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Reducing the Travel Burden for Patients to Access Specialized Medicines in Paraná, Brazil

Paula Rossignoli, PhD, Roberto Pontarolo, PhD, Fernando Fernandez-Llimos, PhD

ABSTRACT

Objectives: This study aimed to evaluate the potential reduction in distance and travel time with a hypothetical municipal distribution of specialized component medicines in the state of Paraná.

Methods: This was a cross-sectional study. Distances and travel times from all the 1025 residential locations in the state of Paraná to dispensing pharmacies were calculated in 2 different models: centralized model with drugs dispensed in the 22 state-owned pharmacies and decentralized model with drugs dispensed in the 399 municipal pharmacies. Road routes were calculated using the Google Maps Distance Matrix API and Euclidean distance using the haversine formula for the southern hemisphere. A sinuosity index was computed by the quotient between these 2 distances. Differences were evaluated through bivariate analyses and effect size measures were reported.

Results: In the centralized model, the mean distance to the pharmacy was 59.5 km (SD 34.1), with a travel time of 1.0 hour (SD 0.5) and 579 residential locations (56.7%) more than 50 km away from the pharmacy, 286 (28.0%) between 25 and 50 km, and 156 (15.3%) less than 25 km. In the decentralized model, the mean distance was 10.8 km (SD 16.6), with a travel time of 0.2 hours (SD 0.3) and 14 locations (1.4%) more than 50 km away from the pharmacy, 96 (9.4%) between 25 and 50 km, and 911 (89.2%) less than 25 km. The decentralized model significantly reduced the sinuosity index.

Conclusions: Implementing a decentralized dispensing of the specialized component drugs in the state of Paraná would produce a significant reduction in distance and travel time for patients enhancing drug accessibility.

Keywords: Brazil, delivery of healthcare, health services accessibility, national health programs.

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Introduction

Equitable access to medicines is a major challenge worldwide.[1,2] Geographic accessibility is one of the factors influencing access and is based on the physical distance or travel time between the patient's home and the place where the service is provided.[3] The dimensions of availability of medicines and geographic accessibility are well-described barriers to access to medicines.[4] The lack of pharmacies close to users' homes results in limited use of necessary medicines for patients with mobility problems.[5]

Studies have shown that people living in remote areas have restrictions on prescriptions and access to newer drugs compared with those living in more central areas, which may limit their chances of controlling the disease.[6-8] Physicians' clinical behavior has been shown to be influenced by patients' geographic location.[9] Unequal access to medicines can exacerbate inequalities in the control of chronic diseases, with those living in more remote areas at a disadvantage.[10] In addition, the provision of medicines close to home is considered essential for the continuity of care of patients discharged from the hospital who require ongoing outpatient treatment.[11]

As a barrier to access, the cost of medicines can account for up to 60% of total healthcare expenditure[2] and can affect family budgets, particularly for the less privileged, reinforcing the importance of free public access to medicines.[12,13] The Brazilian National Health Service (*Sistema Único de Saude* [SUS]) is a public and universal system publicly funded. The SUS has been described as a rapidly evolving health system that is still struggling to achieve universal and equitable coverage,[14] through the regionalization and decentralization of access to health services.[15] At the outpatient level, standardized medicines in the SUS are those included in the National List of Essential Medicines[16] and are divided into 3 groups for the purposes of financing, acquisition, and mode of access (ie, basic, strategic, and specialized). The basic component includes medicines prescribed in primary healthcare and dispensed in basic health units. The strategic component includes medicines for the treatment of HIV/AIDS and endemic diseases (eg, tuberculosis, malaria, leprosy, Chagas' disease). Finally, the specialized component (CEAF) covers high-cost and highly complex medicines used in the treatment of chronic diseases, including rare diseases, whose treatment lines are described in the Ministry of Health's Clinical Protocols and Therapeutic Guidelines.[17,18] Access to CEAF drugs requires previous assessment of compliance with the criteria described in the Ministry of Health's Clinical Protocols and Therapeutic Guidelines.[19] The CEAF has been the subject of several studies, focusing on both budgetary impact and pharmacoepidemiologic and pharmacoeconomic aspects, but only studies for specific clinical conditions have evaluated access to CEAF drugs.[20]

Geographic accessibility studies are essential tools for planning interventions to reorganize care, which can lead to greater flexibility and wider access to medicines, thereby ensuring greater therapeutic effectiveness.[20] Using the state of Paraná as a case study, we hypothesize that the distribution of CEAF medicines in each municipality, instead of in the state pharmacies in the municipality where the 22 health regions are located, would facilitate access and reduce the burden of travel for patients. Therefore, the objective of this study was to measure the potential reduction in distance and travel time with a hypothetical municipal distribution of CEAF medicines in the state of Paraná.

