

2021

Determinants and effects of abortion accessibility in the United States

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BOSTON UNIVERSITY
SCHOOL OF PUBLIC HEALTH

Dissertation

**DETERMINANTS AND EFFECTS OF
ABORTION ACCESSIBILITY IN THE UNITED STATES**

by

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Submitted in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

2021

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“Abortion is not about babies, it’s not about families; abortion is about women’s hopes, dreams, potential, the rest of their lives. Abortion is a matter of survival for women.”

George Tiller, Abortion Provider, Murdered June 2009

DEDICATION

This work is dedicated to the people, especially the Black women, who take on the work of reproductive justice. And to Louisa, may you be the author of your life.

ACKNOWLEDGMENTS

First, I owe many thanks to my dissertation committee, Drs. Lauren Wise, Kenneth Rothman, Abby Rudolph, and Terri-Ann Thompson. Your thoughtful questions, support, and guidance helped me to learn so much. Thanks to Dr. Kevin Lane who served as an external reviewer and provided invaluable feedback. This dissertation would not have been possible without the kind guidance of Dennis Milechin who shared knowledge and expertise without hesitation. I am also grateful to Dr. Rachel Jones of the Guttmacher Institute and Dr. Ushma Upadhyay of Advancing New Standards in Reproductive Health at the University of California San Francisco who willingly shared data and expertise.

I am so thankful for the friendship and support offered by my classmates over my time as a doctoral student. Your brilliance, passion, and kindness sustained me through the challenges of completing this work. I am especially grateful to Miriam Haviland, Lysie Ranker, and Laura Sampson with whom I have shared so much cheese and laughter, and one very emotional train ride to Providence. I am also thankful for colleagues at Ibis Reproductive Health whose dedication to justice has been a well of inspiration.

My family has offered so much support and guidance without which I would not have completed this work. Mum and Dad, thank you for encouraging my curiosity, demonstrating each day how to contribute to a more just world, celebrating my successes, and offering a space to land. Will, thank you for always pushing me to think critically and demonstrating that happiness can be cultivated. Rob, Susan, and Gaby, you became family during this time, for which I am so lucky. Thank you for supporting this work

from the start. Fanni, you helped this work over the finish line by stepping into our family and giving so much love — köszönöm szépen.

I am deeply grateful to my partner, Jeremy. Thank you for feeding our family, both literally and figuratively. Without your dinners and love none of this would be possible. And thank you to Louisa who reminded me why this work is important and was an incomparable companion.

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ABSTRACT

Abortion, the termination of pregnancy, is safe when provided as a surgical procedure by a trained provider or when the correct dosage of the drugs mifepristone and/or misoprostol are used. Despite this, many barriers to abortion care exist. In the United States (US), targeted state-level abortion restrictions create barriers to care, which make it so that people who wish to utilize abortion care face difficulty or are unable to do so. Such barriers to care have important public health implications, as studies have shown that individuals who cannot access wanted abortion care have poorer psychological, physical, social, and economic outcomes than those who obtained care. This dissertation aims to examine one component of abortion access, accessibility, operationalized as the drive time from a woman's home to the nearest abortion-providing facility. We employ a novel measure of abortion accessibility constructed from three data sources: (1) the Advancing New Standards in Reproductive Health facility database; (2) US Census estimates and shapefiles; and (3) OpenStreetMap data.

In the first study, we used geographic information systems (GIS) to explore the effect of programmatic and policy changes related to telemedicine for medication abortion services (TMAB) on population-level measures of abortion accessibility, or

drive time to the nearest abortion-providing facility. We found that either expansions in TMAB services or removal of TMAB bans could improve abortion accessibility in the US. For these two exposure scenarios, compared to the current abortion provision scenario, increases in the proportion of women within a 30-, 60-, and 90-minute drive time of an abortion-providing facility ranged from 1.25 percentage points, or an additional 781,556 US women aged 15-44 years with accessibility, to 5.66 percentage points, or an additional 3,530,423 US women aged 15-44 years with accessibility.

In the second study, we used GIS to assess the potential effect of the geographic unit of analysis (i.e., block group, ZIP code tabulation area [ZCTA], or county) on misclassification of the proportion of US women of reproductive age within a 30-minute drive time of an abortion-providing facility relative to a measure calculated using Census blocks. We found that block group- or ZCTA-based estimates of abortion accessibility were an underestimate, but resulted in little misclassification relative to measures constructed using Census blocks at the national level; however, county-based measures substantially underestimated abortion accessibility compared with Census block-based measures. Nationwide, the Census block-based abortion accessibility estimate was 0.35 percentage points greater than the block group-based estimate, 2.72 percentage points greater than the ZCTA-based estimate, and 24.21 percentage points greater than the county-based estimate. By state, the Census block-based abortion accessibility estimate ranged from 0 to 8.51 percentage points greater than the block group-based estimate, from 0 to 27.86 percentage points greater than the ZCTA-based estimate, and from 0 to 79.49 percentage points greater than the county-based estimate. Given that state-level

ZCTA-based estimates could be substantially different from the Census block-based estimate, ZCTA-based estimates are likely not appropriate for state-level analyses or US analyses stratified by state.

Finally, in the third study, we assessed the relationship between level of accessibility in an abortion client's home ZCTA and the gestational age at which the client obtained abortion care, using fine stratification by propensity score to control confounding. We found that compared with living in a ZCTA with >0% accessibility, living in a ZCTA with 0% accessibility was associated with a decreased risk of being at or beyond 14 weeks' gestation at abortion visit. These unexpected findings could be due to a selection bias induced by limiting the sample to those who obtained abortion care, uncontrolled or poorly controlled confounding, misclassification of exposure and/or outcome, and/or unidentified effect measure modification by state abortion provision landscape.

Through these three dissertation studies, we highlighted the potential impact on abortion accessibility in the US with different changes in programming and policy, quantified misclassification of abortion accessibility, and examined how misclassification varied by geographic measure and location. The third study in this dissertation suggests a need for more research to identify how selection bias may affect studies of abortion access in the US that rely on data only from those who are able to access care.

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LIST OF ABBREVIATIONS

ANSIRH.....	Advancing New Standards in Reproductive Health
APS	Abortion Patient Survey
DAG.....	Directed acyclic graph
GIS	Geographic information systems
TMAB.....	Telemedicine for medication abortion
US	United States
ZCTA	ZIP code tabulation area

CHAPTER 1: Introduction

In the United States (US), previous studies indicate that womenⁱ who did not receive wanted abortion care had poorer psychological, physical, social, and economic outcomes than those who did obtain wanted care.¹⁻⁷ Furthermore, current and subsequent children of women who obtained wanted abortion care had better social and economic outcomes than children of women who did not obtain wanted abortion care.^{8,9} Given that abortion is a determinant of health, and that there are well-documented barriers to abortion care,¹⁰⁻²¹ there is significant interest in measuring access to abortion and identifying opportunities to expand access to care. In 1981, Penchansky and Thomas defined access to health care as an umbrella term encompassing five domains including accessibility. Accessibility is often operationalized as how far a person lives from health services, regardless of their immediate need for those services.²²

This dissertation aims to address three specific gaps in the literature on abortion accessibility. First, although researchers hypothesize that clinic-based telemedicine for medication abortion (TMAB) service implementation could expand abortion accessibility in the US, there are not currently data to support this hypothesis. The one existing study of TMAB-related accessibility increases was limited, as it focused on one facility network, did not account for inter-state travel, operationalized accessibility as the number of miles traveled rather than drive time, and only assessed travel distances for those who

ⁱ Not all individuals who seek abortion care identify as women. To date, much of the abortion literature has focused on the experience of “women.” In this dissertation, when citing past literature that was reported as including “women,” we will use that language. Similarly, the US Census data we used included the population of US “women.” When referring to people who received abortion care, we will use the term “client.”

utilized services, not changes to accessibility for all people who might desire abortion care.

Second, studies often operationalize abortion accessibility as distance or drive time to an abortion-providing facility using counties or ZIP codes as the unit of analysis and the smallest commonly-used geography in this literature is the block group,^{23–25} but these studies might be susceptible to accessibility misclassification. To our knowledge, no studies have used Census blocks, the smallest geographic unit provided by the Census, to assess abortion accessibility. This is despite evidence that when aggregate demographic data are used as a proxy for an individual characteristic in the US, the degree of bias increased with increasing size of the geographic unit.²⁶ Furthermore, to our knowledge, no studies in the literature have compared the use of blocks to larger geographic units for public health analyses.

Third, studies of interventions to increase abortion access demonstrate that greater abortion accessibility resulting from these interventions is associated with earlier gestational age at abortion,^{27–29} but the association between accessibility and gestational age at abortion outside the context of intervention assessment has not been well-studied. Although surgical and medication abortion are widely considered to be low risk at any gestational age, greater gestational age at the time of abortion is associated with increased health risks.^{30–32} Furthermore, both the direct and indirect costs of abortion care increase with increasing gestational age.³³ Therefore, understanding determinants of gestational age at abortion is important to improve health and wellbeing.

This dissertation will expand on the existing literature by: (1) quantifying the

potential impact of TMAB expansion, or ban removal, on abortion accessibility for all US women of reproductive age; (2) assessing the potential magnitude of abortion accessibility misclassification resulting from calculations based on block groups, ZCTAs, or counties as compared to Census blocks; and (3) determining the extent to which level of abortion accessibility is associated with gestational age at abortion.

**CHAPTER 2: Examining the potential impact of telemedicine for medication
abortion-related programming and policy changes on abortion accessibility in the
United States**

Introduction

In the United States (US), despite the fact that abortion is legal, safe, and supported by major medical organizations,³⁴ many state-level restrictions create barriers to care.¹⁰⁻²¹ Findings from the Turnaway Study, a prospective cohort study of US women seeking abortion care, indicate that barriers to abortion access that prevent people from utilizing abortion care within gestational age limits can result in poor health outcomes. Specifically, this research showed that US women who did not receive wanted abortion care had poorer psychological, physical, social, and economic outcomes than those who did obtain care.^{1-5,6(p),7} Furthermore, current and subsequent children of women who obtained abortion care had better social and economic outcomes than did children of women who did not obtain wanted abortion care.^{8,9}

In 2008, Planned Parenthood of the Heartland launched a telemedicine for medication abortion (TMAB) care delivery model to overcome state-level barriers to abortion, including physician-only medication abortion dispensing regulations. Under this model, clients visit a health center where an abortion provider is not physically present and meet with a remote clinician via videoconference. As in an in-person medication abortion visit, the clinician answers the client's questions and may watch as the client is given the first dose of abortion medication. Evaluations found that, compared with in-person medication abortion, TMAB is equally or more safe, effective, and acceptable to

clients and providers.³⁵⁻³⁷ Since 2008, Planned Parenthood expanded TMAB services to additional states where the service was not banned. However, as of 2018, nearly half of Planned Parenthood health centers did not offer abortion services,³⁸ and, due in part to the politicization of abortion, TMAB was banned in 19 US states.³⁹

In 1981, Penchansky and Thomas defined access to health care as an umbrella term encompassing five domains: availability, accessibility, accommodation, affordability, and acceptability.²² Accessibility, defined as, “the relationship between the location of supply and the location of clients,” is often operationalized as how far a person is from health services, regardless of their immediate need for those services. Researchers hypothesize that TMAB implementation could expand abortion accessibility in the US. One observational study evaluated the effect of the 2008 implementation of TMAB in the Planned Parenthood of the Heartland health center network. This study compared clients who accessed in-person medication abortion in the two years prior to TMAB implementation with all medication abortion clients (in-person and telemedicine) in the two years after implementation and found that clients who were seen after TMAB implementation traveled slightly shorter distances than those seen before TMAB implementation.⁴⁰ However, this state-level analysis focused on one facility network; did not account for inter-state travel; operationalized accessibility as the number of miles traveled rather than drive time, so did not account for variability in terrain and traffic; and only assessed travel distances for those who utilized services, not changes to accessibility for all people who might desire abortion care. The decreases in travel distance observed among abortion clients post-TMAB implementation may also be attributable to

differences in demographic characteristics between those using abortion services in the periods before and after TMAB implementation that were not accounted for in the analysis.

We sought to expand on the existing literature by quantifying the potential impact of TMAB expansion, or ban removal, on abortion accessibility for all US women of reproductive age. Here we present a geographic information systems (GIS) analysis to assess the potential effect of (1) TMAB expansion and (2) TMAB ban removal on abortion accessibility among women of reproductive age living in the US.

Methods

Facility Eligibility

Abortion-providing facility locations were obtained from the 2018 Advancing New Standards in Reproductive Health (ANSIRH) facility database,⁴¹ which included 925 facilities operating in 2018. We excluded facilities that were noted as not being open in 2018 (n=83). We then abstracted the addresses of all Planned Parenthood health centers operating in 2018, both those that did and did not offer abortion services (TMAB or in-person), from a list of all health centers on the Planned Parenthood Federation of America website³⁸ (n=600). After adding all Planned Parenthood health centers to the ANSIRH facility database, we removed facilities with duplicate addresses (n=351). In total, we included 1,091 facilities in this analysis.

Outcome

Abortion accessibility was operationalized as the proportion of US women aged 15-44 years who lived within a 30-, 60-, or 90-minute drive time of an abortion-providing facility (i.e., 0-30 minutes, 0-60 minutes, and 0-90 minutes, respectively). The majority of studies to date have used driving distance rather than driving time to examine abortion accessibility.²³⁻²⁵ Furthermore, there is no single acceptable driving distance to abortion care for all potential clients. For these reasons, we selected drive times that encompassed a range of potentially acceptable values, including for clients who wish to visit a nearby facility (e.g., 30 minutes) and those who wish to travel further to protect their anonymity (e.g., 90 minutes). Additionally, this range of values could reflect differences in acceptable driving distances across the country due to geography, rurality, or culture, such as abortion stigma and/or attitudes toward abortion. Conducting the same analysis with three different definitions of accessibility served as a sensitivity analysis to understand the effect of our exposures of interest on three potential measures of abortion accessibility under different assumptions about what is acceptable accessibility.

To calculate abortion accessibility, we geocoded the 1,091 facilities' addresses using the *ggmap* package in R version 4.0.2.⁴² The *ggmap* package uses the GoogleMaps API to geocode addresses. Prior to geocoding, all "&" were removed from addresses to improve *ggmap* geocoding.⁴³ All addresses were successfully geocoded. Latitudes and longitudes for all addresses not geocoded at the rooftop level and a random sample of 50 addresses geocoded at the rooftop level were manually checked using GoogleMaps and inaccuracies (n=3, all of which were not geocoded at the rooftop level) were corrected

and geocoding was rerun.

