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DATAWATCH Medicare Part D Preferred Pharmacy Networks And The Risk For Pharmacy Closure, 2014–23

Medicare Part D plans incentivize the use of specific pharmacies through preferred networks. We found that independent pharmacies and pharmacies in low-income, Black, and Latinx neighborhoods were less likely to be preferred by most Part D plans than chains and pharmacies in other neighborhoods. Pharmacies that were not preferred by most plans were 70–350 percent more likely to close than other pharmacies.

harmacy benefit managers have increasingly incorporated "preferred" pharmacy networks into Medicare Part D plans.^{1,2} These networks differentiate between contracted (innetwork) pharmacies, offering cost-saving incentives to beneficiaries who use specific preferred pharmacies. Despite the growth of Part D preferred pharmacy networks since 2014,² and amid concerns about their role in pharmacy closures,³ there is limited information regarding the exclusivity of these networks and their association with closures. As of 2023, 97.7 percent of Medicare Part D stand-alone prescription drug plans (PDPs) and 43.8 percent of Medicare Advantage prescription drug (MA-PD) plans used preferred pharmacy networks (exhibit 1). However, only two in five pharmacies were preferred for most Medicare Part D plans that served their areas (exhibit 2). DOI: 10.1377/hlthaff.2024.01452 HEALTH AFFAIRS 44, NO. 5 (2025): 539-545 ©2025 Project HOPE— The People-to-People Health Foundation, Inc.

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SOURCE Authors' analysis of data from the Medicare Part D pharmacy network files, 2014–23. **NOTES** The data source contains information on all Part D plans except for national Program of All-Inclusive Care for the Elderly plans, employer-sponsored plans, non-Medicare-Medicaid Plan Demonstration plans, and plans for which information has been suppressed by the Centers for Medicare and Medicaid Services because of data inaccuracy or other issues. Each plan can be uniquely identified using contract, plan, and segment identifiers. Plans with preferred pharmacy networks are those that incentivize patients to use specific "preferred" pharmacies for lower cost sharing. PDP is (stand-alone) prescription drug plan. MA-PD is Medicare Advantage prescription drug (plan).



SOURCE Authors' analysis of data from the National Council for Prescription Drug Programs, 2014–23; and the Medicare Part D pharmacy network files, 2014–23. **NOTES** Preferred pharmacy status characterizes the extent to which pharmacies participate in Medicare Part D preferred pharmacy networks. Pharmacies were categorized as preferred for \geq 50% of Part D plans with preferred networks (referred to as "most plans"), preferred for <50% of plans, nonpreferred (preferred for no plans), or out of network (for all plans in their service area).

Medicare Part D plans that use preferred pharmacy networks discourage beneficiaries from filling their prescriptions at nonpreferred (yet in-network) pharmacies by subjecting beneficiaries to higher cost sharing if they use nonpreferred pharmacies.³ Therefore, we hypothesized that preferred pharmacy networks may increase the risk for closure among nonpreferred pharmacies, as well as among out-of-network pharmacies that are not contracted with any Part D plan. Preferred pharmacy networks may also worsen inequities in pharmacy access if they disproportionately exclude independent pharmacies (which have lower contracting power than chains) and the few existing pharmacies located in low-income, Black, and Latinx neighborhoods.4,5

In this study, we characterized pharmacies participating in Medicare Part D preferred pharmacy networks (exposure) in the United States. We also examined whether participation varied across geographic areas, to identify localities and neighborhoods in which expanding preferred pharmacy networks through federal and state reforms is critical. Finally, we evaluated the association between participation in Medicare Part D preferred pharmacy networks and pharmacy closures (outcome).

Study Data And Methods

We used data from the National Council for Prescription Drug Programs' dataQ database to identify all licensed chain and independent pharmacies during the period 2014–23⁶ and to determine when each pharmacy newly opened or permanently closed. We then used Medicare Part D pharmacy network files for the same period⁷ to identify the preferred pharmacy status for all pharmacies. The sample for the study period consisted of 87,909 pharmacies (representing 99.1 percent of retail pharmacies) and 11,354 Medicare Part D plans, including 6,667 plans with preferred pharmacy networks.

