Bipartisan Policy Center

The 2018 Voting Experience

POLLING PLACE LINES

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Introduction

The 118.5 million Americans who cast ballots in 2018 represented the largest number ever to vote in a midterm election.[1] Although the number of people voting by mail has been steadily increasing over the past two decades, 2018 also set a record for the number of votes cast in-person in a midterm election, 91.2 million. This was a 39% increase in the number of in-person ballots cast compared with the last midterm election in 2014.

The good news is that despite the surge in turnout in 2018, unacceptably long lines to vote were infrequent. Among in-person voters, only 6% reported waiting more than 30 minutes before they could cast a ballot.[2] The bad news is that the percentage of voters reportedly waiting more than 30 minutes to vote doubled since 2014, when it was only 3%. By drilling down into the data, it's clear that in some states, the surge in long wait times was especially dramatic. Furthermore, disparities persist in states where voters do experience long lines, with long wait times more likely to occur in precincts with high minority populations, high population density, and low incomes.

The U.S. voting experience is a constantly changing playing field. Voters cast ballots by mail, in person at early voting sites, and through apps available to members of the military. But most voters nationwide still go to polling places on Election Day. Whether they experience no line, a short line, or an indefensible line is the outcome of many policy decisions. These include resource availability and deployment, precinct size and location, ballot length, poll workers, and timing.

For those precincts with unacceptably long lines in 2018, local election administrators need to diagnose what went wrong to ensure that problems do not re-emerge in 2020, when it is likely that turnout will be greater than in 2016, the last presidential election. Even so, for the voters in jurisdictions with lines less than 30 minutes long, the findings in this report will help policymakers and administrators to improve the voting experience in 2020 and beyond.

SUMMARY OF FINDINGS

This report documents the results of a nationwide study that the Bipartisan Policy Center and the Massachusetts Institute of Technology conducted in 3,119 individual polling places across the country to measure wait times at the polls during the 2018 midterms. It provides the type of fine-grained analysis of voters' reality as they waited to cast ballots that survey data cannot replicate.

As BPC and MIT found in a previous study of wait times during the 2016 election, long wait times in 2018 were primarily an early morning phenomenon. For the average voter in this study, there were only 7.8 people in line when they arrived at the polls at any point during Election Day. However, if they arrived right when polls opened, they faced a line of 21.2 people. At the same time, 35.8% of line measurements taken at precincts in the study showed no one waiting in line to vote, despite 2018 being the highest-turnout midterm election in a century.

The Presidential Commission on Election Administration (PCEA) recommended[3] that no voter should wait more than 30 minutes to vote. The average wait time in this study was 8.9 minutes; 4.8% of precincts saw wait times that exceeded 30 minutes, while 1.5% exceeded an hour.

The 3,119 precincts in the study represented 2.7% of the estimated 116,000 Election Day polling places nationwide.[4] Over 2.4 million voters visited these polling places on Election Day, representing 3.3% of all Election Day voters. The precincts in the study came from 211 local jurisdictions that were located in 11 states plus Washington, D.C. Among these 211 jurisdictions, 21 experienced average wait times of greater than 30 minutes in at least one polling place.

30 MINUTES TO VOTE

Too often the patchwork of election policies across the country creates barriers to voter-centric reform. BPC focuses on researching, developing, and making policy recommendations on the voting process that improve the voting experience.

The 30-minute benchmark for acceptable in-person wait times to vote was articulated in the final report of the bipartisan PCEA and has become generally accepted as the maximum acceptable wait time for voters under normal circumstances.[5] If voters arrive at the polls at a fairly stable pace, election officials can plan for this traffic, using online tools such as those made available by the Caltech/MIT Voting Technology Project (VTP) to assign resources—poll books, poll workers, and voting booths/machines—to keep lines to a manageable level.[6]

BPC and MIT's research, both in 2016 and in 2018, reveals one important exception to the proviso of voters arriving "at a fairly stable pace." A significant number of voters line up at the polls long before they open, creating an instant backlog at many polling places the moment the polls open. However, as this research also shows, *in most cases* these lines resolve within the first couple of hours of the voting day.

Therefore, in almost every case, the dynamics of polling place lines are predictable and within acceptable bounds. When unacceptably long lines do occur, that is typically because the precinct did not have sufficient staff and equipment resources to clear out the opening backlog at a steady pace. Other reputed causes of unreasonably long lines—such as a bus arriving with scores of voters in the middle of the day or hundreds of voters arriving all at once after business hours—certainly occur, but are the exception, not the rule.

CAUSES OF LONG LINES

One-off circumstances, such as unanticipated service failures or an unexpected influx in arrivals within a short window, can cause long lines. The data indicate, however, that policy decisions in certain states cause or exacerbate many of the longest lines and have led to long lines for years. Academic studies have identified structural causes of long lines such as resource availability and deployment, precinct size and location, ballot length, poll workers, and timing.[7,8]

CONSEQUENCES OF LONG LINES

Why be concerned about long wait times to vote? After all, one could argue that long lines are a sign of great voter interest and democratic fervor. Certainly, pictures of long lines of voters in elections in developing democracies are evidence that citizens of those countries are responding enthusiastically to the transition from tyranny. Be that as it may, the United States is not a developing democracy. It has conducted mass elections for centuries. In the jurisdictions most prone to long lines, large urbanized cities and counties, local governments already have access to scientific management techniques to guard against inconveniencing voters unnecessarily.

Scholarly research has demonstrated the real costs of making voters wait in line to vote. For instance, responses to the 2016 Voting and Registration Supplement of the Current Population Survey suggest that over 560,000 eligible voters failed to cast a ballot because of problems related to polling place management, including long lines.

Long lines also exact monetary costs. Research conducted for the PCEA estimated that the wage equivalent of the time spent waiting to vote in 2012 was over half a billion dollars, which was also about one-fifth of the total budget of local election offices in 2012.[9]

Long lines also influence future elections. In a dissertation written at Harvard University in 2017, Stephen Pettigrew used sophisticated statistical techniques to estimate how many people failed to vote in 2014 because of long lines in 2012. The answer, nearly 200,000, speaks to the persistent effects of long lines in the minds of voters.[10]

The likelihood that voters will stand in a long line is not equally distributed across the voting population. Relying on answers to the 2018 Cooperative Congressional Election Study (CCES), for instance, these are characteristics of voters who wait longer than others:

- African American (11.5 minutes) and Hispanic (11.7 minutes) voters waited longer, on average, than white voters (8.8 minutes).
- Early in-person voters (12.2 minutes) waited longer than Election Day voters (7.8 minutes).
- Residents of the most densely populated neighborhoods waited 25% longer than residents of the least densely populated neighborhoods.[11]
- Voters in Georgia (18 minutes) waited 23 times longer than voters in Vermont (46 seconds).

These factors regularly appear in academic studies of wait times.[12,13] Below is a look at how these factors influence line lengths and wait times in the BPC/MIT study.

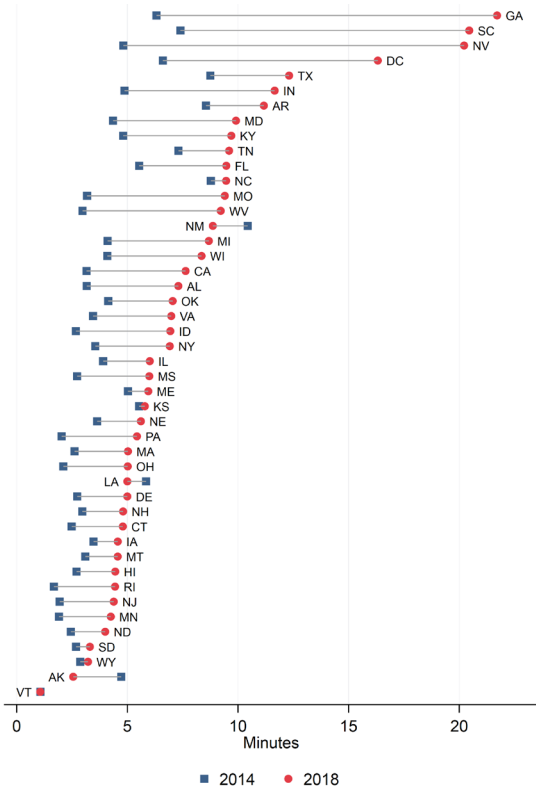
Still, based on two years of wait-time data from thousands of precincts across the country, it is clear that the typical voter experience doesn't involve waiting in a long line. Many of the one-off instances of lines in the study are a knock-on consequence—something went wrong in the polling place and was not resolved quickly. An example is equipment failure or a power outage. If an electronic poll book fails, the line can grow to extraordinary lengths in a matter of minutes if a replacement isn't available or if the failure is not resolvable locally with paper backup pollbooks. If replacements are unavailable or must be delivered from a warehouse across a large county, the line is likely to grow to the point that nothing can be done to ameliorate the problem until the polls close for the day.

Voting Lines in 2018: An Overview

Although the amount of time voters wait to cast a ballot is a major factor that determines the voter's overall opinion about the polling place experience, it is rare for jurisdictions to gather direct information about how long voters wait—this project is a major exception. And even the BPC/MIT Polling Place Line Study does not include participation from all states. Therefore, to gain insight into the typical experience of waiting to vote in 2018, researchers must rely on another source of data.

Luckily, for a decade the CCES has been asking voters how long they waited to vote, and the group did so again in 2018. Although answers to this survey question do not drill down to the precinct level like the BPC/MIT study does, it does sketch a broad portrait of waiting to vote in 2018 compared with wait times in past elections.

Figure 1: Average wait time to vote on Election Day, 2014 and 2018



Note: States omitted because fewer than 20% cast votes on Election Day: Arizona, Colorado, Oregon, Utah, and Washington
Source: CCES[17]

First, the BPC/MIT study examines average wait times. Looking only at respondents who voted in person on Election Day, the average reported wait time in 2018 was 8.7 minutes.[14] Keeping in mind the PCEA's 30-minute benchmark, 5.7% of Election Day voters reported waiting more than half an hour to vote.[15] These wait times were significantly greater than in 2014, the last midterm federal election, when 2.4% of Election Day voters waited more than half an hour and the average wait time was 4.5 minutes.[16] Figure 1 illustrates state averages in 2018 (red circles) compared with 2014 (blue squares).

