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Geographic access to buprenorphine prescribers for patients who use public transit

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Abstract

Objective: Urban Medicaid enrollees with opioid use disorder often rely on public transit to reach buprenorphine prescribers. Research has not shown whether public transit provides this population with adequate geographic access to buprenorphine prescribers. We examined travel times to buprenorphine prescribers by car and public transit in urban areas, and determined whether car-based Medicaid regulatory standards produce their intended geographic coverage.

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Methods: We obtained data for this study from the Substance Abuse and Mental Health Services Administration's Buprenorphine Practitioner Locator, Microsoft Bing Maps, and the American Community Survey. We examined four urban counties at the centers of the metropolitan statistical areas with the highest 2017 accidental drug poisoning death rates: Kanawha, WV; Montgomery, OH; Philadelphia, PA; and St. Louis City, MO. These counties comprised 696 census tracts representing 1,038,564 households. We calculated travel times from each census tract center to the nearest buprenorphine prescribers by car and public transit, and compared that to 30-minute regulatory standards and by whether census tracts had below median levels of car access. We calculated Global Moran's I statistics to determine whether spatial clustering was present among census tracts with limited access to buprenorphine prescribers.

Results: Households in all but two census tracts could access a buprenorphine prescriber within 30 minutes by car. However, households in 12.1% (84) of census tracts could not do so by public transit. The correlation between car- and public transit-based travel times to the nearest buprenorphine prescriber was 0.11 (95% CI = 0.07–0.22). More than 15% (47,918) of households in the two less densely populated counties could not travel to the nearest prescriber in 30 minutes and resided in census tracts where access to cars was relatively low. There was no evidence of spatial clustering among census tracts with public transit travel times exceeding 30 minutes, or among census tracts with public transit travel times exceeding 30 minutes and below median values of access to cars.

Conclusions: Geographic access to buprenorphine prescribers is overestimated by regulatory standards that apply car-based travel time estimates, which are a weak proxy for public transit-based travel times. Since geographic areas with limited access to buprenorphine prescribers do not tend to cluster near one another, individually targeted interventions may be necessary to improve buprenorphine access and utilization.

Keywords

Buprenorphine; Geographic access; Medications for opioid use disorder; Opioid use disorder; Public transit; Medicaid

1. Introduction

More than 2.1 million Americans have opioid use disorder (OUD), resulting in nearly 50,000 deaths from opioid overdose annually (Ahmad, Rossen, Spencer, Warner, & Sutton, 2018; Bose, Hedden, Lipari, Park-Lee, & Tice, 2018). Medications for opioid use disorder (MOUD), including buprenorphine, are effective treatments for OUD (Substance Abuse and Mental Health Services Administration, 2019b); however, less than 20% of persons with OUD actually receive these therapies (Wu, Zhu, & Swartz, 2016). A major challenge to the initiation and maintenance of therapy with MOUD is travel burden (Palmer, Murphy, Piselli, & Ball, 2009; Priester et al., 2016; Sutter, Gopman, & Leeman, 2017; Syed, Gerber, & Sharp, 2013), as persons using buprenorphine typically require frequent visits to prescribers over a period of months or years (Substance Abuse and Mental Health Services Administration, 2019b). For Medicaid enrollees, who compose 38% of persons with OUD (Zur & Tolbert, 2018), geographic access to care may be especially difficult, as their low

incomes and low rates of car ownership increase the burden of travel to receive MOUD (Anthes, 2018; Buzza et al., 2011; Syed et al., 2013).

Under federal law, states are required to implement time- and distance-related Medicaid access monitoring standards for managed care organizations. These standards are meant to ensure that Medicaid enrollees can access covered services “within reasonable timeframes”, to which end states must establish time and distance travel standards (Medicaid and CHIP Payment and Access Commission, 2016). The most common of these standards is a rule that a primary care provider be available within a 30-minute car drive, though considerable variation in this rule exists across states (Forbes, 2018; Murrin, 2014; Rosenbaum, Schmucker, & Beckerman, 2018). States are not required to develop monitoring standards for MOUD prescribers (Medicaid and CHIP Payment and Access Commission, 2016), nor do states appear to have done so (Medicaid.gov, 2016).