Methods

A cross-sectional study following Strengthening the Reporting of Observational Studies in Epidemiology recommendations was conducted to compare 2 models of drug dispensing in the state of Paraná. Paraná is one of the 27 states of Brazil, situated in the southern region with a surface area of 199 315 km^2 and a population of approximately 11.5 million inhabitants, which places it in the middle of Brazil's population densities and ranks the seventh Human Development Index among Brazilian states. In terms of health organization, Paraná is divided into 399 municipalities grouped into 22 health regions, congregated into 4 macroregions. As in many other Brazilian states, CEAF medicines were initially dispensed in state-owned pharmacies located in the main cities of the 22 health regions.

Data Gathering

The list of residential locations in the state of Paraná was obtained from the Brazilian Institute of Geography and Statistics (IBGE) in June 2023, including the name of the location, territorial typology (urban or rural), type of location (city, village, isolated urban area, village, nucleus, settlement project, and indigenous village), and geographic coordinates of the centroid in decimal notation (www.ibge.gov.br). The exact location of public pharmacies was obtained from the Health Department of the State of Paraná (www.saude.pr.gov.br). Residential locations on islands without an established land route were excluded (n = 4).

Data Analysis

Distances were calculated from each residential location centroid described by the IBGE database to (1) the corresponding state-owned pharmacy in the health region (centralized model) and (2) to the city (head of the municipality) centroid (decentralized model). Distance calculations were performed using the Google Maps Distance Matrix API, considering the geographic coordinates of each residential location provided by IBGE and the coordinates of the reference state-owned pharmacy for the region. The API calculations were performed over 3 working days (July 17-19, 2023) between 9:30AM and 10:00AM. If the residential location corresponded to the location of the pharmacy, the distances were considered to be zero kilometers and zero minutes.

The haversine formula for the southern hemisphere was used to calculate the Euclidean distance between 2 coordinates:

$$ED = 6371 * \cos^{-1}\left(\left(\cos\left((90 - LAT2) * \frac{\pi}{180}\right) * \cos\left((90 - LAT1) * \frac{\pi}{180}\right)\right) + \left(\sin\left((90 - LAT2) * \frac{\pi}{180}\right) * \sin\left((90 - LAT1) * \frac{\pi}{180}\right) * \cos\left((LON1 - LON2) * \frac{\pi}{180}\right)\right)\right)$$

A difficulty index (sinuosity index) was calculated by dividing the road distance by the Euclidean distance. This index represents the difficulty of the route between 2 points and is greater the further away from the value of 1. The sinuosity index is commonly used to identify mountain road stretches with a high risk of traffic accidents.[21]

$$SI = \frac{road\ distance}{Euclidean\ distance}$$

A descriptive analysis of the distance and travel time was conducted for the 2 dispensing models (ie, centralized and decentralized), presenting measures of central tendency (mean) and dispersion (SD). The normality of the distributions was calculated using the Kolmogorov–Smirnov test, with additional visual inspection of the quintile-quintile plot. Bivariate analysis was performed using parametric tests. Route difficulty indices between the 2 models were compared using paired *t* tests. Effect measures were calculated according to American Statistical Association recommendations (ie, Cohen's d, eta2).[22]

Results

A total of 1025 residential locations were identified in the IBGE database across the 399 municipalities of Paraná, classified as 399 cities (urban), 344 towns (urban), 175 isolated urban areas (urban), 96 villages (rural), 7 nuclei (rural), 3 settlement projects (rural), and 1 indigenous village (rural).

On average, each municipality contained 3 sites (SD 1.7; range 1-12). Four of these localities were located on islands and it was not possible to calculate distances by land, so they were excluded from the analyses. The number of municipalities and residential locations was evenly distributed across the macroregions, ranging from 93 municipalities in the east to 115 in the northwest and from 223 localities in the north to 290 in the northwest.

Both distance and travel time presented a distribution close to normality, with significant Kolmogorov–Smirnov (*P* = .001) but diagonal distribution in the quintile-quintile plot with some minor deviations along each of the tails, which should not prevent from using parametric tests.[23] In the original centralized dispensing model, the mean distance from a residential location to a dispensing pharmacy was 59.5 km (SD 34.1; median 56.2; interquartile range [IQR] 33.2–80.0), varying from 65.4 (SD 45.0) in the east macroregion to 54.6 (SD 28.8) in the northwest and from 86.0 (SD 39.0) in region 5 to 34.9 (SD 17.6) in region 13 (Table 1). A

Table 1. Distance in km (one way) to dispensing pharmacy in centralized and decentralized models of CEAF dispensing.

