14.18	16.06	14.50	-6.57	4.66	-4.90
Texas 19	175	13.45	12.70	13.70	7.45	10.34	4.45
Texas 20	215	16.67	15.38	16.78	34.88	20.25	7.90
Texas 21	242	18.86	20.60	18.85	108.93	52.16	5.81
Texas 22	264	16.89	16.15	16.98	18.52	9.50	10.17
Texas 23	133	22.56	22.39	21.90	64.90	56.35	3.95

Notes: Columns 5-7 (*Disparity*) correspond to the coefficients on the interaction between a congressional district fixed effect and the "Fraction Black" variable from the voter-level regression of wait time on the full set of congressional district fixed effects and the interaction of those fixed effects with "Fraction Black", omitting the constant and clustering standard errors at the polling place level. Column 7 provides empirical-Bayes-adjusted estimates of these congressional-district-level disparities to account for measurement error. Similarly, Column 4 provides empirical-Bayes-adjusted estimates of the unadjusted congressional-district-level means shown in Column 2

Table A.9: Congressional District-Level Measures of Wait Time and Disparities (10)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Unadjusted		**Bayesian**	**Unadjusted**		**Bayesian**
State & District	**N**	**Mean**	**Std Dev**	**Adjusted Mean**	**Disparity**	**Std Error**	**Adjusted Disparity**
Texas 24	236	13.88	14.04	14.09	-2.55	7.31	-0.85
Texas 25	217	18.09	16.65	18.13	2.24	10.40	2.08
Texas 26	410	18.40	16.74	18.41	38.07	24.20	6.82
Texas 27	157	24.32	23.42	23.41	-75.44	24.77	-8.08
Texas 28	141	18.65	17.15	18.65	-7.88	16.05	-0.58
Texas 29	147	11.72	9.40	11.94	2.51	5.20	2.38
Texas 30	203	14.83	14.81	15.04	-6.35	4.16	-4.99
Texas 31	218	15.52	15.65	15.70	12.08	18.69	4.03
Texas 32	312	14.74	14.62	14.88	1.60	7.16	1.73
Texas 33	145	14.77	13.93	15.04	7.06	11.81	3.94
Texas 34	112	19.22	19.36	19.13	11.09	44.74	2.38
Texas 35	166	17.69	19.91	17.80	-13.70	8.79	-6.41
Texas 36	224	13.63	12.69	13.82	-9.44	7.10	-5.30
Utah 01	119	18.77	14.51	18.76	-57.57	9.26	-28.32
Utah 02	253	33.75	25.70	31.88	30.66	72.88	2.56
Utah 03	594	25.83	20.48	25.56	-158.01	192.90	0.80
Utah 04	235	31.41	26.84	29.59	63.87	87.85	2.95
Vermont 01	165	14.83	13.09	15.03	6.78	33.08	2.34
Virginia 01	1,053	16.08	13.81	16.10	-4.14	8.19	-1.52
Virginia 02	1,022	18.78	15.44	18.78	4.57	7.22	3.60
Virginia 03	674	21.25	19.32	21.17	-1.26	3.84	-0.80
Virginia 04	824	19.96	16.86	19.94	-0.56	4.08	-0.16
Virginia 05	535	17.89	13.99	17.90	15.11	7.00	10.43
Virginia 06	562	18.61	15.96	18.61	-7.10	8.88	-2.84
Virginia 07	1,049	20.08	15.48	20.07	-1.75	5.48	-0.81
Virginia 08	569	17.49	15.32	17.51	14.38	6.85	10.07
Virginia 09	444	16.52	15.36	16.58	2.08	12.75	2.00
Virginia 10	1,347	14.54	11.45	14.57	13.47	10.77	6.95
Virginia 11	951	15.98	13.55	16.00	14.18	5.49	11.08
WestVirginia 01	141	15.85	13.88	16.04	2.34	12.68	2.09
WestVirginia 02	333	19.50	12.00	19.48	7.08	7.20	5.19
WestVirginia 03	126	18.27	17.00	18.31	-7.86	27.65	0.90
Wisconsin 01	536	17.11	15.52	17.14	2.79	6.60	2.52
Wisconsin 02	525	16.82	14.17	16.86	14.09	15.11	5.37
Wisconsin 03	394	17.22	13.62	17.26	-0.27	23.26	1.63
Wisconsin 04	377	15.50	13.48	15.58	3.33	2.78	3.22
Wisconsin 05	662	15.67	13.22	15.71	-19.14	14.96	-4.07
Wisconsin 06	516	16.57	12.93	16.61	-32.77	18.73	-5.14
Wisconsin 07	261	17.58	13.78	17.62	-30.10	58.11	0.99
Wisconsin 08	455	17.15	13.44	17.18	7.23	17.75	3.13
Wyoming 01	286	20.65	13.15	20.59	17.90	44.17	2.72