As these standards assume that Medicaid enrollees have access to a car, they likely underestimate the travel burdens facing this population, particularly in urban areas where low-income persons experience disparities in access to cars and are reliant on public transit (Chaiyachati, Hom, Hubbard, Wong, & Grande, 2018; Goldberg, 2001; The Zebra, 2019). Examining the potential travel burdens that persons with OUD face, assuming that they do not have access to a car, could inform policies that would reduce geographic barriers to MOUD access, such as non-emergency medical transportation, mobile clinics, and telemedicine.

The objective of this study was to examine potential travel times to the nearest buprenorphine prescriber by car and public transit in urban areas that the opioid epidemic has impacted. Our approach accounts for road structure, traffic conditions, and public transit routes. We compared travel times to the 30-minute car-based travel standard that many state Medicaid agencies employ for primary care, and examined whether public transit facilitates access to MOUD for households in areas with less access to cars. We also identified whether households with long travel times to their nearest buprenorphine prescriber and lower rates of car access are clustered together geographically and thus well situated for area-specific interventions, such as mobile clinics (Hall et al., 2014).

2. Methods

2.1 Study design

We examined potential travel times from the geographic centers of census tracts to buprenorphine prescribers by car and public transit using a publicly available list of buprenorphine prescribers, United States census data on population characteristics and car access, and publicly available municipal databases containing information on the built environment of urban areas and their public transit systems. We performed cluster analyses to determine if census tracts with poor access were spatially adjacent. Knowing whether this is the case could help policy-makers to prioritize built-environment or mobile health services interventions versus alternative transportation approaches.

We conducted our census tract analyses in the four urban counties that are the centers of metropolitan statistical areas that had the highest mortality rates for accidental drug poisoning nationally in 2017, using vital statistics data from the National Center for Health Statistics (University of Pittsburgh Graduate School of Public Health, 2019). This measure is appropriate and preferable to accidental drug poisoning deaths specifically from opioids for three related reasons. First, the opioid epidemic may be more properly characterized as part of a broader drug epidemic (Jalal et al., 2018). Second, polysubstance use is quite common among persons with OUD, meaning that it is often unclear which specific drug is responsible for an accidental drug poisoning death (Winkelman, Chang, & Binswanger, 2018). Third, there is considerable variation in coding practices among medical examiners and coroners (Robinson, 2017). Focusing more broadly on accidental drug poisoning deaths thus allows us to avoid bias in county selection due to these issues.

2.2 Study population

Our unit of analysis was the census tract. We included all census tracts in the four urban counties of our sample: Montgomery County (Ohio), St. Louis City (Missouri), Kanawha County (West Virginia), and Philadelphia County (Pennsylvania). We used United States Census Bureau data to estimate number of households in each census tract. These counties represent some of the urban areas most affected by the opioid epidemic in the United States. Pennsylvania and West Virginia have the highest number and rate of opioid-related deaths, respectively (Centers for Disease Control and Prevention, 2020). Dayton, seat of Montgomery County, has some of the highest drug overdose rates in Ohio, and is also one of the states most affected by the opioid epidemic (Bowman, 2018). While Missouri has lower opioid-related death rates than Pennsylvania and West Virginia, St Louis City County has a substantially higher overdose death rate than the rest of the state (Missouri Department of Health & Senior Services, 2017).

2.3 Data

Our two primary data sources were a list of buprenorphine prescribers from the Substance Abuse and Mental Health Services Administration (SAMHSA), and demographic and geographic information from the United States Census Bureau.

To identify buprenorphine prescribers and their locations, we used SAMHSA's publicly available Buprenorphine Practitioner Locator database (Substance Abuse and Mental Health Services Administration, 2019a), a record of waived buprenorphine prescribers. Prescribers enter their addresses upon receiving their waiver. Prescribers may opt out of being listed publicly, though these prescribers are significantly less likely to actually prescribe buprenorphine (Jones & McCance-Katz, 2019). We queried this database on July 25, 2019.

For census tract-level population counts and demographics, we used the 2017 American Community Survey 5-year estimates (United States Census Bureau, 2020a). Demographic characteristics included population size and households' access to cars, which we used to identify census tracts where the population is particularly reliant upon public transit service.

To identify the geographic centers of census tracts, we used the Census Bureau's 2010 TIGER census tract shapefiles (United States Census Bureau, 2020b).

We obtained supplemental information on county-level demographics from the Health Resources and Services Administration's 2017–2018 Area Health Resource File (Health Resources and Services Administration, 2019), and city-level transportation characteristics from [walkscore.com](https://www.walkscore.com) (Walk Score, 2019), TomTom (TomTom, 2019), the Texas A&M Urban Transportation Institute (Texas A&M Transportation Institute, 2019), and Lyft and Uber.