Health region (number of municipalities)	Residential locations	Centralized (km), mean (SD)	Decentralized (km), mean (SD)	Difference (km), mean (SD)
East (n = 93)	237	65.4 (45.0)	15.5 (28.5)	50.0 (41.2)
Region 1 (n = 7)	15	85.9 (83.7)	39.4 (95.1)	46.9 (37.9)
Region 2 (n = 29)	73	54.5 (37.4)	11.7 (14.3)	42.8 (36.0)
Region 3 (n = 12)	33	83.8 (52.6)	16.9 (19.1)	67.0 (51.1)
Region 4 (n = 9)	18	38.0 (22.0)	9.9 (13.7)	28.2 (23.0)
Region 5 (n = 20)	52	86.0 (39.0)	15.4 (16.3)	70.7 (44.3)
Region 6 (n = 9)	25	48.9 (31.0)	10.2 (10.8)	38.7 (31.6)
Region 21 (n = 7)	21	52.7 (21.5)	20.6 (20.1)	31.5 (28.2)
West (n = 94)	271	61.7 (28.6)	10.2 (10.3)	51.4 (29.8)
Region 7 (n = 15)	37	59.3 (32.3)	9.8 (11.3)	49.5 (29.1)
Region 8 (n = 27)	79	64.0 (29.8)	9.3 (8.9)	54.2 (30.8)
Region 9 (n = 9)	27	65.9 (20.1)	6.0 (5.8)	59.9 (19.7)
Region 10 (n = 25)	54	65.4 (30.2)	10.5 (13.0)	55.0 (33.1)
Region 20 (n = 18)	74	56.1 (26.5)	12.8 (9.8)	43.4 (28.2)
North (n = 97)	223	56.7 (32.0)	9.0 (10.4)	47.8 (32.8)
Region 16 (n = 17)	41	43.6 (27.2)	7.5 (8.2)	36.1 (27.7)
Region 17 (n = 21)	46	56.4 (30.0)	10.2 (13.3)	46.3 (35.3)
Region 18 (n = 21)	45	54.2 (26.1)	8.7 (9.4)	45.6 (25.1)
Region 19 (n = 22)	45	71.1 (29.6)	9.1 (10.7)	62.0 (30.4)
Region 22 (n = 16)	47	57.5 (40.0)	9.2 (9.9)	48.3 (39.1)
Northwest (n = 115)	290	54.6 (28.8)	8.9 (10.3)	45.7 (30.1)
Region 11 (n = 25)	66	63.7 (29.7)	9.8 (9.3)	54.0 (30.9)
Region 12 (n = 21)	57	53.4 (22.6)	11.9 (13.4)	41.5 (24.8)
Region 13 (n = 11)	17	34.9 (17.6)	7.7 (11.6)	27.2 (19.0)
Region 14 (n = 28)	64	59.3 (34.8)	9.1 (11.4)	50.2 (36.4)
Region 15 (n = 30)	86	48.9 (25.7)	6.4 (6.4)	42.5 (27.3)
State of Paraná (n = 399)	1.021	59.5 (34.1)	10.8 (16.6)	48.7 (33.5)

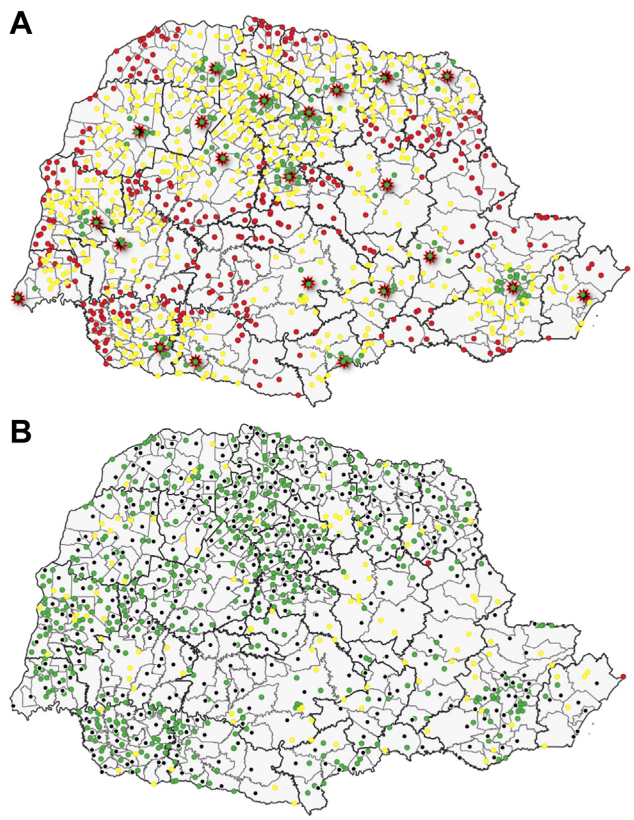
CEAF indicates specialized component.

