Patients Adapt: The Mitigated Impact of Retail Pharmacy Closures

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Abstract

Retail pharmacies are the most frequently visited healthcare provider in the United States. They dispense over 150 billion daily doses of prescription medication to Americans each year and offer an array of basic health services to the public. However, the number of retail pharmacies has declined significantly in recent years, with even more pharmacies scheduled to close in the near future. The surge of recent pharmacy closures has raised significant concern about pharmacy access, though there is little evidence on the effects of pharmacy access. This study aims to fill that gap. Using a stacked difference-in-difference approach, I find that patients decrease their prescription drug use following their primary pharmacy's closure, but only 1.5 percent. Instead, patients strongly and rapidly adapt by using mail-order pharmacies and switching from 1-month prescriptions to 3-month prescriptions. There is little evidence that primary pharmacy closure significantly impacts downstream healthcare utilization.

1 Introduction

Retail pharmacies, the most frequently visited healthcare service provider, play a central role in the U.S. healthcare system. Most directly, pharmacies dispense prescription drugs, which are increasingly ubiquitous in modern medical practice. Patients only benefit from drugs they can access, and in this way, retail pharmacies mediate the relationship between pharmaceutical innovation and patient outcomes. Better access to pharmaceuticals may increase medication adherence, which is known to be a significant determinant of efficacy.

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In addition, pharmacies provide important healthcare services beyond dispensing drugs. Pharmacists can perform basic medical services (e.g., vaccinations) and provide medical advice concerning prescription and over-the-counter medications, chronic disease management, and preventive health. The average patient sees a pharmacist between 1.5 and 11 times as often as their primary care doctor (Tsuyuki et al., 2017; Ho and et al., 2020), and several studies have shown that pharmacy and pharmacist-involved care can successfully improve patient health, including significant reductions in blood pressure, cholesterol, and even hospitalizations (Mossialos et al., 2015; Tannenbaum and Tsuyuki, 2013). However, despite the importance of pharmacies, relatively little economic research has investigated their value to patients or to other providers.

This question is rapidly becoming more salient with a wave of recent retail pharmacy closures. The three largest pharmacy chains in the United States—CVS, Walgreens, and Rite Aid—have all announced large-scale closures. Walgreens announced in October 2024 that it would begin closing 1200 stores (Associated Press, 2024). Seven months later, CVS announced it would be closing 200 of its stores (Newsweek, 2025). Rite Aid, which had 2000 stores in 2023, has declared bankruptcy twice and will close its remaining stores (CBS News, 2025; The New York Times, 2025). These estimates compound earlier closures; since 2018, both CVS and Walgreens have already closed around 1000 stores each. In total, 29.4% of pharmacies that existed in 2010 have now closed (Guadamuz et al., 2024). The unprecedented magnitude of these closures has provoked significant public concern about pharmacy access from medical practitioners and policymakers alike (Baskin, 2025). Many have claimed that pharmacy closures will negatively impact the elderly, the disabled, and minorities, who tend to use a higher number of prescription drugs and are disproportionately located in areas that have experienced a pharmacy closure (The New York Times, 2024).

On the other hand, the impact of pharmacy closures may be overstated. Recent research suggests that demand-side preferences dominate supply-side barriers in food purchasing choices (Allcott et al., 2019), and this pattern may extend to pharmaceutical consumption. Further, patients may adapt more easily to a pharmacy closure than to other types of store closures. Patients can request longer prescriptions (e.g., 90-day prescriptions instead of 30-day prescriptions) to reduce necessary trips to a pharmacy, or turn to mail-order prescriptions to avoid retail pharmacies altogether.

Pharmacy closures could even have positive impacts on patients and the rest of the healthcare system. Many medical experts have expressed concern about over-prescribing, as well as the burden of pharmaceuticals on healthcare spending. As implied by the larger literature on ordeals (Nichols and Zeckhauser, 1982; Besley and Coate, 1992), adding a barrier to receiving prescriptions may effectively reduce marginal prescriptions among those who receive negligible benefit or significant risk. Further, prescription drugs necessarily require a prescription from a physician or other healthcare professional. Reducing unnecessary prescriptions could therefore reduce the utilization of these other healthcare services.