After geocoding all addresses, we used R's *osrm* package⁴⁴ to calculate 30-, 60-, and 90-minute drive time isochrones for each facility. The *osrm* package calculates drive times based on the OpenStreetMap road network. OpenStreetMap is a map data platform founded in 2004 that uses a routing algorithm to determine drive times between locations. OpenStreetMap's open source "volunteered geography" data, similar to Wikipedia, are collected and uploaded by users worldwide. OpenStreetMap data are manually validated by contributors who review data to ensure accuracy and data-driven tools are used to identify errors for editing. A 2018 case study that included OpenStreetMap data for the state of Massachusetts found that these data were complete and accurate.⁴⁵

To identify the population living within a given drive time to an abortion-providing facility, we used Census block shapefiles from the 2010 US Census and 2010 Census block-level population data from the National Historical Geographic Information System of IPUMS.⁴⁶ For each block, the number of women of reproductive age was calculated by summing the block counts of women in age categories inclusive of ages 15 through 44.

Using the *sf* package in R,⁴⁷ we identified the intersection between blocks and isochrones to determine the fraction of each block within 30-, 60-, and 90-minute drive times, respectively. Similar to an analysis by Pollini et al.,⁴⁸ using these fractions, we calculated the number of women aged 15-44 years who lived less than 30, 60, and 90 minutes from an abortion-providing facility, respectively, by multiplying the intersection fraction by the total number of women aged 15-44 years who lived in that block. We then

determined the fraction of reproductive aged US women in each state and for the US overall who lived within the drive times of interest in each of the three scenarios (i.e., reference and two exposure scenarios), by dividing the number of women aged 15-44 years within the specified drive time across all blocks in the area of interest (i.e., country or state) by the total number of women aged 15-44 years in that area. For both the country and individual states, we assumed no barriers to inter-state travel.

Exposures

The reference (unexposed) scenario was abortion accessibility based on the ANSIRH facility database and Planned Parenthood health centers that offered abortion care in 2018 (i.e., existing levels of provision) (n=850), referred to as the “current” scenario, hereafter. We examined two exposure scenarios: (1) expansion of TMAB services to all Planned Parenthood health centers that did not offer abortion in 2018 in states where TMAB was legal (programmatic change; referred to as the “TMAB expansion” scenario, hereafter); and (2) removal of all state-level TMAB bans (policy change; referred to as the “TMAB ban removal” scenario, hereafter). TMAB expansion assumes that in 2018, TMAB was expanded in states where legal. In other words, in addition to the current level of provision, all Planned Parenthood health centers in states that did not have a TMAB ban also offered TMAB, for a total of 996 abortion-providing facilities. TMAB ban removal assumes that in 2018, state-level TMAB bans were removed so that in addition to the current level of provision, all Planned Parenthood health centers in all states offered TMAB (i.e., the level of provision assumed in the TMAB expansion scenario plus all Planned Parenthood health centers in states with a

TMAB ban), for a total of 1,091 abortion-providing facilities. We identified facilities that met these criteria using publicly-available 2018 data on state TMAB bans from the Guttmacher Institute.³⁹ In 2018, 19 states banned TMAB.²¹ As noted above, Planned Parenthood health centers that did not offer abortion care were identified from data on the Planned Parenthood Federation of America website.³⁸

Analyses

We calculated the difference in the proportion of US women aged 15-44 years residing within 30-, 60-, and 90-minute drive times of an abortion-providing facility, respectively, between each exposure scenario and the reference scenario. To assess effect measure modification by population density, we calculated estimates stratified by Census block urban versus rural status. All geographies were visualized and processed using the North America Albers Equal Area Conic projection.⁴⁹

Results

Of the 241 health centers operating in 2018 that did not offer abortion care, 95 (39.4%) were located in states that banned TMAB services. As shown in Figure 2.1, TMAB bans were common in states in the Southeast and Middle of the United States.

The drive time isochrones for all three drive time measures or accessibilities (i.e., ≤ 30 , ≤ 60 , and ≤ 90 minutes) across all three provision scenarios (i.e., current, TMAB expansion, and TMAB ban removal) are depicted in Figure 2.2. In the US, in 2018, 65.3%, 80.5%, and 88.9% of women aged 15-44 years lived within 30, 60, or 90 minutes of an abortion-providing facility, respectively. Under the TMAB expansion scenario,

68.3%, 82.6%, and 90.1% of women lived within a 30-, 60-, or 90-minute drive time, respectively. In the TMAB ban removal scenario, 70.9%, 84.7%, and 91.7% of women lived within a 30-, 60-, or 90-minute drive time, respectively. As shown in Table 2.1, across all scenarios and drive times, a greater proportion of women living in urban blocks lived within the given drive time compared with women living in rural blocks. Abortion accessibility across all three scenarios and drive times varied widely between states (see Table 2.1). For example, in the TMAB expansion scenario for a 30-minute drive time, accessibility ranged from 3.9% in Wyoming to 100% in the District of Columbia.

Both TMAB expansion and ban removal resulted in expanded abortion accessibility for US women aged 15-44 years compared to the current accessibility scenario. The smallest percentage point increase in accessibility was a 1.25 percentage point difference between current and TMAB expansion scenarios at a 90-minute drive time, meaning that an estimated 781,556 additional US women aged 15-44 years who did not live within a 90-minute drive time in the current scenario would live within that drive time given this programming change. The largest percentage point increase in accessibility was 5.66 for the difference between current and TMAB ban removal scenarios at a 30-minute drive time, meaning that an estimated 3,530,423 additional US women aged 15-44 years who did not live within a 30-minute drive time of an abortion-providing facility would live within that drive time given this policy change (see Table 2.2). Across all drive times and scenarios, rural blocks saw greater increases in accessibility compared with urban blocks.

Generally, in states with TMAB bans, TMAB expansion resulted in little if any

change in accessibility and in states without TMAB bans, the TMAB expansion and ban removal scenarios resulted in very similar if not the same accessibility. However, there were exceptions for specific states. For example, in Illinois, Kentucky, and Ohio, states without bans, the TMAB ban removal scenario resulted in increases in 30-minute accessibility relative to the TMAB expansion scenario. Similarly, in North Dakota, Michigan, Indiana, and Wisconsin, despite having TMAB bans, the TMAB expansion scenario resulted in some 30-minute accessibility increase. In both of these cases, these increases that contradict the state's ban status are due to accessibility increases in nearby states with the opposite ban status (see Figure 2.1 and Table 2.2).

Discussion

In this analysis, which employed the smallest geographic unit available through the US Census, assumed no barriers to inter-state travel, and examined a variety of potentially acceptable drive times, we found that changes to TMAB programming and policy could expand abortion accessibility in the US. Removing all state TMAB bans and expanding TMAB services to all Planned Parenthood health centers that did not offer abortion care in 2018 would result in over 3.5 million additional US women aged 15-44 years living within 30 minutes of an abortion-providing facility. These findings are consistent with those that demonstrated increased access in one clinic network after the implementation of a TMAB program⁴⁰ and further illustrate how TMAB could impact accessibility for all reproductive-aged women in the US.

While these policy and programming changes universally increase abortion

accessibility, there was variation in the magnitude of the increase by state, neighboring states, current accessibility, and rural versus urban block classification. In some states, the considered changes resulted in little gain in abortion accessibility, whereas in other states, gains were more notable; it appears that this variation could be due to a combination of factors, including whether the state has a TMAB ban, current level of abortion provision, and the number of health centers not offering care. Additionally, we saw evidence that changes to provision in one state can impact accessibility in another.

Percentage point increases in accessibility relative to the current scenario were often largest for the 60-minute drive time scenario, not the 90-minute drive time scenario. This finding may be explained by the fact that the potential absolute increase for the 90-minute drive time scenario is smaller than for the 60-minute drive time scenario, as there was greater accessibility in the current scenario with a 90-minute drive time compared with a 60-minute drive time. An additional explanation for this seemingly counterintuitive finding is that 60-minute drive time isochrones for facilities where care provision was “added” when assuming policy or program changes usually did not overlap with the isochrones for facilities that were already providing care, whereas they did overlap for 90-minute drive times. In other words, a greater proportion of the isochrones for facilities implementing care covered area that was not already covered by an isochrone in the 60-minute drive time scenario compared to the 90-minute drive time scenario. Despite this evidence of isochrones overlapping in some cases, even in a scenario where all Planned Parenthood health centers offered abortion care, in some states, less than half of the female population aged 15-44 years lived within 90 minutes of

an abortion-providing facility.

These analyses indicate one abortion care expansion option that would increase the accessibility of clinic-based abortion care. In particular, our findings suggest that TMAB programming or policy changes could have larger benefits for rural communities. Given the growing use of telemedicine, particularly in light of the COVID-19 pandemic,⁵⁰ and well-established acceptability of TMAB services,^{35,36} these changes are likely to be highly acceptable abortion provision options.

Limitations

A major limitation of this study is possible misclassification of abortion accessibility. Perhaps most importantly with regard to accessibility misclassification, this study is susceptible to the ecological fallacy, as a population-level measure of accessibility stands in for an individual-level measure. In other words, although population-level accessibility may increase for a particular block, an individual who lives in this block may not be able to easily get to an abortion-providing facility; individuals may experience better or worse abortion accessibility than that in their home block based on day-to-day travel patterns outside their home block, or may take different driving routes or encounter different traffic patterns than those calculated for these analyses. For example, if a woman lives in an area with poor abortion accessibility but works in an area with acceptable abortion accessibility, they may have good accessibility near work, but their accessibility would be classified as poor.

Similarly, given that our analysis assumed women had access to a vehicle at their home location, we will have misclassified accessibility at the individual level for women

who do not have access to a vehicle. In 2017, the majority of households in the US had one or more vehicles (92.2%);⁵¹ however, the fact that a household has a vehicle does not mean it can be used readily by a person seeking abortion care if they do not have a driver's license, if they are unable to disclose their need for abortion and/or if they do not have access to the vehicle because it is being used by other members of the household.

Additionally, we used three dichotomous drive times (≤ 30 , ≤ 60 , and ≤ 90 minutes). These dichotomies were selected to represent a range of reasonable distances: 30 minutes may be reasonable for individuals who wish to visit a nearby abortion-providing facility, whereas 90 minutes may be acceptable to those who wish to travel farther to protect their anonymity or for those who live in more rural areas, where longer travel times are more acceptable. However, by dichotomizing this measure, we may again misclassify the outcome for some women.

Misclassification of accessibility may also arise because we calculated accessibility using data from the ANSIRH facility database. The facility database may not be a complete census of abortion-providing facilities and could result in an undercount of facilities and, consequently, of accessibility. However, because the database was constructed using Internet search terms that mimicked those of people seeking services,⁴¹ we believe that our definition of accessibility closely represents the lived experience of US women of reproductive age.

There is a temporal mismatch between our abortion facility data, which included facilities operating in 2018; the population data we used, which were from the 2010 US Census; and the road network data that we used to construct drive time isochrones, which

were from OpenStreetMap in 2021. We chose to use the 2018 ANSIRH data because it was the most up-to-date available and most complete facility data ANSIRH had collected when we launched this study. Block-level population data are only available from the US Census Bureau for the decennial Census, so we used the most recent data available from 2010. As a result, findings may not be valid if the population distribution changed between 2010 and 2018, or if road networks and addresses changed significantly between 2018 and 2021.

If misclassification of abortion accessibility due to these mechanisms is differential by location such that it is differential by TMAB ban status (i.e., exposure status), our results could be either an over or underestimate of the effect of these exposures on abortion accessibility. This differential misclassification of abortion accessibility by exposure scenario may be likely given demographic differences between states with and without TMAB bans.

Additionally our population were limited to those who identify as “female” in response to the US Census question “What is [the respondent’s] sex?,” so may not be generalizable to those who identify as transgender, non-binary, or gender expansive.

Furthermore, aggregating to the state and federal level could mask heterogeneity of the effect of TMAB expansion or bans across blocks within a given state. In other words, these findings do not provide evidence of effects of TMAB on accessibility at geographic units smaller than the state.

Our analysis also only considers one element of access, accessibility operationalized as driving time, which alone cannot ensure access to abortion care. Other

factors that influence abortion access include the hours of operation, cost of care, and cultural competency of staff and providers. While accessibility alone likely misclassifies abortion access, across all three scenarios the population does not change, therefore we expect our estimates of effect, percentage point changes, to be unbiased; however, if the factors that affect individual access vary by location such that they vary by exposure status (i.e., TMAB ban), our results could be either an over or underestimate of effect.

Finally, this analysis considered only two changes in abortion provision scenarios, programming and policy changes. Given resource constraints, it is unlikely that one provider network would expand services so dramatically, even in the face of policy changes. These analyses estimate the upper limit of expansion should only Planned Parenthood make service changes; however, other program and policy changes (e.g., clinic openings and closures) over time within and outside the Planned Parenthood system are likely and would affect the exact proportion of the population with access to abortion care. These estimates serve as an example of how policy and program shifts could affect accessibility.

Conclusions

Our findings point to areas where increased abortion provision would have the greatest impact on accessibility, as defined by the number of reproductive-aged women within a given drive time of an abortion-providing facility. Even with these changes, large numbers of women would have inadequate abortion accessibility according to our measures. These data may be used by health care advocates and funders as they consider where to invest policy- and program-specific resources to improve abortion accessibility

in the US.

This study uses a broadly-applicable framework to measure abortion accessibility. The study design can easily be adapted to assess the effects of different abortion service expansions or restrictions on the same measure of accessibility. Such projections may be particularly useful to help determine resource and funding allocation as the abortion provision and policy landscape shifts.