significant difference between these distances was found at the macroregional level (F = 5.289; $P = .001$), albeit with a very small effect size (eta2 = 0.015; 95% CI 0.003–0.031), this difference being driven by the greater distance in the eastern region. The most extreme distances of more than 150 km were found in 8 residential locations in regions 1 (1 location), 2 (1 location), 3 (5 location), and 5 (1 location), located between 357 and 156 km from the dispensing pharmacies. Of the 1021 sites analyzed, 579 (56.7%) were more than 50 km from the dispensing pharmacy, 286 (28.0%) were between 25 and 50 km, and 156 (15.3%) were less than 25 km (Fig. 1A). In this centralized dispensing model, the mean travel time to the dispensing pharmacy was 1.0 hour (SD 0.5; median 0.9; IQR 0.6–1.3), varying from 1.2 hours (SD 0.7) in the eastern macroregion to 0.9 hours (SD 0.9) in the northwest and between 1.6 hours (SD 1.4) in region 1 and 0.7 hours (SD 0.4) in region 4. A significant difference between travel times was also found at the macroregional level (F = 13.994; $P < .001$), again with a very small effect size (eta2 = 0.040; 95% CI 0.018–0.064), although again this difference was only produced by the longer travel time in the eastern region. The 3 most extreme travel times were from settlements in regions 1, 3, and 2, which were 5.6, 3.4, and 3.5 hours away from pharmacies, respectively. Of the 1021 residential locations, 466 (45.6%) were more than 1 hour away from the dispensing pharmacy, 404 (39.6%) were between 30 and 60 minutes away, and 151 (14.8%) were less than 30 minutes away (Fig. 2A).

In the decentralized dispensing model, the mean distance from sites to a dispensing pharmacy was 10.8 km (SD 16.6; median 8.6; IQR 0.0–16.8), varying from 15.5 (SD 28.5) in the east macroregion to 8.9 (SD 10.3) in the northwest and from 39.4 (SD 95.1) in region 1 to 6.0 (SD 5.8) in region 9 (Table 1). A significant difference between distances was also found at the macroregional level (F = 8.608; $P < .001$), again with a very small effect size (eta2 = 0.025; 95% CI 0.008–0.044), with this difference also only being produced by greater distance from the eastern region. The 3 most extreme distances occurred in settlements in regions 1, 3, and 5, which were 377, 87, and 71 km away from dispensing pharmacies, respectively. Of the 1021 residential locations analyzed, 14 (1.4%) were more than 50 km from the dispensing pharmacy, 96 (9.4%) were between 25 and 50 km, and 911 (89.2%) were less than 25 km (Fig. 1B). In this decentralized dispensing model, the mean travel time to the dispensing pharmacy was 0.2 hours (SD 0.3; median 0.2; IQR 0.0–0.3), varying from 0.3 hours (SD 0.6) in the eastern macroregion to 0.2 hours (SD 0.2) in the other 3 macroregions and between 0.8 hours (SD 1.9) in region 1 and 0.1 hours (SD 0.1) in regions 9 and 15. A significant difference was also found between travel times at the level of the macroregions (F = 11.697; $P < .001$), again with a very small effect size (eta2 = 0.033; 95% CI 0.013–0.056), with this difference again only being produced by the longer travel time in the eastern region. The 3 most extreme travel times were from residential locations in regions 1, 3, and 5, which were 7.5, 1.9, and 2.0 hours away from pharmacies, respectively. Of the 1021 settlements, 17 (1.7%) were more than 1 hour away from the dispensing pharmacy, 105 (10.3%) were between 30 and 60 minutes away, and 899 (88.0%) were less than 30 minutes away (Fig. 2B).