For each pharmacy in each year, we defined preferred pharmacy status as whether a pharmacy participated as preferred or nonpreferred for Medicare plans (PDPs and MA-PD plans) with preferred networks for which the contracted service area included the store's ZIP code (that is, in their service area).⁷ We considered pharmacies that were not in network for any plan (in their

Our findings indicate that the exclusion of pharmacies from preferred pharmacy networks within Medicare Part D contributes to pharmacy closures.

service area) as being out of network. Pharmacies were grouped into four time-varying categories: preferred for at least 50 percent of plans (also referred to as "most plans"), preferred for less than 50 percent of plans, nonpreferred (for all plans), and out of network (for all plans in their service area) for each year.

We linked pharmacies (using their ZIP codes) to data from the National Center for Health Statistics⁸ (2013, county level) and the Census Bureau's American Community Survey (2018–22, ZIP Code Tabulation Area level)⁹ to measure neighborhood demographic factors (urbanicity, predominant race and ethnicity, and percentage with income below the federal poverty level [with 20 percent of the population or higher referred to as "low income"]) and market factors (percentage uninsured, percentage Medicare insured, ratio of private to public insurance, and pharmacies per 10,000 people).

Detailed information on all study measures is in online appendix exhibit A1.¹⁰

We examined annual trends in preferred pharmacy status and the distribution of that status by pharmacy type and neighborhood demographic and market characteristics.

To assess factors associated with pharmacy closures, we followed pharmacies from the index date of 2014 or their year of opening (whichever was later) until their closure (the last year they were reported as active) or the end of the study period (2023), resulting in nine one-year intervals when a closure could happen. We estimated closure rates as the number of pharmacies that closed during the period 2015–23 divided by the number of pharmacies in operation at any time during the period 2014–22 (that is, after we excluded pharmacies that newly opened in 2023).⁴ To account for differences in follow-up, we also estimated one-year closure rates, or the cumulative incidence of closure within a year of index, using time-to-event methods.

Finally, we used adjusted Cox proportional hazard models to assess the association between time-varying preferred pharmacy status and pharmacy closures, accounting for pharmacy type and neighborhood demographic and market factors during the entire study period.

We performed statistical analyses using R. This study was determined to be exempt by the University of Southern California Institutional Review Board.

Limitations included our inability to capture all mechanisms that may have led to closures (such as pharmacy-level prescription volume and market consolidation), our inability to assess the impact of other preferred pharmacy networks (that is, employer-sponsored and Medicaid plans), and our use of neighborhood demographic and market factors as proxies for the population that each pharmacy served.

Study Results

The percentage of Medicare Part D PDP plans with preferred pharmacy networks increased from 70.2 percent in 2014 to 97.7 percent in 2023, a trend mirrored by MA-PD plans, for which the percentage rose from 15.6 percent to 43.8 percent (exhibit 1). During this period, the median number of plans (including those with preferred networks) that each pharmacy could serve (that is, in-network plans based on negotiated contracts) grew from forty-seven to seventy-two and from twenty-four to forty, respectively (appendix exhibit A2).¹⁰ In addition, the median number of plans each pharmacy could serve as a preferred pharmacy increased from four to fifteen.

The total number of pharmacies in the US was stable between 2014 (n = 63,861) and 2023 (n = 63,060) (exhibit 2). During this period, the proportion of pharmacies that were preferred by at least 50 percent of plans increased from 10.9 percent to 42.3 percent. In 2023, 41.1 percent of pharmacies were preferred by less than 50 percent of plans, 12.5 percent were non-preferred, and 4.0 percent were out of network.

Pharmacy participation in Medicare Part D networks varied across states (exhibit 3). As of 2023, the proportion of pharmacies that were preferred by most plans ranged from 4.3 percent in North Dakota to 59.2 percent in Oregon.

Nationwide, 83.4 percent of pharmacies participated in Medicare Part D preferred networks (preferred for at least one plan), but participation also varied markedly by county (appendix exhibit A3).¹⁰ A total of 171 counties, with 1.1 mil-

EXHIBIT 3

Medicare Part D preferred pharmacy status among pharmacies, by state, 2023



SOURCE Authors' analysis of data from the National Council for Prescription Drug Programs, 2023; and the Medicare Part D pharmacy network files, 2023. **NOTE** Preferred pharmacy status characterizes the extent to which pharmacies participate in Medicare Part D preferred networks, as defined in the exhibit 2 notes.