With these competing theoretical concerns, the value of pharmacies is an empirical question. However, it is a difficult question to answer, as the relationship between pharmacy use and health services utilization is severely confounded by the patient's underlying health. Even if pharmaceutical access actually improves health, sicker patients may nevertheless be more likely than healthier patients to both use pharmaceuticals and suffer negative health consequences, which could bias the relationship.

To overcome this potential issue, I exploit plausibly exogenous shocks to patients' pharmacy access to estimate the value of pharmacies. Specifically, I focus on the closure of a patient's primary pharmacy as a measure of pharmacy access. First, the closure of a patient's primary pharmacy represents a large, discrete, and observable shock in access. Particularly given the coarse and sometimes inconsistent data available for pharmacies, the clarity of the shock could minimize measurement error. Second, primary pharmacy closure is a policy-relevant shock given the recent surge of announced pharmacy closures; the results of this analysis will be able to speak directly to the predicted consequences of the closures policy-makers are considering. Third, data support that patients tend to repeatedly visit the same pharmacy. Between 2010 and 2012, the median Medicare Part D patient received 97% of their prescriptions from their modal pharmacy, and over 35% of Medicare Part D patients ever only used one pharmacy. Therefore, the closure of a patient's primary pharmacy may be the most salient shock to pharmacy access.

Using Medicare Claims data, I implement a two-way fixed effects difference-in-differences model to estimate the effect of pharmacy closure on patient health outcomes and healthcare utilization, comparing outcomes for patients whose primary pharmacy closed earlier against outcomes for patients whose primary pharmacy closed later. The patient fixed effects, which flexibly control for all time-invariant patient-level factors, alleviate concerns that selection effects are driving the results, while time fixed effects, which flexibly control for all patient-invariant time-level factors, account for secular trends in the outcome. A key identifying assumption of the difference-in-differences strategy is parallel trends: that, absent the closure, those patients whose primary pharmacy closed would have continued along a parallel trajectory in the outcome as those whose primary pharmacy did not close. I provide support for this assumption using an event study, in which I show that the outcomes were, conditional on the fixed effects, parallel up until the time of closure and diverge afterwards. Finally, I address concerns about biased estimates in difference-in-differences studies with heterogeneous treatment effects by implementing a stacked event study that strictly compares cohorts of treated patients against those who were not treated until after the end of the event study period.

I find that following a primary pharmacy closure, patients experience a statistically significant but small decrease in the use of prescription medications. The magnitude of this effect – less than a 2% decrease in days of prescription supply – is small in part due to significant patient adaptation. Patients immediately begin using mail-order pharmacies and substituting 1-month prescriptions for 90-day prescriptions. Ultimately, I find minimal evidence of any effect on downstream health outcomes.

These findings contribute to the existing literature using natural experiments to estimate the value of healthcare services. Recent studies have used similar approaches to estimate the value of skilled nursing facilities (Einav et al., 2025), long-term care hospitals (Einav et al., 2023), hospice (Gruber et al., 2025), hospitals (Alexander and Richards, 2023a,b), primary care facilities (Bischof and Kaiser, 2021), and obstetrics units (Fischer et al., 2024).

This paper also contributes to the burgeoning literature on pharmacies and pharmaceutical access. Many studies, particularly in the public health and healthcare services literature, have documented potentially concerning trends surrounding pharmacy access. Many of these descriptive studies show that many patients may not have ready access to a pharmacy (Ying et al., 2022), that pharmacy closures have increased over time (Guadamuz et al., 2024) and that closures are concentrated in areas with high shares of low-income or minority individuals (Qato et al., 2014; Wisseh et al., 2021; Guadamuz et al., 2020). Only a few studies have used causal methods to understand the effect of pharmaceutical access. Two studies exploit pharmacy closures to estimate the effects on use of specific drug classes (Anderson et al., 2024; Qato et al., 2019). This study aims to provide a more comprehensive analysis of the effects of pharmacy closures, including patient adaptation and downstream health consequences. Chandra et al. (2021) exploit quasi-exogenous variation in pharmaceutical prices to estimate the effect of patient cost-sharing on pharmaceutical use and patient health, finding that Medicare patients are extremely elastic with respect to price for prescription medications. This study examines whether that elasticity extends to other forms of pharmaceutical access.

