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BRIEF REPORT

Pharmacy deserts: More than where pharmacies are

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ABSTRACT

Background: In the United States, geographic access is a major driver of health care disparities. Studies have shown that pharmacy deserts are prevalent in the United States, even in major metropolitan areas. However, one limitation often cited by these studies is the use of distance rather than travel time to define pharmacy deserts.
Objective: The aim of this study was to assess pharmacy deserts using travel time and to provide a more holistic approach by incorporating analysis of private vehicles and public transportation.
Methods: Pharmacy details were collected from the National Provider Identifier database and neighborhood characteristics from collected census data for the four largest U.S. cities. Pharmacy access was evaluated using open-source routing engines. We determined neighborhoods in pharmacy deserts using both distance and travel time analyses. Sensitivity analysis was performed to determine changes to pharmacy deserts based on small changes in travel time.
Results: Of 4654 neighborhoods identified in the four cities of interest, 670 (14.4%) neighborhoods were in pharmacy deserts based on distance. Despite accounting for 28.9% of all neighborhoods, predominantly white neighborhoods only accounted for 4.3% of pharmacy deserts. When evaluating pharmacy deserts by car and public transportation, predominantly white neighborhoods accounted for 2.3% and 1.7% of total pharmacy deserts, respectively. Finally, by reducing travel time from 15 minutes to 10 minutes, pharmacy deserts by car and public transportation increased by 105% and 199%, respectively. All but 3 of the new pharmacy deserts found in the sensitivity analysis were found in nonpredominantly white neighborhoods.
Conclusion: Using travel time and incorporating modes of transportation, we found that disparities in pharmacy access are more than just where pharmacies are located geographically. There are additional layers of disparities, such as access to public transportation, that need to be addressed to reduce the number of pharmacy deserts.

Background

Health care disparities have long been a concern in the United States. One major driver of disparities is transportation barrier, often due to physical distance and lack of access to public and private transportation.[1,2] Poor access has repeatedly been shown to be associated with worse clinical outcomes.[3-5] One meta-analysis found most studies identified evidence of a distance decay association, where patients living farther away from health care facilities had worse outcomes.[6] Another study found that for those with life-threatening conditions, increased distance to a hospital is associated with an increase in mortality.[4] In the United States, areas with low access to physicians and pharmacies are common and disproportionately impact minority communities.[7-9]

Pharmacies have long played an integral role in delivering quality and timely care for patients by dispensing critical medications such as naloxone and offering preventative care and vaccinations.[10,11] These roles have further expanded since the start of the COVID-19 pandemic by providing essential services such as testing and vaccinations across the country.[12] Researchers aiming to quantitatively study low access to

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pharmacies in the United States have developed the concept of "pharmacy deserts."[7,13]

Adapted from the United States Department of Agriculture's (USDA) definition of "food deserts," pharmacy deserts are low-income communities who are also burdened with poor access to pharmacies.[14] Conventionally, measures of access have been distance-based—either Euclidean, "as the crow flies" distances from pharmacies or, if more sophisticated, using street network data to compute the actual driving distance.[14-16]

These distance measures have different access thresholds for urban and rural areas (e.g., 1 mile for urban settings and 10 miles for rural settings), also adapted from USDA food deserts. For example, in a recent study, Guadamuz et al. used the street network driving distance approach to evaluate pharmacy deserts in the four largest U.S. cities and found that pharmacy deserts were persistently more common in Black and Latino neighborhoods.[13] The authors acknowledged that one limitation of that study was the use of distance rather than travel time to define pharmacy deserts. We agree, believing that travel time is a more ecologically valid measure of access than distance, especially in urban settings, when the two can be more dramatically different. In addition, this serves as an opportunity to evaluate the lack of access to private vehicles and public transportation as barriers to accessing care.[17] We therefore sought to build a model that incorporates real world travel conditions into calculations of health care equity and access.

Objectives

The aim of this study was to assess the differences between using travel time and distance as the benchmark for access in four urban U.S. cities. In addition, we aim to provide a more holistic approach by incorporating access to both private vehicles and public transportation. We hypothesized that incorporating public transportation and travel time will better reflect the present state of disparities in pharmacy access.