2.4 Outcomes

Our primary outcome was the minimum travel time in minutes between the geographic center of each census tract and the nearest buprenorphine prescriber, by car and public transit. It is important to note that this is a measure of the *potential* travel burden facing those who may seek treatment for OUD, not a measure of travel burden borne by patients diagnosed with OUD. Minimum travel time is thus a measure of the accessibility of care—travel time between patients and providers, and not the availability of care—the set of healthcare providers from which a patient may choose, subject to capacity constraints (Guagliardo, 2004).

We first obtained the longitude-latitude coordinates of population and prescriber locations. We defined population locations as the geographic centers (i.e., centroids) of census tracts. Their geographic coordinates are given in the Census Bureau's 2010 TIGER census tract shapefiles. We defined prescriber locations as the street addresses of prescribers' practices. We used the OpenCage GeoCoder (OpenCage GmbH, 2019) to geocode prescribers' geographic coordinates (i.e., convert them to longitude-latitude coordinates). The OpenCage Geocoder queries addresses against several different databases to create highly accurate estimates of geographic coordinates. We included all prescribers located in the four study counties' census tracts, and prescribers located in adjacent counties' census tracts.

We then used a two-step process to estimate travel times between the longitude-latitude coordinates of census tracts and buprenorphine prescribers. First, for computational reasons, we identified the five buprenorphine prescribers closest to each census tract's geographic center by Euclidean distance. Second, we calculated road-based travel times to these prescribers by both car and public transit using Microsoft Bing Maps' application programming interface (Microsoft, 2019). Bing Maps accounts for road structure, speed limits, traffic lights and stops, congestion, and public transit routes when calculating travel time. We calculated travel times on Thursday, August 1, 2019, at 9:00 AM, to approximate a typical weekday transit experience. For aggregated results at the county level, we calculated household-weighted means of car and public transit travel time across census tracts.

We compared car and public transit travel times to a 30-minute travel time threshold. We used this threshold as it is the most prevalent Medicaid access monitoring standard (Murrin, 2014). We also used a 90-minute threshold to identify census tracts with very limited access to buprenorphine prescribers.

We defined a census tract as having *limited access* to buprenorphine prescribers if it was not possible to reach the nearest buprenorphine prescriber by car or public transit within 30 minutes, and the census tract rate of households' access to cars was below the county median (see below).

Finally, to estimate the population-level impact of our census tract-based calculations, we used United States Census Bureau data to determine the number of households represented in each census tract.

2.5 Exposures

We used United States Census Bureau data to estimate the proportion of households with access to a car at the census tract level. We categorized each census tract according to whether the proportion of its households with access to at least one car was below the median among census tracts in the census tract's county. We used a county-specific threshold because counties organize their public transit system according to local population characteristics and geography. Low-income households' lower rates of access to cars and the costs of car ownership both suggest that many Medicaid enrollees likely lack access to cars (Goldberg, 2001; Klein & Smart, 2017; The Zebra, 2019).

We compared counties according to their demographic and provider supply characteristics reported in the Area Health Resource File, and city transportation characteristics. City transportation characteristics refer to the city centers of each county and describe the ease of travel. Walk scores measure walkability to neighborhood resources, and transit scores are a measure of access to public transit (Walk Score, 2019). Congestion levels and travel measure the percentage of roadways that are occupied and congested during rush hour, respectively (Texas A&M Transportation Institute, 2019). Private rideshare services indicate whether Uber and Lyft were available at the time of our analysis.

2.6. Statistical analysis

We calculated the Global Moran's I statistic for each county to determine whether there was spatial clustering among: census tracts whose public transit travel times to the nearest buprenorphine prescriber exceeded 30 minutes; and census tracts that had limited access to buprenorphine prescribers (i.e., no car or public transit access to a buprenorphine prescriber within 30 minutes, below county median car access). Global Moran's I statistics estimate the similarity of a given geographic unit to nearby geographic units (Moran, 1950). To calculate Global Moran's I statistics, we treated census tracts that touched one another at one point or more as adjacent (i.e., Queen Contiguity).

We examined the census tract-level correlation between car- and public transit-based travel times to the nearest buprenorphine prescriber using a Pearson's correlation coefficient.