Medicare Part D preferred pharmacy status among pharmacies, by pharmacy, neighborhood demographic, and market factors, 2023

		Preferred pharmac			
		Preferred			
	Total	≥50% of plans	<50% of plans	Nonpreferred	Out of network
Overall	100.0%	42.3%	41.1%	12.5%	4.0%
Pharmacy type					
Chain	60.3	69.6	27.5	2.4	0.6
Independent	39.7	0.8	61.9	27.9	9.3
Neighborhood demographic factors ^b					
Urbanicity ^c					
Urban	31.5	38.7	41.6	14.4	5.4
Suburban	43.8	48.3	37.7	10.2	3.7
Rural	24.7	36.2	46.6	14.2	2.9
Predominant race and ethnicity ^d					
White	67.6	45.2	40.3	11.1	3.5
Black	5.2	31.3	50.7	13.3	4.7
Latinx	8.7	32.8	43.2	18.5	5.5
Diverse	18.3	39.4	40.4	14.9	5.3
Percent of population below federal poverty level					
<20%	82.9	45.1	39.3	11.7	3.9
≥20% (area considered "low income")	16.8	28.8	50.0	16.5	4.7
Market factors ^b					
Uninsured					
<10%	68.9	43.5	41.4	11.3	3.7
≥10%	30.8	39.7	40.3	15.2	4.7
Medicare					
<20%	87.5	42.9	40.6	12.4	4.1
≥20%	12.2	38.0	44.4	13.7	3.9
Private-to-public insurance ratio [®]					
≥2.0	53.1	48.4	36.8	10.8	3.9
1.0–1.9	34.6	38.6	43.7	13.7	4.0
<1.0	12.0	26.1	52.5	16.7	4.7
Pharmacies per 10,000 people					
Critical access pharmacy [†]	6.6	20.3	56.4	20.7	2.6
<2.0	29.0	51.1	36.8	9.1	3.0
≥2.0	64.3	40.6	41.5	13.2	4./

SOURCE Authors' analysis of data from the National Council for Prescription Drug Programs, 2014–23; the Medicare Part D pharmacy network files, 2014–23; and the American Community Survey, 2018–22. **NOTE** n = 63,060 pharmacies. *Preferred pharmacy status characterizes the extent to which pharmacies participate in Medicare Part D preferred pharmacy networks, as defined in the exhibit 2 notes. All differences across statuses were statistically significant (p < 0.001). *Area-level information applied to pharmacies based on their location. *Counties containing a principal city and located in a Metropolitan Statistical Area (MSA) with a population of 1 million or more were classified as urban; counties located in MSAs with a population of 250,000 or more that do not qualify as urban were considered suburban; and all other counties were considered rural. *Predominant race and ethnicity was categorized as White (\geq 50% of the population is non-Latinx White), Black (\geq 50% non-Latinx Black), Latinx (\geq 50% Latinx), or diverse (no single racial or ethnic group exceeding 50%). *Population that is privately insured divided by the population that is publicly insured alone. 'The sole pharmacy in a neighborhood.

lion inhabitants across twenty-six states, had no pharmacies participating in Medicare Part D preferred pharmacy networks.

Pharmacy, demographic, and market factors were also associated with differences in preferred pharmacy status (exhibit 4). Although independent pharmacies constituted 39.7 percent of US pharmacies in 2023, only 0.8 percent of independent pharmacies were preferred by most plans. Conversely, 69.6 percent of chain pharmacies were preferred by most plans. Pharmacies located in low-income (28.8 percent), Black (31.3 percent), and Latinx (32.8 percent) neighborhoods were less likely to be preferred by most plans than pharmacies in higher-income (45.1 percent) and White (45.2 percent) neighborhoods (all p < 0.001). Pharmacies located in neighborhoods with greater proportions of Medicare-insured populations and lower private-to-public insurance ratios were also less likely to be preferred for most Medicare Part D plans, as were pharmacies that were critical access pharmacies (all p < 0.001).

Of the 85,359 pharmacies in operation at any point during 2014–22, 28.1 percent had closed by 2023, including 3.9 percent that closed within one year of their index date (exhibit 5). All-time and one-year closure rates were higher among

EXHIBIT 5

		Closure rate	Closure rate		Hazard ratio ^d	
	Total ^a	All time ^b	1 year ^c	Unadjusted	Adjusted ^e	
Overall	100.0%	28.1%	3.9%	g	g	
Preferred pharmacy status ^f						
Preferred ≥50% of plans	37.4	16.8	1.9	Ref	Ref	
Preferred <50% of plans	46.2	34.5	2.3	2.02****	1.69****	
Nonpreferred	12.1	25.3	6.4	4.09****	3.14****	
Out of network	4.3	66.5	7.8	6.55****	4.53****	