Methods

Data sources

Data on retail pharmacies were collected from the National Provider Identifier database, a publicly available database hosted by the Department of Health and Human Services (https://npiregistry.cms.hhs.gov/), extracting only taxonomies relevant to typical retail pharmacies ("Pharmacy" - 333600000X and "Community/Retail Pharmacy" - 3336C0003X). This excluded pharmacy types such as mail order or long-term care pharmacies that would not be readily accessible to community members seeking to fill prescriptions. Demographic and household vehicle access data were collected from American Community Survey (https://www.census.gov/programs-surveys/acs). The four U.S. cities included in this study, New York City (NYC), Los Angeles (LA), Chicago, and Houston, were chosen because they are the four most populous in the United States, allow comparison of this study to previous work[13] analyzing the same locations, and represent differences in urban density and public transit penetrance. For example, NYC has the highest population density of any major city in the United States and has a robust public transit system consisting of buses, ferries, and the largest subway system in the world. In contrast, Houston has a low population density and a more modest system of buses and light rail. City boundaries and public transit data were collected from municipality websites. Census blocks and tracts within each city were determined using city boundaries.

Neighborhood characteristics

Census tracts were used to approximate local neighborhoods. We evaluated the accessibility of pharmacies across different neighborhoods categorized by race, income level, and household vehicle access. Racial categorization was determined by the predominant racial and ethnic composition (≥50% white, Black, or Latino; diverse neighborhoods are areas that did not have a predominant group). Low-income neighborhoods were areas where at least 20% of households had incomes below the federal poverty level. Low household vehicle access neighborhoods were areas where more than 100 households had no access to vehicles. These characteristics are outlined in a previous study on this topic.[13]

Pharmacy access

Two open-source routing engines were used to compute travel times, Open Source Routing Machine (http://project-osrm.org/) for car and walking travel and OpenTripPlanner (https://www.opentripplanner.org/) for public transit travel.

To ensure that the fastest (and not just closest) pharmacy was analyzed, travel times for walking, car, and public transit were computed for every census block to the Euclidean nearest 25 pharmacies, with the shortest duration trip recorded. For public transit, we used 9:00 AM on a Monday morning as the trip time. A population-weighted mean for the census tract (neighborhood) was computed from constituent block level times. Because not all blocks have a viable public transit route (e.g., not within our designated maximum public transit walking distance of 1000 m), if 50% or more of blocks within a tract had no public transit route, the entire tract was deemed to not have public transit access.

For comparison, we performed both distance- and time-based assessment of pharmacy deserts. We defined a distance-based pharmacy desert as a low-income neighborhood whose population-weighted mean drive distance to the nearest pharmacy was greater than 1 mile for neighborhoods with high vehicle access or 0.5 miles for neighborhoods with low vehicle access.

For travel time analysis, we adopted a 15-minute cutoff, similar to USDA's methodology for determining food deserts.[14] Therefore, time-based pharmacy deserts were defined as low-income neighborhoods whose population-weighted mean travel time to the quickest pharmacy was at least a 15-minute drive for neighborhoods with high vehicle access or a 15-minute walk (at 3 miles per hour) for neighborhoods with low vehicle access. Analogously, a public transit pharmacy desert was defined as a low-income neighborhood whose population-weighted mean travel time to the quickest pharmacy by walking and public transit was greater than 15 minutes if the neighborhood had public transit access or greater than 15 minutes by walking alone if it did not.