We performed all analyses in the R Statistical Package version 3.5.1. We defined statistical significance as a 2-sided $P < .05$. All data were publicly available; therefore, the research project did not meet the University of Pittsburgh's definition of human subjects research.

3. Results

We included all 696 census tracts from the four counties in our cohort, representing a total of 1,035,539 households. Census tract (household) counts from each county were 53 (76,412) in Kanawha County, 384 (594,778) in Philadelphia County, 153 (223,894) in Montgomery County, and 106 (140,455) in St. Louis City County. We excluded 118 of 1,541 (7.7%) prescribers from our analysis whose addresses could not be determined within one kilometer (0.62 miles).

3.1 Sample county characteristics

The four sample counties broadly followed two patterns in terms of demographic and transportation characteristics (Table 1). Two counties, St. Louis City and Philadelphia, had higher population densities per square mile than Montgomery and Kanawha. St. Louis City (79.3%) and Philadelphia (69.1%) also had lower median household rates of access to cars than Montgomery (84.5%) and Kanawha (90.0%). St. Louis City and Philadelphia also had higher walk and transit scores, indicating it is easier to access neighborhood resources by foot and by public transit in those counties. However, those two counties' higher traffic indices and congestion scores indicate it is more difficult to travel by car. All four counties had a similar number of buprenorphine prescribers per 100,000 population, ranging from 21.5 in Montgomery County to 23.9 in Philadelphia County.

The locations of buprenorphine prescribers and census tract population counts are shown in Figure 1. The geographic distributions of prescribers exhibit considerable variation between the four counties. In Kanawha County, prescribers' locations indicate that travel time to the nearest prescriber is largely determined by travel time to the population center of the county. Prescribers are somewhat more dispersed in Montgomery and St. Louis City Counties, though there is still a cluster of providers in the county seat of Montgomery County, Dayton. Prescribers are dispersed throughout Philadelphia County, though the majority are located in the southwestern third of the county.

3.2 30-minute access to buprenorphine prescribers by car and public transit

Households residing in 99.7% (694) of census tracts could access a buprenorphine prescriber within 30 minutes by car (Figure 2 and Table 2). However, households in 12.1% (84) of census tracts could not access a buprenorphine prescriber within 30 minutes by public transit. We found large variation in public transit access across counties. For example, only households in 1.0% (4) of Philadelphia County census tracts could not access a buprenorphine prescriber within 30 minutes by public transit, compared to 29.4% (45) of households in Montgomery County census tracts and 60.4% (32) of households in Kanawha County census tracts. Public transit times in Montgomery County and Kanawha County sometimes exceeded 30 minutes by large margins. Specifically, travel times to the nearest buprenorphine prescriber exceeded 90 minutes for 10.5% (16) of Montgomery County census tracts and 39.6% (21) of Kanawha County census tracts.

Census tracts where public transit travel times to the nearest buprenorphine prescriber were more than 30 minutes appeared to be scattered throughout Montgomery and Kanawha

counties (Figure 3). Accordingly, we found that census tracts with public transit travel times exceeding 30 minutes were not clustered near one another, as indicated by the Global Moran's I statistics for Kanawha County ($I = 0.11$; $P < 0.07$) and Montgomery County ($I = 0.03$; $P < 0.25$).

The Pearson correlation coefficient between census tracts meeting the 30-minute access standard by car and by public transit was 0.14 (95% CI = 0.07–0.22; $P < 0.001$), indicating that a census tract meeting the typical 30-minute access monitoring standard by car is not a strong predictor of whether it meets the standard by public transit.

3.3 Public transit in census tracts with limited car access

More than 45.2% (38) of census tracts with below median levels of car access also lacked 30-minute public transit service to the nearest buprenorphine prescriber (Table 2). These census tracts were located throughout the two counties where limited access was prevalent, Montgomery and Kanawha (Figure 4). All but 5 (6.0%) of the 38 census tracts with limited access to buprenorphine prescribers were in these two counties. Census tracts with limited access to buprenorphine prescribers did not cluster near one another in Montgomery County (Global Moran's $I = -0.01$; $P < 0.49$) or Kanawha County (Global Moran's $I = -0.06$; $P < 0.67$).