The rest of the paper proceeds as follows. In section 2, I provide details on the landscape of pharmacies in the United States. In section 3 and subsection 3.3, I describe the data used for this analysis and the stacked event study approach. In section 4, I provide my main findings, which are discussed in section 5. I conclude in section 6.

2 Background

2.1 Pharmacies as Healthcare Providers

Pharmacies are the most commonly used healthcare provider in the United States.[2] Each year, approximately 60,000 pharmacies dispense over 150 billion daily doses of prescription medications to Americans (IQVIA Institute, 2025), and one survey finds that nearly 70% of American voters visit a retail pharmacy each month. Approximately half of all Americans have used a prescription medication in the past 30 days (Centers for Disease Control and Prevention, 2025).

Pharmacies are particularly and increasingly important for Medicare beneficiaries. Prescription drug claims are the most common among all Medicare claims, roughly 64% more common than non-institutional outpatient claims and 666% more common than all institutional claims combined (Figure 1).Indeed, the average Medicare beneficiary fills 2.9 prescriptions per month. 72.2% of Medicare beneficiaries enrolled in a Part D plan receive a prescription in any given month, and 32.7% receive more than three. Prescription drug spending among Medicare Part D increases significantly each year (Figure 2).

Retail pharmacies, the subject of this paper, are the most commonly used type of pharmacy, accounting for approximately 83% of prescriptions in the US overall as of 2024 (IQVIA Institute, 2025) and 76.9% of prescriptions among Medicare beneficiaries as of 2019. Approximately 13.1% of Medicare prescriptions are filled by long-term care pharmacies, which contract with long-term care facilities (e.g., nursing homes) to provide medication to institutionalized patients. These patients are typically unaffected by pharmacy closures because the institution manages patient access, delivery, and use of prescription medications. Mail-order pharmacies, on the other hand, offer a viable alternative for many patients whose primary pharmacy has closed, a possibility that will be explored in this paper. However, despite con-

[2] Technically, the federal definition of healthcare providers includes only those authorized to provide services under Medicare Part B and, therefore, excludes pharmacies and pharmacists. Many states include pharmacists as healthcare providers.