Table 1
Neighborhood characteristics by predominant race

City	Racial makeup	Neighborhood descriptions			
		Population	Neighborhoods (%)	Poverty ≥ 0.2 (%)	No cars ≥ 100 (%)
New York City	Total	78,79,889	2,129 (100.0)	689 (100.0)	1847 (100.0)
	White	29,06,992	669 (31.4)	90 (13.1)	537 (29.1)
	Diverse	23,83,007	630 (29.6)	173 (25.1)	552 (29.9)
	Black	13,77,077	423 (19.9)	142 (20.6)	366 (19.8)
	Latino	12,12,813	407 (19.1)	284 (41.2)	392 (21.2)
Los Angeles	Total	36,90,113	1,013 (100.0)	390 (100.0)	400 (100.0)
	White	11,37,615	263 (26.0)	12 (3.1)	52 (13.0)
	Diverse	8,50,960	232 (22.9)	55 (14.1)	87 (21.8)
	Black	1,17,493	27 (2.7)	17 (4.4)	13 (3.3)
	Latino	15,84,045	491 (48.5)	306 (78.5)	248 (62.0)
Chicago	Total	26,77,706	808 (100.0)	324 (100.0)	545 (100.0)
	White	7,62,389	244 (30.2)	17 (5.2)	176 (32.3)
	Diverse	3,22,374	113 (14.0)	39 (12.0)	87 (16.0)
	Black	9,97,400	279 (34.5)	214 (66.0)	185 (33.9)
	Latino	5,95,543	172 (21.3)	54 (16.7)	97 (17.8)
Houston	Total	25,07,766	704 (100.0)	236 (100.0)	212 (100.0)
	White	5,17,082	170 (24.1)	6 (2.5)	23 (10.8)
	Diverse	6,13,384	195 (27.7)	22 (9.3)	65 (30.7)
	Black	3,75,146	82 (11.6)	51 (21.6)	32 (15.1)
	Latino	10,02,154	257 (36.5)	157 (66.5)	92 (43.4)

Results

A total of 4654 neighborhoods were identified in the four cities of interest. There are 1170 diverse neighborhoods without a predominant race, 1346 predominantly white, 1327 predominantly Latino, and 811 predominantly Black. LA and Houston had the highest percentage of Latino neighborhoods (48.5% and 36.5%, respectively), whereas Chicago had the highest percentage of Black neighborhoods (34.5%). There were 5239 active pharmacies, 3297 (62.9%) of which were in NYC (Table 1).

Of the 4654 neighborhoods, 3004 (64.5%) had low vehicle access. NYC had the greatest number of low-vehicle access neighborhoods (1847 of 2129, 86.8%), and Houston had the fewest (212 of 704, or 30.1%). Black neighborhoods had the highest rates of poor vehicle access (596 of 811, 73.5%), followed by diverse (791 of 1170, 67.6%), Latino (829 of 1327, 62.5%), and white (788 of 1346, 58.5%) neighborhoods.

Pharmacy deserts based on distance

When determined by distance, there were a total of 670 (14.4%) pharmacy deserts across the 4 cities, 237 (35.4%) of which were in Chicago, despite only having 17.4% of the total number of neighborhoods. NYC had 26 pharmacy deserts, accounting for 3.9% of total pharmacy deserts and 1.2% of total neighborhoods. Of 1346 total predominantly white neighborhoods, only 29 (2.2%) were in pharmacy deserts. Latino, Black, and diverse neighborhoods had 344 (25.9%), 203 (25.0%), and 94 (8.0%) pharmacy deserts, respectively (Table 2).

Pharmacy deserts based on car travel time

When evaluating pharmacy deserts based on travel time by car, the number of pharmacy deserts reduced across all four cities. There were a total of 130 pharmacy deserts. Chicago had the highest rate, with 56 of 808 neighborhoods (6.8%) having poor access to pharmacies. LA, Houston, and NYC had 46 (4.5%), 25 (3.6%), and 3 (0.1%) pharmacy deserts, respectively. Predominantly Black neighborhoods are most likely to be in a pharmacy desert (59 of 811, 7.3%), followed by Latino (58 of 1327, 4.4%), diverse (11 of 1170, 0.9%), and white (3 of 1346, 0.2%) neighborhoods.

Pharmacy deserts based on public transit travel time

There were a total of 118 pharmacy deserts when accounting for public transportation. LA accounted for 81 (68.6%) of pharmacy deserts despite only having 21.8% of total neighborhoods. Predominantly Latino neighborhoods were most likely to be in a pharmacy desert (91 of 1327, 6.9%), followed by Black (18 of 811, 2.2%), diverse (7 of 1170, 0.6%), and white (2 of 1346, 0.1%) neighborhoods.