Based on the number of households in each census tract, we estimated that 12.8% (28,626) of households in Montgomery County and 24.3% (19,292) of households in Kanawha County had limited access to buprenorphine prescribers (Figure 4). Overall, 15.8% (47,918) of the households in these census tracts have limited access to buprenorphine prescribers. This limited access reflects limited public transit infrastructure and the geographic distribution of buprenorphine prescribers in these counties. In contrast, only 2.1% (2,924) of households in St. Louis City County and 0.9% (5,156) of households in Philadelphia County had limited access to buprenorphine prescribers.

3.4 Sensitivity analysis

We tested whether our findings were robust to the number of closest prescribers by Euclidean distance for which we calculated travel times. To do so, we re-estimated car-based travel times in Montgomery County when considering the closest, five closest, and ten closest prescribers by Euclidean distance. Mean travel times were not significantly different from one another using these approaches. The magnitude of the difference was small as well; mean travel time decreased by five seconds when considering the ten closest prescribers instead of the five closest prescribers.

4. Discussion

In two of the four urban centers with the highest death rates from accidental drug poisoning in the United States, 15.8% (47,918) of households resided in areas with low access to cars and without public transit service to a buprenorphine prescriber within 30 minutes, a travel time threshold that state Medicaid programs frequently use.

Our findings have significant policy implications. First, existing car-based Medicaid access monitoring standards often do not reflect whether persons dependent upon public transit can reach buprenorphine prescribers in a reasonable timeframe. This is particularly troubling because most persons with OUD reside in urban areas (Romo, Ulbricht, Clark, & Lapane, 2018). After incorporating estimates of car availability and public transit travel times, we found that many urban households cannot access a buprenorphine prescriber within 30 minutes even though one is available within a 30-minute car drive. We also found a weak relationship between travel time to the nearest buprenorphine prescriber by car and by public transit. Both findings indicate that *separate* Medicaid access monitoring standards for public transit are needed.

Second, interventions aimed at improving geographic access to buprenorphine prescribers need to be tailored to individual communities. We found that areas with low car access and limited public transit were not clustered geographically; rather, geographically distinct neighborhoods experienced limited access to buprenorphine prescribers. As such, health systems seeking to identify and treat persons experiencing disparities in access to buprenorphine prescribers will need to target interventions at granular geographies.

Several tools are available to policy-makers to mitigate disparities in geographic access to MOUD. Mobile clinics may be effective in underserved areas where demand for MOUD is high, though they may be less efficient in areas with small patient populations. Telemedicine for OUD is expanding and could mitigate the burden of travel, but it is primarily used as a complement to in-person care and to support providers with less expertise (Huskamp et al., 2018). Altering public transit routes, while possible, is difficult; public transit systems face many other constraints in changing routes aside from access to healthcare.

These facts and our finding that areas with limited access to buprenorphine prescribers do not cluster geographically suggest that nonemergency medical transportation (NEMT) is a promising tool to increase geographic access to buprenorphine prescribers. NEMT is a covered Medicaid benefit that consumes less than one percent of Medicaid's total budget, and healthcare systems and insurers increasingly cover it (Frazee, Lewis, Rodriguez, & Fisher, 2016; Garrity & McGehee, 2014; Pope, 2016). Transportation to MOUD prescribers can be a large component of NEMT programs. For example, there were nearly 13,000 NEMT trips to MOUD prescribers in May 2018 in Cuyahoga County, Ohio, which made up 72 percent of all NEMT trips in the county (Anthes, 2018). Lyft and Uber have recently begun offering NEMT services, potentially increasing the scope and effectiveness of this service (Powers, Rinefort, & Jain, 2016). NEMT is also likely to be affordable in an urban context because, as we found, travel times by car can be quite short in areas where public transit travel times are long. NEMT, thus, may be a cost-effective intervention available to Medicaid policy-makers and healthcare systems seeking to improve OUD-related health outcomes, especially in urban areas. Additionally, expanded NEMT has the potential to reduce disparities in access to MOUD. Persons with physical disabilities that make travel difficult and lower income populations that tend to lack access to cars both stand to benefit greatly from reduced geographic barriers to care, as would demographic groups with limited time to devote to travel to receive care, such as single parents with childcare responsibilities and workers with inflexible and uncertain schedules.