Association of Medicare Part D preferred pharmacy status with pharmacy closures in the US, 2014-23

SOURCE Authors' analysis of data from the National Council for Prescription Drug Programs, 2014–23; the Medicare Part D Pharmacy Network Files, 2014–23; and the American Community Survey, 2018–22. **NOTE** n = 85,359 pharmacies. *Pharmacies in operation at any point between 2014 and 2022. *Number of pharmacies that closed between 2015 and 2023 divided by the number of pharmacies in operation at any time between 2014 and 2022. *Closure within 1 year of the index date, accounting for differences in follow-up. d'Hazard ratios denote the risk for pharmacy closure, as assessed using Cox proportional hazard models. *Adjusted for pharmacy, demographic, and market factors (details are in appendix exhibit A4; see note 10 in text). *Preferred pharmacy status characterizes the extent to which pharmacies participate in Medicare Part D preferred pharmacy networks, as defined in the exhibit 2 notes. ****p < 0.001

pharmacies that were preferred by less than 50 percent of plans (34.5 percent all-time and 2.3 percent one-year closure rates), nonpreferred (25.3 percent and 6.4 percent, respectively), or out of network (66.5 percent and 7.8 percent, respectively) than pharmacies that were preferred by most plans (16.8 percent and 1.9 percent, respectively). In adjusted regressions, pharmacies that were preferred by less than 50 percent of plans (hazard ratio: 1.69), nonpreferred (HR: 3.14), or out of network (HR: 4.53) were more likely to close than pharmacies that were preferred by most plans (all p < 0.001). Other important factors associated with increased closure risk included being an independent store (HR: 1.50) and being in a Black (HR: 1.28) or Latinx (HR: 1.16) neighborhood (all p < 0.001) (appendix exhibit A4).¹⁰

As a sensitivity analysis, we examined preferred pharmacy status as a continuous percentage by dividing the number of plans that classified a pharmacy as "preferred" by the total number of plans with preferred networks that each pharmacy could serve (appendix exhibit A5).¹⁰ Each 10-percentage-point increase in preferred pharmacy status was associated with a 14 percent reduction in the risk for closure (HR: 0.86; p < 0.001), even after we adjusted for the number of plans that each pharmacy could serve.

Discussion

To our knowledge, this was the first study to investigate trends in and the impact of differences in the participation of pharmacies in preferred pharmacy networks within Medicare Part D. Although the share of pharmacies preferred by Medicare Part D plans increased substantially from 2014 to 2023, our findings indicate that independent pharmacies and those located in low-income, Black, and Latinx neighborhoods were more likely to be excluded from these networks.

Our findings also indicate that the exclusion of pharmacies from preferred pharmacy networks within Medicare Part D contributes to pharmacy closures. Pharmacies that were not preferred by most Part D plans were 70–350 percent more likely to close during our study period than other pharmacies. These findings suggest that federal and state policy makers should consider Medicare Part D payment and delivery reforms that ensure that preferred pharmacy networks do not disproportionately exclude pharmacies in lowincome, Black, and Latinx neighborhoods.

As previously argued,^{5,11} federal pharmacy benefit manager reforms that expand preferred pharmacy networks and codify acceptable standards for equitable networks across counties and neighborhoods are warranted. For example, the Centers for Medicare and Medicaid Services should reevaluate their Part D network adequacy standards and ensure that pharmacy benefit managers do not design networks that disproportionately exclude certain types of pharmacies in neighborhoods whose residents are predominantly low income and Black or Latinx. CMS regulators should also consider provisions that mandate preferred status for pharmacies at high risk for closure, especially those in pharmacy deserts.

We also found that the extent of pharmacy participation in Medicare Part D preferred networks varied across states. In twenty-six states, there was at least one county in which not a single pharmacy was preferred for any Medicare Part D plan. Although states are preempted from regulating most aspects of Medicare plans,¹² several states have introduced regulations that govern aspects of the design and implementation of pharmacy networks by pharmacy benefit managers.¹³ Therefore, along with critically needed federal reforms, states should consider pharmacy benefit manager reforms that promote more inclusive and equitable pharmacy networks and

pharmacy reimbursement, even if they apply to only a limited segment of plans.