Tables and Figures

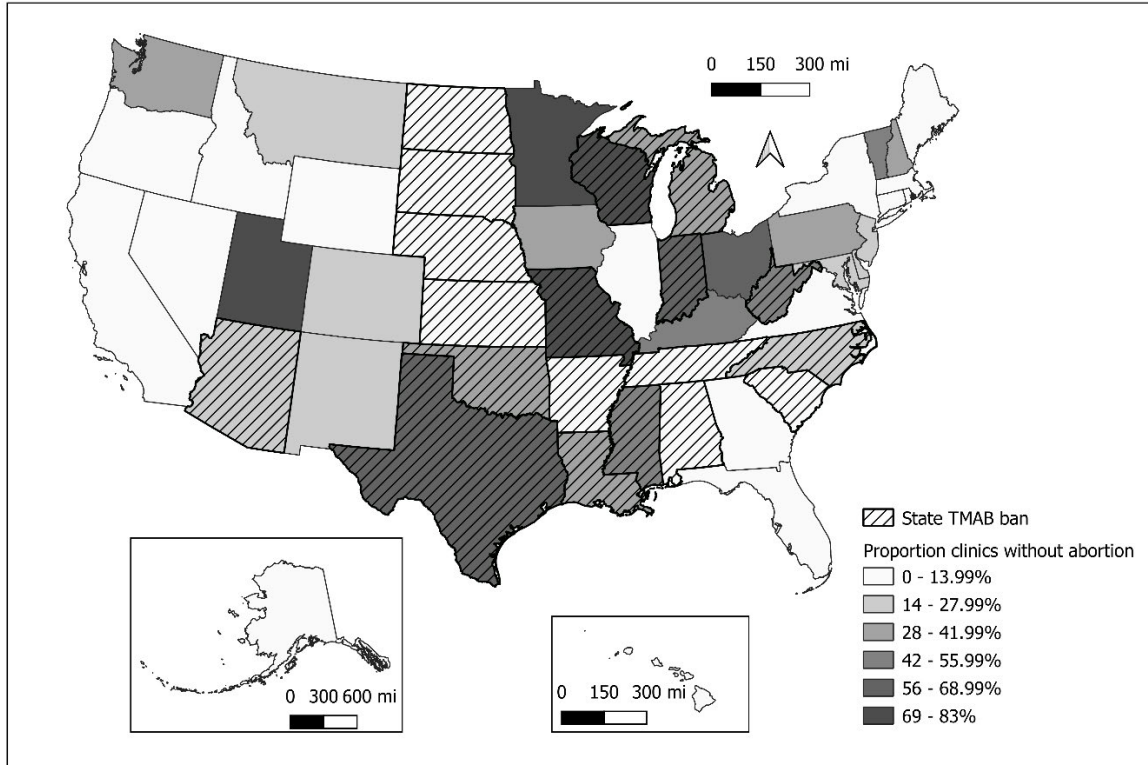


Figure 2.1. States with telemedicine for medication abortion (TMAB) bans (November 2018) and the proportion of Planned Parenthood health centers that do not offer abortion services (December 2018). Data sources: The Guttmacher Institute and Planned Parenthood Federation of America.

A) CURRENT

30-minute drive time



65.3%

60-minute drive time



80.5%

90-minute drive time



88.9%

Proportion of reproductive-aged women within drive time

B) EXPANSION



68.3%



82.6%



90.1%

Proportion of reproductive-aged women within drive time

C) BAN REMOVAL

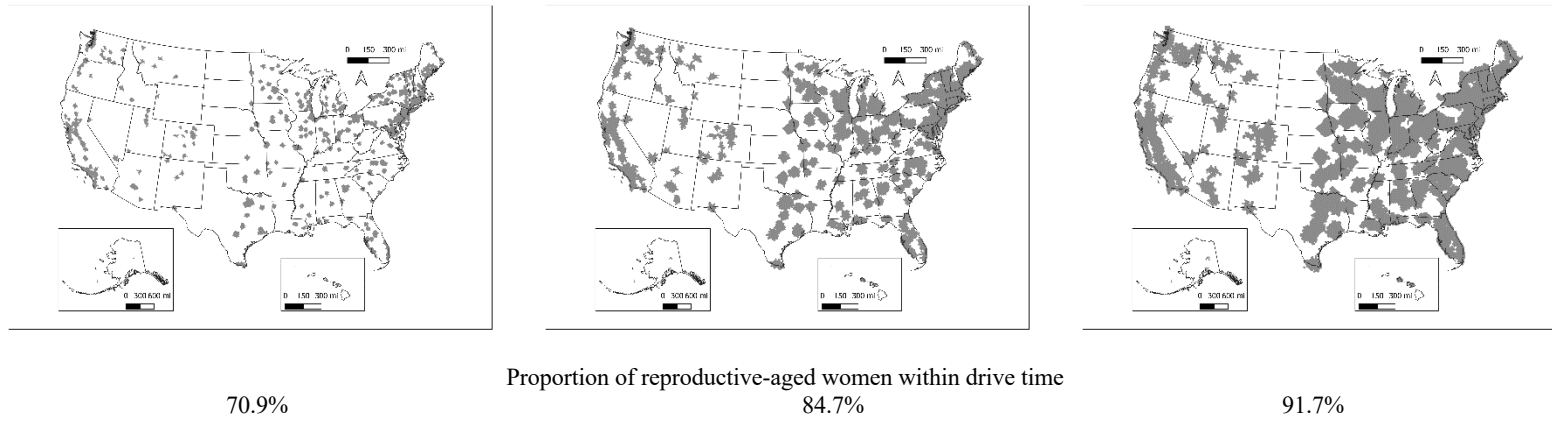


Figure 2.2a-c. 30-, 60-, and 90-minute drive time isochrones for: (a) current, (b) TMAB expansion, and (c) TMAB ban removal abortion provision scenarios and proportion of the US women aged 15-44 years living within given drive time.

Area (women age 15-44)	30-minute drive time			60-minute drive time			90-minute drive time		
	Current n (%)	TMAB expansion n (%)	TMAB ban removal n (%)	Current n (%)	TMAB expansion n (%)	TMAB ban removal n (%)	Current n (%)	TMAB expansion n (%)	TMAB ban removal n (%)
United States (n=62,374,964)	40,706,619 (65.3)	42,610,902 (68.3)	44,237,224 (70.9)	50,232,616 (80.5)	51,498,804 (82.6)	52,813,274 (84.7)	55,437,165 (88.9)	56,215,481 (90.1)	57,192,252 (91.7)
Urban blocks (n=52,372,305)	39,172,014 (74.8)	40,738,658 (77.8)	42,122,417 (80.4)	45,524,303 (86.9)	46,366,702 (88.5)	47,239,363 (90.2)	48,533,183 (92.7)	48,975,125 (93.5)	49,509,863 (94.5)
Rural blocks (n=10,002,659)	1,534,605 (15.3)	1,872,244 (18.7)	2,114,807 (21.1)	4,708,313 (47.1)	5,132,102 (51.3)	5,573,911 (55.7)	6,903,982 (69.0)	7,240,356 (72.4)	7,682,389 (76.8)
States that do not ban TMAB (n=40,811,811)	30,195,064 (74.0)	32,091,268 (78.6)	32,151,176 (78.8)	35,640,156 (87.3)	36,863,952 (90.3)	36,817,907 (90.2)	38,168,498 (93.5)	38,875,741 (95.3)	38,944,188 (95.4)
Alaska (n=143,229)	104,009 (72.6)	104,009 (72.6)	104,009 (72.6)	112,517 (78.6)	112,517 (78.6)	112,517 (78.6)	113,488 (79.2)	113,488 (79.2)	113,484 (79.2)
California (n=7,876,871)	7,200,160 (91.4)	7,411,853 (94.1)	7,411,853 (94.1)	7,683,952 (97.6)	7,765,623 (98.6)	7,765,629 (98.6)	7,823,895 (99.3)	7,827,679 (99.4)	7,827,679 (99.4)
Colorado (n=1,025,085)	820,760 (80.1)	828,681 (80.8)	828,681 (80.8)	918,382 (89.6)	926,220 (90.4)	926,220 (90.4)	950,676 (92.7)	956,727 (93.3)	956,727 (93.3)
Connecticut (n=691,265)	683,472 (98.9)	683,472 (98.9)	683,472 (98.9)	691,265 (100)	691,265 (100)	691,265 (100)	691,265 (100)	691,265 (100)	691,265 (100)
Delaware (n=179,232)	145,157 (81.0)	146,410 (81.7)	146,410 (81.7)	168,180 (93.8)	168,180 (93.8)	168,180 (93.8)	179,155 (100)	179,155 (100)	179,155 (100)
District of Columbia (n=162,314)	162,314 (100)	162,314 (100)	162,314 (100)	162,314 (100)	162,314 (100)	162,314 (100)	162,314 (100)	162,314 (100)	162,314 (100)
Florida (n=3,560,982)	2,761,728 (77.6)	2,795,995 (78.5)	2,795,995 (78.5)	3,284,483 (92.2)	3,290,539 (92.4)	3,290,539 (92.4)	3,483,367 (97.8)	3,490,250 (98.0)	3,490,250 (98.0)
Georgia (n=2,073,006)	1,067,086 (51.5)	1,067,086 (51.5)	1,067,086 (51.5)	1,471,042 (71.0)	1,474,674 (71.1)	1,474,674 (71.1)	1,758,120 (84.8)	1,758,375 (84.8)	1,758,357 (84.8)

Hawaii (n=262,107)	148,873 (56.8)	148,873 (56.8)	148,887 (56.8)	208,680 (79.6)	208,680 (79.6)	208,680 (79.6)	215,583 (82.2)	215,583 (82.2)	215,583 (82.2)
Idaho (n=306,303)	147,540 (48.2)	147,560 (48.2)	147,560 (48.2)	201,639 (65.8)	203,687 (66.5)	203,687 (66.5)	216,281 (70.6)	219,610 (71.7)	219,610 (71.7)
Illinois (n=2,631,753)	1,868,866 (71.0)	1,871,655 (71.1)	1,917,899 (72.9)	2,280,312 (86.6)	2,281,836 (86.7)	2,356,025 (89.5)	2,483,370 (94.4)	2,484,311 (94.4)	2,498,635 (94.9)
Iowa (n=576,692)	210,871 (36.6)	264,672 (45.9)	264,672 (45.9)	330,111 (57.2)	337,639 (58.5)	337,639 (58.5)	454,519 (78.8)	464,269 (80.5)	464,269 (80.5)
Kentucky (n=854,846)	223,237 (26.1)	313,919 (36.7)	320,607 (37.5)	306,960 (35.9)	467,238 (54.7)	498,261 (58.3)	463,380 (54.2)	591,559 (69.2)	641,122 (75.0)
Maine (n=231,923)	173,911 (71.9)	198,247 (81.9)	198,247 (81.9)	235,782 (97.5)	237,206 (98.1)	237,206 (98.1)	241,434 (99.8)	241,434 (99.8)	241,434 (99.8)
Maryland (n=1,193,402)	969,696 (81.3)	1,026,601 (86.0)	1,026,602 (86.0)	1,115,758 (93.5)	1,140,688 (95.6)	1,140,688 (95.6)	1,172,442 (98.4)	1,183,743 (99.2)	1,183,743 (99.2)
Massachusetts (n=1,350,576)	1,028,560 (76.2)	1,073,590 (79.5)	1,073,590 (79.5)	1,310,918 (97.1)	1,311,221 (97.1)	1,311,221 (97.1)	1,332,257 (98.6)	1,332,257 (98.6)	1,332,257 (98.6)
Minnesota (n=1,045,681)	519,284 (49.7)	736,532 (70.4)	736,532 (70.4)	698,105 (66.8)	918,660 (87.9)	918,660 (87.9)	805,459 (77.0)	1,004,640 (96.1)	1,004,640 (96.1)
Montana (n=179,670)	89,982 (50.0)	90,231 (50.2)	90,231 (50.2)	102,076 (56.8)	102,758 (57.2)	102,758 (57.2)	120,669 (67.2)	121,045 (67.4)	121,045 (67.4)
Nevada (n=549,924)	486,330 (88.4)	487,146 (88.6)	487,146 (88.6)	508,838 (92.5)	511,472 (93.0)	511,472 (93.0)	527,373 (95.9)	528,384 (96.1)	528,384 (96.1)
New Hampshire (n=250,133)	163,554 (65.4)	177,988 (71.2)	177,988 (71.2)	232,989 (93.1)	239,120 (95.6)	239,120 (95.6)	246,212 (98.4)	249,433 (99.7)	249,433 (99.7)
New Jersey (n=1,738,419)	1,660,407 (95.5)	1,666,307 (95.9)	1,666,307 (95.9)	1,734,628 (99.8)	1,735,320 (99.8)	1,735,320 (99.8)	1,738,419 (100)	1,738,419 (100)	1,738,419 (100)
New Mexico (n=398,587)	177,563 (44.5)	198,299 (49.8)	198,299 (49.8)	255,773 (64.2)	276,037 (69.3)	276,037 (69.3)	287,074 (72.0)	290,959 (73.0)	290,959 (73.0)
New York (n=4,047,947)	3,697,111 (91.3)	3,740,953 (92.4)	3,740,953 (92.4)	3,987,355 (98.5)	3,998,317 (98.8)	3,998,317 (98.9)	4,035,054 (99.7)	4,035,215 (99.7)	4,035,215 (99.7)

Ohio (n=2,235,171)	1,164,529 (52.1)	1,587,054 (71.0)	1,594,011 (71.3)	1,706,071 (76.3)	1,985,836 (88.8)	1,994,528 (89.2)	2,105,213 (94.2)	2,185,671 (97.8)	2,189,863 (98.0)
Oregon (n=754,077)	563,332 (74.7)	569,900 (75.6)	569,900 (75.6)	659,547 (87.5)	663,049 (87.9)	663,049 (87.9)	696,002 (92.3)	696,840 (92.4)	696,840 (92.4)
Pennsylvania (n=2,442,538)	1,397,722 (57.2)	1,671,112 (68.4)	1,671,117 (68.4)	1,873,388 (76.7)	2,108,533 (86.3)	2,108,533 (86.3)	2,119,595 (86.8)	2,257,659 (92.4)	2,257,659 (92.4)
Rhode Island (n=214,647)	185,049 (86.2)	185,049 (86.2)	185,049 (86.2)	214,503 (99.9)	214,503 (99.9)	214,503 (99.9)	214,503 (99.9)	214,503 (99.9)	214,503 (99.9)
Utah (n=602,120)	243,808 (40.5)	509,292 (84.6)	509,291 (84.6)	469,366 (78.0)	555,323 (92.2)	555,323 (92.2)	502,262 (83.4)	567,769 (94.3)	567,769 (94.3)
Vermont (n=118,297)	61,971 (52.4)	93,948 (79.4)	93,948 (79.4)	104,336 (88.2)	117,610 (99.4)	117,610 (99.4)	114,089 (96.4)	118,297 (100)	118,297 (100)
Virginia (n=1,652,698)	947,622 (57.3)	948,097 (57.4)	948,097 (57.4)	1,326,898 (80.3)	1,334,709 (80.8)	1,337,068 (80.9)	1,594,452 (96.5)	1,595,005 (96.5)	1,595,395 (96.5)
Washington (n=1,355,704)	1,116,409 (82.3)	1,180,272 (87.1)	1,180,272 (87.1)	1,268,108 (93.5)	1,307,298 (96.4)	1,307,298 (96.4)	1,296,935 (95.7)	1,334,521 (98.4)	1,334,521 (98.4)
Wyoming (n=106,612)	4,151 (3.9)	4,151 (3.9)	4,151 (3.9)	15,880 (14.9)	15,880 (14.9)	15,880 (14.9)	23,641 (22.2)	25,362 (23.8)	25,362 (23.8)
States that ban TMAB (n=21,553,153)	10,511,554 (48.8)	10,519,627 (48.8)	12,086,059 (56.1)	14,592,458 (67.7)	14,634,845 (67.9)	15,832,051 (73.5)	17,268,671 (80.1)	17,339,756 (80.5)	18,248,095 (84.7)
Alabama (n=960,620)	406,295 (42.3)	406,295 (42.3)	406,295 (42.3)	638,269 (66.4)	638,269 (66.4)	638,269 (66.4)	823,211 (85.6)	823,211 (85.6)	823,222 (85.7)
Arizona (n=1,262,557)	912,768 (72.3)	912,768 (72.3)	943,087 (74.7)	1,058,837 (83.9)	1,060,218 (84.0)	1,063,104 (84.2)	1,132,553 (89.7)	1,134,756 (89.9)	1,135,365 (89.9)
Arkansas (n=569,446)	156,459 (27.5)	156,459 (27.5)	156,459 (27.5)	274,723 (48.2)	274,723 (48.2)	274,723 (48.2)	404,121 (71.0)	404,121 (71.0)	408,303 (71.7)
Indiana (n=1,287,393)	548,423 (42.6)	548,649 (42.6)	752,308 (58.4)	763,971 (59.3)	778,299 (60.5)	986,064 (76.7)	1,037,911 (80.6)	1,040,855 (80.8)	1,170,067 (90.9)
Kansas (n=554,584)	238,756 (43.1)	238,756 (43.1)	244,102 (44.0)	320,444 (57.8)	320,444 (57.8)	331,601 (59.8)	396,971 (71.6)	396,971 (71.6)	414,866 (74.8)