This study has limitations. First, SAMHSA's Buprenorphine Practitioner Locator reports only buprenorphine prescribers who choose to be listed publicly upon receipt of their waiver. While this could lead to overestimates of travel time, prescribers that opt out of being listed cannot be seen by patients searching for a buprenorphine prescriber and are significantly less likely to prescribe buprenorphine (Jones & McCance-Katz, 2019). Second, buprenorphine prescribers not being available due to other access barriers may underestimate travel time. Such barriers include prescribers' willingness to accept new patients, prescribers' hours of availability, and other nongeographic barriers to access (Penchansky & Thomas, 1981). We may underestimate travel time in cases where the nearest buprenorphine prescriber is unavailable for one of these reasons. Third, data were not available on the percentage of Medicaid enrollees with OUD without access to cars at the census tract level. This percentage is likely greater than the percentage of households without access to cars within a given census tract. Thus, our findings may underestimate the degree to which limited car access creates geographic barriers to accessing buprenorphine prescribers. Fourth, there is some measurement error that occurs in our measurement of travel time by assigning each population's location to the centroid of their census tract. However, the relatively small size of census tracts in urban areas considerably limits the extent of this measurement error. Fifth, while our analysis identifies granular geographic areas in which geographic access to buprenorphine prescribers is limited, it does not identify where persons with opioid use disorders are located. Local healthcare systems seeking to use tools similar to ours should combine the tools presented in this analysis with local data on the severity of the opioid epidemic, such as ambulance calls for overdoses, to identify geographic areas in need of localized interventions. Last, the study is limited to four urban centers, all of which exhibited distinct variation in travel time to buprenorphine prescribers. Other urban areas may not adhere to the patterns observed in this study. Policy-makers considering interventions based on the findings of this study should therefore consider the unique needs of and public transit infrastructure in their communities.

Future efforts should incorporate public transit in estimates of geographic access for persons with OUD. This is especially critical given low access to cars among lower income populations (Anthes, 2018; Syed et al., 2013), and the prevalence of OUD in urban areas (Rigg & Monnat, 2015). While geographic access to care for OUD is a pressing issue in rural communities, it is also an important issue in urban areas.

5. Conclusion

In two of the four urban centers with the highest rates of accidental drug poisoning deaths in the United States, roughly a third of households had limited access to cars and insufficient public transit service to reach the nearest buprenorphine prescriber within 30 minutes. Applying rural access standards to urban areas is not sufficient to ensure that persons with OUD living in urban areas have access to MOUD.

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HIGHLIGHTS

- Public transit often does not provide access buprenorphine prescribers in urban areas
- Medicaid access monitoring standards do not capture public transit access to buprenorphine prescribers
- Urban areas with limited geographic access to buprenorphine prescribers tend to be isolated from one another
- Areas with limited public transit access to buprenorphine prescribers often have low rates of car access
- Public transit-based travel times to buprenorphine prescribers can exceed 90 minutes

Figure 1. Geographic distributions of buprenorphine prescribers and population. Buprenorphine prescriber locations were obtained from SAMHSA's Buprenorphine Practitioner Locator. Their addresses were converted to longitude-latitude coordinates using the OpenCage Geocoder. Census tract-level population counts were obtained from the U.S. Census Bureau's 2018 5-Year American Community Survey.

Figure 2. Distributions of travel times to the nearest buprenorphine prescriber by car and public transit.

The distributions of car- and public transit-based travel times are shown in pink and blue, respectively. The dashed red line graphs the typical 30-minute Medicaid access monitoring standard for travel to primary care providers by car. Estimates of the number of households without 30-minute public transit service to the nearest buprenorphine prescriber are made using counts of the number of households in each census tract.

Figure 3. Car and public transit travel time in minutes to the nearest buprenorphine prescriber by census tracts.

Travel times calculated from geographic centers of census tracts. Census tracts in which public transit is not available (6 in Montgomery, 10 in Kanawha) are displayed as 90+.

Figure 4. Joint geographic access to buprenorphine prescribers by public transit and access to cars.

Census tracts without access to the nearest buprenorphine prescriber within 30 minutes are coded as having limited public transit service. Census tracts with public transit travel times over 100 minutes or without service were included in the limited public transit service category. Census tracts with below-median car access are coded as having limited car access. The median values of households without car access are 7.86% (Montgomery), 8.81% (Kanawha), 30.81% (Philadelphia), and 23.06% (St. Louis City). The percentage of households with limited or no access to buprenorphine prescribers is

calculated as the household-weighted number of census tracts in a county with public transit times over 30 minutes and car access below the given county's median car access level.

Table 1.

County characteristics.