Sensitivity analysis

Sensitivity analysis was performed to determine how changes in the travel time threshold can affect the number of pharmacy deserts. By reducing travel time to 10 minutes, the total number of pharmacy deserts by car and public transportation increased to 267 (105% increase from 130) and 353 (199% increase from 118), respectively. white neighborhoods only had 3 additional pharmacy deserts for each mode of transportation, whereas Black and Latino neighborhoods had substantially more pharmacy deserts. By increasing travel time to 20 minutes, the total number of pharmacy deserts by car and public transportation decreased to 72 (45% decrease from 130) and 86 (27% decrease from 118), respectively.

Discussion

To our knowledge, this is the first study to examine the prevalence of pharmacy deserts using travel time and incorporating availability of public transportation in this

Table 2
Pharmacy Deserts based on distance and travel time

City	Racial makeup	Pharmacy deserts					
		Based on distance		Based on travel time			
		Distance (%)	Population	Walk or car (%)	Population	Public transit (%)	Population
New York City	Total	26(100.0)	39,191	3 (100.0)	21,118	0 (0.0)	—
	White	3 (11.5)	4,295	0 (0.0)	2,180	0 (0.0)	—
	Diverse	6 (23.1)	3,717	1 (33.3)	1,036	0 (0.0)	—
	Black	3 (11.5)	11,022	1 (33.3)	8,436	0 (0.0)	—
	Latino	14 (53.8)	20,157	1 (33.3)	9,466	0 (0.0)	—
Los Angeles	Total	241 (100.0)	6,60,287	46 (100.0)	1,69,266	81 (100.0)	2,94,442
	White	7 (2.9)	58,875	0 (0.0)	5,232	1 (1.2)	17,538
	Diverse	37 (15.4)	70,863	4 (8.7)	11,735	6 (7.4)	22,047
	Black	9 (3.7)	85,450	7 (15.2)	38,741	9 (11.1)	56,516
	Latino	188 (78.0)	4,45,099	35 (76.1)	1,13,558	65 (80.2)	1,98,341
Chicago	Total	237 (100.0)	7,85,960	56 (100.0)	2,37,665	6 (100.0)	52,697
	White	16 (6.8)	65,130	1 (1.8)	10,773	0 (0.0)	5,189
	Diverse	31 (13.1)	44,943	5 (8.9)	5,082	0 (0.0)	543
	Black	157 (66.2)	5,30,463	43 (76.8)	1,82,146	5 (83.3)	32,910
	Latino	33 (13.9)	1,45,424	7 (12.5)	39,664	1 (16.7)	14,055
Houston	Total	166 (100.0)	7,78,695	25 (100.0)	1,34,084	31 (100.0)	1,43,123
	White	3 (1.8)	59,907	1 (4.0)	10,624	1 (3.2)	12,353
	Diverse	20 (12.0)	35,343	1 (4.0)	3,317	1 (3.2)	3,437
	Black	34 (20.5)	2,19,993	8 (32.0)	42,372	4 (12.9)	30,307
	Latino	109 (65.7)	4,63,353	15 (60.0)	77,771	25 (80.6)	97,026

calculation. Although previous studies have shown that there are significant disparities in access to care, including access to pharmacies, these studies have not incorporated travel time in their calculations.[3] We found that regardless of the method, predominantly white neighborhoods are less likely to be in a pharmacy desert compared with predominantly Black and Latino neighborhoods.

Disparities in accessing pharmacies are not only because of the geographic location of neighborhoods but are also a product of lack of access to transportation, both for private vehicles and public transportation. A systematic review found that patients often found lack of vehicles to be a major barrier to accessing care, and those with no access to vehicles are less likely to receive timely care.[8] In our study, we found that white neighborhoods are more likely to have access to vehicles than Black neighborhoods across all 4 cities. This disparity is further worsened when evaluating pharmacy deserts using travel time by car, where virtually no pharmacy deserts were found in white neighborhoods across the four cities.