Louisiana (n=928,335)	379,556 (40.9)	379,556 (40.9)	384,163 (41.4)	513,014 (55.3)	513,014 (55.3)	517,572 (55.8)	631,803 (68.1)	631,803 (68.1)	657,710 (70.8)
Michigan (n=1,918,594)	1,266,013 (66.0)	1,266,456 (66.0)	1,392,683 (72.6)	1,671,563 (87.1)	1,672,135 (87.2)	1,770,068 (92.3)	1,823,942 (95.1)	1,824,008 (95.1)	1,859,053 (96.9)
Mississippi (n=604,036)	117,546 (19.5)	117,546 (19.5)	146,934 (24.3)	189,162 (31.3)	189,162 (31.3)	251,103 (41.6)	323,710 (53.6)	323,710 (53.6)	394,424 (65.3)
Missouri (n=1,176,684)	376,490 (32.0)	376,490 (32.0)	705,610 (60.0)	613,139 (52.1)	613,139 (52.1)	875,809 (74.4)	712,336 (60.5)	712,360 (60.5)	1,001,513 (85.1)
Nebraska (n=355,031)	211,657 (59.6)	211,657 (59.6)	211,657 (59.6)	236,643 (66.7)	236,643 (66.7)	236,643 (66.7)	253,329 (71.4)	253,329 (71.4)	253,329 (71.4)
North Carolina (n=1,949,350)	958,379 (49.2)	958,379 (49.2)	976,764 (50.1)	1,468,246 (75.3)	1,468,246 (75.3)	1,480,912 (76.0)	1,772,768 (90.9)	1,772,768 (90.9)	1,774,259 (91.0)
North Dakota (n=129,143)	33,554 (26.0)	33,643 (26.1)	33,643 (26.1)	35,693 (27.6)	35,972 (27.9)	35,972 (27.9)	53,649 (41.5)	54,055 (41.9)	54,055 (41.9)
Oklahoma (n=736,629)	366,862 (49.8)	366,862 (49.9)	378,389 (51.4)	474,958 (64.5)	474,958 (65.5)	495,914 (67.3)	592,838 (80.5)	592,838 (80.5)	616,201 (83.7)
South Carolina (n=928,310)	370,507 (39.9)	370,507 (39.9)	370,507 (39.9)	668,078 (72.0)	668,078 (72.0)	668,386 (72.0)	826,244 (89.0)	826,244 (89.0)	827,856 (89.2)
South Dakota (n=152,353)	41,619 (27.3)	41,619 (27.3)	41,619 (27.3)	48,803 (32.0)	48,803 (32.0)	48,803 (32.0)	69,215 (45.4)	69,221 (45.4)	69,221 (45.4)
Tennessee (n=1,274,350)	550,176 (43.2)	550,176 (43.2)	550,176 (43.2)	863,936 (67.8)	863,936 (67.8)	863,936 (67.8)	1,048,224 (82.2)	1,048,224 (82.2)	1,048,224 (82.2)
Texas (n=5,326,162)	3,125,768 (58.7)	3,125,768 (58.7)	3,597,542 (67.5)	3,988,498 (74.9)	3,988,498 (74.9)	4,220,899 (79.2)	4,358,508 (81.8)	4,358,508 (81.8)	4,489,041 (84.3)
West Virginia (n=341,981)	45,853 (13.4)	45,853 (13.4)	61,139 (17.9)	111,313 (32.5)	132,486 (38.7)	139,300 (40.7)	185,081 (54.1)	228,833 (66.9)	234,338 (68.5)
Wisconsin (n=1,097,595)	404,873 (36.9)	412,188 (37.6)	732,982 (66.8)	653,168 (59.5)	657,822 (59.9)	932,973 (85.0)	822,257 (74.9)	843,941 (76.9)	1,017,048 (92.7)

Table 2.1. Proportion of female population aged 15-44 years living within the specified drive time of abortion-providing facility by urban/rural block status and state for all three drive times and provision scenarios.

Area	Health centers not offering abortion, 2018 n (%)	30-minute drive time		60-minute drive time		90-minute drive time	
		TMAB expansion vs. current (% point difference)	TMAB ban removal vs. current (% point difference)	TMAB expansion vs. current (% point difference)	TMAB ban removal vs. current (% point difference)	TMAB expansion vs. current (% point difference)	TMAB ban removal vs. current (% point difference)
United States	241 (22.1)	3.05	5.66	2.03	4.14	1.25	2.81
Urban blocks	235 (21.9)	2.99	5.63	1.61	3.27	0.84	1.86
Rural blocks	6 (37.5)	3.38	5.80	4.24	8.65	3.36	7.78
States that do not ban TMAB overall and ordered by percentage change for TMAB expansion vs. current scenario							
States that do not ban TMAB	146 (16.9)	4.65	4.79	3.00	2.89	1.73	1.90
Alaska	0 (0)	0.00	0.00	0.00	0.00	0.00	0.00
Connecticut	0 (0)	0.00	0.00	0.00	0.00	0.00	0.00
District of Columbia	0 (0)	0.00	0.00	0.00	0.00	0.00	2.79
Georgia	0 (0)	0.00	0.00	0.18	0.18	0.00	0.00
Hawaii	0 (0)	0.00	0.00	0.00	0.00	0.00	11.71
Rhode Island	0 (0)	0.00	0.00	0.00	0.00	1.29	1.29
Wyoming	0 (0)	0.00	0.00	0.00	0.00	19.05	19.05
Idaho	0 (0)	0.01	0.01	0.67	0.67	0.00	0.00
Virginia	0 (0)	0.03	0.03	0.47	0.62	5.65	5.65
Illinois	3 (8.1)	0.11	1.86	0.06	2.88	0.00	0.00
Montana	1 (16.7)	0.14	0.14	0.38	0.38	0.04	0.58
Nevada	1 (10.0)	0.15	0.15	0.48	0.48	0.11	0.11
New Jersey	7 (14.0)	0.34	0.34	0.04	0.04	0.18	0.18
Delaware	1 (20.0)	0.70	0.70	0.00	0.00	0.00	3.23
Colorado	7 (23.3)	0.77	0.77	0.76	0.76	0.00	0.00
Oregon	2 (11.8)	0.87	0.87	0.46	0.46	0.97	0.97

Florida	8 (11.0)	0.96	0.96	0.17	0.17	0.00	0.00
New York	8 (7.1)	1.08	1.08	0.27	0.27	0.21	0.21
California	14 (7.8)	2.69	2.69	1.04	1.04	0.00	0.00
Massachusetts	2 (7.4)	3.33	3.33	0.02	0.02	0.00	1.83
Washington	10 (35.4)	4.71	4.71	2.89	2.89	10.88	10.88
Maryland	4 (14.3)	4.77	4.77	2.09	2.09	0.00	24.58
New Mexico	2 (25.0)	5.20	5.20	5.08	5.08	0.19	0.19
New Hampshire	3 (30.0)	5.77	5.77	2.45	2.45	0.17	0.22
Iowa	3 (30.0)	9.33	9.33	1.31	1.31	0.00	3.17
Maine	3 (13.0)	10.06	10.06	0.59	0.59	0.00	2.45
Kentucky	2 (50.0)	10.61	11.39	18.75	22.38	0.00	0.17
Pennsylvania	14 (38.9)	11.19	11.19	9.63	9.63	1.09	1.09
Ohio	21 (63.6)	18.90	19.21	12.52	12.91	0.59	0.59
Minnesota	17 (73.9)	20.78	20.78	21.09	21.09	0.00	0.00
Vermont	6 (50.0)	27.03	27.03	11.22	11.22	3.60	3.79
Utah	7 (70.0)	44.09	44.09	14.28	14.28	3.56	3.56
<i>States that ban TMAB overall and ordered by percentage change for TMAB ban removal vs. current scenario</i>							
States that ban TMAB	95 (42.2)	0.04	7.31	0.20	5.75	0.33	4.54
Alabama	0 (0)	0.00	0.00	0.00	0.00	0.00	0.00
Arkansas	0 (0)	0.00	0.00	0.00	0.00	0.00	0.00
Nebraska	0 (0)	0.00	0.00	0.00	0.00	0.05	0.05
South Carolina	0 (0)	0.00	0.00	0.00	0.03	1.61	1.61
South Dakota	0 (0)	0.00	0.00	0.00	0.00	1.69	1.69
Tennessee	0 (0)	0.00	0.00	0.00	0.00	1.98	17.75
North Dakota	0 (0)	0.07	0.07	0.22	0.22	0.31	0.31
Louisiana	2 (33.3)	0.00	0.50	0.00	0.49	0.00	0.00
Kansas	0 (0)	0.00	0.94	0.00	0.65	0.23	10.27
North Carolina	4 (19.1)	0.00	0.96	0.00	2.01	0.00	0.00

Oklahoma	2 (33.3)	0.00	1.56	0.00	2.84	0.95	0.95
Arizona	3 (23.1)	0.00	2.40	0.11	0.34	0.00	0.73
West Virginia	1 (50.0)	0.00	4.47	6.19	8.18	12.79	14.40
Mississippi	1 (50.0)	0.00	4.87	0.00	10.25	0.01	0.01
Michigan	12 (33.3)	0.02	6.60	0.03	5.13	0.00	0.00
Texas	30 (57.7)	0.00	8.86	0.00	4.36	2.77	2.77
Indiana	12 (63.2)	0.02	15.84	1.11	17.33	0.00	0.08
Missouri	10 (83.3)	0.00	27.97	0.00	22.32	0.03	0.05
Wisconsin	18 (75.0)	0.67	29.89	0.42	25.49	14.99	20.79

Table 2.2. Percentage point change in abortion accessibility compared to current provision scenario for the US population and by block urban/rural status and state for all drive times.

CHAPTER 3: Geographic misclassification: Comparing Census blocks, block groups, ZIP code tabulation areas, and counties for geographic information systems analyses of abortion accessibility in the United States

Introduction

Access to wanted abortion care is a determinant of psychological, physical, social, and economic outcomes in the United States (US).¹⁻⁷ As a result, there is interest in measuring abortion accessibility in the US. Some studies operationalize abortion accessibility for either a population or an individual as distance or drive time to an abortion-providing facility. Many of these studies use counties or ZIP codes as the unit of analysis and the smallest commonly-used geography in this literature is block groups.²³⁻²⁵ Of the US Census geographic units commonly used in abortion accessibility studies, counties are the largest (n=3,143 in US), followed by ZIP code tabulation areas (ZCTAs, the Census unit which roughly corresponds with ZIP codes⁵²) (n=32,989), and then block groups (n=217,740); Census blocks are the smallest geographic unit used by the Census (n= 11,078,297).⁵³ To our knowledge, no studies of abortion accessibility have used Census block as the geographic unit of analysis.

Results from the Public Health Disparities Geocoding Project make up the bulk of the literature on the comparison of geographic units of analysis for public health research in the US.⁵⁴ In studies by that research team, socioeconomic data from the smaller geographic units that they evaluated, census tract and block groups, more consistently predicted expected health disparities than did ZIP code-level measures, though in some cases census tract measures were more predictive than those from the smaller geographic

unit, block groups.⁵⁵⁻⁵⁹ In a separate analysis, Soobader et al. concluded that the size of bias from the use of aggregate socioeconomic status data as a proxy for individual status in the US increased with increasing size of the geographic unit.²⁶ As a result of the potential misclassification induced by the use of larger geographic units of analysis, studies in the literature may misclassify abortion accessibility due to reliance on larger geographic units, though no studies have examined this potential error. Furthermore, to our knowledge, no studies in the public health literature have compared Census blocks to larger geographic units.

For public health decision-making, misclassification of abortion accessibility may result in misallocation of clinical and/or funding resources. Therefore, our analysis sought to determine the potential magnitude of abortion accessibility misclassification resulting from calculations based on block groups, ZCTAs, or counties as compared to blocks.

Methods

We used geographic information systems (GIS) to assess the potential effect of the geographic unit of analysis (i.e., block group, ZCTA, or county) on the degree of misclassification of the proportion of US women of reproductive age within a 30-minute drive time of an abortion-providing facility.

The 2018 Advancing New Standards in Reproductive Health (ANSIRH) facility database⁴¹ included 925 abortion-providing facilities operating in 2018. We excluded those that were noted as not being open in 2018 (n=83). We then supplemented the facility database with the locations of all Planned Parenthood health centers that offered

abortion in 2018 from a list of health centers on the Planned Parenthood Federation of America's website³⁸ (n=241). After adding all Planned Parenthood health centers to the ANSIRH facility database, we removed facilities with duplicate addresses (n=233). In total, we included 850 abortion-providing facilities in this analysis.

Abortion accessibility was operationalized as the proportion of US women aged 15-44 years who lived within a 30-minute drive time of an abortion-providing facility. We selected this drive time as it was closest to commonly used driving distance cut points used in the existing literature examining abortion accessibility for abortion clients (e.g., 25 miles).⁶⁰

To calculate abortion accessibility, we geocoded the 850 facilities' addresses using the *ggmap* package in R version 4.0.2.⁴² The *ggmap* package uses the GoogleMaps API to geocode addresses. Prior to geocoding, all "&" were removed from addresses to improve *ggmap* geocoding.⁴³ All addresses were geocoded with *ggmap*. Latitudes and longitudes for all addresses not geocoded at the rooftop level and a random sample of 50 addresses geocoded at the rooftop level were manually checked using GoogleMaps and inaccuracies (n=3, all in addresses not geocoded at the rooftop level) were corrected and geocoding rerun.