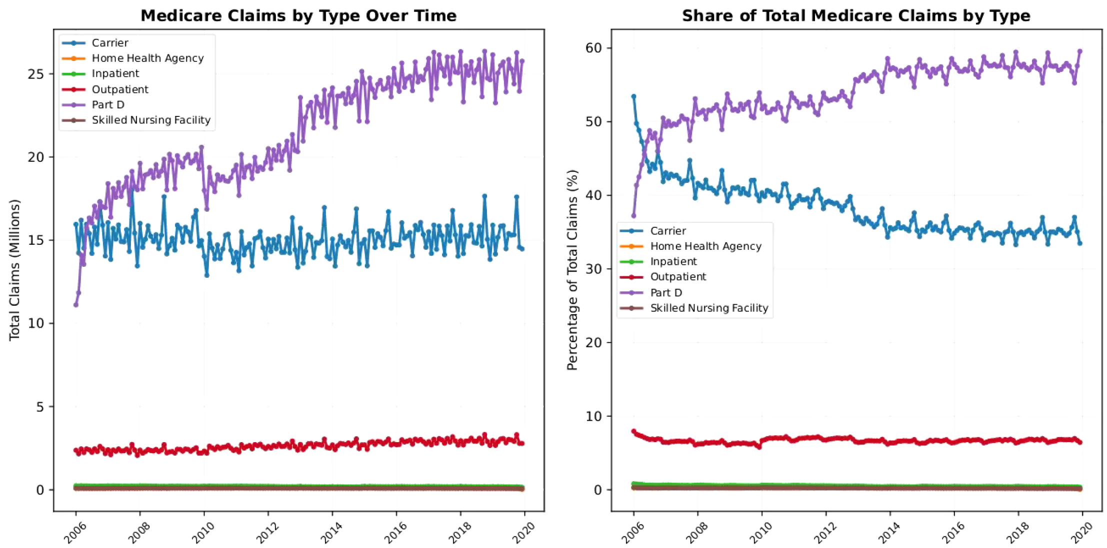

Figure 1: Medicare Claim Types Over Time

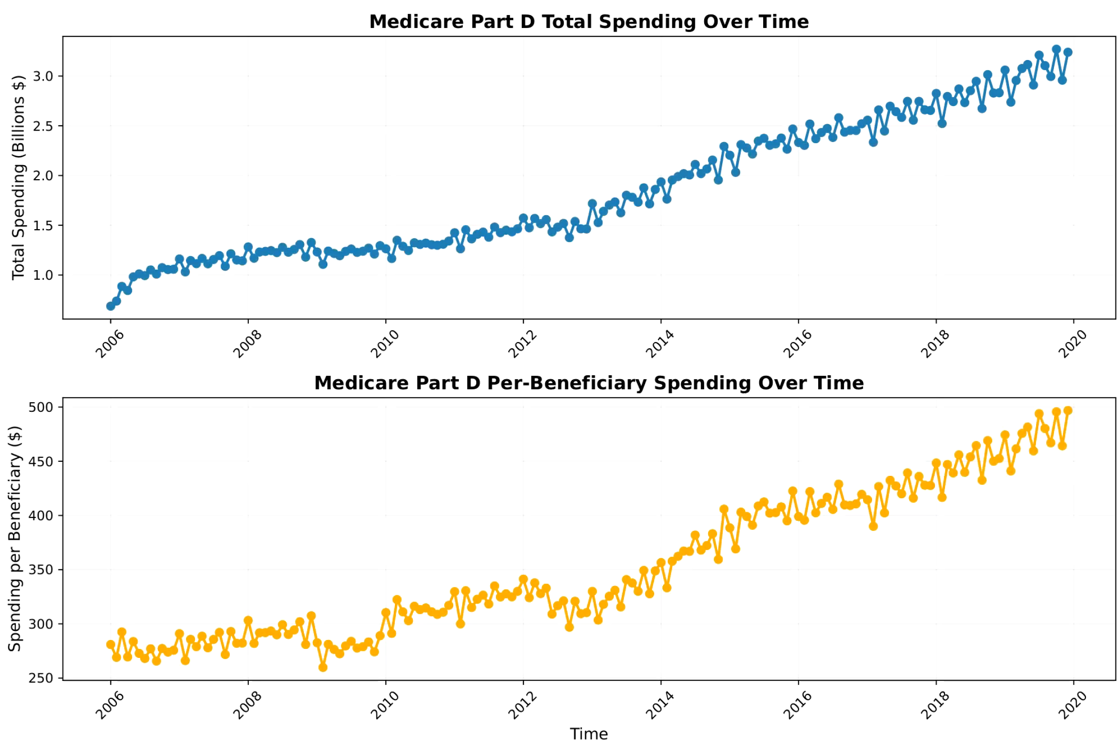

Figure 2: Medicare Part D Spending at Retail Pharmacies Over Time

tinued efforts by insurance companies encouraging patients to use mail-order pharmacies, utilization in the Medicare population remains low (Do and Geldsetzer, 2021); only 8.0% of Medicare prescriptions are filled by mail order.

Beyond dispensing prescription drugs, pharmacies provide a myriad of other healthcare services (Shepler, 2014). Medicare requires that Part D plans provide Medication Therapy Management (MTM), which is commonly offered via community pharmacists (Barnett et al., 2009; Pellegrin et al., 2017; Winston and Lin, 2009). Pharmacies also provide basic disease management (Klepser et al., 2012), preventive services, laboratory services, and health education. Research suggests these services may avert more costly healthcare utilization (Pellegrin et al., 2017) and improve patient health outcomes (Kraemer et al., 2012; Branham et al., 2013). External evidence consistently supports that elderly patients, in particular, value and have strong relationships with their pharmacists and rely on pharmacies for a variety of health services.