These federal and state efforts are necessary to protect pharmacies from closure and reduce persistent racial and ethnic inequities in access to pharmacies and medications among older adults,^{5,14} and specifically Medicare Part D beneficiaries. ■

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NOTES

- Hoadley J, Cubanski J, Neuman T. Medicare Part D at ten years: the 2015 marketplace and key trends, 2006–2015 [Internet]. San Francisco (CA): KFF; 2015 Oct [cited 2025 Mar 18]. Available from: https://files.kff .org/attachment/report-medicarepart-d-at-ten-years-the-2015-market place-and-key-trends-2006-2015
- 2 Xu J, Trish E, Joyce G. Part D beneficiaries' incentives and responses under preferred pharmacy networks. Am J Manag Care. 2023;29(4): 180-6.
- 3 Federal Trade Commission, Office of Policy Planning. Pharmacy benefit managers: the powerful middlemen inflating drug costs and squeezing Main Street pharmacies [Internet]. Washington (DC): FTC; 2024 Jul [cited 2025 Mar 18]. Available from: https://www.ftc.gov/system/files/ ftc_gov/pdf/pharmacy-benefitmanagers-staff-report.pdf
- 4 Guadamuz JS, Alexander GC, Zenk SN, Qato DM. Assessment of pharmacy closures in the United States from 2009 through 2015. JAMA Intern Med. 2020;180(1):157-60.
- 5 Guadamuz JS, Wilder JR, Mouslim MC, Zenk SN, Alexander GC, Qato DM. Fewer pharmacies in Black and Hispanic/Latino neighborhoods compared with White or diverse neighborhoods, 2007–15. Health Aff

(Millwood). 2021;40(5):802–11. 6 National Council for Prescription

- Drug Programs. dataQ [home page on the Internet]. Scottsdale (AZ): NCPDP; c 2009–23 [cited 2025 Apr 8]. Available from: https://dataq .ncpdp.org/
- 7 Centers for Medicare and Medicaid Services. Quarterly prescription drug plan formulary, pharmacy network, and pricing information [Internet]. Baltimore (MD): CMS; [last modified 2025 Apr 2; cited 2025 Apr 20]. Available from: https://data .cms.gov/provider-summary-bytype-of-service/medicare-part-dprescribers/quarterly-prescriptiondrug-plan-formulary-pharmacynetwork-and-pricing-information
- 8 National Center for Health Statistics. NCHS Urban-Rural Classification Scheme for Counties [Internet]. Hyattsville (MD): NCHS; [last updated 2024 Sep 17; cited 2025 Apr 8]. Available from: https://www.cdc .gov/nchs/data-analysis-tools/ urban-rural.html
- 9 Census Bureau. American Community Survey (ACS) [Internet].
 Washington (DC): Census Bureau;
 [last updated 2025 Apr 2; cited 2025
 Apr 20]. Available from: https://www.census.gov/programssurveys/acs
- 10 To access the appendix, click on the

Details tab of the article online.

- 11 Guadamuz JS, Alexander GC, Kanter GP, Qato DM. More US pharmacies closed than opened in 2018–21; independent pharmacies, those in Black, Latinx communities most at risk. Health Aff (Millwood). 2024; 43(12):1703–11.
- 12 Centers for Medicare and Medicaid Services. Medicare managed care manual [Internet]. Baltimore (MD): CMS; 2011 Nov 4. Chapter 10, MA organization compliance with state law and preemption by federal law; [cited 2025 Mar 18]. Available from: https://www.cms.gov/regulationsand-guidance/guidance/manuals/ downloads/mc86c10.pdf
- 13 Government Accountability Office. Prescription drugs, Selected states' regulation of pharmacy benefit managers [Internet]. Washington (DC): GAO; 2024 Mar [cited 2025 Mar 16]. (Pub. No. GAO-24-106898). Available from: https://www.gao .gov/assets/d24106898.pdf
- 14 Qato DM, Alexander GC, Chakraborty A, Guadamuz JS, Jackson JW. Association between pharmacy closures and adherence to cardiovascular medications among older US adults. JAMA Netw Open. 2019;2(4):e192606.