Of note, there are fewer pharmacy deserts when using a 15-minute travel time instead of the more conventionally used 1-mile distance from the nearest pharmacy. This is likely because in most settings, those with vehicles can travel much farther than 1 mile in 15 minutes (at an average of only 4 mph). Although this by no means reduces the severity of pharmacy deserts in these cities, we believe that it serves as a resource for health care providers and public health officials to better pinpoint neighborhoods with poor vehicle access that have a more dire need of pharmacies. In addition, given these findings, we believe that the threshold for pharmacy deserts should be adjusted in urban settings to better reflect their population and geographic density. Finally, we found that there are far fewer pharmacy deserts in NYC compared with other cities in our study. This is likely because NYC has a much higher population density and walk score than the other cities in our study.[18,19]

We aimed to create a more holistic assessment of pharmacy deserts by incorporating public transportation, especially because a large proportion of residents in urban settings do not have access to vehicles. We found similar patterns in racial disparities across the four cities where virtually no pharmacy deserts were found in white neighborhoods. By incorporating public transportation, Chicago had far significantly fewer (6 vs. 56) pharmacy deserts, whereas LA had many more (81 vs. 46). In LA, all but 1 pharmacy desert were found in non-white neighborhoods. This suggests that in addition to disparities in location of pharmacies, there could be an underlying disparity in public infrastructure in LA where non-white neighborhoods have poorer access to public transportation than white neighborhoods.

It is worth noting that by our (and USDA) definition, only low-income neighborhoods can be considered pharmacy deserts. Our data showed that Black and Latino neighborhoods accounted for 17.4% and 28.5% of overall neighborhoods but 25.9% and 48.9% of low-income neighborhoods, respectively. Because they are over-represented in low-income neighborhoods, Black and Latino neighborhood representation in pharmacy deserts is likely impacted.

In our sensitivity analysis, we discovered that there are substantially more pharmacy deserts when reducing the threshold from 15 minutes to 10 minutes. Almost all the additional pharmacy deserts are found in non-white neighborhoods. This likely suggests that in addition to those living in pharmacy deserts under the current definition, there are many more non-white neighborhoods that are currently at a risk of becoming pharmacy deserts.

Both the distance and time thresholds used in this study were translated from food desert definitions developed by the USDA (e.g., 1 mile in urban settings and 10 miles in rural settings). Although these have face validity and are reasonable starting points, given the amount of research effort put into the topic, a more thorough and defensible approach to establishing and validating distance- and time-based thresholds for pharmacy deserts is warranted.

Although pharmacy access—be it measured by distance or time—is a logistical challenge to health care, it remains unclear how much this translates to health care outcomes. The impact of food deserts, for instance, is still debated.[20] There have been some efforts to connect pharmacy desert status and outcomes such as adherence and overutilization of more acute medical services for populations in Italy and rural Pennsylvania.[21,22] Further work on the current study would hope to examine similar outcome measures across these four urban geographies.

Limitations

Our study has several limitations. First, when evaluating travel time, we computed travel times at one time during the day (9 AM on a Monday) and did not incorporate traffic variation. Car routes, and hence, travel times, are computed with average traffic patterns, whereas public transport times are computed by their scheduled route times. Because traffic patterns and public transport schedules vary across the day, a more robust model might incorporate traffic load and compute travel times at multiple times during the day. Second, it is likely that some patients have barriers to walking 0.5 miles to the nearest pharmacy. Third, although we utilized census tract data, which provides us with granular data on vehicle access, neighborhood characteristics ultimately do not represent individual access to vehicles. Finally, our study focused on major metropolitan areas in the United States, which may not be generalizable to other cities or nonurban areas.

Conclusion

Our study showed that there are profound racial disparities in access to pharmacies regardless of methodology, and black and Latino neighborhoods were more likely to be in pharmacy deserts than white neighborhoods. In addition, we found that non-white neighborhoods have poorer access to both private vehicles and public transportation. Equitable access to pharmacies is a crucial aspect of health equity, and our study showed that not only are there disparities in the geographic locations of pharmacies but also in access to vehicle and public transportation. It is imperative for us to address these inequities by both improving both presence of pharmacies and access to private and public transportation.

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