Two things are notable about Figure 1. First, three states (Georgia, South Carolina, and Nevada) and the District of Columbia stand out compared with the other states in terms of how long voters waited to vote on Election Day. Georgia had a wait time of 21.7 minutes, or 2.5 times the national average.

Second, not only do the wait times of these three states and D.C. stand out compared

with other states in 2018, but the *change* from 2014 to 2018 also stands out. In 2014, 90% of the states—including Georgia, South Carolina, Nevada, and the District of Columbia—had an average wait time that ranged between 2.7 and 7.4 minutes. Thus, not only did these four states stand out in comparison with the other states in 2018, they stood out compared with the *change* in wait times from 2014 to 2018.

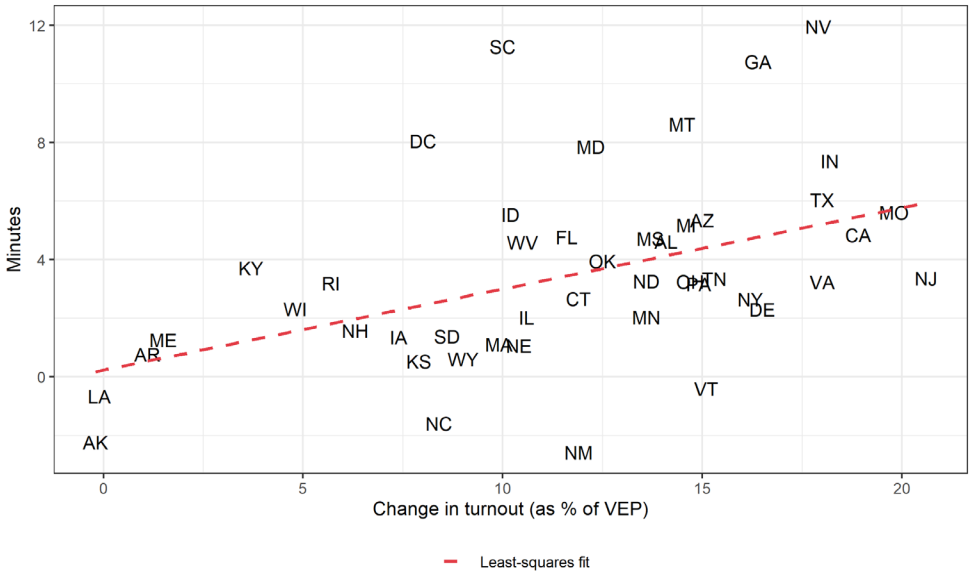
Why were wait times in 2018 double those of 2014? The most obvious answer is that turnout was greater in 2018—38% greater, when measured as a percentage of the voting-eligible population (VEP).[18] In fact, 2018 was the first time since 1912 that midterm turnout as a percentage of VEP was above 50%, which is closer to presidential election turnout levels.[19]

Because Little's Law, which is described below, explains that a main factor determining how long voters wait is the number of people who turn out to vote, it shouldn't be surprising that wait times were longer in 2018—especially if local officials did nothing else to affect wait times, such as change the number of check-in stations or speed up the check-in process.

Although the national turnout rate in 2018 was 38% greater in 2018 than in 2014, there was considerable variation across the states around this nationwide average. For instance, Utah saw an increase of 72%, while Alaska was essentially unchanged.

The reason why some states saw bigger turnout increases in 2018 than others is an important topic but not especially relevant for gaining an understanding of why wait times were longer in 2018 than in 2014. Whether turnout increased

Figure 2: Change in average wait time to vote on Election Day (2014 to 2018) plotted against change in voter turnout



Sources: CCES 2014 and 2018;[20] United States Election Project[21]

because of a more energized electorate, changes to voter registration laws, or interest in particular races, the more turnout increases, the more polling places feel pressure to accommodate the increase in voters.

If increased turnout is the reason why wait times in 2018 were greater than in 2014, then there should be a high correlation between the turnout change between 2014 and 2018 and the wait-time change. Figure 2 illustrates that there is a correlation, although it is not "high."[22] In the figure, the horizontal axis shows the change in turnout from 2014 to 2018, while the vertical axis shows the increase in wait times. The red line shows the best-fit line through the data points.[23]

On average, states that saw larger increases in turnout also experienced larger increases in Election Day wait times. Still, not all states with big turnout surges saw equally large increases in wait times. New Jersey and Virginia are examples of states that saw significant turnout increases but experienced relatively moderate increases in wait times.

The scatterplot in Figure 2 shows that dramatic turnout increases do not explain the large increases in wait times in Georgia, South Carolina, Nevada, and the District of Columbia. Several states with equally large turnout increases saw relatively minor increases in their wait times. It must be the case that the states that experienced big wait-time increases in 2018 pushed the resources at hand, mainly check-in locations and voting machines, to their capacity limits or beyond. These issues will be explored further below.

The BPC/MIT Polling Place Line Study

BPC and MIT joined together to create the BPC/MIT Polling Place Line Study. It is a program with a simple goal: to provide local election jurisdictions with actionable data about the lines that formed at their polling places, mostly on Election Day, but in some cases, during early voting. Academic projects conducted in the 2014 and 2016 elections informed the BPC/MIT program, but the study featured one important constraint: The method of collecting data had to be simple and easily implemented by poll workers. To that end, researchers developed a simple coding sheet and a set of instructions that helped poll workers record the number of people standing in line during every hour of the voting day.

All told, 211 local jurisdictions provided usable data for the program in 2018, ranging from Metz Township, MI, with 230 registered voters, to San Diego County, CA, with nearly 3 million registered voters.

The BPC/MIT Polling Place Line Study is extremely simple to implement; the designers were mindful of not adding too much extra time and effort to a poll worker's already busy job description. Researchers estimate the amount of time that a poll worker spent collecting line information was less than one minute at the top of each hour. Every hour, starting when the polling place opened, the poll worker simply had to count how many people were standing in the check-in line and record that single number on a handwritten sheet along with the number of poll books available at the time. Figure 3 shows a typical data-collection form.

Figure 3: Typical data-collection form

Line Length Data Collection Sheet
Bedford County, Virginia
November 6, 2018

Precinct: #104 Stewartsville Rescue Squad

Instructions. Please use this sheet to record the number of people standing in line to check in to vote *plus* the number checking in at the indicated times, along with the number of poll books available to accept voters to check in.

If there is no one standing in line at the indicated time *and* no one checking in, please enter a zero ("0").

If you are unable to record the line length at a particular time, enter an "X" in the corresponding space.

Time	Number in line†	Number of poll books
When polls open @ 6:00 a.m.*	9	2
7:00 a.m.	0	2
8:00 a.m.	2	2
9:00 a.m.	3	2
10:00 a.m.	0	2
11:00 a.m.	8	2
12:00 noon	4	2
1:00 p.m.	3	2
2:00 p.m.	0	2
3:00 p.m.	1	2
4:00 p.m.	2	2
5:00 p.m.	4	2
6:00 p.m.	3	2
7:00 p.m.	0	2

†Include the number checking in at that time.

At what time did the last voter check in to vote? 6:40pm

*If the polls opened at some time other than 6:00 a.m., indicate that time here: —

Source: BPC/MIT[24]

At the end of Election Day, the participating counties and municipalities collected all the sheets from their polling places and sent them to BPC or MIT. MIT then keyed in the data and produced an individualized report for each county. After Election Day, MIT gathered data about the number of voters who turned out in person at each of the polling places in the study. (This information was easy to gather from the reports issued by the local jurisdictions in the course of canvassing the election results.)

Each local jurisdiction received a report that contained at least two parts. The first was a spreadsheet of the data that poll workers had collected on the paper coding forms. The second part of the report calculated the average number of people in line, or line length, during the day; also, by using turnout information, the report calculated the average wait time to vote at each precinct in the jurisdiction. (See below for a discussion on how this calculation was performed.)

Figure 4 shows an example of this kind of report. Election Day turnout was based on official reports published by the local jurisdictions that researchers used to calculate the arrivals-per-minute simply by dividing Election Day turnout by the number of minutes the polls were open during the day. Then, we calculated average line length directly from the observational data provided by the participating jurisdictions. The average wait-time calculations for each precinct used Little's Law, described in greater detail below.

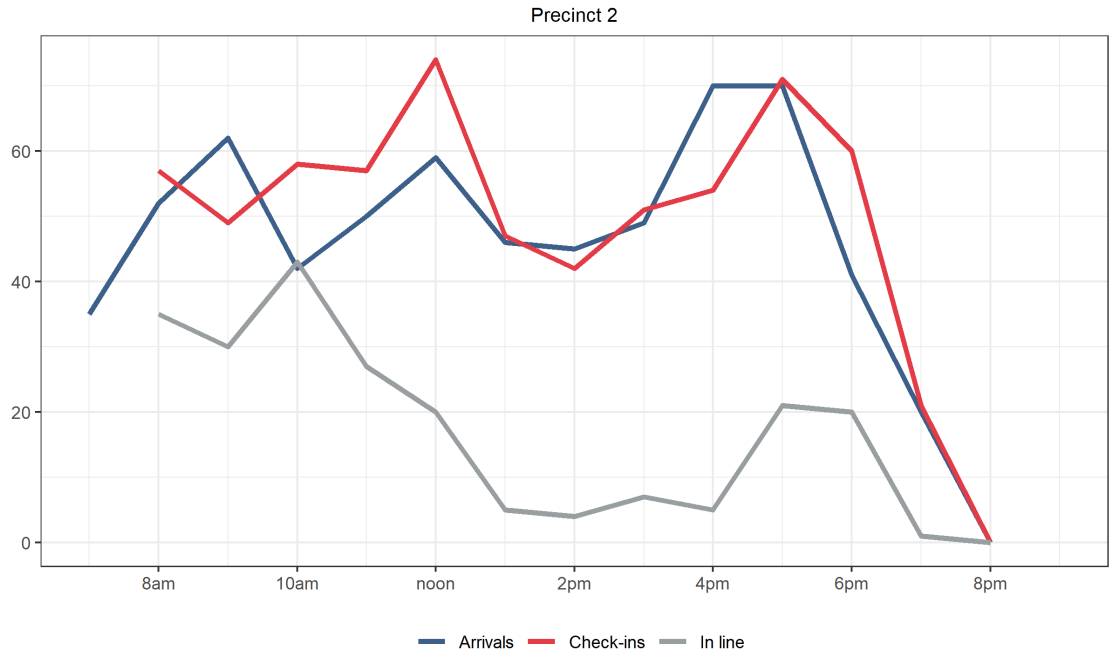
Figure 4: Example precinct wait-time report (excerpt)