After geocoding all addresses, we used R's *osrm* package⁴⁴ to calculate 30-minute drive time isochrones for each facility. The *osrm* package calculates drive times based on the OpenStreetMap road network. OpenStreetMap is a map data platform founded in 2004 that uses a routing algorithm to determine drive times between locations. OpenStreetMap's open source "volunteered geography" data, similar to Wikipedia, are

collected and uploaded by users worldwide. OpenStreetMap data are manually validated by contributors who review data to ensure accuracy and data-driven tools are used to identify errors for editing. A 2018 case study that included data from OpenStreetMap data for the state of Massachusetts found that these data were complete and accurate.⁴⁵

To identify the population within a given drive time, we used block, block group, ZCTA, and county shapefiles from the 2010 US Census. We additionally obtained 2010 Census block-, block group-, ZCTA-, and county-level population data from the National Historical Geographic Information System of IPUMS.⁴⁶ For each geographic unit, the number of women of reproductive age was calculated by summing counts of women in age categories inclusive of ages 15 through 44 years.

Using the *sf* package in R,⁴⁷ we identified the intersection between the geographic units of interest and facility isochrones to determine the fraction of each geographic unit within 30 minutes of an abortion-providing facility. Using an approach similar to Pollini et al,⁴⁸ we calculated the number of women aged 15-44 years who live within 30 minutes or less from an abortion-providing facility by multiplying the intersection fraction by the total number of women aged 15-44 years living in that geographic unit. We then estimated the fraction of US women aged 15-44 years who lived less than 30 minutes from an abortion-providing facility by state and for the US overall, by dividing the number of women within the specified drive time in that area by the total number of reproductive-aged women in that area.

We calculated the difference in estimates of the proportion of US women aged 15-44 years residing within a 30-minute drive time of an abortion-providing facility

calculated using block groups, ZCTAs, and counties, respectively, compared with Census blocks. We also stratified our estimates by state. For analyses stratified by state, we assigned ZCTAs to states based on the county in which the majority of the ZCTAs population (>50%) was located according to the Census' ZCTA to County Relationship File.⁵¹ All geographies were visualized and processed using the North America Albers Equal Area Conic projection.⁴⁹

Results

Figure 3.1 illustrates the 30-minute drive time isochrones around facilities providing abortion care in 2018. A block-based estimate indicates that 65.32% of the 62,374,964 US women aged 15-44 years lived within a 30-minute drive time of an abortion-providing facility in 2018 (see Table 3.1). Block group-, ZCTA-, and county-based estimates indicated that 64.90%, 62.54%, and 41.06%, respectively, of women aged 15-44 years lived within 30 minutes of an abortion-providing facility.

Accessibility varied widely across states (see Table 3.1). In all states, accessibility estimates calculated using blocks, block groups, ZCTAs, and counties differed, except in Washington DC, where 100% of women aged 15-44 years lived within a 30-minute drive time of an abortion-providing facility according to all four estimates.

At the country level, the block-based estimate of abortion accessibility was larger than all other estimates; the block-based abortion accessibility estimate was 0.35 percentage points greater than the block group-based estimate, 2.72 percentage points greater than the ZCTA-based estimate, and 24.21 percentage points greater than the county-based estimate (Table 3.2).

By state, the block-based abortion accessibility estimate ranged from 0 to 8.51 percentage points greater than the block group-based estimate, from 0 to 27.86 percentage points greater than the ZCTA-based estimate, and from 0 to 65.61 percentage points greater than the county-based estimate. In some states, differences between block group, ZCTA, and county estimates were quite different from one another; for example, Massachusetts' block-based estimate was only 0.05 percentage points greater than the block group-based estimate and 0.47 percentage points greater than the ZCTA-based estimate, but the block-based estimate was 21.17 percentage points greater than the county-based estimate. Other states had more consistent estimates across all measures. For example, for Wyoming, the block-based estimate was 0.60 percentage points greater than the block group-based estimate, 3.06 percentage points greater than the ZCTA-based estimate, and 3.62 percentage points greater than the county-based estimate. For every state, the percentage point difference between the block and county-based estimate was greater than the difference between the block- and ZCTA-based estimate, which was greater than the difference between the block- and block group-based estimate.

Discussion

We found that use of counties, the largest geographic unit we considered, may dramatically underestimate abortion accessibility compared with blocks, while block group- or ZCTA-based national estimates of abortion accessibility in the US may result in little misclassification relative to measures constructed using blocks. These findings are in line with the existing literature, which indicates that variables constructed using larger geographic units compared with smaller geographic units are poorer proxies for

individual data.^{26,55-59} Use of counties to calculate this measure of abortion accessibility resulted in a dramatic underestimate of the proportion of women aged 15-44 years who lived within a 30-minute drive time of an abortion-providing facility both nationally and across all states.

These findings have implications for the existing abortion accessibility literature. Estimates of population-level abortion accessibility are often used descriptively for public health advocacy and planning. Our findings demonstrate that these descriptions may be substantially biased if counties are used for country-level analyses, or if counties or ZCTAs are used for state-level analyses. For causal analyses that use this population-level measure of abortion accessibility as the exposure or outcome of interest, results could also be biased if larger geographies are used to calculate accessibility. Given that we calculate accessibility based on area intersections, we do not expect that geographies with 100% or 0% accessibility would be affected by misclassification, as the entirety of that geography would be either within or outside of a drive time isochrone. Categorizing this measure of abortion accessibility could result in considerable misclassification across categories, but dichotomization of either 100% versus <100% or 0% versus >0%, or a categorization of 0%, >0%-<100%, and 100% should entail little misclassification, and may be reasonable if a continuous measure of accessibility calculated using a small geography is not feasible.

Although the ZCTA-based estimate for US accessibility only differed from the block-based estimate by three percentage points, there was notable variation in the state-level percentage point difference comparing ZCTA-based estimates with block-based

estimates across states, from 0 to 27.86 percentage points. One explanation for this wide variation in percentage point difference at the state level is that some ZCTAs cross state borders and we chose to assign ZCTAs to states based on the state in which the majority of the ZCTA's population resided, which resulted in misclassification of state for some of the ZCTA's population. Given that there was substantial misclassification of abortion accessibility in some states using the ZCTA-based measure, ZCTA-based estimates are likely not appropriate for state-level analyses in all states or US analyses stratified by state.

While each of the considered geographies resulted in some misclassification relative to blocks, there are important considerations that may make other units more favorable. Importantly, block-based estimates are computationally intensive; state block shapefiles from the US Census range in size from 3.97 megabytes to 709.58 megabytes of data and total 10.45 gigabytes. Furthermore, for privacy protection-related reasons, abortion-providing facility and individual-level data are often not available at small geographic units, such as a block. Given these limitations, block group- or ZCTA-based estimates may be more practical for widespread use for nationwide estimates and block group-based estimates may be appropriate for state-level analyses. However, when possible, and particularly when estimate precision is important and may inform resource or funding allocation, block-based estimates appear to be the most appropriate choice.

Limitations

As in the first study in this dissertation, one limitation of this study is potential misclassification of abortion accessibility. For this study, it is particularly important to

highlight that our measure of abortion accessibility does not account for population distribution within geographic units of analysis, as it does not account for where in a given geography individual women lived. In other words, for example, if only a fraction of a ZCTA overlapped with a drive time isochrones, our measure would misclassify abortion in that ZCTA if residents were not evenly distributed throughout the ZCTA. Given that larger geographies may be more likely to partially intersect isochrones than smaller geographies, misclassification of accessibility may be differential across considered geographic units, biasing estimates.

Finally, we only considered one drive time (i.e., 30 minutes) when defining abortion accessibility. We selected this drive time given its potential correlation with existing driving distance data; however, the magnitude of misclassification by geographic unit of analysis may vary if other definitions of abortion accessibility were used.

Conclusions

These findings indicate that in order to reduce the impact of ecological bias when calculating estimating this measure of abortion accessibility in the US, studies should use the smallest feasible geographic unit, with block group- and ZCTA-based estimates offering similar results to block-based estimates at the national level. While it is conceivable that the results of this study could apply more broadly to any health care service distributed similarly to abortion care, future studies should use the broadly generalizable approach we took in this study to assess the degree of misclassification of accessibility for other measures of resource allocation and drive time accessibility in the US.

Tables and Figures



Figure 3.1. 30-minute drive time isochrones for abortion-providing facilities in 2018.

Area (population)	Block estimate n (%)	Block group estimate n (%)	ZCTA estimate n (%)	County estimate n (%)
United States (62,374,964)	40,706,619 (65.32)	40,482,882 (64.90)	39,008,943 (62.54)	25,608,196 (41.06)
Alabama (960,620)	406,295 (42.30)	400,404 (41.68)	371,248 (38.65)	199,718 (20.79)
Alaska (143,229)	104,009 (72.62)	91,815 (64.10)	64,112 (44.76)	10,040 (7.01)
Arizona (1,262,557)	912,768 (72.30)	909,210 (72.01)	847,464 (67.12)	121,506 (9.62)
Arkansas (569,446)	156,459 (27.48)	154,036 (27.05)	132,286 (23.23)	80,733 (14.18)
California (7,876,871)	7,200,160 (91.41)	7,175,252 (91.09)	6,869,869 (87.22)	3,268,921 (41.50)
Colorado (1,025,085)	820,760 (80.07)	811,890 (79.20)	752,515 (73.41)	333,452 (32.53)
Connecticut (691,265)	683,472 (98.87)	682,619 (98.75)	680,264 (98.41)	595,156 (86.10)
Delaware (179,232)	145,157 (80.99)	143,773 (80.22)	141,440 (78.91)	117,031 (65.30)
District of Columbia (162,314)	162,314 (100.00)	162,314 (100.00)	162,314 (100.00)	162,314 (100.00)
Florida (3,560,982)	2,761,728 (77.56)	2,741,000 (76.97)	2,648,934 (74.44)	1,385,386 (38.90)
Georgia (2,073,006)	1,067,068 (51.48)	1,060,936 (51.18)	1,023,412 (49.37)	930,045 (44.74)
Hawaii (262,107)	148,873 (56.80)	147,302 (56.20)	133,334 (50.87)	29,296 (11.18)
Idaho (306,303)	147,540 (48.17)	144,955 (47.32)	117,538 (38.37)	55,104 (18.00)
Illinois (2,631,753)	1,868,866 (71.01)	1,863,691 (70.82)	1,842,783 (70.02)	1,216,341 (46.22)
Indiana (1,287,393)	548,423 (42.60)	543,108 (42.19)	521,124 (40.48)	425,911 (33.08)
Iowa (576,692)	210,871 (36.57)	207,898 (36.05)	202,643 (35.14)	136,995 (23.76)
Kansas (554,584)	238,756 (43.05)	237,290 (42.79)	228,808 (41.26)	162,304 (29.27)
Kentucky (854,846)	223,237 (26.11)	221,749 (25.94)	208,221 (24.36)	167,817 (19.63)
Louisiana (928,335)	379,556 (40.89)	376,273 (40.53)	354,203 (38.15)	180,202 (19.41)
Maine (231,923)	173,911 (71.89)	169,039 (69.87)	160,580 (69.24)	88,988 (38.37)
Maryland (1,193,402)	969,696 (81.25)	966,337 (80.97)	956,945 (80.19)	826,378 (69.25)

Massachusetts (1,350,576)	1,028,560 (76.16)	1,027,905 (76.11)	1,022,220 (75.69)	742,645 (54.99)
Michigan (1,918,594)	1,266,013 (65.99)	1,261,144 (65.73)	1,230,545 (64.14)	906,545 (47.25)
Minnesota (1,045,681)	519,284 (49.66)	517,770 (49.52)	501,682 (47.98)	355,593 (34.01)
Mississippi (604,036)	117,546 (19.46)	115,021 (19.04)	102,270 (16.93)	40,951 (6.78)
Missouri (1,176,684)	376,490 (32.00)	374,150 (31.80)	362,333 (30.79)	278,734 (23.69)
Montana (179,670)	89,982 (50.08)	85,521 (47.60)	55,181 (30.70)	13,135 (7.31)
Nebraska (355,031)	211,657 (59.62)	210,350 (59.25)	208,901 (58.84)	185,554 (52.26)
Nevada (549,924)	486,330 (88.44)	481,754 (87.60)	461,987 (84.01)	49,178 (8.94)
New Hampshire (250,133)	163,554 (65.39)	161,221 (64.45)	158,685 (63.44)	98,103 (39.22)
New Jersey (1,738,419)	1,660,407 (95.51)	1,655,681 (95.24)	1,642,854 (94.50)	1,488,104 (85.60)
New Mexico (398,587)	177,563 (44.55)	171,923 (43.13)	143,619 (36.03)	66,115 (16.59)
New York (4,047,947)	3,697,111 (91.33)	3,689,491 (91.14)	3,666,762 (90.58)	3,074,878 (75.96)
North Carolina (1,949,350)	958,379 (49.16)	952,601 (48.87)	911,984 (46.78)	799,133 (40.99)
North Dakota (129,143)	33,554 (25.98)	33,133 (25.66)	32,987 (25.54)	5,248 (4.06)
Ohio (2,235,171)	1,164,529 (52.10)	1,160,869 (51.94)	1,140,968 (51.05)	794,962 (35.57)
Oklahoma (736,629)	366,862 (49.80)	365,022 (49.55)	346,827 (47.08)	243,279 (33.03)
Oregon (754,077)	563,332 (74.70)	556,627 (73.82)	501,593 (66.52)	203,082 (26.93)
Pennsylvania (2,442,538)	1,396,153 (57.16)	1,395,714 (57.14)	1,380,131 (56.50)	1,214,250 (49.71)
Rhode Island (214,647)	185,049 (86.21)	184,792 (86.09)	181,939 (84.76)	170,574 (79.47)
South Carolina (928,310)	370,507 (39.91)	365,915 (39.42)	329,897 (35.54)	156,977 (16.91)
South Dakota (152,353)	41,619 (27.32)	41,406 (27.18)	40,843 (26.81)	18,803 (12.34)
Tennessee (1,274,350)	550,176 (43.17)	547,481 (42.96)	516,131 (40.50)	457,075 (35.87)
Texas (5,326,162)	3,125,768 (59.69)	3,112,998 (58.45)	2,994,268 (56.22)	2,207,975 (41.46)

Utah (602,120)	243,808 (40.49)	240,371 (39.92)	225,607 (37.47)	151,304 (25.13)
Vermont (118,297)	61,971 (52.39)	60,039 (50.75)	56,661 (47.90)	39,539 (33.42)
Virginia (1,652,698)	947,622 (57.34)	945,115 (57.19)	911,370 (55.14)	768,987 (46.53)
Washington (1,355,704)	1,116,409 (82.35)	1,107,391 (81.68)	1,027,414 (75.78)	391,565 (28.88)
West Virginia (341,981)	45,853 (13.41)	44,022 (12.87)	38,825 (11.35)	22,765 (6.66)
Wisconsin (1,097,595)	404,873 (36.89)	403,055 (36.72)	393,526 (35.85)	168,310 (15.33)
Wyoming (106,612)	4,151 (3.89)	3,508 (3.29)	887 (0.83)	293 (0.27)

Table 3.1. Proportion of female population aged 15-44 years living within 30-minute drive time of abortion-providing facility using block-, block group-, ZCTA-, and county-based estimates.