APPENDIX

Appendix Exhibit A 1. Detailed Definitions of Study Measures

Study Measures	Data Source	Area Unit (if applicable)	Definition/Categorization
<i>Outcome:</i> Pharmacy Closure	NCPDP (2014-2023) ¹	-	Permanent closure of a pharmacy in operation at any point during the study period. Because NCPDP is census of pharmacies, ¹ pharmacies missing from subsequent annual NCPDP datasets (unique pharmacy identifier) were classified as permanently <i>closed</i> . ² Conversely, pharmacies newly appearing in the data were considered newly <i>opened</i> for that year. ² We defined the year of pharmacy closure as one year after the year the pharmacy was last considered in operation by NCPDP. ²
Covariates: Pharmacy	-Level Factors		
<i>Primary exposure:</i> Preferred pharmacy status	NCPDP (2014- 2023) ¹ & Medicare Part D Pharmacy Network Files (2014- 2023) ³	-	 Time-varying (yearly) extent to which pharmacies participate in the preferred pharmacy networks of eligible plans (plans whose contracted service area includes the store's ZIP code)³ Preferred for ≥50% of plans with preferred networks Preferred for <50% of plans with preferred networks Non-preferred (preferred for no plans with preferred networks) Out-of-network (for all Part D plans) Note: A few pharmacies were only in-network for Medicare Part D plans without preferred networks (on average 336 pharmacies [or 0.5%] per year). These pharmacies were categorized as "preferred for ≥50% of plans with preferred networks."
Pharmacy type	NCPDP (2014-2023) ¹	-	 Based on NCPDP pharmacy ownership information³ Chain (≥4 pharmacies under common ownership) Independent (1-3 pharmacies under common ownership)
Covariates: Neighborh	ood-Level Demographic	Factors	
Urbanicity	NCHS (2013) ⁴	County	 Based on the NCHS⁴ Urban-Rural Classification Scheme for Counties^{2,5} Urban (counties containing a principal city and located in MSAs with populations ≥1 million) Rural (Counties in MSAs with populations ≥ 250,000 that do not qualify as "urban") Rural (all other counties)
Predominant race/ethnicity	ACS (2018-2022) ⁶	ZCTA	 Predominant racial/ethnic population in the neighborhood White (≥ 50% NL White) Black (≥ 50% NL Black) Latinx (≥ 50% Latinx) Diverse (no single racial/ethnic group above exceeded 50%)
Poverty	ACS (2018-2022) ⁶	ZCTA	 % of population living in households whose income is less than the federal poverty level <20% (also referred to as "higher-income") ≥20% (also referred to as "low-income")
Covariates: Neighborh	ood-Level Market Factor	S	
Uninsured	ACS (2018-2022) ⁶	ZCTA	% of population without health insurance • <10% • ≥10%
Medicare	ACS (2018-2022) ⁶	ZCTA	% of population insured with Medicare • <20% • ≥20%
Private-to-public insurance ratio	ACS (2018-2022) ⁶	ZCTA	Population with private insurance divided by population with public insurance (alone) • ≥2.0 • 1.0-1.9 • <1.0
Pharmacies per 10000 persons	NCPDP (2014-2023) ¹ & ACS (2018-2022) ⁶	ZCTA	 Number of pharmacies per 10,000 persons, assessed in the most recent year a pharmacy was operational CAPs (the sole pharmacy in a neighborhood) < 2.0 ≥ 2.0

Notes: ACS = American Community Survey; NCHS=National Center for Health Statistics; NCPDP = National Council for Prescription Drug Programs; MSA=metropolitan statistical area; NL = non-Latinx; ZCT A = ZIP code tabulation area.

Appendix Exhibit A 2. Trends in the Median Number of Medicare Part D Plans Each Pharmacy Can Serve, 2014-2023

	Plans, Median No. (IQR)				
		Plans without	Plans with		
		Preferred	Preferred		
		Pharmacy	Pharmacy	Preferred	
	Total Plans ^a	Networks ^b	Networks ^c	Pharmacy Status ^d	
2014	47 (38, 61)	22 (16, 36)	24 (21, 27)	4 (1, 8)	
2015	41 (33, 53)	16 (10, 27)	24 (20, 27)	7 (3, 12)	
2016	43 (33, 57)	19 (11, 30)	22 (20, 27)	9 (4, 14)	
2017	39 (30, 52)	15 (8, 25)	24 (20, 29)	10 (6, 16)	
2018	45 (34, 61)	12 (6, 22)	32 (27, 38)	15 (9, 21)	
2019	52 (41, 70)	15 (8, 24)	37 (31, 43)	18 (12, 25)	
2020	59 (45, 79)	16 (9, 27)	42 (35, 50)	20 (12, 29)	
2021	66 (51, 88)	18 (11, 30)	47 (39, 56)	22 (11, 33)	
2022	66 (50, 91)	19 (12, 30)	46 (36, 58)	21 (10, 35)	
2023	72 (55, 96)	30 (21, 43)	40 (33, 50)	15 (3, 28)	

Sources: Authors' analysis of data from the National Council for Prescription Drug Programs (2014-2023) and the Medicare Part D Pharmacy Network Files (2014-2023).