Precinct	Election Day turnout	Avg. line length	Arrivals per minute	Avg. wait time	Time last voter checked in	# of data entries
1001 Goldsboro Fire Hall	592	2.6	0.8	3.4	7:50 PM	14
2001 Greensboro VFC Community Hall	1377	0.7	1.8	0.4	7:55 PM	12
3001 Denton Fire Hall	1395	1.6	1.8	0.9	7:55 PM	14
4001 Preston Fire Hall	1249	5.7	1.6	3.6	8:00 PM	14
5001 Federalsburg Fire Hall	1071	2.2	1.4	1.6	7:50 PM	14
7001 Ridgely Fire Hall	1081	1.1	1.4	0.8	7:55 PM	14
8001 Colonel Richardson High School	618	0.8	0.8	1.0	7:58 PM	13

Source: BPC/MIT[25]

Counties that were able to provide hourly data about voter check-ins from their e-poll-book systems received an additional report. This report calculated how many voters had arrived at the polling place each hour. The details of the report each jurisdiction received is illustrated by the graph in Figure 5, which displays the data provided by the county for one particular precinct, includes the line length at the start of each hour (the solid gray line), the number of check-ins each hour (the red line), and when the voters arrived (the blue line).

Figure 5: Typical graph showing hourly precinct arrivals, check-ins, and number of voters waiting in line



Source: BPC/MIT[26]

The Science Behind the BPC/MIT Polling Place Line Study

The foundation of the BPC/MIT Polling Place Line Study is queuing theory, a field of management science and operations research that characterizes how long it takes to provide services to customers—be they grocery store patrons, medical office patrons, or cars exiting a parking lot—in terms of three major factors: (1) the arrival patterns of customers, (2) how long it takes to serve customers, and (3) how many stations, such as check-out stands, customers can be served at. Although there are limitations in drawing analogies between voters and customers, in the case of managing polling places, the analogy is very apt.

A full description of the science behind the program can be found in *Managing Polling Place Resources*, published by the VTP in 2015.[27]

A core concept in queuing theory is Little's Law, which states that in a stable system,[28] the long-term number of people waiting in line is equal to the long-term arrival rate multiplied by the average time a customer spends in the system. Using a little algebra, if one knows the arrival rate at a polling place and the average number of people in the check-in line to vote, one can then calculate the average wait time at a polling place with the following equation:

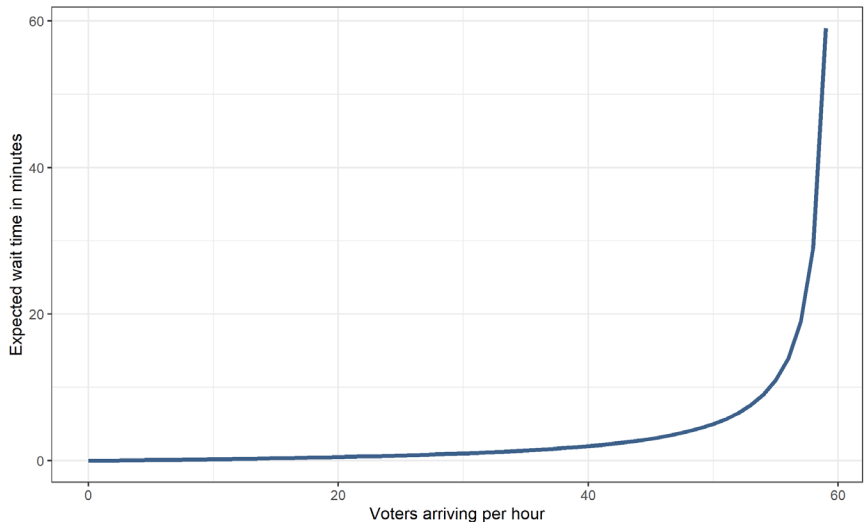
$$\textit{Average wait time} = \frac{\textit{Average line length}}{\textit{Arrival rate}}$$

The jurisdictions involved in the BPC/MIT Polling Place Line Study provided the number of people who voted on Election Day at each of the precincts in the study. Using the information from the data-collection forms already discussed, the average line length was calculated using the Little's Law formula.

There are other methods to calculate average wait times. In particular, if one knows the number of check-in stations in a polling place, how long it takes to check in a voter, and the arrival rate of voters, it is possible to estimate the average wait time to check-in. The VTP polling place toolkit website contains a spreadsheet that election officials can use to make this calculation and see whether they have enough resources in polling places to keep wait times to reasonable lengths.[29]

Using calculations from this spreadsheet, one can demonstrate how wait times fluctuate from election to election as the turnout level fluctuates. Consider a typical polling place with one check-in station that that is open for a 12-hour voting day and that can check in a voter in one minute, on average. Figure 6 graphs how average wait times change as the hourly arrival rate varied from zero to 60 voters per hour.

Figure 6: Example of how wait times to vote vary as the number of voters arriving per hour varies



The primary insight in this example is that there is virtually no wait to vote across all values of arrival rates, but when the arrival rate reaches a critical point, the expected wait time increases exponentially. With 40 voters per hour, the average wait time is only two minutes; at 50 voters, it is five minutes; at 55 voters, the wait time is 11 minutes; and at 59 voters per hour, the wait time is almost an hour.

The sharp inflection of the graph at around 55 voters is sometimes called the "elbow of death," as the arrival rate approaches the polling place's "utilization limit" of 60 voter check-ins per hour.[30]

The example shown in Figure 6 is relevant to understand why some states—or precincts—can see big increases in turnout and yet not see wait times increase, while others can see similar turnout increases and see wait times explode. If a precinct's arrival rate was previously far from its utilization limit, it can more easily absorb an increase in turnout than a precinct that was previously close to its limit.

In this example, a precinct (Precinct A) that had previously had an arrival rate of 30 voters per hour, far from the utilization limit, and then experienced an increase in the arrival rate to 42 voters per hour would see its average wait time

increase from one minute to 2.3 minutes. Another precinct (Precinct B) that had previously had an arrival rate of 45 voters per hour, much closer to the utilization limit, would see its wait time increase from three to 19 minutes if it experienced the identical arrival-rate increase of 12 voters per hour. Furthermore, 21% of voters would wait more than 30 minutes in Precinct B; 5% would wait more than an hour. (Practically no one would wait more than 30 minutes to vote in Precinct A, even at an arrival rate of 42 voters per hour.)

The states and local jurisdictions that saw the biggest increases in wait times in 2018, such as Georgia, South Carolina, Nevada, and D.C., probably were near their own local utilization limits in 2014, and thus near the elbow of death. With a dramatic increase in turnout, but without an adequate increase in resources, such as voting machines and poll books, wait times exploded. The other states that saw similar turnout increases in 2018 but experienced minor wait-time increases, such as Virginia and New Jersey, probably had few precincts near the elbow in 2014, resulting in greater polling place resilience when the surge hit in 2018.[31]

It is significant that most of the states with the biggest increases in wait times rely heavily on electronic voting machines, both direct-recording electronic machines and ballot-marking devices, and thus cannot easily or inexpensively expand polling place capacity whenever turnout surges. Therefore, it seems especially important for states with electronic machines to assess their resource needs well in advance of elections that might see big turnout surges.

The Results of the BPC/MIT Polling Place Line Study in 2018

Clearly, there are a variety of ways to manage long Election Day lines. To take a narrower focus, it's valuable to examine the results of the BPC/MIT Polling Place Line Study, to look at who participated, and to learn generally from the data gathered.

BPC put out a nationwide call, asking for local jurisdictions to participate in the program in 2018. BPC made every effort to encourage jurisdictions of all types from across the country to participate. Still, this was a voluntary program, so the jurisdictions were not chosen randomly.

Nonetheless, the demographic characteristics of the precincts included in this study closely correspond to nationwide demographics. This correspondence can be tested using data from the political data firm Catalist, a company that provides voter file information to campaigns.

As Table 1 shows, the demographic (and other) characteristics of the participating jurisdictions are very similar to the characteristics of local jurisdictions nationwide. The sample of jurisdictions has slightly greater African American populations, more college graduates, and more renters than nationwide. This probably reflects the fact that a few very large urbanized jurisdictions were part of the program, whereas the smallest and most rural jurisdictions primarily came from three states—Connecticut, Michigan, and Virginia—that had statewide participation programs. Later in this report, it will be shown that precincts with large minority populations tend to have longer wait times than precincts that are nearly all white. Thus, this report's estimates of average wait times may slightly overestimate the true national average. Because the oversampling of predominantly African American precincts is slight, it is likely that the overestimate of national wait times is also slight.

Table 1

Demographics vs. Catalist Data

	Sample	Nationwide
White	75.4%	77.4%
Black	11.8%	10.2%
Hispanic	6.9%	7.6%
Other race	6.0%	4.8%
Over 65	24.8%	25.3%
College graduates	38.9%	32.1%
Living in poverty	10.5%	11.8%
Renters	10.6%	7.6%

WHO PARTICIPATED IN THE PROGRAM?

The BPC/MIT Polling Place Line Study in 2018 included 219 local jurisdictions, of which 211 produced Election Day line data that was usable for this report.

Appendix A lists the 211 jurisdictions that provided usable polling place line data in 2018.