Area	<i>Block group vs. block estimate</i>	<i>ZCTA vs. block estimate</i>	<i>County group vs. block estimate</i>
United States	-0.35	-2.72	-24.21
District of Columbia	0.00	0.00	0.00
Massachusetts	-0.05	-0.47	-21.17
Pennsylvania	-0.08	-0.72	-7.51
Rhode Island	-0.12	-1.45	-6.74
Connecticut	-0.12	-0.46	-12.78
South Dakota	-0.14	-0.51	-14.98
Minnesota	-0.14	-1.68	-15.65
Virginia	-0.15	-2.19	-10.81
Ohio	-0.16	-1.05	-16.53
Wisconsin	-0.17	-1.03	-21.55
Kentucky	-0.17	-1.76	-6.48
New York	-0.19	-0.75	-15.37
Illinois	-0.20	-0.99	-24.79
Missouri	-0.20	-1.20	-8.31
Tennessee	-0.21	-2.67	-7.31
Texas	-0.24	-2.47	-17.23
Oklahoma	-0.25	-2.72	-16.78
Michigan	-0.25	-1.86	-18.74
Kansas	-0.26	-1.79	-13.79
New Jersey	-0.27	-1.01	-9.91
Maryland	-0.28	-1.07	-12.01
Arizona	-0.28	-5.17	-62.67
North Carolina	-0.30	-2.38	-8.17
Georgia	-0.30	-2.11	-6.61
California	-0.32	-4.19	-49.91
North Dakota	-0.33	-0.44	-21.92
Louisiana	-0.35	-2.73	-21.47
Nebraska	-0.37	-0.78	-7.35
Indiana	-0.41	-2.12	-9.52
Mississippi	-0.42	-2.53	-12.68
Arkansas	-0.43	-4.25	-13.30
South Carolina	-0.49	-4.37	-23.00
Iowa	-0.52	-1.43	-12.81
West Virginia	-0.54	-2.05	-6.75
Utah	-0.57	-3.02	-15.36
Florida	-0.58	-3.17	-38.65
Hawaii	-0.60	-5.93	-45.62
Wyoming	-0.60	-3.06	-3.62
Alabama	-0.61	-3.65	-21.50
Washington	-0.67	-6.56	-53.47
Delaware	-0.77	-2.07	-15.69
Nevada	-0.83	-4.43	-79.49
Idaho	-0.84	-9.79	-30.18

Colorado	-0.87	-6.66	-47.53
Oregon	-0.89	-8.19	-47.77
New Hampshire	-0.93	-1.95	-26.17
New Mexico	-1.41	-8.52	-27.96
Vermont	-1.63	-4.49	-18.96
Maine	-2.01	-2.65	-33.52
Montana	-2.48	-19.37	-42.77
Alaska	-8.51	-27.86	-65.61

Table 3.2. Percentage point difference in abortion accessibility estimates calculated using block groups, ZCTAs, and counties compared to estimates calculated using blocks. States ordered by percentage point difference between block group- and block-based estimates.

CHAPTER 4: Abortion accessibility and gestational age at abortion visit

Introduction

Although surgical and medication abortion are low risk in the United States (US), greater gestational age at the time of abortion is associated with increased health risks.^{30–32} Furthermore, both the direct and indirect costs of abortion care increase with increasing gestational age.³³ Therefore, gestational age is a critical determinant of abortion outcomes and identifying determinants of gestational age at abortion could help improve wellbeing.

Studies of interventions that affected abortion access demonstrate that greater abortion accessibility is associated with earlier gestational age at abortion.^{27–29,61} In one of these studies, compared with before implementation of a telemedicine for medication abortion service (TMAB), clients at a network of clinics were more likely to be in the first trimester of pregnancy after TMAB implementation.²⁷ Similarly, studies show that financial and logistical barriers to abortion care are associated with presenting for abortion at a later gestational age.^{28,29}

Despite evidence that gestational age is a marker of abortion access, the association between accessibility (i.e., travel time or distance to care) and gestational age at abortion has not been well-studied. We sought to determine the extent to which level of abortion accessibility is associated with gestational age at abortion. We hypothesized that having poor abortion accessibility would be associated with an increased risk of obtaining abortion care at later gestational ages.

Methods

We examined the association between abortion accessibility and gestational age at abortion using data from the Guttmacher Institute's 2014 Abortion Patient Survey (APS).⁶² The 2014 APS is a cross-sectional, nationally-representative sample survey of English- and Spanish-speaking abortion clients presenting at a sample of 87 non-hospital, abortion-providing facilities and physician's offices in the United States (US) that responded to the Guttmacher Institute's 2011 Abortion Provider Census. Participating facilities were stratified by the number of abortions performed in 2011 and affiliation with a national organization. Large facilities ($\geq 5,000$ cases per year) were oversampled to better characterize the range in caseload. Facilities that declined participation (41% of active clinics approached) or had more than 50% unusable data (13%) were replaced with another eligible facility that had not previously been invited to participate. All data were self-reported by clients on written questionnaires administered at the abortion-providing facility. Ultimately, 46% of facilities and 76% of clients who were eligible to participate (i.e., were clients of participating facilities in the recruiting time frame) did so. Nonresponse for any given variable ranged from 0.2% to 13%. Missing data on key variables, including gestational age, education, previous abortion, marital status, and age were imputed by Guttmacher investigators using a "hot deck" single imputation.⁶² We included all clients surveyed in the 2014 APS, excluding those who were missing home ZIP code (necessary to compute the exposure), those who were referred to abortion care due to miscarriage, and those who were more than eight weeks' gestation when they discovered they were pregnant (i.e., the cutoff for medication abortion provision in 2014).

Abortion Accessibility

Participants were assigned accessibility status based on abortion accessibility in their residential ZIP code tabulation area (ZCTA). ZCTA-level abortion accessibility was measured as the proportion of US women aged 15-44 years who lived within a 60-minute drive time of an abortion-providing facility in 2015. To calculate this measure of abortion accessibility, we used Advancing New Standards in Reproductive Health's (ANSIRH) 2015 Facility Database. The 2015 Facility Database was constructed using online searches for abortion facilities using natural language searches and includes facilities that offer only medication abortion, only surgical abortion, and both medication and surgical abortion care. Of the 925 facilities in the database, we excluded those that were closed (n=93), facilities funded through the Ryan program that did not advertise services (n=27), and facilities that ANSIRH researchers were uncertain as to whether they offered abortion care (n=24).

To calculate abortion accessibility, we geocoded the 781 included facilities using the *ggmap* package in R version 4.0.2.⁴² The *ggmap* package uses the GoogleMaps API to geocode addresses. Prior to geocoding, all "&" were removed from addresses to improve *ggmap* geocoding.⁴³ All addresses were geocoded with *ggmap*. Latitudes and longitudes for all addresses not geocoded at the rooftop level were manually checked using GoogleMaps and inaccuracies were corrected and geocoding rerun.

After geocoding facility addresses, we used R's *osrm* package, which uses the OpenStreetMap road network,⁴⁴ to calculate 60-minute drive time isochrones for each facility. The *osrm* package calculates drive times based on the OpenStreetMap road

network. OpenStreetMap is a map data platform founded in 2004 that uses a routing algorithm to determine drive times between locations. OpenStreetMap's open source "volunteered geography" data, similar to Wikipedia, are collected and uploaded by users worldwide. OpenStreetMap data are manually validated by contributors who review data to ensure accuracy and data-driven tools are used to identify errors for editing. A 2018 case study that included data from OpenStreetMap data for the state of Massachusetts found that these data were complete and accurate.⁴⁵

To identify the population within a given drive time, we used ZIP code tabulation area ZCTA shapefiles from the 2010 US Census. We obtained 2010 Census ZCTA-level population data from the National Historical Geographic Information System of IPUMS.⁴⁶ We calculated the number of reproductive-aged women in each ZCTA by summing counts of women in age categories inclusive of ages 15 through 44 years.

Using the *sf* package in R,⁴⁷ we identified the intersection between each ZCTA and facility isochrones to determine the fraction of each geographic unit within 60 minutes of an abortion-providing facility. Using these fractions, we calculated the number of women aged 15-44 years who live within 60 minutes of an abortion-providing facility by multiplying the intersection fraction by the total number of women aged 15-44 years living in that ZCTA.

Ultimately, each participant's self-reported ZIP code from the APS was linked to the corresponding ZCTA using the UDS Mapper ZIP Code to ZCTA crosswalk⁶³ and their home ZCTA was assigned the corresponding ZCTA-level abortion accessibility, as calculated above. For our analysis, ZCTA-level abortion accessibility was dichotomized

as 0% accessibility or >0% accessibility, with 0% accessibility the exposure of interest and >0% accessibility considered as the reference.

Gestational Age at Abortion

The outcome was gestational age at abortion. Participants were asked for the first day of their last menstrual period and survey date was recorded. Gestational age was then calculated as the difference between survey date (i.e., date of abortion) and self-reported date of last menstrual period. Participants were also asked to report their gestational age in weeks in response to the question “About how many weeks pregnant are you?” For participants with missing last menstrual period date, the response to this question was used for gestational age. Guttmacher researchers also imputed gestational age in whole weeks for those with missing data on both last menstrual period date and self-reported weeks’ gestation. For this analysis, gestational age at abortion was a binary variable indicating whether the client was in the second trimester of pregnancy (i.e., ≥ 14 versus < 14 weeks’ gestation). The second trimester is a commonly used cut point by service providers and other stakeholders, largely because of the number of legal restrictions targeting provision of abortion care after the first trimester.⁶⁴

Covariates

We used propensity score methods to more efficiently control for confounding in adjusted analyses given the low prevalence of abortion visits at ≥ 14 weeks’ gestation. Propensity scores were calculated to estimate the likelihood of living in a ZCTA where 0% of women aged 15-44 years live within a 60-minute drive time of an abortion-

providing facility compared with living in a ZCTA where >0% of the population of reproductive-aged women live within 60 minutes of an abortion-providing facility. In the propensity score models, we included variables that we believed *a priori* were confounders of the relationship between abortion accessibility and gestational age at abortion visit, or we believed *a priori* were strong predictors of gestational age at abortion (see Figure 4.1 for directed acyclic graph (DAG)), as well as all first order interactions between included covariates.

Included covariates were individual-level, self-reported variables from the APS⁶² and state-level variables were from the Correlates of State Policy Project of the Institute for Public Policy and Social Research at Michigan State University.⁶⁵ Individual-level variables included: age (continuous); education (less than high school, high school or GED, some college or associate's degree, or college or more); poverty status (<100% of Federal Poverty Limit, 100-199% of Federal Poverty Limit, or 200+% of Federal Poverty Limit based on self-reported income category); history of medication or surgical abortion (yes or no); self-reported gestational age in weeks at which they found out they were pregnant assessed as "About how pregnant were you when you found out you were pregnant?" in weeks; and religious affiliation (yes or no) assessed as "What religion are you now, if any?" (Protestant, Catholic, Jewish, or Other). State-level variables included whether the state banned use of private insurance to pay for abortion care (yes or no), whether the state banned use of public insurance to pay for abortion care (yes or no), and whether the state mandated a waiting period between receipt of abortion counseling and receipt of abortion care (yes or no).

Analyses

We used logistic regression to calculate a propensity score for each participant, indicating the probability of living in a ZCTA where 0% of the women aged 15-44 years lived within 60 minutes of an abortion-providing facility conditional on covariates. After calculating propensity scores, we ordered all respondents by propensity score and trimmed areas of non-overlap. Then, all exposed respondents (i.e., home ZCTA accessibility equal to 0%) were ordered by propensity score and sub-divided into 20 strata. Unexposed respondents (i.e., home ZCTA accessibility equal to >0%) were then divided into the same strata as the exposed respondents based on their propensity scores.

We applied fine stratification weights for the average treatment effect in the treated (ATT), as described by Desai and Franklin.⁶⁶ These weights equal 1 for all exposed (i.e., those with 0% accessibility) and for those in the unexposed group (i.e., those with >0% accessibility) the weights are $(N_{\text{exposed in stratum}}/N_{\text{total exposed}})/(N_{\text{unexposed in stratum}}/N_{\text{total unexposed}})$. Subsequently, we calculated weighted odds ratios and 95% confidence intervals to estimate the overall effect and variance by calculating marginal effects estimates using generalized linear models with exposure as the only independent variable. We selected this weighting approach instead of Mantel-Haenszel pooling because, as Desai et al. note, this approach does not require the homogeneity assumption and provides stable estimates for a large number of strata, as well as in the setting of sparsely populated strata.⁶⁷ This model estimates the average treatment effect among the 0% accessibility category. Given that the outcome was uncommon, odds ratios should approximate the relative risk. To assess whether there was effect measure modification

by whether a participant had a prior abortion, we also calculated propensity score-weighted odds ratios stratified by prior abortion status. All propensity score analyses were conducted using the *PSS fine stratification weighting* macro in SAS version 9.4.⁶⁶⁻⁶⁸

Sensitivity Analyses

To assess the extent to which there was variation in gestational age by accessibility, which might limit the potential effect of differences in when participants discovered their pregnancies, we calculated the median gestational age at abortion in both exposure groups among those who discovered they were pregnant at or before five weeks' gestation.

We also conducted two sets of sensitivity analyses using the same fine stratification by propensity score methods described above. First, to assess whether gestational age at the time of discovering the pregnancy affected our estimates due to medication abortion eligibility, we limited our sample to those who discovered their pregnancy at seven or fewer weeks' gestation, six or fewer weeks' gestation, and five or fewer weeks' gestation. Second, although 14 weeks' gestation is the most clinically relevant cut-point for abortion access given that many abortion restrictions target abortion provided after the first trimester, to assess the sensitivity of our findings to other gestational age outcome dichotomizations, we repeated our analyses using two different outcome cut points: ≥ 12 versus < 12 weeks' gestation and ≥ 10 versus < 10 weeks' gestation at abortion.