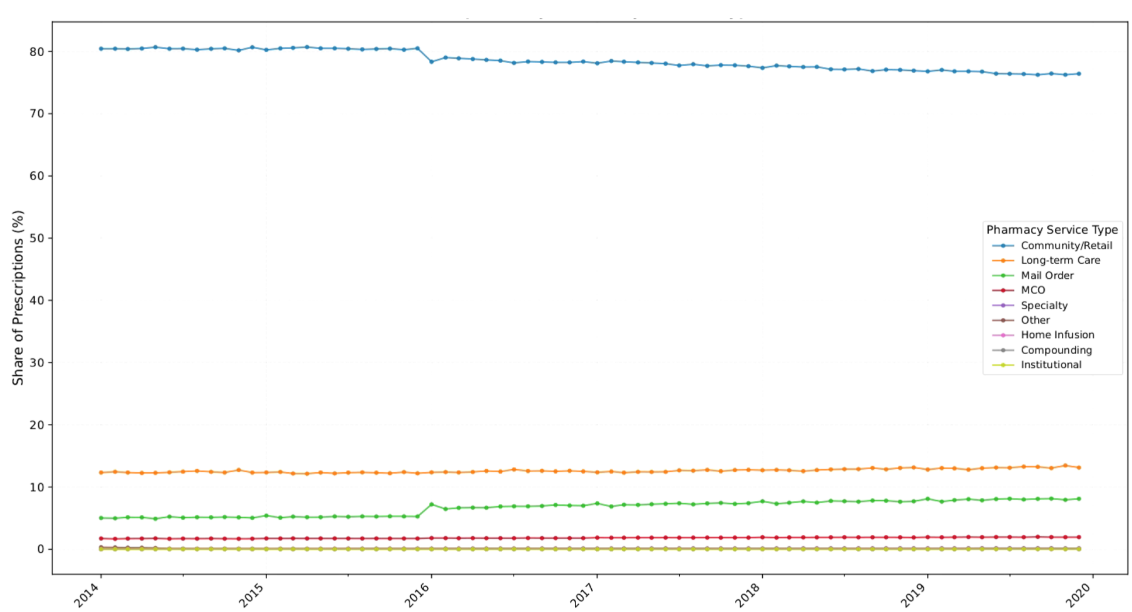

Figure 3: Trends in Mail-Order Pharmacy Use Among Medicare Beneficiaries, 2014–2019

Medicare's prescription drug benefit, known as Medicare Part D, spends hundreds of billions of dollars at retail pharmacies each year (Figure 2); other payers including Medicaid, private insurers, and out-of-pocket spending contribute hundreds of billions of dollars more.

While retail pharmacies dispense the vast majority of prescriptions in the United States, they are not the only type of pharmacy accessible to patients. Most Medicare Part D plans offer patients the option to receive prescriptions from licensed mail-order pharmacies. These mail-order pharmacies typically offer lower prices than retail pharmacies, and so both insurance providers and the government have encouraged patients to increase their use of mail-order pharmacies. However, utilization of mail-order pharmacies, particularly among Medicare patients, remains low (Do and Geldsetzer, 2021). The Medicare Claims data began categorizing Part D pharmacies consistently beginning in 2014, and the share of prescriptions filled by mail-order pharmacies has consistently remained under 10% until at least 2019 (Figure 3). According to one survey, 85% of patients report preferring retail pharmacies to their mail-order counterparts.

2.2 Why Pharmacies Close

For most of the current century, the US retail pharmacy sector experienced healthy growth (Qato et al., 2017). Between 2010 and 2017, the number of pharmacies grew by an average of 1.4% per year (Qato et al., 2024b). However, that trend reversed starting in 2018. At first, the decline was slow; between 2018 and 2021, the number of retail pharmacies decreased by 0.6% each year. However, today, over twenty percent of retail pharmacies in the US are projected to close in the next year (Bacci et al., 2025). The three largest pharmacy chains – CVS, Walgreens, and Rite Aid – have each announced major waves of closures over the next year.