Notes: IQR = interquartile range.

a Number of Medicare Part D stand-alone prescription drug plans (PDP) and Medicare Advantage drug plans (MA-PD) whose contracted service area includes the pharmacy's ZIP code. **b** Number of plans without preferred pharmacy networks whose contracted service area includes the pharmacy's ZIP code. **c** Number of plans with preferred pharmacy networks whose contracted service area includes the pharmacy's ZIP code. **d** Number of plans that consider said pharmacy as "preferred" and whose contracted service area includes the pharmacy's ZIP code.



Sources: Authors' analysis of data from the National Council for Prescription Drug Programs (2023) and the Medicare Part D Pharmacy Network Files (2023).

Notes: Pharmacy participation in Medicare Part D preferred pharmacy networks was defined as pharmacies that were considered "preferred" by at least one plan with a preferred network. County-level participation in Medicare Part D preferred pharmacy networks was classified as 0% (no pharmacies participated, n=171), 0.1%-74.9% (n=609), ≥75.0%-99.9% (n=1133), and 100% (all pharmacies participated, 1074). An additional 156 counties had no pharmacies in 2023.

Appendix Exhibit A 4. Association of Pharmacy, Demographic, and Market Factors on Pharmacy Closures, 2014-2023

		Closure rate,	Closure rate,	HR ^d	
	Total, ª %	all time, ^b %	1-year, % °	Unadjusted	Adjusted ^e
Overall	85,359	28.1	3.9	-	-
Preferred pharmacy status ^f					
Preferred \geq 50% of plans	37.4	16.8	1.9	Ref.	Ref.
Preferred < 50% of plans	46.2	34.5	2.3	2.02****	1.69****
Not preferred	12.1	25.3	6.4	4.09****	3.14****
Out-of-network	4.3	66.5	7.8	6.55****	4.53****
Pharmacy type					
Chain	56.1	21.3	3.0	Ref.	Ref.
Independent	43.9	36.8	5.1	2.13****	1.50****
Demographic factors ^g					
Urbanicity ^h					Ref.
Urban	32.4	30.5	4.3	Ref.	0.97*
Suburban	42.7	26.1	3.7	0.82****	0.98
Rural	24.9	28.5	3.9	0.90****	
Predominant race/ethnicity ⁱ					
White	66.3	26.3	3.6	Ref.	Ref.
Diverse	18.6	29.8	3.8	1.18****	1.08****
Black	5.9	35.7	4.9	1.49****	1.28****
Latinx	9.3	33.2	5.5	1.38****	1.16****
Poverty					
< 20%	81.9	26.9	3.7	Ref.	Ref.
≥ 20% ("Low-income")	18.1	33.4	4.7	1.32****	1.04**
Market factors ^g					
Uninsured					
< 10%	68.2	27.1	3.6	Ref.	Ref.
≥ 10%	31.8	30.3	4.6	1.16****	1.04**
Medicare					
< 20%	87.6	28.0	3.9	Ref.	Ref.
≥ 20%	12.4	28.8	4.0	1.03*	0.99
Private to public insurance ratio ^j					
≥ 2.0	51.9	26.0	3.6	Ref.	Ref.
1.0 - 1.9	35.3	29.4	4.2	1.16****	1.03*
< 1.0	12.8	33.0	4.4	1.36****	1.01
Pharmacies per 10,000 perso	ons				
CAP	6.5	25.7	3.0	Ref.	Ref.
< 2.0	27.1	22.4	3.0	0.85****	1.05
≥ 2.0	66.5	30.7	4.4	1.26****	1.41****

Sources: Authors' analysis of data from the National Council for Prescription Drug Programs (2014-2023), the Medicare Part D Pharmacy Network Files (2014-2023), and the American Community Survey (2018-2022).