These jurisdictions covered a broad swath of the United States. By the numbers:

- 11 states, plus the District of Columbia
- 18.0 million registered voters[32]
- 10.5 million votes cast, or 9% of nationwide turnout
- 3,119 precincts

All told, the jurisdictions provided more than 41,000 hourly records of line-length data. Coupled with the 2016 effort, this represents the largest, most broad-based observational study ever conducted of wait times in polling places.

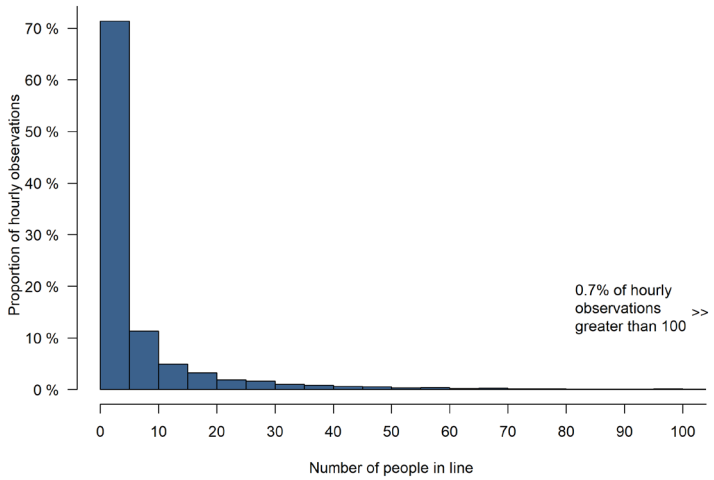
FINDINGS

There are six main empirical findings that are important to emphasize.

1. **The average number of people in line at any given time was 7.8. However, this average masks an important detail: Most lines were very short, but a few were very long.**

The graph in Figure 7 shows the distribution of the number of people standing in line each hour for the precincts included in the study. The average line length was 7.8 people. However, a small number of precincts that experienced incredibly long lines strongly influences this average. Compare the average with the median number of people in line, which is just two. In other words, half of the hourly line counts were longer than two people and half were shorter. Finally, the modal (that is, the most common) number of people in line at any hourly observation was zero. Overall, just over one-third (35%) of all the recordings in the data had nobody in line at all.

Figure 7: Distribution of all 41,264 observed hourly line lengths across 3,119 voting locations in the 2018 election

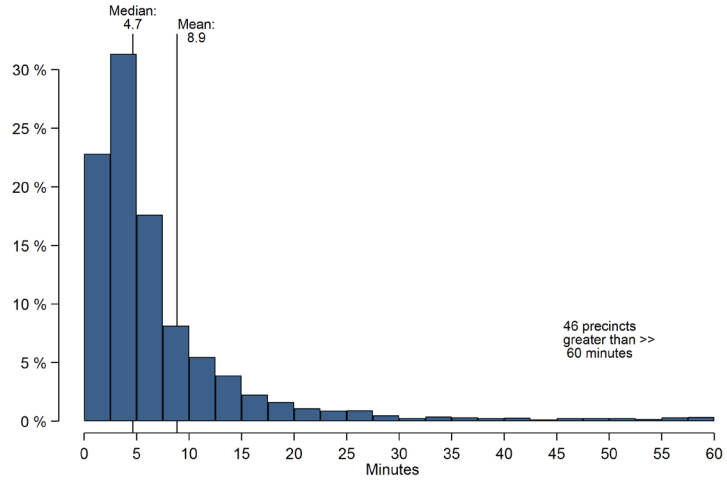


Source: BPC/MIT[33]

A major challenge of running an election is not about understanding how long lines will be *on average*. Instead, election officials must account for how long the line will be *at its worst*. Another way of exploring the line-length data is to ask how long the *longest* line was for each precinct in the sample. For 70% of precincts, there were 10 or more people in line at least once during the day. Put another way, 30% of precincts *never* had more than 10 people in line throughout the entire time they were open.[34] Only 13% experienced a line of 50 or more during the day. Finally, just one in 30 precincts (3.3%) had more than 100 people standing in line to vote at least once during the day.

2. **The average wait time for precincts in the study was 8.9 minutes. The small number of precincts with very long average wait times also influenced this result. In addition, only a small proportion of precincts had average wait times of greater than 30 minutes.**

Figure 8: Average wait times in 3,119 polling places



Source: BPC/MIT[35]

In all, there was enough data to calculate the average hourly wait time in 97.6% of the precincts in the study (3,043 out of 3,119). Figure 8 shows the estimated average wait time for voters in these polling places. In most areas, lines were typically very short. The mean wait time across these precincts was 8.9 minutes; the median was just 4.7 minutes. Just over three-quarters (78.7%) of precincts had an average wait time of less than 10 minutes. These findings are largely consistent with survey-based estimates of average wait times from the 2018 election, which found that 76% of voters waited less than 10 minutes to vote.

However, some areas had much longer wait times. At the high end, one out of 20 (4.8%) precincts had average wait times that were longer than 30 minutes.

3. **Average wait times are longer in precincts with a high percentage of minority voters, more renters, and lower incomes.**

One of the most important policy questions in recent years has been about the relationship between polling place wait times and demographic factors, particularly race. Until very recently, the statistical correlation between the race of a voter and the waiting time to vote has been based on public-opinion studies. These studies have regularly found that African American and Hispanic voters wait longer to vote than whites.

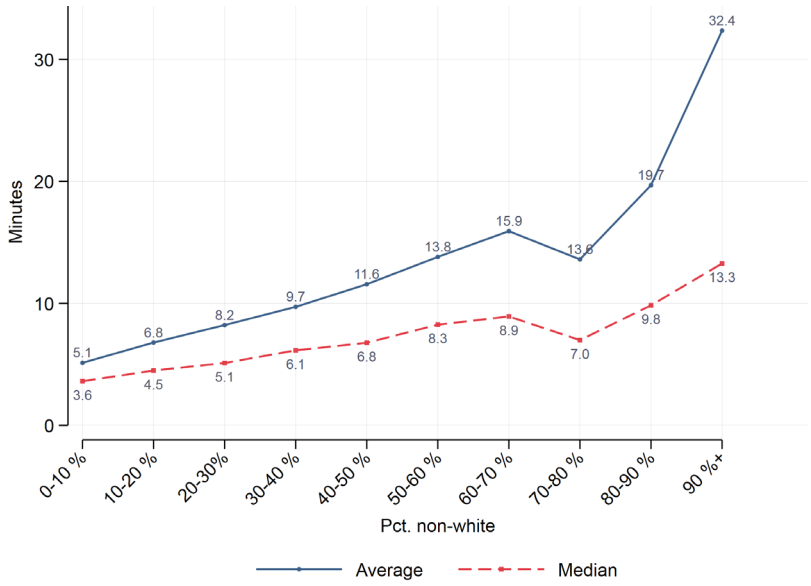
The findings in the BPC/MIT report are consistent with public-opinion-based studies.

Public-opinion surveys are valuable for exploring the perceptions voters have formed about their voting experience and for characterizing those experiences nationwide. One limitation of public-opinion surveys is that they rely on voters' memories, which can become clouded over time and influenced by what they hear others report. An advantage of direct-observation studies, such as this one, is that they directly measure wait times and don't depend on the recall of voters.

This study, therefore, provides a good opportunity to verify public-opinion studies that have previously correlated demographic factors with wait times. BPC and MIT have been able to match most of the precincts from the study with demographic data obtained from Catalist. Using this matched data, we can see whether demographic characteristics of polling places are correlated with wait times without public-opinion surveys.

First, precincts with a higher proportion of minority voters tend to have longer wait times than precincts that are predominantly white. Figure 9 illustrates this finding; it graphs the average wait time as a function of the percentage of registered voters in a precinct who are non-white.

Figure 9: Average wait times as a function of percent that is non-white



Source: BPC/MIT[36]

Consistent with past studies, the more voters in a precinct who are non-white, the longer the wait times. In precincts with 10% or less non-white voters, the average wait time was 5.1 minutes, the median was 3.6. In precincts with 90% or more non-white voters, the average and median climb to 32.4 and 13.3 minutes, respectively.

Two patterns are particularly important to notice in Figure 9. First, the mean and median are fairly close to each other in precincts with low non-white populations, and then they diverge significantly in precincts with high non-white populations.

Because outliers strongly influence averages, this divergence between the mean and median wait times indicates that in predominantly minority precincts, there are a few precincts with exceptionally long wait times that are pulling up the average. This is not to dismiss problems experienced in precincts with greater than 80% minority populations. But it is to suggest that the few precincts that have extraordinarily long lines are disproportionately in minority communities.

The second pattern is related to the first. The average and median wait times march upward in a fairly linear fashion in the range of 0% to 70% minority population, then the average begins to grow exponentially. This underscores that the mismatch between resources and voting demand is especially great in precincts with a large fraction of minority voters.

Another demographic of interest is the percentage of the population who are renters. A large rental population implies an area with a great deal of population turnover. With high population turnover, two factors might

increase wait times: (1) new voters, whose inexperience with the process may slow down check-in and voting times; and (2) highly mobile voters who may find themselves in the wrong precinct on Election Day and thus casting provisional ballots, another process that can slow down lines.

Precincts in areas with more renters, in fact, experience longer wait times, as illustrated by Figure 10. The relationship is not as dramatic as that seen with race, but the pattern occurs, nonetheless. In precincts where fewer than 10% of residents are renters, the mean wait time was 7.9 minutes and the median was 4.4 minutes. In the few precincts where the rental rate exceeded 60%, the average grew to 16.6 minutes, with the median at 8.1 minutes. Finally, as discussed above,

Figure 10: Average wait times as a function of percent who are renters

Source: BPC/MIT[37]

the fact that the mean and median are fairly close in low-rental areas suggests that there are many fewer precincts with exceptionally high wait times. This is in contrast to the high-rental areas, where the mean and median are quite far apart.