Notes: Columns 5-7 (*Disparity*) correspond to the coefficients on the interaction between a congressional district fixed effect and the "Fraction Black" variable from the voter-level regression of wait time on the full set of congressional district fixed effects and the interaction of those fixed effects with "Fraction Black", omitting the constant and clustering standard errors at the polling place level. Column 7 provides empirical-Bayes-adjusted estimates of these congressional-district-level disparities to account for measurement error. Similarly, Column 4 provides empirical-Bayes-adjusted estimates of the unadjusted congressional-district-level means shown in Column 2

Table A.10: (100 Most Populous) County-Level Measures of Wait Time and Disparities (1)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			Unadjusted		**Bayesian**	**Unadjusted**		**Bayesian**
County & State	**Population**	**N**	**Mean**	**Std Dev**	**Adjusted Mean**	**Disparity**	**Std Error**	**Adjusted Disparity**
Alameda California	1,629,615	430	19.31	16.95	19.29	10.76	6.89	10.54
Allegheny Pennsylvania	1,229,605	572	19.02	16.73	19.01	-0.91	5.13	-0.91
BaltimoreCity Maryland	619,796	220	24.41	17.88	24.08	1.23	4.29	1.21
Baltimore Maryland	828,637	806	31.25	20.88	30.99	1.49	4.17	1.47
Bergen NewJersey	937,920	433	11.45	11.12	11.52	0.87	5.80	0.85
Bernalillo NewMexico	674,855	161	20.30	15.10	20.19	-42.40	28.36	-32.35
Bexar Texas	1,892,004	530	18.26	18.60	18.26	5.37	8.72	5.18
Bronx NewYork	1,455,846	355	20.59	16.59	20.52	-0.64	3.99	-0.65
Broward Florida	1,890,416	560	21.55	17.64	21.48	-0.08	4.67	-0.08
Bucks Pennsylvania	626,486	712	22.94	18.60	22.85	-31.53	13.08	-29.58
ChicagoCity Illinois	5,238,541	1,603	20.10	16.25	20.09	1.26	1.52	1.26
Clark Nevada	2,112,436	670	15.33	13.57	15.36	6.17	9.10	5.94
Cobb Georgia	739,072	759	20.29	17.14	20.26	5.06	5.35	4.99
Collin Texas	914,075	388	14.36	16.28	14.45	7.22	10.49	6.88
ContraCosta California	1,123,678	471	17.71	14.66	17.72	7.23	6.92	7.08
Cuyahoga Ohio	1,257,401	754	16.88	13.83	16.89	6.87	1.67	6.86
DC DistrictofColumbia	672,391	179	27.49	22.94	26.56	8.38	4.62	8.30
Dallas Texas	2,552,213	767	14.64	15.16	14.68	-2.28	2.11	-2.28
Davidson Tennessee	678,322	255	14.82	13.85	14.91	5.20	3.86	5.16
DeKalb Georgia	736,066	335	18.25	16.91	18.25	0.22	2.50	0.22
Denton Texas	781,321	346	18.62	16.93	18.60	21.07	24.12	16.94
DuPage Illinois	931,826	697	14.37	13.09	14.40	33.82	27.92	25.61
Duval Florida	912,043	275	12.62	11.77	12.72	6.00	5.98	5.90
ElPaso Texas	834,825	194	15.42	15.17	15.53	36.92	46.46	19.46
Erie NewYork	923,995	407	12.58	12.49	12.66	6.57	5.33	6.49
Essex Massachusetts	775,860	292	11.77	11.76	11.88	22.51	13.63	20.90
Essex NewJersey	800,401	293	17.52	16.33	17.54	-2.76	3.25	-2.75
Fairfax Virginia	1,142,004	1,262	14.75	12.45	14.77	24.18	6.77	23.73
Fairfield Connecticut	947,328	708	12.81	11.92	12.85	13.23	5.94	13.03
FortBend Texas	711,421	134	17.11	16.33	17.18	5.01	9.16	4.82
Franklin Ohio	1,253,507	1,238	20.93	16.17	20.91	4.54	3.21	4.52
Fresno California	971,616	291	19.79	16.96	19.73	14.02	14.65	12.85
Fulton Georgia	1,010,420	483	20.90	17.40	20.84	4.72	3.01	4.70
Gwinnett Georgia	889,954	779	30.16	24.64	29.82	17.67	7.87	17.22
Hamilton Ohio	808,703	654	22.33	15.89	22.27	7.05	3.25	7.02
Harris Texas	4,525,519	1,282	13.61	15.20	13.64	1.31	2.72	1.30
Hartford Connecticut	897,417	768	11.40	12.04	11.45	6.18	2.68	6.16
Hennepin Minnesota	1,224,763	1,063	17.54	14.92	17.55	10.20	6.47	10.02
Hidalgo Texas	839,539	119	20.06	20.08	19.84	1,032.15	431.93	15.63
Hillsborough Florida	1,351,087	468	18.05	14.63	18.05	0.87	5.04	0.85