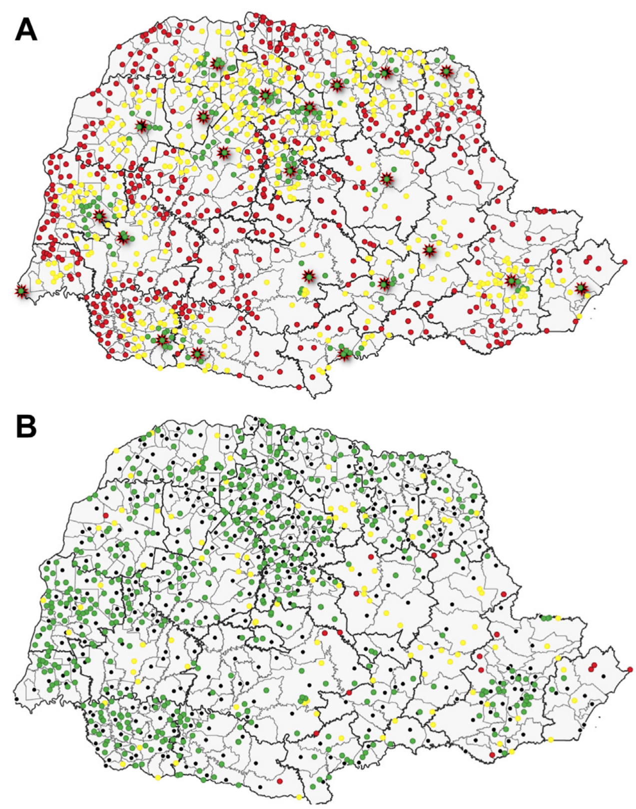
There were no differences between the macroregions in distance reduction in the 2 models (F = 1.511; $P = .210$; eta2 = 0.004; 95% CI 0.000–0.013). The mean reduction in distance from the site to the dispensing pharmacy was 48.7 (SD 33.5) and ranged from 51.4 (SD 29.8) in the west macroregion to 45.7 (SD 30.1) in the northwest macroregion (Table 1). Although a significant difference

Figure 1. Distribution of locations and distance to dispensing pharmacy in centralized (A) and decentralized (B) models. Colors represent distance intervals to the pharmacy.



Black indicates 399 cities (0 km); green, <25 km; yellow, 25-50 km; red, >50 km.

Figure 2. Distribution of locations and travel times to dispensing pharmacy in centralized (A) and decentralized (B) models. Colors represent travel time intervals to the pharmacy.



Black indicates 399 cities (0 minutes); green, <30 minutes; yellow, 30-60 minutes; red: >60 minutes.

in travel time reduction was found between the macroregions (F = 3.368; P = .018), the effect size of this difference is negligible (eta2 = 0.010; 95% CI 0.000–0.023). The average reduction in travel time was 0.8 (SD 0.5) and ranged from 0.8 (SD 0.7) in the west macroregion to 0.7 (SD 0.4) in the northwest macroregion. In 42 sites, the distance to the dispensing pharmacy was greater in the decentralized model than in the centralized model, with values ranging from 20.1 to 0.1 km and travel times ranging from 1.9 to less than 0.1 hours (Table 2).

The average altitude of all areas in the state of Paraná is quite similar, except for the east macroregion, which includes coastal municipalities, whereas others are more than 1200 meters above sea level. The sinuosity index of the route, measured by the ratio of road distance to Euclidean distance, went from 1.36 (95% CI 1.34–1.38) in the centralized model to 1.22 (95% CI 1.19–1.25), a significant difference (t = −11.094; $P < .001$; Cohen's d = −0.347; 95% CI −0.284 to −0.410). These differences were similar between macroregions (Table 3) and there were no hypothetical differences between the 2 models.

Discussion

Between the 2 potential CEAF drug distribution models in the state of Paraná (Brazil), the decentralized model (ie, dispensing in municipal pharmacies) reduced patients' travel distance by approximately 50 km and travel time by 0.8 hours (one way) compared with the centralized model (ie, dispensing in regional pharmacies). This reduction in time and distance would be accompanied by a significant reduction in the sinuosity of the route between the 2 models. The results obtained in the centralized model are in line with the situation reported in other states of Brazil. A study in Minas Gerais, the second most populated, revealed that patients treated with a CEAF medicine for their Alzheimer's disease lived in a municipality separated on average more than 40 km from the location where the medicine was dispensed.[20] A study conducted in Rio de Janeiro state, the third most populated, reported that CEAF medicines for 90 of the 93 municipalities were dispensed in only 25 dispensing sites.[24] Shifting from the centralized dispensing model to the suggested decentralized model would improve these scenarios.