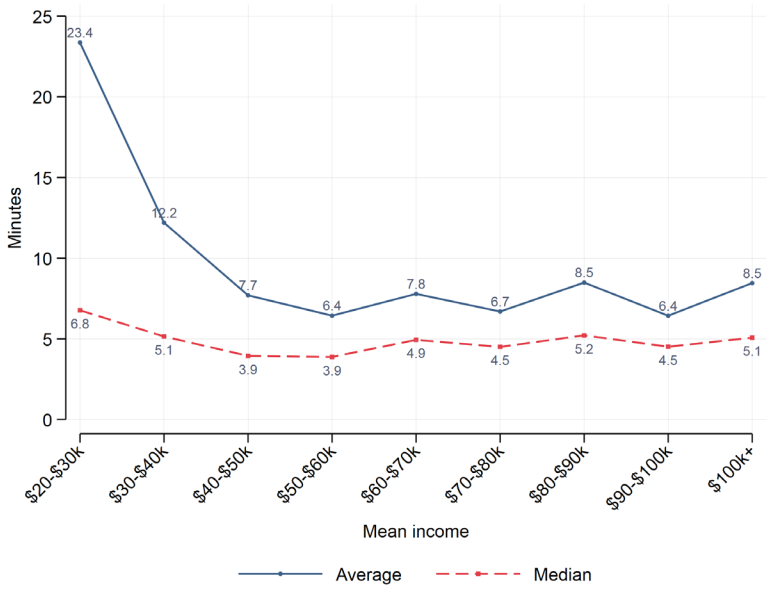
A final demographic factor of wait times is income. Income is correlated with a number of factors that might cause long lines. One is political clout; election officials representing jurisdictions with higher average incomes may be more successful in agitating for extra resources if wait times creep up.[38]

As Figure 11 shows, the correlation between a precinct's income and wait times is largely determined by especially long wait times in the lowest-income areas. Considered together, the average wait time in precincts with an average income of less than $40,000 is 15.4 minutes, compared with 7.7 minutes in other precincts. Beyond average incomes of $40,000, average wait times are relatively flat, fluctuating randomly.

Interestingly enough, the median wait time, 4.7 minutes, is essentially constant for all levels of average income. This means that low-income precincts are much more likely to experience exceptionally long lines than middle- and upper-income precincts. For instance, 3.4% of the precincts with average incomes of less than $40,000 had average wait times of greater than 30 minutes. This contrasts with 0.7% of precincts with higher average incomes. In other words, precincts in areas with average incomes of less than $40,000 were four times more likely to experience wait times of greater than 30 minutes than precincts in areas with incomes above that.

Of course, the three demographic factors discussed here are all correlate with each other. Precincts with high minority populations tend to have lower average

Figure 11: Average wait times as a function of average income



Source: BPC/MIT[39]

incomes and more renters. Which factor has the most statistical power in explaining average wait times?

The answer is race. A simple statistical model provides the answer; Appendix B reports its results. In summary, it is the case that race and the percentage of renters individually show statistically significant influences on average wait times. However, once researchers explore all three demographics simultaneously, the only factor that retains explanatory power is race.[40] The analysis suggests that the difference in wait times between a precinct that is 100% non-white and one that is 100% white is 20 minutes.

This effect is quite large, but consistent with other studies. Unfortunately, we did not design this study to explore the causes of wait times beyond easily measured factors such as demographics and arrival rates. The small amount

of research that has probed this question suggests that longer lines in minority-dominated precincts are primarily due to local differences in political influence, which result in minority precincts being less well-supported on Election Day.[41,42,43,44]

4. The longest lines tended to occur in the morning, right after the polls opened.

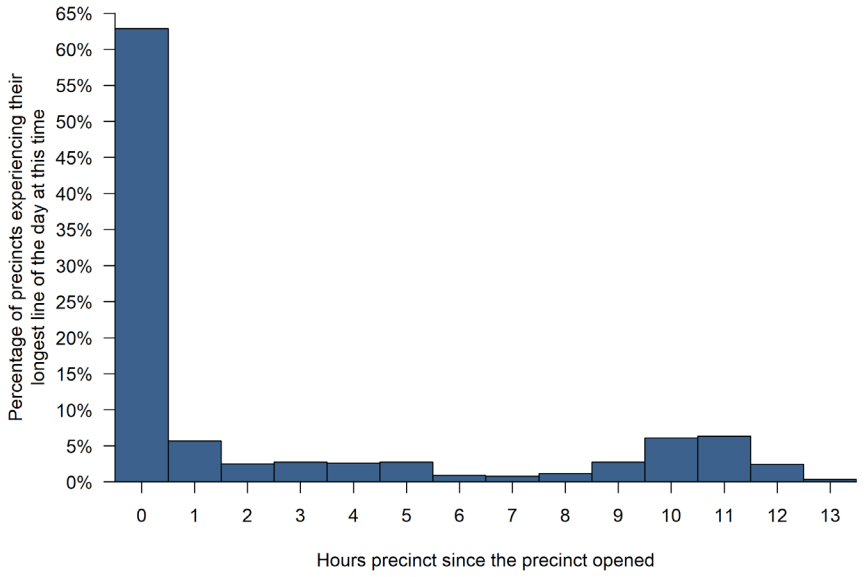
When Americans vote on Election Day, they tend to vote in the morning. According to the 2014 Survey of the Performance of American Elections, the last time the survey was conducted during a midterm election, 22% of Election Day voters had cast a vote by 9 a.m. and 48% had voted by noon. The statistics for 2016 were very similar—24% and 56%, respectively.

Across all the precincts reflected in this study, the longest lines tended to be present the moment the polls opened, which was due to the large number of voters who lined up early. Lines during the first couple of hours of voting remained long even in the best of circumstances because the large number of voters who arrived before work hours encountered the backlog of voters caused by the opening queue.

Figure 5 above provides an example of this pattern; it showed the arrival, check-in, and line-length dynamics of a representative precinct. In that example, 35 people were waiting in line to vote when the precinct opened at 8 a.m. Between 8 and 9 a.m., another 52 people arrived. Because the poll workers were able to check in 57 people during that first hour, the line shrank from 35 at 8 a.m. to 30 at 9 a.m. In the first couple of hours of voting, poll workers were unable to clear the backlog of voters created by the line of voters already in place when the polls opened. It was only late in the day, when hourly arrivals eased up a bit, that the line began to steadily drop. (It also helped that for the 11 a.m.-to-noon hour, the number of voters that poll workers were able to check in surged by about 50% for that one hour, allowing more of the line to clear.)

To highlight the more general point, the graph in Figure 12 presents the hour in which each precinct in the study reported its longest line on Election Day. To account for different precinct opening times in different jurisdictions, the x-axis of the graph displays the number of hours since the precinct opened. (For instance, if the polls opened at 7 a.m. and the longest line appeared at that time, the results for the opening hour are reported for Hour 0. If the longest line occurred at 8 a.m., the line is reported as occurring at Hour 1.) The y-axis shows the proportion of precincts that experienced their longest lines at this time.

Figure 12: When did precincts experience the longest line of the day?



Source: BPC/MIT[45]

The overwhelming majority of Election Day precincts, 63%, had their longest lines when the doors opened. An additional 6% had their longest lines during the first hour of voting. In other words, 69% of Election Day precincts had their longest lines within the first hour of voting, with the lines declining after that.

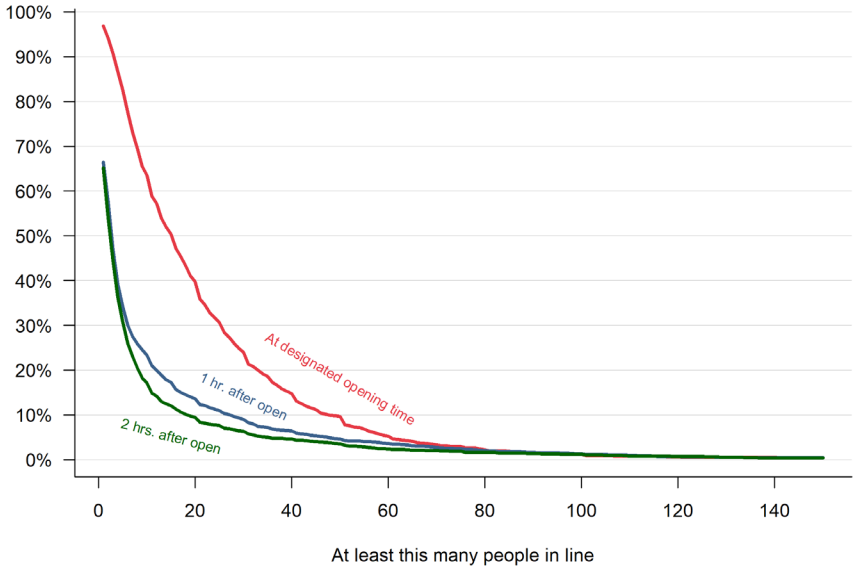
In 2018, there was a notable surge in longest lines around the period between nine and 12 hours after poll openings. (This surge did not occur in 2016.) This time generally corresponds with the late-afternoon/end-of-work-day period. (For example, if polls open at 6 a.m., then the period between nine and 12 hours later would be from 3 p.m. to 6 p.m.) Overall, 17.5% of precincts experienced their longest lines at this time. This is in contrast with 2016, when the corresponding figure was approximately 1%.

This difference could be a result of the sample of precincts being slightly different in 2018 than in 2016. While this is a real possibility, it is more likely that midterm voters (such as in 2018) tend to be different from on-year voters (such as 2016).