Notes: CAP=critical access pharmacy, defined as the sole pharmacy in a neighborhood; HR = hazard ratio; Ref. = reference. **a** Pharmacies in operation at any point between 2014 and 2022. **b** All time closure rate was defined as the number of pharmacies that closed between 2015 and 2023 divided by the number of pharmacies in operation at any time between 2014 and 2022. **c** Closure within 1 year of index date, accounting for differences in follow-up. **d** HRs denote the risk of pharmacy closure, as assessed using Cox proportional hazard models. **e** Adjusted for pharmacy, demographic, and market factors. **f** Preferred pharmacy status characterizes the extent to which pharmacies participate in Medicare Part D preferred pharmacy networks. Pharmacies were categorized as preferred for $\geq 50\%$ of Part D plans with preferred networks, preferred for < 50% of plans, non-preferred (preferred for no plans), or out-of-network (for all plans in their service area). **g** Area-level information applied to pharmacies based on their location. **h** Counties containing a principal city and located in a metropolitan statistical area (MSA) with populations ≥ 1 million were classified as *urban*, counties located in MSAs with a population $\geq 250,000$ that do not qualify as *urban* were considered *suburban*; and all other counties were considered *rural*. **i** Predominant race/ethnicity was categorized as White ($\geq 50\%$ of the population is non-Latinx [NL] White), Black ($\geq 50\%$ NL Black), Latinx ($\geq 50\%$ Latinx), or Diverse (no single racial/ethnic group exceeding 50%). **j** Population that is privately insured divided by the population that is publicly insured alone. * p < 0.1, ** p < 0.05, *** p < 0.01.

Appendix Exhibit A 5. Sensitivity Analysis: Association of Number of Medicare Part D Plans, the Percentage of Plans with Preferred Pharmacy Networks, and Preferred Pharmacy Status on Pharmacy Closures, 2014-2023

		Closure			
	Total	Median (IQR)		HRª	
Medicare Part D participation	Median (IQR)	Active	Closed	Unadjusted	Adjusted ^b
All pharmacies					
Total Plans, ° No.	52.0 (38.0, 71.0)	54.0 (39.0, 73.0)	42.0 (31.0, 58.0)	0.85****	0.87****
Plans with Preferred Pharmacy Networks, ^d %	63.0 (50.0 <i>,</i> 73.9)	63.6 (51.3, 74.2)	57.9 (42.6, 71.0)	0.91****	1.00
Preferred Pharmacy Status, ^e %	41.0 (20.8, 64.3)	44.9 (24.0, 66.7)	23.1 (4.8, 42.1)	0.81****	0.86****

Sources: Authors' analysis of data from the National Council for Prescription Drug Programs (2014-2023), the Medicare Part D Pharmacy Network Files (2014-2023), and the American Community Survey (2018-2022).

Notes: HR = hazard ratio **a** HRs denote the risk of pharmacy closure, as assessed using Cox proportional hazard models. Analysis includes all retail pharmacies in operation at any point between 2014 and 2022 and closures were assessed from 2015 to 2023. For interpretability, covariates were scaled by 10 in the regressions. **b** Adjusted for pharmacy, demographic, and market factors. **c** Number of Medicare Part D stand-alone prescription drug plans (PDP) and Medicare Advantage drug plans (MA-PD) whose contracted service area includes the pharmacy's ZIP code. **d** Number of plans with preferred pharmacy networks, divided by number of total plans. **e** Number of plans that consider said pharmacy as "preferred", divided by number of plans with preferred pharmacy networks. * p < 0.1, *** p < 0.01, **** p < 0.001.

APPENDIX REFERENCES

- 1. National Council for Prescription Drug Programs. dataQ. December 1, 2023. Accessed May 28, 2024. https://dataq.ncpdp.org/
- 2. Guadamuz JS, Alexander GC, Zenk SN, Qato DM. Assessment of Pharmacy Closures in the United States From 2009 Through 2015. *JAMA Internal Medicine*. 2020;180(1):157-160. doi:10.1001/jamainternmed.2019.4588
- 3. Centers for Medicare and Medicaid Services. Quarterly Prescription Drug Plan Formulary, Pharmacy Network, and Pricing Information. 2024. Accessed May 28, 2024. https://data.cms.gov/provider-summary-by-type-of-service/medicare-part-d-prescribers/quarterly-prescription-drug-plan-formulary-pharmacy-network-and-pricing-information
- 4. National Center for Health Statistics. Urban Rural Classification Scheme for Counties. 2017. Accessed October 27, 2023. https://www.cdc.gov/nchs/data_access/urban_rural.htm
- 5. Pew Research Center. Evaluating what makes a U.S. community urban, suburban or rural. November 22, 2019. Accessed April 10, 2024. https://www.pewresearch.org/decoded/2019/11/22/evaluating-what-makes-a-us-community-urban-suburban-or-rural/
- 6. US Census Bureau. American Community Survey (ACS). Census.gov. December 1, 2023. Accessed February 10, 2024. https://www.census.gov/programs-surveys/acs