Models for assessing the geographic accessibility of health services can include analyses of absolute and relative distance and travel time[25] and are important for measuring the accessibility of health services in general, including pharmacy services.[11] The use of geographic information systems in pharmacy accessibility studies is still in its infancy in countries such as Brazil.[26,27] Our study used 3 accessibility measures: absolute distance (Euclidean), distance considering the best route by car, and travel time using geographic information systems. To avoid traffic congestion effects, we used the Google API simultaneously to calculate distance and travel time for both models at a reasonable time of day to travel to the pharmacy, which ensures comparability.

There is no consensus on the distance or travel time to the nearest pharmacy that constitutes a pharmaceutical desert. A study conducted in the United States considered geographic pharmaceutical deserts as locations where the nearest community

Table 2. Travel time in hours (one way) to dispensing pharmacy in centralized and decentralized models of CEAF dispensing.

Health region (number of municipalities)	Residential locations	Centralized (h), mean (SD)	Decentralized (h), mean (SD)	Difference (h), mean (SD)
East (n = 93)	237	1.2 (0.7)	0.3 (0.6)	0.8 (0.7)
Region 1 (n = 7)	15	1.6 (1.4)	0.8 (1.9)	0.8 (1.1)
Region 2 (n = 29)	73	1.2 (0.8)	0.3 (0.3)	0.9 (0.7)
Region 3 (n = 12)	33	1.4 (0.8)	0.4 (0.4)	1.0 (0.7)
Region 4 (n = 9)	18	0.7 (0.4)	0.2 (0.3)	0.5 (0.4)
Region 5 (n = 20)	52	1.3 (0.5)	0.3 (0.4)	1.0 (0.6)
Region 6 (n = 9)	25	0.8 (0.5)	0.2 (0.2)	0.6 (0.5)
Region 21 (n = 7)	21	1.0 (0.4)	0.4 (0.4)	0.6 (0.5)
West (n = 94)	271	1.0 (0.4)	0.2 (0.2)	0.8 (0.4)
Region 7 (n = 15)	37	1.0 (0.5)	0.2 (0.2)	0.8 (0.4)
Region 8 (n = 27)	79	1.1 (0.4)	0.2 (0.2)	0.9 (0.5)
Region 9 (n = 9)	27	1.1 (0.3)	0.1 (0.1)	0.9 (0.3)
Region 10 (n = 25)	54	1.1 (0.5)	0.2 (0.2)	0.9 (0.5)
Region 20 (n = 18)	74	0.9 (0.4)	0.2 (0.2)	0.6 (0.4)
North (n = 97)	223	1.0 (0.5)	0.2 (0.2)	0.8 (0.5)
Region 16 (n = 17)	41	0.8 (0.4)	0.2 (0.2)	0.6 (0.4)
Region 17 (n = 21)	46	1.0 (0.5)	0.2 (0.3)	0.8 (0.6)
Region 18 (n = 21)	45	0.9 (0.4)	0.2 (0.2)	0.7 (0.3)
Region 19 (n = 22)	45	1.2 (0.5)	0.2 (0.3)	1.0 (0.5)
Region 22 (n = 16)	47	1.0 (0.6)	0.2 (0.2)	0.8 (0.6)
Northwest (n = 115)	290	0.9 (0.9)	0.2 (0.2)	0.7 (0.4)
Region 11 (n = 25)	66	1.0 (0.4)	0.2 (0.2)	0.8 (0.4)
Region 12 (n = 21)	57	0.9 (0.3)	0.2 (0.2)	0.7 (0.4)
Region 13 (n = 11)	17	0.6 (0.3)	0.1 (0.2)	0.4 (0.3)
Region 14 (n = 28)	64	1.0 (0.5)	0.2 (0.2)	0.8 (0.5)
Region 15 (n = 30)	86	0.8 (0.4)	0.1 (0.1)	0.7 (0.4)
State of Paraná (n = 399)	1.021	1.0 (0.5)	0.2 (0.3)	0.8 (0.5)

CEAF indicates specialized component.

Table 3. Difficulty of moving to the dispensing pharmacy in centralized and decentralized models.