5. **Although lines tend to be the longest at the beginning of the day, they dissipate quickly in most precincts.**

Although lines tend to be the longest at the beginning of the day, most precincts managed to reduce the length of their lines quickly. Figure 13 shows the percentage of the Election Day precincts in which the line at Hour 0, Hour 1, or Hour 2 was of a certain length. The percentage of precincts with any given line length decreased with each passing hour. For example, 7.5% of precincts had more than 50 people in line when they opened, but within one hour, that number had dropped to 4.3%, falling to 3.2% within two hours. Similarly, while

Figure 13: Percentage of precincts with at least a certain number of people in line early in the day



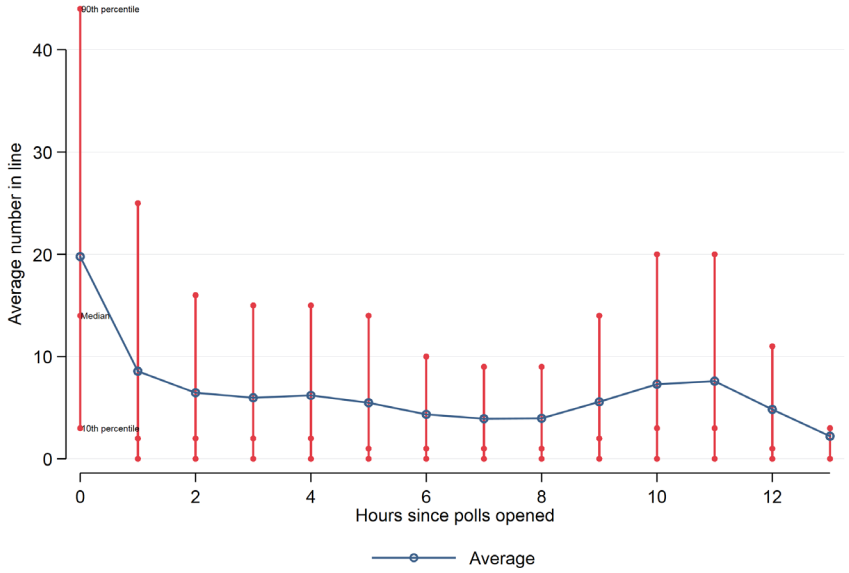
Source: BPC/MIT[46]

only about 34.6% of precincts had fewer than 10 people in line at the beginning, 82.8% had lines of fewer than 10 people within two hours.

Comparing these results with the BPC/MIT report from 2016, there are two important patterns. First, the length of lines when the polls opened was not appreciably shorter in 2018 than in 2016. Second, these opening lines dissipated much more quickly in 2018, which was a major reason overall wait times in 2018 remained less than in 2016.

Given the results reported thus far, it should not be surprising that average lines on Election Day tended to drop as the day progressed. Figure 14, which displays a graph of average line lengths for each hour of the day, illustrates this. In addition, Figure 14 shows the hourly median and the 10th and 90th percentiles. As before, the chart accounts for the fact that polls open at different times by calling the opening hour "Hour 0," the end of the first hour "Hour 1," etc. (For instance, in a state where the polls open at 7 a.m., Hour 0 is 7 a.m., Hour 1 is 8 a.m., etc.)

Figure 14: Average number of people in line each hour after polls open



Source: BPC/MIT[47]

Consistent with the data reported above, the average precinct saw 20 people in line when the doors opened on Election Day 2018. By the end of the first hour, that number had been more than cut in half, to 8.6. Even though there was a small surge toward the end of the day, the average in any hour was never as great as it was in the first hour of voting.

The data plotted in Figure 14 that show the variability of line lengths each hour help to round out the picture. Note that the median and mean at opening time are relatively close (median = 14 and mean = 20), which indicates that line lengths across precincts in the study occurred fairly symmetrically. Even by the end of the first hour, the median (2) is quite far from the mean (8.6). Also note that the 90th percentile value at the end of the first hour (25) is far above the mean. This pattern holds from Hours 1 to 13. Statistically, this shows that a small number of outlier precincts with exceptionally long lines heavily influence the average line length after the first hour. The typical precinct has only a handful of people waiting to check in—the median is no more than three people in line after the opening. Finally, it is notable that the variance of line lengths increases dramatically between Hours 9 and 11. Again, because the mean and median are not affected much, this shows that extraordinarily long lines to vote in the hours after work are rare, even if they are troubling.

6. **If a precinct clears its morning line quickly, it is unlikely to experience long wait times for the rest of the day. If the morning line persists, long wait times are likely to occur for the entire day.**

There is a crush of morning voting on Election Day. The BPC/MIT Polling Place Line Study shows the importance of clearing that morning line. A high volume of voters at the start of the day—both those waiting when the polls open and those coming soon after they open—will lead to lines at most precincts. However, most of those precincts showed the ability to clear those lines within the first couple of hours of voting, never to experience them again for the rest of the day. Conversely, the precincts that could not clear their morning lines after a couple of hours were highly likely to see long lines and long wait times until they closed their doors, often hours after the official polling place closing time.

Do long lines early in the day make a precinct more likely to be burdened by long lines after 5 p.m.? Does having a long line right now mean that a precinct is likely to have one in two or six hours?

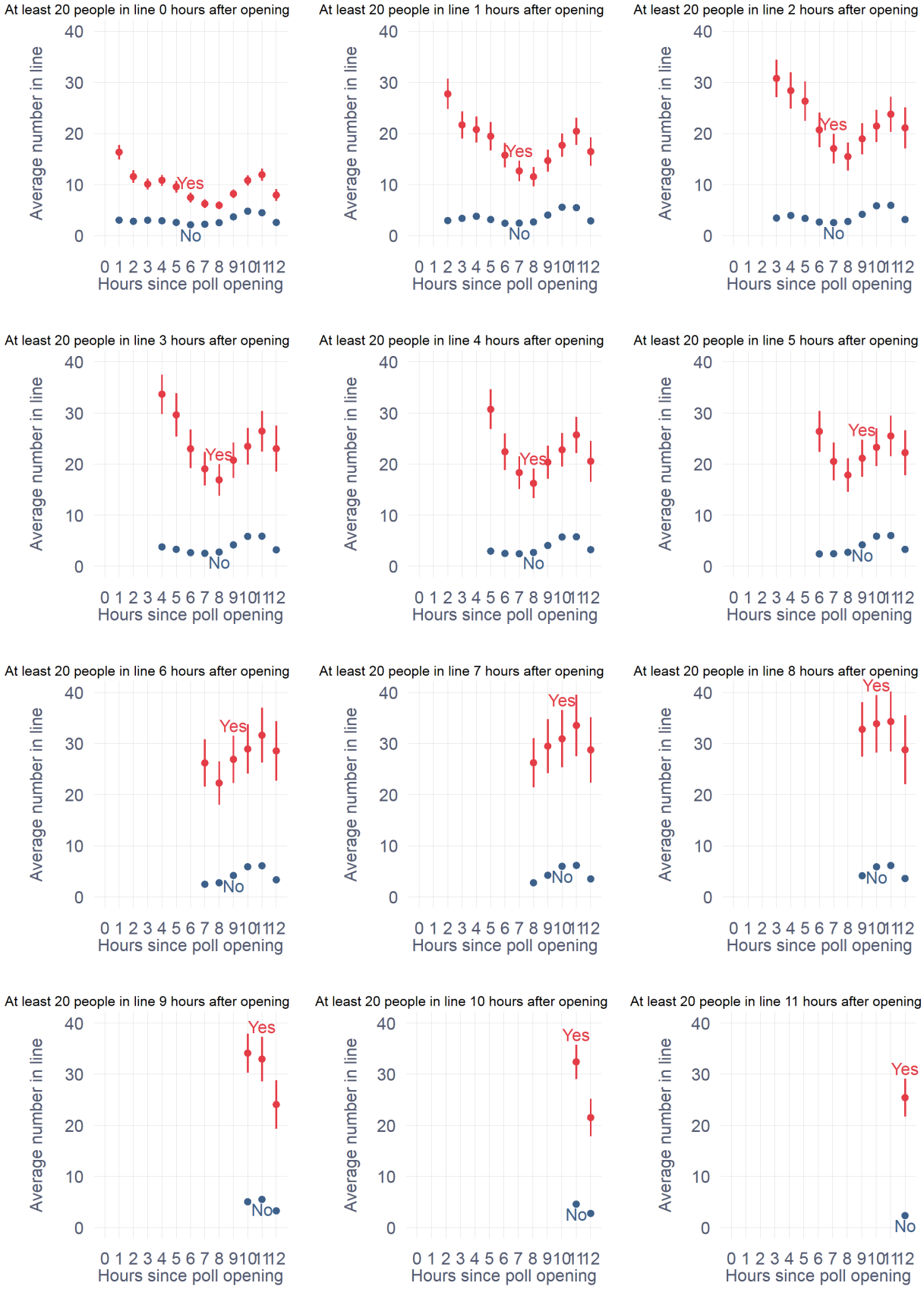
Overall, the data suggest that the answers to these questions are no to the first and yes to the second. While precincts that have long lines right when the polls open are slightly more likely to have long lines later in the day, most precincts with long lines at the opening see those lines recede fairly quickly. However, as the day progresses, if a precinct has a long line later in the morning or in the afternoon, it is unlikely the lines will shorten appreciably until closing time.

The graphs in Figure 15 illustrate these points. This figure has 12 graphs. Each graph shows the average number of people in line later in the day, broken down by whether there were 20 or more people in line at that hour or less than 20 people in line. For instance, the very first graph charts the average number of people in line each hour for the rest of the day, for precincts that had 20 or more people in line when the polls opened ("Yes") and for precincts that had fewer than 20 in line ("No"). In these precincts, if there were at least 20 people in line when the polls were open, there are an average of 16.4 in line at the end of Hour 1, 11.6 in line at the end of Hour 2, etc. In contrast, if there were fewer than 20 people in line when the polls opened, there was an average of 3.1 and 2.8 in line at the end of Hours 1 and 2, respectively.

Scanning across all the graphs, notice that the circles in red climb from one graph to the next. This shows that as the day progresses, having 20 or more people in line at any moment portends longer and longer lines down the road. For instance, in precincts that have more than 20 people in line when the polls open, the average line length at the end of Hour 4 is 10.8 people. However, in precincts that have more than 20 people in line at the end of Hour 1, the average number of people in line at the end of Hour 4 rises to 20.8. If there are still more than 20 people in line at the end of Hour 2, the average number in line at the end of Hour 4 rises again to 28.4.

This shows how precincts very quickly diverge in the morning according to two paths: those that can get the lines under control within an hour or two and those that cannot.