Notes: Columns 6-8 (*Disparity*) correspond to the coefficients on the interaction between a county fixed effect and the "Fraction Black" variable from the voter-level regression of wait time on the full set of county fixed effects and the interaction of those fixed effects with "Fraction Black", omitting the constant and clustering standard errors at the polling place level. Column 7 provides empirical-Bayes-adjusted estimates of these congressional-district-level disparities to account for measurement error. Similarly, Column 5 provides empirical-Bayes-adjusted estimates of the unadjusted congressional-district-level means shown in Column 3. Column 2 displays the population of each listed county; we just show the 100 largest counties (by population in the 2017 American Community Survey's five-year estimates).

Table A.10: (100 Most Populous) County-Level Measures of Wait Time and Disparities (2)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			Unadjusted		Bayesian	Unadjusted		Bayesian
County & State	**Population**	**N**	**Mean**	**Std Dev**	**Adjusted Mean**	**Disparity**	**Std Error**	**Adjusted Disparity**
Hudson NewJersey	679,756	10	17.93	21.48		5.01	154.65	
Jackson Missouri	688,554	950	42.65	26.94	41.96	-7.08	6.63	-6.97
Jefferson Alabama	659,460	854	26.41	18.03	26.29	1.94	2.58	1.94
Jefferson Kentucky	764,378	833	12.25	10.49	12.28	-0.24	2.29	-0.24
Kent Michigan	636,376	646	22.67	16.64	22.60	6.91	7.33	6.75
Kern California	878,744	259	17.76	12.33	17.77	-23.78	9.84	-22.93
Kings NewYork	2,635,121	693	20.52	15.79	20.49	5.91	1.79	5.90
Lake Illinois	704,476	522	16.03	13.07	16.06	22.98	12.30	21.62
Lee Florida	700,165	185	19.00	17.61	18.95	23.38	19.01	20.33
LosAngeles California	10105722	2,719	22.62	18.41	22.60	4.23	2.87	4.21
Macomb Michigan	864,019	1,248	19.38	13.64	19.37	5.34	5.18	5.28
Maricopa Arizona	4,155,501	1,378	21.61	19.29	21.58	4.01	6.58	3.93
Marion Indiana	939,964	726	23.54	20.81	23.42	-15.18	7.67	-14.85
Mecklenburg NorthCarolina	1,034,290	574	25.05	18.44	24.90	5.25	4.28	5.20
Miami-Dade Florida	2,702,602	537	21.02	17.99	20.96	4.71	3.95	4.68
Middlesex Massachusetts	1,582,857	642	11.48	8.98	11.51	3.59	4.26	3.56
Middlesex NewJersey	837,288	558	16.95	15.04	16.97	1.01	10.70	0.93
Milwaukee Wisconsin	956,586	600	16.08	13.86	16.10	0.86	2.82	0.86
Monmouth NewJersey	627,551	448	11.00	9.89	11.06	-4.22	4.49	-4.20
Monroe NewYork	748,680	556	15.24	15.05	15.29	0.45	6.19	0.43
Montgomery Maryland	1,039,198	829	19.90	14.41	19.89	5.99	4.98	5.92
Montgomery Pennsylvania	818,677	714	20.81	18.54	20.76	7.95	10.09	7.61
NewHaven Connecticut	862,127	536	13.46	14.59	13.53	19.11	7.62	18.66
NewYork NewYork	1,653,877	524	20.49	18.31	20.43	2.73	5.26	2.69
Norfolk Massachusetts	694,389	290	12.04	9.28	12.11	3.30	4.86	3.26
Oakland Michigan	1,241,860	1,843	23.23	16.57	23.20	7.12	3.24	7.09
Ocean NewJersey	589,699	254	13.18	14.36	13.33	17.05	31.32	12.01
Oklahoma Oklahoma	774,203	975	28.88	21.65	28.69	5.21	5.89	5.12
Orange California	3,155,816	1,202	21.92	17.47	21.88	-19.00	22.43	-15.99
Orange Florida	1,290,216	443	19.13	14.99	19.11	-4.22	4.34	-4.20
PalmBeach Florida	1,426,772	662	20.87	18.95	20.82	-2.41	4.65	-2.40
Philadelphia Pennsylvania	1,569,657	286	16.08	18.40	16.16	3.75	3.58	3.72
Pima Arizona	1,007,257	247	16.89	15.01	16.93	6.60	19.21	5.64
Pinellas Florida	949,842	396	19.59	16.05	19.55	2.99	5.16	2.95
Polk Florida	652,256	291	16.55	14.51	16.59	-5.87	5.99	-5.80
PrinceGeorge's Maryland	905,161	547	21.76	16.30	21.70	-1.74	3.35	-1.74
Providence RhodeIsland	633,704	403	21.05	18.16	20.97	29.43	17.35	26.19
Queens NewYork	2,339,280	1,056	21.59	17.05	21.55	6.83	2.18	6.81
Riverside California	2,355,002	1,137	21.13	17.28	21.10	26.14	10.10	25.08
Sacramento California	1,495,400	482	17.83	15.87	17.84	0.98	7.73	0.93