Results

After excluding APS participants who were missing home ZIP code (n=590), had a listed ZIP code that was not included in the UDS Mapper ZIP code to ZCTA crosswalk (n=52), were referred to abortion care due to miscarriage (n=155), or did not discover their pregnancy until nine weeks' gestation or later (n=1,346), our final analytic sample was 6,237 clients. In total, 5,956 clients were included as participants; 279 of the 5,604 individuals (5.0%) who lived in ZCTAs with >0% accessibility and two of the 633 (0.3%) who lived in ZCTAs with 0% accessibility were trimmed due to non-overlap of propensity scores.

Participants were from all US states and Washington, DC, except for Hawaii, Montana, and Rhode Island, with the number of participants per state ranging from 1 to 898. Participants from California (n=893), Florida (n=396), New York (n=493), Pennsylvania (n=309), and Virginia (n=422) each represented more than five percent of the sample. There was only one participant each from Arkansas, Nebraska, and Vermont.

Distribution of the gestational age at which included participants discovered they were pregnant and at which they had an abortion are shown in Figure 4.2. Among both accessibility groups, median gestational age at discovery of pregnancy was five weeks' gestation and median gestational age at abortion was eight weeks'.

Among the participants, propensity scores ranged from 0.00880 to 0.42819. Propensity score weight distribution in each exposure category is shown in Figure 4.3. Before weighting, the distribution of propensity score was different between the exposure categories. As expected, after weighting, propensity score distribution was nearly

identical between the two exposure categories (see Figure 4.4). The post-weighting c-statistic was 0.51, indicating good balance of covariates between the exposed and unexposed groups after weighting by propensity score (see Table 4.1).

Propensity score-weighted pooled odds ratios and 95% confidence intervals are shown in Table 4.2. We found that compared with living in a ZCTA with >0% accessibility, living in a ZCTA with 0% accessibility was associated with a decreased risk of being ≥ 14 weeks' gestation at abortion visit (propensity score-weighted OR: 0.77, 95% CI: 0.46-1.28).

When we stratified by whether the participant had a prior abortion, odds ratios from propensity score-based fine stratification and weighting analyses were in different directions for the two groups. Among those who had not had a prior abortion we observed a weighted odds ratio of 0.48 (95% CI: 0.22, 1.03), indicating that living in a 0% accessibility ZCTA was associated with decreased risk of obtaining abortion care at ≥ 14 weeks' gestation. Among those who had a prior abortion, living in a 0% accessibility ZCTA was associated with increased risk of obtaining abortion care at ≥ 14 weeks' gestation (weighted OR=1.20, 95% CI: 0.69, 1.41).

Sensitivity Analyses

When we excluded those who found out they were pregnant after five weeks' gestation, median gestational age at abortion was seven weeks among both those with 0% accessibility and those who lived with >0% accessibility.

Results of the remaining sensitivity analyses are shown in Table 4.2. When the sample was restricted to participants who learned about their pregnancy at or before

seven weeks' gestation (n=5,858), at or before six weeks' gestation (n=5,341), and at or before or five weeks' gestation (n=4,113), the odds ratios from propensity score-based fine stratification and weighting analyses were in the same direction and of similar magnitude to the odds ratio calculated using the sample that learned of their pregnancy at or before eight weeks' gestation (weighted OR=0.68, 95% CI: 0.37, 1.23; weighted OR=0.65, 95% CI: 0.33, 1.25; and weighted OR=0.69, 95% CI: 0.28, 1.67, respectively).

When we considered alternative dichotomizations for the outcome, gestational age at abortion, the odds ratios from propensity score-based fine stratification and weighting analyses were in the opposite direction, indicating that living in a ZCTA with 0% accessibility compared with >0% accessibility was associated with presenting for care at a later gestational age, though odds ratios were close to the null. When dichotomized as ≥ 12 versus < 12 weeks' gestation at abortion visit we observed a propensity score-weighted odds ratio of 1.03 (95% CI: 0.71, 1.51) and when dichotomized as ≥ 10 versus < 10 weeks' gestation we observed a propensity score-weighted odds ratio of 1.11 (95% CI: 0.86, 1.42).

Discussion

In this study, which assessed the effect of ZCTA-level abortion accessibility on abortion clients' gestational age at abortion, we unexpectedly found that living in a ZCTA where 0% of women aged 15-44 years lived within a 60-minute drive time of an abortion-providing facility was associated with lower risk of obtaining abortion care at or after 14 weeks' gestation. This finding contradicts the one study to date examining this relationship, which found an association between increased accessibility due to

implementation of a telehealth for medication abortion model in a health care system and increased proportion of abortions within that health system occurring prior to the second trimester; however, both exposure and outcome were different in our study and we considered individual-level experiences rather than population-level.²⁷ Similarly, findings from analyses stratified by prior abortion status were unexpected; among participants who had a prior abortion, living in a 0% accessibility ZCTA was associated with increased risk of obtaining abortion care at or after 14 weeks' gestation, while among those who had not had a prior abortion, living in a 0% accessibility ZCTA was associated with decreased risk of obtaining abortion care at or after 14 weeks' gestation. This contradicts our hypothesis that those with prior abortion experiences would be able to navigate poor accessibility landscapes more easily than those without a prior abortion experience. Our findings are likely explained by limitations to this study.

Limitations

In this study, there is a potential for selection bias; as in many studies of abortion, we condition on receipt of abortion by only including individuals who receive clinic-based abortion care. By conditioning in this way, those who wished to obtain abortion care but were unable to do so and those who obtained abortion care outside of a clinical setting are excluded. Given our unexpected findings, we believe that there are likely unmeasured confounders of the relationship between receipt of abortion and gestational age at time of abortion, such as social support or social stigma. As a result of conditioning on receipt of abortion at a clinic, these uncontrolled confounders could induce a selection bias and result in bias toward and beyond the null, resulting in an

estimate of effect in the opposite direction from the truth.

Misclassification of abortion accessibility is also possible from the same mechanisms as reported in Chapters 1 and 2 of this dissertation. In this study, there is also an increased risk of misclassification of abortion accessibility because we used a larger spatial boundary (i.e., ZCTA versus block) that may be more heterogeneous. Individuals may experience different abortion accessibility than that assigned to them based on their ZIP code of residence. Furthermore, in Chapter 2 of this dissertation we found that ZCTAs were more likely to misclassify abortion accessibility compared with smaller geographies. Our measure of abortion accessibility for this study dichotomized accessibility as 0% or >0%, which may mitigate concerns related to misclassification of geographies that do not overlap entirely with a drive time isochrones; however, dichotomization of exposure may mask heterogeneity of effect. There may also be exposure misclassification due to the use of ZIP codes to assign ZCTAs. Grubestic and Matisziw reported that there can be spatial mismatch between ZIP codes and ZCTAs.⁶⁹ As a result, by assigning ZCTA-level accessibility based on ZIP codes, we may misclassify accessibility for some participants.

Additionally, for this analysis we used the 2015 ANSIRH facility database, as the timing of those data more closely matched the APS timing than the 2018 ANSIRH facility database; however, unlike the 2018 database, this database was not verified using mystery shopper methods and it may not accurately identify abortion-providing facilities. If any of this misclassification differs by location (e.g., by urban/rural status), our results may be biased.

Additionally, we only considered one definition of abortion accessibility (i.e., 60 minute drive time). We selected this intermediary driving time as compared to a shorter (i.e., 30 minute) or longer (i.e., 90 minute) drive time to account for variation in definitions of accessibility. This may not be considered an accessible driving distance for those living in urban areas, while those living in rural areas may consider longer drive times to be accessible. As a result, this dichotomization of abortion accessibility may mask effects of accessibility on gestational age at abortion.

Similarly, there are concerns that because participants did not all discover their pregnancies at the same gestational age, our estimates of effect could be influenced by variation in gestational age at pregnancy discovery. Clients who discovered their pregnancies at later gestational ages have reduced opportunity to obtain abortion care at earlier gestational ages, which represents a form of selection bias. While our study design does not allow us to account for time at risk, in sensitivity analyses that were restricted to include only those who discovered their pregnancy at or before seven weeks', at or before six weeks', and at or before five weeks' gestation, the magnitude and direction of estimates of effect were similar. Median gestational age at abortion was also similar across exposed and unexposed groups among those who discovered their pregnancy at or before five weeks' gestation indicating that differential gestational age at discovery of pregnancy may not have affected our results.

Additionally, gestational age at which the pregnancy was discovered may be misclassified. We restricted by gestational age at pregnancy discovery for both the main analyses and sensitivity analyses. We may observe biased estimates if gestational age at

pregnancy discovery was misclassified.

Furthermore, gestational age at abortion may be misclassified for some clients. Studies that compare gestational age dating using self-reported last menstrual period versus ultrasound indicate that gestational age is misclassified when using self-reported date of last menstrual period.⁷⁰⁻⁷⁵ Compared with ultrasound dating, reports of the date of last menstrual period from young women and Black and Hispanic women tend to either over- or under-report gestational age.^{71,72} As a result, there is concern that this misclassification may be differential by abortion accessibility (e.g., due to differential distribution of younger women and Black and Hispanic women across the US) and could bias results unpredictably. Furthermore, due to dichotomization of the outcome we may mask the true association between abortion accessibility and gestational age at abortion. This concern appears valid given that the direction of our association changed when we considered alternative outcome dichotomizations (i.e., ≥ 12 versus < 12 weeks' and ≥ 10 versus < 10 weeks') in sensitivity analyses. Although 14 weeks' gestation is the most clinically meaningful cut point for considering first versus second trimester abortion care and accompanying abortion restrictions, there may be non-clinically meaningful considerations that affect abortion utilization at earlier gestational ages.

Gestational age at abortion may also be misclassified due to imputation. For those clients missing LMP, we used self-reported weeks' gestation at abortion, where available. Self-reported weeks' gestation could be more accurate than LMP if based on an ultrasound in early pregnancy. Furthermore, if clients reported neither LMP nor weeks' gestation, gestational age could be misclassified if Guttmacher Institute's imputation

procedures did not include all variables needed to accurately impute gestational age at abortion. Bias could arise if accuracy in the reporting or imputation of gestational age at abortion depended on abortion accessibility.

There is also the potential for uncontrolled and/or residual confounding. We used a DAG (see Figure 4.1) to identify covariates for the propensity score model and included only those variables thought to be true confounders or strong predictors of the outcome. Despite these efforts, confounding may remain if we failed to account for all measured confounders, there is misclassification or misspecification of one or more measured confounders, or if any confounders are unmeasured. Such uncontrolled or residual confounding could bias our results upward or downward.

Additionally, there may be unaccounted for random effects at the ZIP code or state level. In cases where there are multiple participants from a ZIP code or state, these random effects could explain some of the covariance relationship between abortion accessibility and gestational age at abortion. Similarly, there could be spatial autocorrelation between covariates that is not accounted for in this study.

Finally, we were unable to conduct analyses stratified by state due to small numbers. It is possible that there is effect measure modification by state abortion provision landscape that is masked in these national-level analyses.

Conclusions

In this study of the effect of abortion accessibility on gestational age at abortion visit, our findings unexpectedly indicate that poor abortion accessibility reduced the risk of presenting for abortion care in the second trimester. We believe that these unexpected

findings could be due to a selection bias induced by limiting the sample to those who obtained abortion care, uncontrolled or poorly controlled confounding, misclassification of exposure and/or outcome, and/or unidentified effect measure modification by state abortion provision landscape. Future studies should examine this potential association in other data sets considering a continuous outcome, as well as the effect of bias in studies of abortion access in the US that use data collected from abortion clients.

Tables and Figures

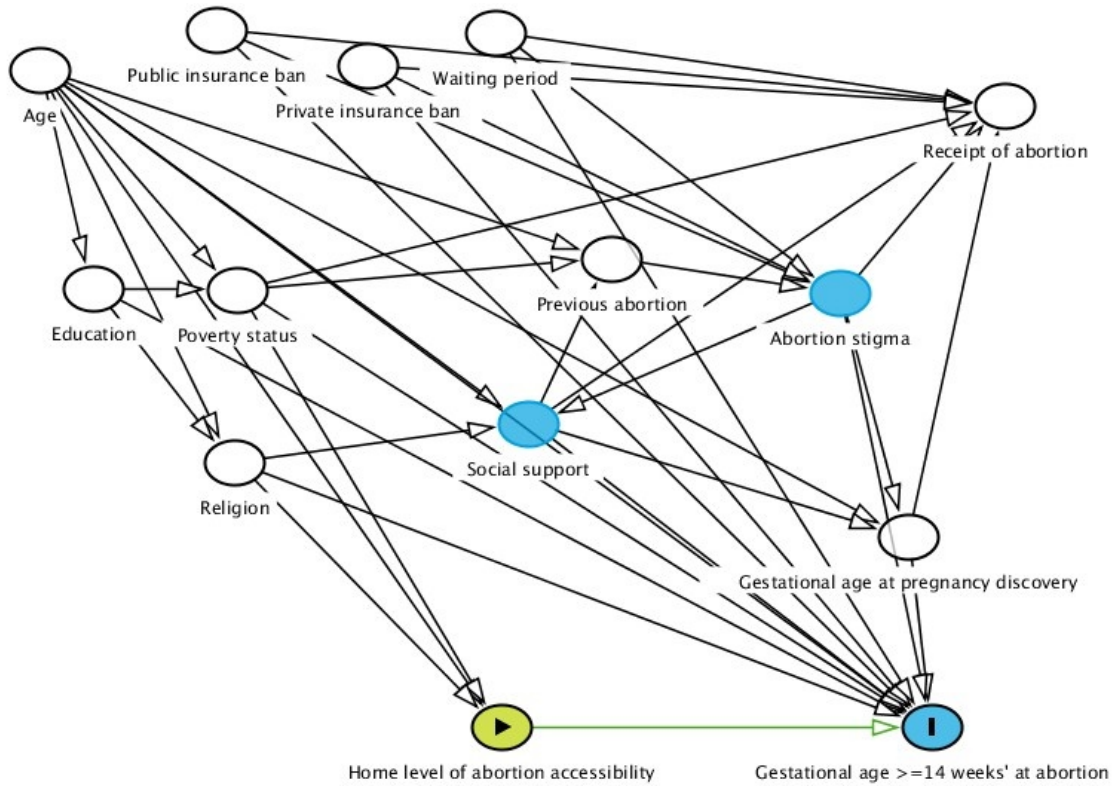


Figure 4.1. Direct acyclic graph for relationship between abortion accessibility and gestational age ≥ 14 weeks' at abortion.