Analysts and pundits have offered several explanations for the sudden increase in pharmacy closure (Fein, 2025). Perhaps the most well founded explanation is the increasing role and consolidation of pharmacy benefit managers (PBMs) in the US healthcare system (Qato et al., 2024a). Essentially, PBMs are intermediaries that contract with both health insurance providers and retail pharmacies to negotiate the price of pharmaceuticals. On one hand, they contract with a health insurance provider, offering to lower the costs of pharmaceutical claims in exchange for access to their patient base. On the other, PBMs leverage the patient base to negotiate lower prices from retail pharmacies. In this way, retail pharmacies trade off margin for quantity when accepting a contract with a PBM, similar to how a physician may offer a discount to be considered in-network for a given health insurance provider.

In recent years, the PBM market has become increasingly horizontally concentrated (Qato et al., 2024a); according to a 2022 report by the Federal Trade Commission, six PBMs now manage over 95% of the prescriptions in the United States. This concentration has granted PBMs greater market power, which they have leveraged to significantly decrease retail pharmacy margins, potentially leading to closures. Indeed, one study finds that pharmacies that were not preferred by most Medicare Part D plans were 70 to 350 percent more likely to close than preferred pharmacies (Qato et al., 2025). Vertical integration could also play a role in pharmacy closures. Three of the largest retail pharmacy providers in the United States – CVS, Walmart, and Walgreens – each own or have a strategic partnership with their own PBM. While this kind of vertical integration has the potential to improve efficiency and decrease costs for patients (Mulligan, 2022), it also has the potential to drive closures of their competitors (Gray et al., 2023).

Another potential explanation for the surge in pharmacy closures is the increasing use of 90-day prescriptions. In the early 2010s, retail pharmacies advocated for policies that enabled and encouraged more 90-day prescriptions. Many representatives from the retail pharmacy industry argued that 90-day prescriptions would increase revenue and operational efficiency while increasing patient convenience. These efforts succeeded, as the share of 90-day prescriptions increased markedly (Liberman and Girdish, 2011). However, many analysts now believe that retail pharmacies' advocacy for more 90-day prescriptions may have backfired. Longer prescription lengths may have increased sales of some low-margin generics, but they also decreased foot traffic and front store sales, which often have a higher margin than prescriptions.

Other frequently cited drivers of pharmacy closures include slow growth of brand-name drug prices, decreasing generic prices, increased usage of prescription discount cards, and increased front store retail theft (American Pharmacists Association, 2025). The exact cause of retail pharmacy closures is beyond the scope of this paper. However, the most common explanations in the literature and policy discourse indicate that closures are not driven by a decrease in quantity demand for prescription drugs.

2.3 Consequences of Pharmacy Closures

While several studies have documented the recent increase in pharmacy closures and posited potential impacts, few have empirically studied how pharmacy closures or decreases to pharmacy access could impact patients. One study using data from IQVIA found that cardiovascular patients experienced an immediate, significant, and persistent decrease in their adherence to statins, beta blockers, and oral anticoagulants ranging from five to six percent (Qato et al., 2019). However, evidence of the impact of pharmacy closures on patient adaptation or downstream health outcomes is absent.

Researchers, policymakers, and advocates have expressed significant concern about the impacts of these closures on patients, particularly minorities and other disadvantaged communities. Past research shows that people living in pharmacy deserts are more likely to identify as a racial or ethnic minority or be disabled, and there is evidence that recent closures are concentrated in areas with higher minority populations (Qato et al., 2024b). Barriers to appropriate healthcare for disadvantaged communities in the US are well documented, and so many worry that this new wave of pharmacy closures has the potential to exacerbate already wide existing disparities.

3 Data

3.1 Dataset Construction

The primary data source for this study is the healthcare claims of a random 20% sample of Traditional Medicare beneficiaries between the years 2009 and 2017[3]. Medicare is near-universal, publicly-provided health insurance for the elderly (over 65), disabled, and end-stage renal disease patients in the United States, and these data contain records of each patient's healthcare utilization, including their use of outpatient, inpatient, home health, skilled nursing facility, and hospice services. Importantly, these data also include claims for pharmaceutical drugs administered under Medicare's Part D benefit, which allow us to track both individual pharmaceutical usage and the operation of pharmacies.