Notes: Columns 6-8 (*Disparity*) correspond to the coefficients on the interaction between a county fixed effect and the "Fraction Black" variable from the voter-level regression of wait time on the full set of county fixed effects and the interaction of those fixed effects with "Fraction Black", omitting the constant and clustering standard errors at the polling place level. Column 7 provides empirical-Bayes-adjusted estimates of these congressional-district-level disparities to account for measurement error. Similarly, Column 5 provides empirical-Bayes-adjusted estimates of the unadjusted congressional-district-level means shown in Column 3. Column 2 displays the population of each listed county; we just show the 100 largest counties (by population in the 2017 American Community Survey's five-year estimates).

Table A.10: (100 Most Populous) County-Level Measures of Wait Time and Disparities (3)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			Unadjusted		**Bayesian**	**Unadjusted**		**Bayesian**
County & State	**Population**	**N**	**Mean**	**Std Dev**	**Adjusted Mean**	**Disparity**	**Std Error**	**Adjusted Disparity**
SaltLake Utah	1,106,700	226	40.18	30.62	37.21	-15.85	85.33	-4.77
SanBernardino California	2,121,220	472	23.39	19.17	23.25	32.00	25.55	25.22
SanDiego California	3,283,665	1,086	19.22	16.79	19.21	23.32	10.77	22.25
SanFrancisco California	864,263	169	17.67	20.16	17.71	10.04	28.83	7.32
SanJoaquin California	724,153	172	16.75	15.40	16.81	27.33	15.04	25.00
SanMateo California	763,450	186	22.46	18.54	22.18	-17.39	45.89	-9.89
SantaClara California	1,911,226	534	17.89	16.58	17.89	-13.97	18.76	-12.37
Shelby Tennessee	937,847	319	14.83	14.95	14.92	1.24	2.65	1.23
StLouis Missouri	999,539	1,418	27.12	19.09	27.03	13.33	2.81	13.28
Suffolk Massachusetts	780,685	182	19.56	17.70	19.47	-3.33	4.98	-3.30
Suffolk NewYork	1,497,595	1,707	14.01	12.22	14.02	16.65	4.00	16.54
Tarrant Texas	1,983,675	708	14.34	13.51	14.38	3.86	4.44	3.82
Travis Texas	1,176,584	419	21.41	20.45	21.29	26.42	11.93	24.96
Tulsa Oklahoma	637,123	811	23.98	19.47	23.88	1.48	8.53	1.41
Ventura California	847,834	341	20.01	17.35	19.95	1.16	19.72	0.88
Wake NorthCarolina	1,023,811	720	24.40	19.21	24.29	14.55	6.45	14.30
Wayne Michigan	1,763,822	1,763	24.80	18.69	24.75	12.95	2.14	12.92
Westchester NewYork	975,321	25	10.84	6.59		168.62	52.87	
Will Illinois	687,727	638	13.23	10.48	13.26	7.03	5.00	6.96
Worcester Massachusetts	818,249	383	12.28	10.26	12.34	-0.89	8.09	-0.89

Notes: Columns 6-8 (*Disparity*) correspond to the coefficients on the interaction between a county fixed effect and the "Fraction Black" variable from the voter-level regression of wait time on the full set of county fixed effects and the interaction of those fixed effects with "Fraction Black", omitting the constant and clustering standard errors at the polling place level. Column 7 provides empirical-Bayes-adjusted estimates of these congressional-district-level disparities to account for measurement error. Similarly, Column 5 provides empirical-Bayes-adjusted estimates of the unadjusted congressional-district-level means shown in Column 3. Column 2 displays the population of each listed county; we just show the 100 largest counties (by population in the 2017 American Community Survey's five-year estimates).