Health region (number of municipalities)	Residential localities	Altitude (m), mean (SD)	Sinuosity index, mean (SD)	
			Centralized	Decentralized
East (n = 93)	237	793 (270)	1.40 (0.51)	1.31 (0.81)
Region 1 (n = 7)	15	18 (25)	2.53 (1.51)	2.15 (2.98)
Region 2 (n = 29)	73	829 (231)	1.27 (0.60)	1.27 (0.28)
Region 3 (n = 12)	33	879 (107)	1.32 (0.19)	1.26 (0.30)
Region 4 (n = 9)	18	856 (101)	1.29 (0.18)	1.14 (0.16)
Region 5 (n = 20)	52	891 (160)	1.30 (0.15)	1.20 (0.20)
Region 6 (n = 9)	25	848 (97)	1.40 (0.25)	1.19 (0.22)
Region 21 (n = 7)	21	840 (110)	1.55 (0.30)	1.47 (0.53)
West (n = 94)	271	515 (189)	1.33 (0.19)	1.19 (0.23)
Region 7 (n = 15)	37	759 (206)	1.40 (0.21)	1.16 (0.17)
Region 8 (n = 27)	79	526 (141)	1.39 (0.22)	1.24 (0.26)
Region 9 (n = 9)	27	334 (123)	1.24 (0.16)	1.66 (0.16)
Region 10 (n = 25)	54	578 (138)	1.30 (0.18)	1.18 (0.29)
Region 20 (n = 18)	74	400 (110)	1.30 (0.17)	1.17 (0.18)
North (n = 97)	223	593 (151)	1.43 (0.31)	1.18 (0.21)
Region 16 (n = 17)	41	688 (147)	1.32 (0.15)	1.19 (0.22)
Region 17 (n = 21)	46	525 (127)	1.32 (0.14)	1.16 (0.20)
Region 18 (n = 21)	45	555 (159)	1.45 (0.28)	1.17 (0.23)
Region 19 (n = 22)	45	574 (104)	1.44 (0.26)	1.18 (0.23)
Region 22 (n = 16)	47	634 (155)	1.62 (0.46)	1.21 (0.19)
Northwest (n = 115)	290	445 (99)	1.29 (0.19)	1.20 (0.26)
Region 11 (n = 25)	66	523 (108)	1.34 (0.28)	1.20 (0.20)
Region 12 (n = 21)	57	387 (47)	1.28 (0.14)	1.19 (0.26)
Region 13 (n = 11)	17	456 (62)	1.33 (0.25)	1.11 (0.19)
Region 14 (n = 28)	64	389 (72)	1.27 (0.18)	1.16 (0.20)
Region 15 (n = 30)	86	464 (94)	1.28 (0.16)	1.25 (0.34)
State of Paraná (n = 399)	1.021	577 (226)	1.36 (0.32)	1.22 (0.44)

pharmacy was 1.6 km or more from a sector centroid and found that the average distance for those living in pharmacy desert locations was 2.2 km.[28] Another study considered pharmacy deserts to be any location at least 16 km from the nearest pharmacy.[29] Still in the United States, research found that 73.1% of the population lived within 3.2 km of a pharmacy and 8.3% of locations had at least 50% of the population living more than 16 km away.[30] In Italy, the average distance to the nearest pharmacy was 6.8 km, according to a study investigating inequalities in access to pharmacies.[31] Our study found an average distance of 59.5 km in the centralized model, which was reduced to 10.8 km in the decentralized model. A study measuring travel time by car to a pharmacy in a North American state found that virtually the entire population (99.7%) lived within 30 minutes of a pharmacy.[32] In relation to the car travel time obtained in our study, it was on average 1 hour in the centralized model and 0.2 hours (12 minutes) in the decentralized model. The studies cited generally showed a shorter distance to pharmacies than the decentralized model of access to CEAF, but they involved a private network of pharmacies, whereas our study involved public government pharmacies.

In general, the geographic location of communities affects the ability of these populations to access healthcare in a timely manner. A retrospective study conducted in Australia found that geographic remoteness of residence was associated with overall poorer survival outcomes for Australian children with leukemia.[33] Other research conducted in Scotland found a significant health impact due to inequalities in the treatment of acute myocardial infarction in remote areas compared with central areas.[34] Distance may also lead to a greater evaluation of whether to seek healthcare, taking into account transport costs and risks,[35] and a study showed that people with difficult access to pharmacies were more likely to report underuse of prescription medicines.[36]

The decentralized access model of CEAF can particularly benefit those who live further away from the community center, including in rural areas. In a systematic review on the access to medicines, the studies evaluated concluded that the population living in urban areas had better access to pharmacies and shorter travel distances.[27] A study in the United States found that the distance traveled by the rural elderly population was 6 times greater than that of urban dwellers, reaching 30.2 km for 10% of the rural population.[37] A study conducted in Greece found that a common barrier to access to disease-modifying biologicals for the treatment of multiple sclerosis, which are part of the CEAF in Brazil, was the distance to the pharmacies where these medicines are dispensed.[38]