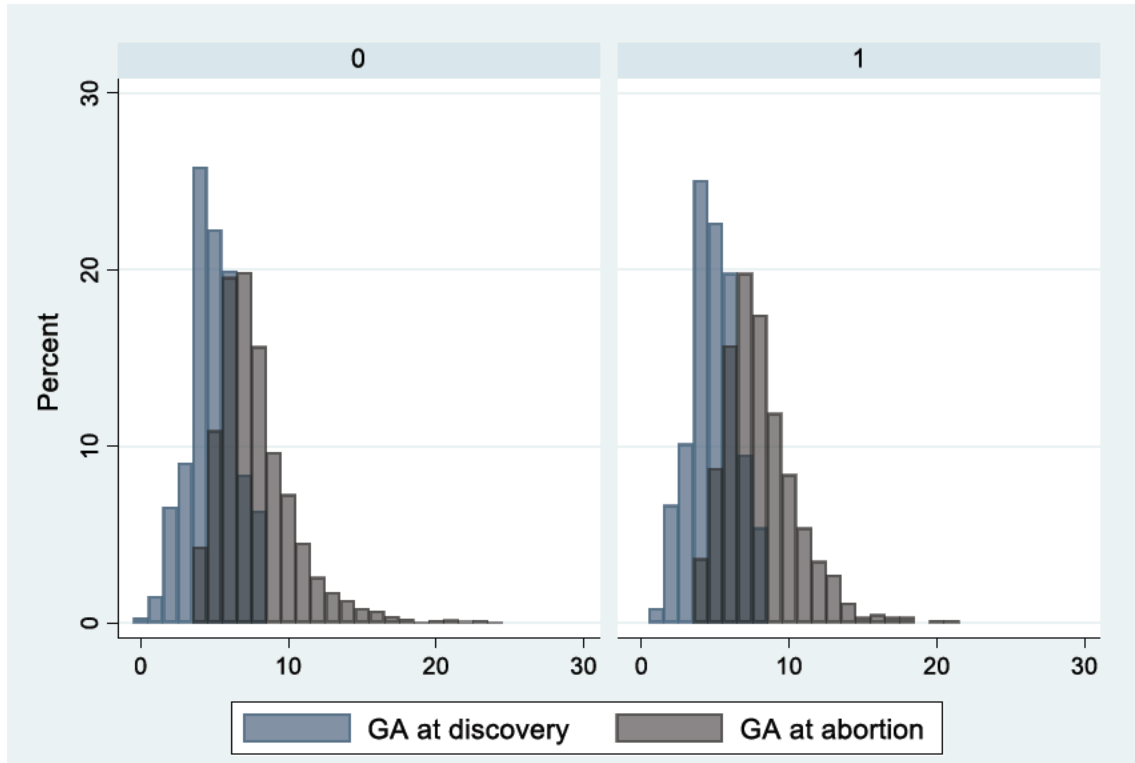


Figure 4.2. Gestational age (GA) at discovery of pregnancy and at abortion, by accessibility status (0=>0%, 1=0%).

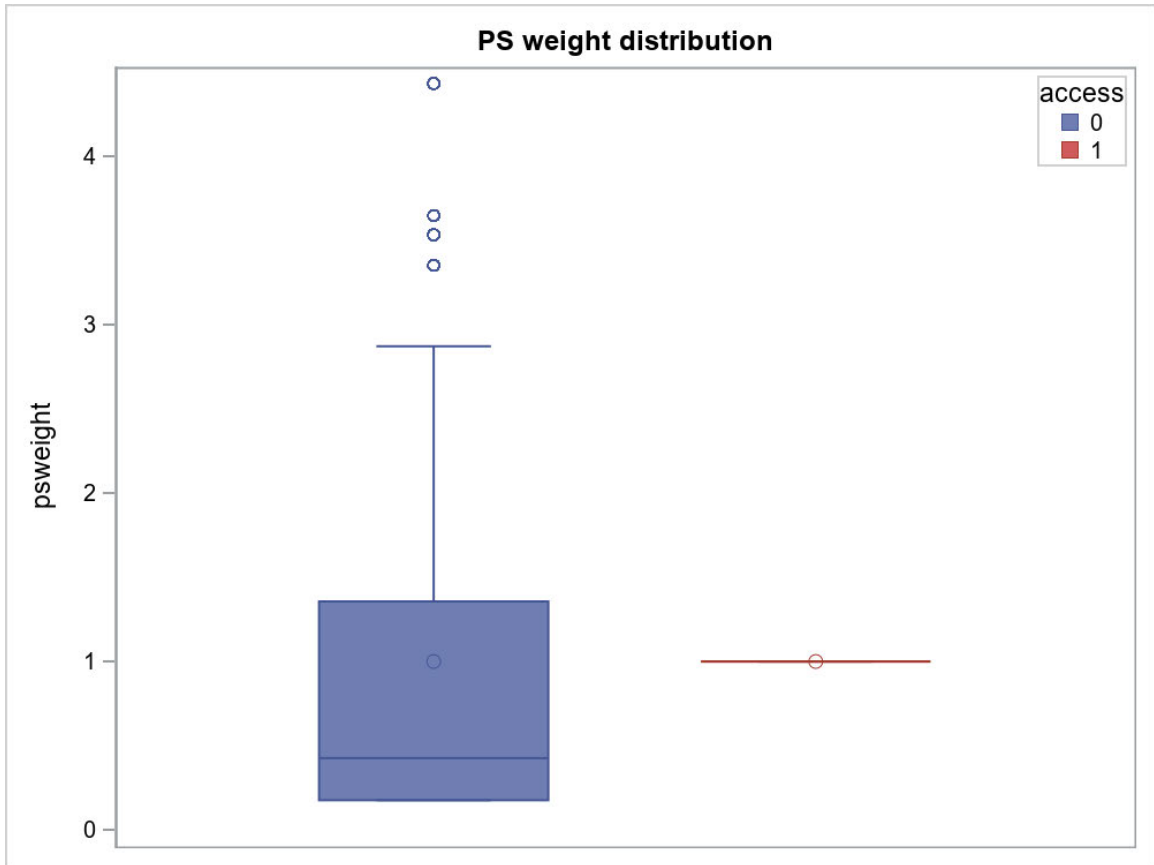


Figure 4.3. Propensity score distribution by accessibility category (0= >0%, 1= 0%).

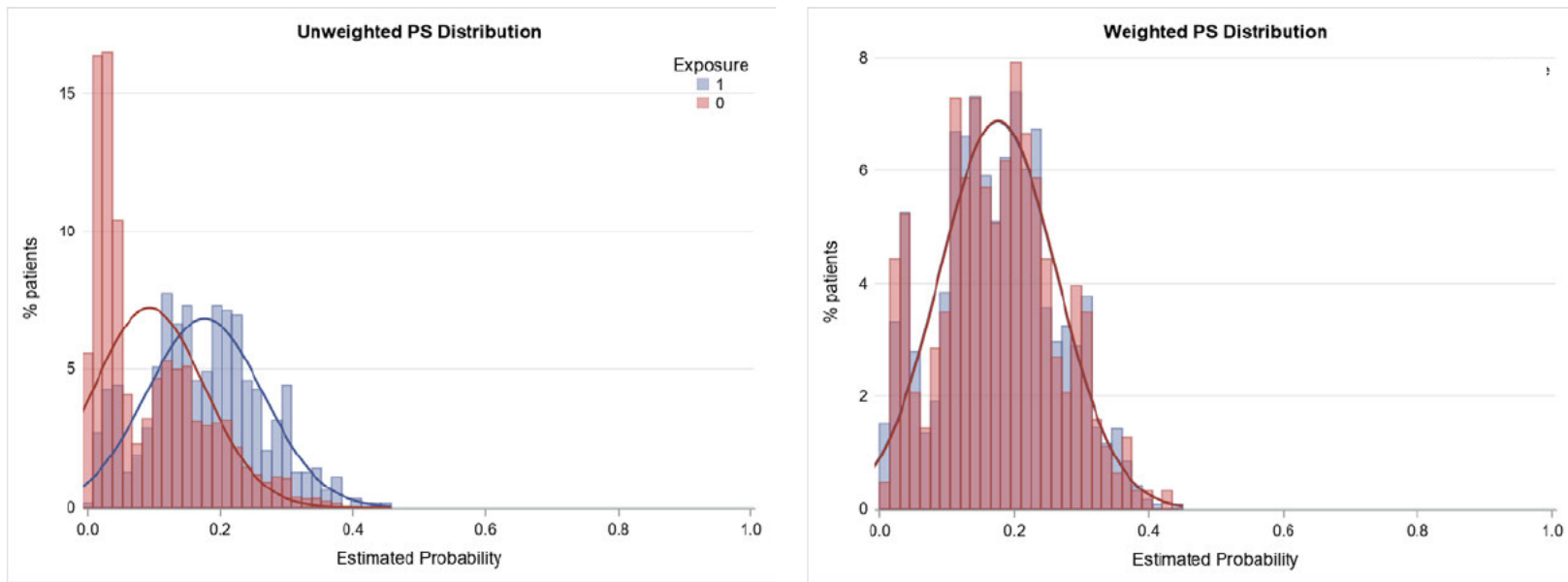


Figure 4.4. Pre- and post-weighting propensity score distribution by exposure category (0= >0%, 1= 0%).

	Accessibility status	
	<i>0%</i> <i>(n=631)</i>	<i>>0%</i> <i>(n=5,325)</i>
	<i>n (%)</i>	<i>n (%)</i>
<i>Average age (SD)</i>	25.8 (5.9)	25.8 (5.9)
<i>Average gestational age when pregnancy was discovered, weeks (SD)</i>	4.9 (1.6)	4.9 (1.6)
<i>Education</i>		
Less than high school	45 (7.1)	374 (7.0)
High school or GED	203 (32.2)	1,716 (32.2)
Some college or associate's degree	286 (45.3)	2,410 (45.3)
College or more	97 (15.4)	825 (15.5)
<i>Poverty status</i>		
<100% Federal Poverty Limit	278 (44.1)	2,372 (44.5)
100-199% Federal Poverty Limit	195 (30.9)	1,634 (30.7)
200+% Federal Poverty Limit	158 (25.0)	1,319 (24.8)
<i>Religious affiliation</i>	399 (63.2)	3,363 (63.2)
<i>Previous abortion</i>	201 (31.9)	1,707 (32.0)
<i>State bans public insurance coverage of abortion</i>	372 (59.0)	3,144 (59.1)
<i>State bans private insurance coverage of abortion</i>	418 (66.2)	3,513 (66.0)
<i>State mandated abortion waiting period</i>	525 (83.2)	4,420 (83.0)

Table 4.1. Participant characteristics by accessibility status, weighted by propensity score.

	Odds ratio	Lower 95% confidence limit	Upper 95% confidence limit
<i>All participants</i>	0.77	0.46	1.28
<i>No prior abortion</i>	0.48	0.22	1.03
<i>Prior abortion</i>	1.20	0.69	1.41

Table 4.2. Propensity-score weighted association between no abortion accessibility compared with any accessibility and receipt of abortion at ≥ 14 weeks' gestation for all participants and stratified by prior abortion status.

Sensitivity analysis	Odds ratio	Lower 95% confidence limit	Upper 95% confidence limit
<i>Gestational age at discovery of pregnancy</i>			
≤7 weeks'	0.68	0.37	1.23
≤6 weeks'	0.65	0.33	1.25
≤5 weeks'	0.69	0.28	1.67
<i>Gestational age at abortion (outcome) dichotomization</i>			
≥12 versus <12 weeks'	1.03	0.71	1.51
≥10 versus <10 weeks'	1.11	0.86	1.42

Table 4.3. Propensity score-weighted association between no abortion accessibility compared with any accessibility and receipt of abortion at ≥14 weeks' gestation from sensitivity analyses (unless alternative outcome specified).

CHAPTER 5: Conclusions

Through this dissertation work we explored three gaps in the abortion accessibility literature. In the first study, we quantified the potential impact of TMAB expansion and TMAB ban removal on abortion accessibility for all US women of reproductive age. In the second study, we determined the potential magnitude of abortion accessibility misclassification resulting from calculations based on block groups, ZCTAs, or counties as compared to blocks. And finally, in the third study, we examined the effect of abortion accessibility on gestational age at abortion.

In the first study, which employed the smallest geographic unit available through the US Census, assumed no barriers to inter-state travel, and examined a variety of potentially acceptable drive times, we found that changes to TMAB programming and policy could expand abortion accessibility in the US. While these policy and programming changes universally increase abortion accessibility, there was variation in the magnitude of the increase. In some states, the considered changes resulted in little gain in abortion accessibility, whereas in other states, gains were quite dramatic. These findings point to potential programming and policy interventions to increase abortion provision to have the greatest impact on accessibility. Despite our findings, even in the scenario with the highest level of accessibility, large numbers of women would have inadequate abortion accessibility according to our measures. This study uses a broadly-applicable framework to measure abortion accessibility, which can easily be adapted to assess the effects of different abortion service expansions or restrictions on the same measure of accessibility.

In the second study, findings demonstrate that block group- or ZCTA-based estimates of abortion accessibility in the US may result in little misclassification relative to measures constructed using blocks at the national level. However, we found that use of counties, the largest geographic unit we considered, may dramatically underestimate abortion accessibility compared with blocks nationally and across all states. Although the ZCTA-based estimate for US accessibility only differed slightly from the block-based estimate, there was notable variation in state-level percentage point differences comparing ZCTA-based estimates with block-based estimates. Block group- or ZCTA-based estimates may be more computationally practical for widespread use to calculate nationwide estimates given the large size of block files; however, for state-level analyses, block group-based estimates may be more appropriate given that for some states, ZCTA-based estimates were substantially misclassified. However, when possible, and particularly when estimate precision is important and may inform resource or funding allocation, block-based estimates remain the most appropriate choice.

Finally, in the third study, our findings unexpectedly suggest that low abortion accessibility reduced the risk of presenting for abortion care in the second trimester. We believe that these findings, which contradict the literature to date, could be due to a selection bias induced by limiting the sample to those who obtained abortion care, uncontrolled or poorly controlled confounding, misclassification of exposure and/or outcome, unidentified effect measure modification by state-level abortion provision and/or masking of small area differences. Future studies should examine this potential association in other data sets, as well as the effect of bias in studies of abortion access in

the US that use data collected exclusively from abortion clients.

The results of this dissertation point to opportunities to improve abortion accessibility in the US, as well as ways to improve the measurement of abortion accessibility. Based on this work we suggest that: (1) findings from our first study should be used to inform resource allocation to improve abortion accessibility through expansion of TMAB services and removal of TMAB bans, (2) future analyses should use the smallest feasible geographic unit when assessing abortion accessibility, and (3) other studies should be undertaken to examine the association between abortion accessibility and continuous gestational age at abortion, as well as to further examine the bias in studies of abortion access in the US that use abortion client data, as well as techniques to minimize bias, such as recruiting study samples outside of clinical settings.

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CURRICULUM VITAE