Figure 15: How the number in line now predicts the number in line the rest of the day



Source: BPC/MIT[48]

Conclusion

After two national iterations of the BPC/MIT Polling Place Line Study, it's clear that long lines most fundamentally form when there is a misallocation of resources necessary to handle the service requirement of a polling place. In other words, there aren't enough poll books, voting booths, ballots, or machines to handle the crowd.

What's more:

1. Lines at polling places can be studied—and brought under control—by using approaches and tools that businesses have been employing for decades.
2. To effectively manage polling places and reduce lines, election officials must collect information about the number of people in line on a regular basis at every polling place in their jurisdiction.
3. Best-practice management techniques and policies that encourage a smooth flow of voters in polling places can reduce long lines.
4. Long lines are not the norm for most voters, but at a substantial fraction of polling places, voters wait longer than the 30-minute maximum, and at a smaller but still troubling group of polling places, lines can stretch for over one hour.
5. Whether it's issues that are unique to a polling place or more general problems relating to chronic capacity shortages, both can cause long lines.
6. Lines are longest on the morning of Election Day.
7. Longer lines are correlated with precincts unable to handle early morning lines and precincts that are more urban, denser, and have higher minority populations.

Want to Know More?

The principles behind the BPC/MIT Polling Place Line Study have been a core part of management science for decades. The following is a brief list of resources that may be especially helpful to election administrators.

- Alexander S. Belenky and Richard C. Larson, "To Queue or Not to Queue?" *OR/MS Today*, 2006. Available at: http://www.orms-today.org/orms-6-06/queues.html. (Brief, accessible introduction to queuing theory as applied to elections.)
- Caltech/MIT Voting Technology Project, "VTP Toolkit." Available at: http://web.mit.edu/vtp/. (Collection of online tools that help with allocating resources and minimizing polling place lines.)
- Charles Stewart III, "Managing Polling Place Resources," *Caltech/MIT Voting Technology Project Report*, 2015. Available at: http://web.mit.edu/vtp/Managing%20Polling%20Place%20Resources.pdf. (Comprehensive report on polling place lines and how to manage and study them.)
- Richard C. Larson and Amedeo R. Odoni, *Urban Operations Research* (Upper Saddle River, NJ: Prentice-Hall, 1981). Available at: http://web.mit.edu/urban_or_book/www/book/. (Chapter 4 provides a straightforward introduction to queuing theory.)

A small-but-growing academic literature has emerged based on public-opinion research and direct observation that address the issues in this report. Below is a brief list of peer-revised articles that dive more deeply into the issues addressed in this report:

- Michael C. Herron and Daniel A. Smith, "Precinct Resources and Voter Wait Times," *Electoral Studies*, 42: 249-263, 2016. Available at: https://doi.org/10.1016/j.electstud.2016.02.014. (Observational study of Hanover, N.H., in 2014 combined with computer simulations to understand the relationship between polling place resources and wait times.)
- Stephen Pettigrew, "The Racial Gap in Wait Times: Why Minority Precincts Are Underserved by Local Election Officials," *Political Science Quarterly*, 132(2): 527-547, 2017. Available at: https://www.stephenpettigrew.com/articles/pettigrew-2017-psq.pdf (Most comprehensive analysis of the influence of race on wait times, based on a large academic survey research study in 2006, 2008, 2012, and 2014.)

- Robert M. Stein, Christopher Mann, Charles Stewart III, et al., "Waiting to Vote in the 2016 Presidential Election: Evidence from a Multi-County Study," *Political Research Quarterly*, March 28, 2019. Available at: https://journals.sagepub.com/doi/abs/10.1177/1065912919832374#articleCitationDownloadContainer. (Largest-ever academic study of polling place dynamics, based on direct observation of precincts in over 25 local jurisdictions.)
- Douglas M. Spencer and Zachary S. Markovits, "Long Lines at Polling Stations? Observations from an Election Day Field Study," *Election Law Journal*, 9(1): 3-17, 2010. Available at: https://doi.org/10.1089/elj.2009.0046. (Perhaps the first academic study of polling place wait times based on direct observation of lines in the 2008 presidential primary in northern California.)
- Charles Stewart III and Stephen Ansolabehere, "Waiting to Vote," *Election Law Journal*, 14(1): 47-53, 2015. Available at: https://doi.org/10.1089/elj.2014.0292.(Overview of research presented to the PCEA about lines at polling places.)

Appendix A. Participating Jurisdictions

Jurisdiction	Precincts	Hourly Observations
Pinal County, AZ	58	776
Orange County, CA	45	614
San Diego County, CA	806	10,271
Boulder County, CO	15	195
Andover, CT	1	15
Ansonia, CT	6	88
Barkhamsted, CT	1	15
Bethlehem, CT	1	15
Bozrah, CT	1	14
Branford, CT	7	98
Brookfield, CT	2	29
Canaan, CT	1	15
Canton, CT	1	14
Colebrook, CT	1	15
Columbia, CT	1	15
Cornwall, CT	1	15
Coventry, CT	1	15
Eastford, CT	1	15
Ellington, CT	2	30
Essex, CT	1	15
Franklin, CT	1	15
Granby, CT	2	30
Hartland, CT	1	15
Killingworth, CT	1	15
Litchfield, CT	4	54
Lyme, CT	1	15
Monroe, CT	2	28
North Stonington, CT	1	14
Prospect, CT	2	30
Salem, CT	1	15
Southington, CT	3	44
Sterling, CT	1	14
Suffield, CT	1	15
Willington, CT	1	14
Windsor Locks, CT	2	30
Windsor, CT	4	57
Wolcott, CT	3	44
Woodstock, CT	1	15

Jurisdiction	Precincts	Hourly Observations
Washington, DC	66	857
Escambia County, FL	59	746
Hernando County, FL	25	320
Marion County, FL	120	1,560
Pasco County, FL	89	1,154
Taylor County, FL	1	13
Fulton County, GA	63	789
Baltimore City, MD	126	1,702
Caroline County, MD	7	97
Carroll County, MD	36	495
Algoma Township, MI	3	42
Augusta Township, MI	1	14
Banks Township, MI	1	14
Baroda Township, MI	1	14
Battle Creek City, MI	6	83
Bear Lake Township, MI	1	14
Beaver Township, MI	1	14
Bedford Township, MI	4	56
Belding City, MI	3	40
Bellevue Township, MI	1	12
Bertrand Township, MI	1	14
Big Creek City, MI	1	12
Blair Township, MI	1	14
Bloomfield Township - Missaukee County, MI	1	14
Bloomfield Township - Oakland County, MI	30	413
Blumfield Township, MI	1	14
Bridgewater Township, MI	1	14
Bridgman City, MI	1	14
Brighton Township, MI	4	54
Brookfield Township, MI	1	14
Buchanan Township, MI	1	14
Carson City, MI	1	14
Casnovia Township, MI	1	14
Charleston Township, MI	1	14
Charlotte City, MI	4	56
Chesaning Township, MI	2	28
City Of Alpena, MI	4	54
Clam Lake Township, MI	1	14
Clearwater Township, MI	1	14
Cleon Township, MI	1	14
Cohoctah Township, MI	1	14
Coloma City, MI	1	14

Jurisdiction	Precincts	Hourly Observations
Columbus Township, MI	2	27
Commerce Township, MI	10	135
Concord Township, MI	1	14
Cooper Township, MI	5	69
Courtland Township, MI	2	28
Deerfield Township, MI	2	28
Delta Township, MI	14	194
Detroit City, MI	50	665
DeWitt Township, MI	3	41
Dexter Township, MI	3	42
Durand City, MI	2	26
Eastpointe Township, MI	11	150
Echo Township, MI	1	14
Elba Township, MI	3	42
Ellis Township, MI	1	14
Eureka Township, MI	2	28
Fairfield Township, MI	1	14
Farmington City, MI	3	41
Filer Township, MI	1	14
Forest Township, MI	1	14
Franklin Township, MI	1	14
Free Soil Township, MI	1	13
Freedom Township, MI	1	14
Fruitland Township, MI	2	28
Fruitport Township, MI	4	54
Gobles City, MI	1	14
Grand Blanc Township, MI	11	150
Grattan Township, MI	2	28
Grosse Pointe Woods City, MI	2	27
Hagar Township, MI	1	14
Harrison City, MI	1	14
Hartford City, MI	1	14
Hartland Township, MI	5	70
Hatton Township, MI	1	14
Hayes Township, MI	3	42
Hazel Park City, MI	1	14
Highland Township, MI	3	39
Howell City, MI	31	423
Jefferson Township, MI	1	13
Juniata and Wells Townships, MI	1	13
Kalamazoo Township, MI	10	133
Kingsford City, MI	1	13
Lake Charter Township, MI	1	14
Lakefield Township, MI	1	14

Jurisdiction	Precincts	Hourly Observations
Lansing City, MI	35	437
Lansing Township, MI	5	65
LaSalle Township, MI	2	28
Leland Township, MI	1	14
Leslie Township, MI	1	14
Lima Township, MI	1	14
Litchfield City, MI	1	14
Locket Township, MI	1	14
Long Lake Township, MI	2	27
Lyndon Township, MI	1	14
Madison Township, MI	3	42
Manistee City, MI	2	28
Manistee County, MI	10	138
Marion Township, MI	4	56
Marquette City, MI	6	84
Mason City, MI	3	42
Metz Township, MI	1	14
New Buffalo City, MI	1	14
Novi City, MI	20	277
Oceola Township, MI	5	68
Olive Township, MI	1	13
Orchard Lake City, MI	1	14
Otsego City, MI	1	14
Ottawa County, MI	45	654
Parma Township, MI	1	14
Paw Township, MI	1	14
Pentland Township, MI	1	13
Petersburg City, MI	1	14
Pittsfield Township, MI	8	104
Pleasant Ridge City, MI	1	14
Port Huron City, MI	9	123
Portage City, MI	12	168
Portage Township, MI	3	42
Raisinville Township, MI	2	28
Richland Township, MI	3	41
Riverview City, MI	3	42
Saginaw Township, MI	13	170
Sand Beach Township, MI	1	14
Scio Township, MI	8	109
Scipio Township, MI	1	14
Sodus Township, MI	1	14
Somerset Township, MI	2	28
St. Charles Township, MI	2	25
St. Clair Shores City, MI	12	163