To begin the analysis, I estimate the closure months of retail pharmacies via the last pharmacy claim available in the Medicare data at a given pharmacy. Beginning in 2009, the Medicare Part D data consistently provide the National Provider Identifier (NPI) of the dispensing pharmacy for each Medicare Part D claim. However, NPIs are unreliable pharmacy identifiers. Many individual pharmacies process claims through multiple NPIs. A pharmacy, its pharmacist, and each of its pharmacy technicians have their own NPIs, and even if they operate as one patient-facing unit, that unit may, at different times, use all of those NPIs. Further, some pharmacies may change their NPI over time after, for example, a change in ownership or location. Treating NPIs as individual pharmacies could overestimate the number of pharmacy closures; if a pharmacy technician retires from a CVS, we may code the last claim using that technician's NPI as a closure, even if the CVS persists and the patient experience is largely unaffected. To address this concern, I develop a clustering algorithm using each NPI's patient composition to assign NPIs to pharmacies.

I restrict the sample of NPIs to NPIs that serve at least 30 unique patients over their existence. Then I construct an adjacency matrix from the collection of all possible NPI pairs.

[3]The 20% random sample is the largest available for Medicare Part D claims

For each pair, I compute a Jaccard score using Equation 1, in which J_{ab} is the Jaccard score for the pair of NPIs a and b, n_a and n_b are the number of unique patients served by NPI a and b respectively, and n_{ab} is the number of unique patients served by both a and b.

$$J_{ab} = \frac{n_{ab}}{n_a + n_b - n_{ab}} \tag{1}$$

Among these pairs, I define connected components by a $J_{ab} \geq 0.1$ and at least 30 shared patients. Finally, I build the clusters of NPIs from the connected components.

With this empirical mapping of NPIs to pharmacies, I identify closing pharmacies as those that cease having any claims at any of their constituent NPIs between 2010 and 2016 and define their closing month accordingly. Importantly, by construction, this procedure finds pharmacy closures in which patients disperse to other pharmacies or stop using any pharmacy. If a pharmacy were to close and redirect all of its patients to one alternative pharmacy, this procedure would incorrectly group together both the closing and alternative pharmacies and fail to recognize the original pharmacy's closure. This could bias my results away from 0 as it potentially excludes the least impactful pharmacy closures.

Next, I assign patients to their primary pharmacy. For each closing pharmacy, I determine whether each patient had more than 50 percent of their pharmacy visits at that pharmacy in the 3 months before closure. If a patient meets those criteria, I assign that pharmacy as the patient's primary pharmacy.[4] I then restrict the sample to patients who are both alive and enrolled in Medicare Part D for the 12 months before and after their primary pharmacy's closure, ultimately yielding a sample of patients whose pharmacy closed and have complete data surrounding that closure.

To estimate the stacked event study, I use this corpus to construct separate datasets for each month in my study period. For each target month, I use all patient-month observations within a 12-month window surrounding the target month for patients whose pharmacy closed

[4] If a patient meets those requirements for multiple closing pharmacies, I use the one that closed the earliest.

in the target month or at least 12 months after the target month. The former, whose pharmacy closes in the middle of the sample, becomes the treated group. The latter, whose primary pharmacy had not yet closed for any period in the window, becomes the control group. Notably, a certain individual may appear in multiple cohort-specific sub-dataframes.

3.2 Outcomes

The outcomes used in this study are derived from the Medicare Claims data. First, we examine the effects of pharmacy closures on pharmacy and prescription drug utilization. The Medicare Claims data do not contain information on actual prescription drug usage; they only include data on prescription drug fills and the characteristics of those fills. Our primary outcomes in this domain are whether the patient filled any prescriptions (extensive margin), the number of trips to a pharmacy, and the days of supply dispensed (intensive margin) in a given month. We define the trips to a pharmacy as unique combinations of fill date and pharmacy; filling multiple prescriptions at the same pharmacy on the same day constitutes one pharmacy trip. Days of supply is a common standardization of prescription lengths reported by the pharmacy and available in the Medicare Claims data. We also estimate the effect on the number of total fills, though this outcome may be less informative than days of supply if patients adapt to pharmacy closure by adjusting the length of their prescriptions.