Characteristic	City, County, State ^a			
	Dayton, Montgomery, Characteristic Ohio	Charleston, Kanawha, West Virginia	Philadelphia, Philadelphia, Pennsylvania	St. Louis, St. Louis City, Missouri
<u>County Demographics^b</u>				
Population (100,000s)	5.32	1.83	15.81	3.09
County Size (Square Miles)	464	911	143	523
Population Density (#/Sq. Mi.)	11595	2141	113795	51575
Male, Aged 18-45 (%)	19.1	19	21.4	23.8
Unemployment Rate (%)	4.9	5	6.2	4.4
Median Income (\$10,000s)	4.72	4.5	4.15	4
Poverty (%)	18.2	16.8	25.3	24.3
Accidental Drug Poisoning Death Rate (per 100,000) ^c	96.9	65.5	64.3	67.1
<u>Provider Supply Per 100,000 Population</u>				
Primary Care Physicians ^d	93.1	136.9	66.9	88.1
Buprenorphine Prescribes ^e	21.5	22.4	23.9	22
<u>City Transportation Characteristics</u>				
No Car Access (%) ^f	15.5	10	30.9	20.7
Walk Score (0-100) ^g	46	32	79	65
Transit Score (0-100) ^g	-	23	67	45
Congestion Level (%) ^h	10	-	24	14
Congested Travel (%) ⁱ	8.4	-	18.8	24.1
Private Rideshare Services ^j	Yes	Lyft Only	Yes	Yes

^aCounties in the sample are the four counties at the centers of metropolitan statistical areas with the highest accidental drug poisoning death rates.

^bAll county demographics except accidental drug poisoning death rates were obtained from the 2017-2018 Area Health Resource File. Characteristics reflect the latest year for which data were available, which was 2017 for population and unemployment rate, 2016 for median income, poverty, and primary care physicians, and 2010 for population density and percent male.

^cObtained from University of Pittsburgh Mortality Information and Research Analytics platform.

^dAlso obtained from 2017-2018 Area Health Resource File.

^eObtained from SAMHSA buprenorphine treatment locator (numerator) and 2017-2018 Area Health Resource File (denominator).

^fObtained from 2013-2017 American Community Survey 5-year estimates.

^gWalk scores measure the walkability of a neighborhood. Transit scores measure how well a neighborhood is served by public transit. Obtained from [walkscore.com](https://www.walkscore.com) for 2019. Not available for Montgomery County.

^hA measure of the extra car travel time for an average trip due to average congestion, relative to uncongested conditions. Obtained from TomTom, which provides data from 2018. Not available for Kanawha County.

ⁱPercentage of vehicle-miles of travel in congested traffic. Obtained from Texas A&M Transportation Institute's 2019 Urban Mobility Report, which reports on 2017 conditions. Not available for Kanawha County.

^jVerified through Uber and Lyft's websites in September 2019.

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Table 2.

Travel times to buprenorphine prescribers by car and public transit.

Household and Census Tract Characteristics ^a	City, County, State			
	Dayton, Montgomery, Ohio	Charleston, Kanawha, West Virginia	Philadelphia, Philadelphia, Pennsylvania	St. Louis, St. Louis City, Missouri
Census Tract Characteristic, No. (%)				
Nearest Prescriber >30 Minutes by Car ^a	0 (0)	2 (3.8)	0 (0)	0 (0)
Nearest Prescriber >30 Minutes by Public Transit ^a	45 (29.4)	32 (60.4)	4 (1.0)	3 (2.8)
Nearest Prescriber >30 Minutes by Public Transit and Below Median Car Access ^b	20 (13.1)	13 (24.5)	2 (0.5)	3 (2.8)
No. of Census Tracts	153	53	384	106
Household Characteristic, No. (%) ^c				
Nearest Prescriber >30 Minutes by Car ^a	0(0)	3,025 (3.8)	0(0)	0(0)
Nearest Prescriber >30 Minutes by Public Transit ^a	72,161 (32.2)	53,097 (66.8)	9,837 (1.7)	2,924 (2.1)
Nearest Prescriber >30 Minutes by Public Transit and Below Median Car Access ^b	28,626 (12.8)	19,292 (24.3)	5,156 (0.9)	2,924 (2.1)
No. of Households	223,894	76,412	594,778	140,455

^aTravel times are calculated from census tract centroids to the nearest buprenorphine prescriber.^bCensus tracts with below median access are those whose households' rate of access to cars is below the median of county census tracts' rate of access to cars.^cHousehold characteristics are determined by the census tracts in which they reside.