There is evidence that barriers to appropriate care can lead to lower medication adherence and poorer outcomes, increasing costs to the healthcare system.[29] A study conducted in Brazil found that regular and free access to CEAF medicines was associated with better adherence to treatment.[34]

Most studies on the geographic accessibility of medicines have focused their analyses and recommendations on the geographic distribution of pharmacies within a region and the density of pharmacies per population.[27,39,40] However, the cumulative effects of inequalities in access to health services and other disadvantages, such as less favorable socioeconomic conditions, require criteria other than population size.[5,41] An analysis of potential locations to establish new hemodialysis centers in Portugal showed differences between the "population burden" (a model including population) and "individual burden" (model not considering the population of the locations).[42] Our study did not take population size into account in its analysis, given that it assumed that every individual, regardless of where they live, has the same right to access healthcare. Furthermore, analyses and public policies based on population density increase inequity, because populations in more remote areas are more vulnerable and have a greater chance of falling ill.[41]

A decentralization scenario like the one in this study has occurred in Portugal during the COVID-19 pandemic, when the points of supply for high-cost medicines were expanded, with access decentralized from hospitals to community pharmacies. A study showed that this change in the distribution of specialized outpatient medicines had a positive impact on treatment adherence, health-related quality of life, and satisfaction and promoted travel savings for users.[43] As a consequence of this study, this decentralized dispensing system will continue for these medicines.

Expanding the network of pharmacies dispensing CEAF from 22 pharmacies (centralized model) to 399 pharmacies (decentralized model) could be economically unfeasible for the state government, given the costs of building and structuring new pharmacies. However, the decentralized model analyzed in this study is based on using the network of municipal pharmacies already existing to dispense basic component medicines (the largest and more highly consumed medicines) and the strategic component (focused on endemic diseases). The number of users of CEAF medicines is much smaller than basic component medicine users, which would not represent an intense overburden for municipal pharmacies' human resources. Software used to manage CEAF dispensing is already available for municipalities accepting the decentralized dispensing model. To support any additional technological costs assumed by the dispensing municipality, the government of Paraná state created a financial incentive (ie, *Incentivo à Organização da Assistência Farmacêutica*) obtained from the reduction in costs resulting from fewer resources allocated to dispensing in state pharmacies. At the end of the day, this decentralization process tends to be close to being cost neutral.

Limitations

In this study, we used the centroids described by IBGE to calculate the distances from the residential location to the pharmacies, ignoring the area of the location, which may lead to some inaccuracy in large locations. In addition, our model considered 1 pharmacy per community, which may have underestimated the differences between the centralized and decentralized models for locations with more than 1 potential pharmacy to dispense CEAF. Generalization of the results outside Brazil may be limited because of the differential characteristics of the CEAF, dispensed only by publicly owned pharmacies and not by private community pharmacies.

Conclusions

There was a significant reduction in distance and travel time between the centralized and decentralized CEAF dispensing models. The study showed great potential for improving geographic accessibility, with an average reduction of 80% in both distance and travel time when CEAF's decentralized dispensing model was implemented in the state of Paraná. Of the 579 locations more than 50 km from the state pharmacy, only 14 remained in this classification. The average travel time would be reduced from 60 minutes in the centralized model to 12 minutes (each way) in the decentralized model. It would be useful to study whether the decentralization of CEAF distribution to municipalities has an impact on the number of users of these medicines. It is expected that increasing medicine accessibility will increase medicine use, resulting in higher equity for the users of the CEAF component. The results obtained in Paraná could be generalizable to the entire Brazil, where similar situations were reported.

Author Disclosures

Author disclosure forms can be accessed below in the Supplemental Material section.

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Author Affiliations: Pharmaceutical Services Management Postgraduate Program (Rossignoli) and Department of Pharmacy(Pontarolo), Universidade Federal do Paraná, Curitiba, Brazil; Applied Molecular Biosciences Unit (UCIBIO), Institute for Health and Bioeconomy (i4HB) (Fernandez-Llimos), and Laboratory of Pharmacology, Department of Drug Sciences, Faculty of Pharmacy, University of Porto, Porto, Portugal (Fernandez-Llimos).

Correspondence: Fernando Fernandez-Llimos, PhD, Laboratorio de Farmacologia, Faculdade de farmácia, Universidade do Porto, R. Jorge de Viterbo Ferreira 228, 4050-313 Porto, Portugal. Email: fllimos@ff.up.pt

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