Jurisdiction	Precincts	Hourly Observations
St. Johns City, MI	3	42
St. Joseph City, MI	3	42
Sterling Heights City, MI	45	613
Sylvan Lake City, MI	1	12
Sylvan Township, MI	1	14
Tawas City, MI	1	14
Taylor City, MI	12	161
Traverse City, MI	7	97
Troy City, MI	25	344
Tuscola Township, MI	1	14
Utica City, MI	1	14
Vevay Township, MI	2	28
Vienna Township, MI	5	70
Walker City, MI	9	126
Waterford Township, MI	6	82
Watertown Township, MI	2	28
West Branch City - Missaukee County, MI	1	14
West Branch City - Ogemaw County, MI	1	14
Westland City, MI	16	216
Whitehall Township, MI	1	14
Wilson Township, MI	1	14
Windsor Township, MI	3	41
Ypsilanti Township, MI	8	107
Minneapolis City, MN	119	1,599
Douglas County, NE	211	2,793
Hamilton County, OH	200	2,707
Arlington County, VA	30	398
Bedford County, VA	30	409
Buchanan County, VA	11	154
Chesapeake City, VA	50	672
Chesterfield County, VA	65	873
Culpeper County, VA	15	210
Fairfax City, VA	4	54
Gloucester County, VA	11	157
Goochland County, VA	10	136
Greene County, VA	4	54
Hanover County, VA	28	383
Louisa County, VA	15	210
Orange County, VA	10	135
Petersburg City, VA	7	95
Prince William County, VA	65	876
Rockingham County, VA	29	402
York County, VA	8	106
	3,180	**42,203**

Appendix B. Regression Analysis of Demographic Factors Affecting Average Wait Times

Variable						
Non-white pct.	20.42*** 2.39	—	—	—	22.36*** (4.30)	20.13** (5.58)
Log (renter pct.)	—	1.24* (0.51)	—	—	0.20 (0.47)	0.05 (0.40)
Log (avg. income)	—	—	-1.77 (2.64)	—	0.17 (1.89)	-1.27 (1.49)
In-person voters (1,000s)	—	—	—	—	0.0002 (0.0006)	(0.0005) (0.0013)
Intercept	3.88*** (0.44)	12.0*** (2.2)	27.41 (29.1)	-0.56 (1.43)	2.05 (20.0)	17.8 (16.4)
N	2,830	2,776	2,830	2,830	2,776	2,776
R^2	.10	.04	.002	.0009	.12	.14
Fixed effects?	No	No	No	No	No	State

* p < .05
** p < .01
*** p < .001

Note: Robust standard errors reported in parentheses. Standard errors also clustered at the state level.

Endnotes

1 Total turnout statistics for 2018 are available at the United States Elections Project, "2018 November General

2 Nationwide wait times in this paragraph are based on responses to the 2016 and 2018 Cooperative Congressional Election Study. Available at: https://cces.gov.harvard.edu.

3 Presidential Commission on Election Administration, *The American Voting Experience: Report and Recommendations of the Presidential Commission on Election Administration*, January 2014. Available at: https://www.eac.gov/assets/1/6/Amer-Voting-Exper-final-draft-01-09-14-508.pdf.

4 The number of Election Day polling places comes from: U.S. Election Assistance Commission, Election Administration and Voting Survey, 2018. Available at: https://www.eac.gov/research-and-data/election-administration-voting-survey/.

5 Presidential Commission on Election Administration, *The American Voting Experience: Report and Recommendations of the Presidential Commission on Election Administration*, January 2014. Available at: https://www.eac.gov/assets/1/6/Amer-Voting-Exper-final-draft-01-09-14-508.pdf.

6 MIT-Caltech Voting Technology Project, *VTP Toolkit*.
Available at: http://web.mit.edu/vtp/.

7 Stephen Pettigrew, "The Racial Gap in Wait Times: Why Minority Precincts Are Underserved by Local Election Officials," *Political Science Quarterly*, 132(2): 527-547, 2017.

8 Robert M. Stein, Christopher Mann, Charles Stewart III, et al., "Waiting to Vote in the 2016 Presidential Election: Evidence from a Multi-County Study." *Political Research Quarterly*, March 2019.
Available at: https://journals.sagepub.com/doi/abs/10.1177/1065912919832374.

9 Charles Stewart III and Stephen Ansolabehere, "Waiting to Vote," *Election Law Journal*, 14(1): 47-53, 2015.

10 Pettigrew, Stephen, "Long Lines and Voter Purges: The Logistics of Running Elections in America," Harvard University, PhD dissertation. 2017.

11 The BPC/MIT Polling Place Line Study defines "least densely populated" as living in a ZIP code that is in the bottom quartile, in terms of population/square mile. It defines "most densely populated" as living in a ZIP code that is in the top quartile. The cut-off points of these two regions are 259/square mile and 3,894/square mile. The average wait time in the least densely populated region is 6.7 minutes; for the most densely populated region, it is 8.4 minutes.

12 Stephen Pettigrew, "The Racial Gap in Wait Times: Why Minority Precincts Are Underserved by Local Election Officials," *Political Science Quarterly*, 132(2): 527-547, 2017.

13 Charles Stewart III and Stephen Ansolabehere, "Waiting to Vote," *Election Law Journal*, 14(1): 47-53, 1985.

14 The 95 percent confidence interval of this estimate is 0.2 minutes.

15 The 95 percent confidence interval of this estimate is 0.3 percentage points.

16 The 95 percent confidence intervals of these estimates are 0.2 percentage points and 0.1 minutes, respectively.

17 Cooperative Congressional Election Study. Available at: https://cces.gov.harvard.edu.

18 United States Elections Project, "2018 November General Election Turnout Rates," December 14, 2018. Available at: http://www.electproject.org/2018g.

19 United States Election Project, "National General Election VEP Turnout Rates, 1789-Present." Available at: http://www.electproject.org/national-1789-present.

20 The correlation between the two variables shown in Figure 2 is r = 0.43.

21 The line of best fit uses the linear regression statistical technique.

22 Cooperative Congressional Election Study, 2014 and 2018. Available at: https://cces.gov.harvard.edu.

23 United States Election Project, "National General Election VEP Turnout Rates, 1789-Present." Available at: http://www.electproject.org/national-1789-present.

24 BPC/MIT Polling Place Line Study.

25 Ibid.

26 Ibid.

27 Charles Stewart III, *Managing Polling Place Resources*, Caltech/MIT Voting Technology Project, 2015. Available at: http://web.mit.edu/vtp/Managing%20Polling%20Place%20Resources.pdf.

28 A "stable system" is one in which average values of the critical elements of the queue—the arrival rate and the amount of time a customer spends in the system—do not trend upward or downward but remain steady across time.

29 MIT-Caltech Voting Technology Project, *VTP Toolkit*. Available at: http://web.mit.edu/vtp/.

30 In the case of voting, polls reach a utilization limit when the number of people who arrive in a period of time (like an hour) exceeds the number of people who can be served during that period. In the example here, the utilization limit is 60 people per hour, because the polling place can only check in 60 people per hour. If more than 60 people arrive per hour, the line must keep growing until arrivals stop. Even when slightly fewer than 60 people arrive per hour, the wait time will be long, because of the variability in when people arrive. However, the line will eventually stabilize, unlike the situation where the arrival rate exceeds the utilization limit.

31 At the risk of immodesty, the BPC/MIT Polling Place Line Study has had a special relationship with Virginia since 2015, in terms of helping to apply the principles of queuing theory to managing polling place resources. Part of that relationship involved providing many Virginia counties with feedback concerning the match between turnout and polling place resources in anticipation of the 2016 election. It is likely that this additional attention to planning played a role in helping Virginia cope with the 2018 turnout surge.

32 Voter registration and turnout statistics come from: U.S. Election Assistance Commission, Election Administration and Voting Survey, 2018. Available at: https://www.eac.gov/research-and-data/election-administration-voting-survey/.

33 BPC/MIT Polling Place Line Study.

34 Because poll workers generally recorded line lengths at the top of each hour, it is likely that some precincts in this study that recorded never having a line of more than 10 people in fact had a longer line at some other time in the hour. However, because line lengths are "sticky" over short periods of time, it is likely that the number of precincts in the study that had *unrecorded* lines of greater than 10 people is relatively small.

35 BPC/MIT Polling Place Line Study.

36 Ibid.

37 Ibid.

38 In the one peer-reviewed journal article that deeply explored the racial divide in wait times, Pettigrew shows that "election officials appear to systematically provide more poll workers and voting machines to white precincts than minority ones." Stephen Pettigrew, "The Racial Gap in Wait Times: Why Minority Precincts Are Underserved by Local Election Officials," *Political Science Quarterly*, 132(2): 528, 2017. To be clear, however, BPC and MIT did not gather data about precinct-level resource allocation among the precincts in this study and therefore cannot directly address the resource-allocation hypothesis in these jurisdictions.

39 BPC/MIT Polling Place Line Study.

40 A multiple regression framework simultaneously explores demographic factors.

41 Stephen Pettigrew, "The Racial Gap in Wait Times: Why Minority Precincts Are Underserved by Local Election Officials," *Political Science Quarterly*, 132(2): 527-547, 2017.

42 Charles Stewart III and Stephen Ansolabehere, "Waiting to Vote," *Election Law Journal*, 14(1): 47-53, 1985.

43 Robert M. Stein, Christopher Mann, Charles Stewart III, et al., "Waiting to Vote in the 2016 Presidential Election: Evidence from a Multi-County Study." *Political Research Quarterly*, March 2019.
Available at: https://journals.sagepub.com/doi/abs/10.1177/1065912919832374.

44 Charles Stewart III, "Waiting to Vote in 2012," *Journal of Law and Politics*, 28: 439-464, 2012-2013.

45 BPC/MIT Polling Place Line Study.

46 Ibid.

47 Ibid.

48 Ibid.

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