We directly measure that form of adaptation by estimating the effect of pharmacy closure on prescription drug length. Specifically, we estimate the effect on number and share of fills that cover either 28-31 days of supply or 84-93 days of supply. Prescriptions of these lengths typically treat chronic conditions and are likely substitutable, so patients responding to a pharmacy closure may substitute from the former to the latter. Fills are categorized into their length via their reported days of supply. In addition, we study the number and share of prescriptions filled by mail-order pharmacies. Like for retail and community pharmacies, we classify mail-order pharmacies by their National Plan and Provider Enumeration System taxonomy codes. Mail-order pharmacies provide a viable alternative for patients who wish to physically visit community pharmacies less often.

Given the public discourse surrounding the potential disparate effects of pharmacy closures on disadvantaged communities, we implement event studies separately by race, age, and disability status. For the latter, we categorize patients based upon their original reason for eligibility for Medicare.

Next, we assess the impact of pharmacy closures on healthcare utilization. These outcomes serve two purposes. First, while the Medicare Claims data do not contain direct information on patient health, healthcare utilization can be an effective proxy. An increase in hospitalizations, for example, would signal a negative effect on patient health. Second, healthcare utilization is a directly relevant outcome for policymakers hoping to rein in healthcare costs. If pharmacy closures increase patients' use of other covered healthcare services, then policies intended to decrease the likelihood of pharmacy closures may be merited. Notably, these effects could either incentivize or disincentivize policies intended to reduce pharmacy closures. Pharmacy closures could reduce other healthcare spending by, for example, decreasing physician visits to receive prescriptions or decreasing hospitalizations from drug-induced side effects. In these cases, investments designed to deter pharmacy closures could be counterproductive in reducing healthcare costs.

3.3 Empirical Approach

The goal of the empirical approach is to estimate the causal effects of a patient's primary pharmacy closure on their health and healthcare utilization outcomes. This presents several challenges. We cannot simply compare the health and healthcare outcomes of patients before and after a closure. Health and healthcare outcomes exhibit strong secular trends, and because observations after a closure mechanically occur later than those before a closure, any naive comparison between the two would be biased by those underlying trends. Further, we cannot compare patients whose primary pharmacy closed to those whose primary pharmacy did not close in the cross-section, as previous research confirms that closures differentially affect different groups of patients.

Instead, I use a two-way fixed effects event study design that flexibly controls for these potential biases. In the canonical event study, the econometrician estimates this model via a regression of the form:

$$y_{ipt} = \sum_{k=\underline{T}, k\neq=-1}^{\bar{T}} \beta_k \text{Pharmacy Closed}_{ip} 1(t=k) + \gamma_i + \gamma_t + \epsilon_{ipt} \tag{2}$$

Here, y_{ipt} is a relevant outcome for individual i at closing pharmacy p during month t. γ_i and γ_t are individual and time fixed effects, and ϵ_{ipt} is a random error term. The coefficients of interest are the set of β_k for $k \in [\underline{T}, \bar{T}]$. For $k > 0$, β_k represents the dynamic effects of pharmacy closure relative to the omitted period. The individual fixed effects flexibly account for any time-invariant selection issues by effectively comparing outcomes within an individual at different points relative to the pharmacy closure. The time fixed effects flexibly account for any secular trends that affect all patients.

In the current setting, however, each patient is assigned to a primary pharmacy based upon their pharmacy usage relative to a closure and so, mechanically, all patients are eventually treated. Therefore, the canonical event study shown in (2) is not identified; relative time is collinear with the time fixed effects. To address this issue, I estimate separate event studies, each centered around a different pharmacy closure month (cohort). For each of these event studies, patients whose primary pharmacy closes after the end of that study period can be used as control units because those patients are untreated throughout the entire study period. The equation of each of these cohort-level event studies is identical to the canonical event study shown in (2), though the sample is different. Each cohort-level event study only contains observations for patients treated at the cohort-specific treatment date or after the cohort-specific event study window ends. I then aggregate the β_k coefficients estimated in each cohort-specific event study using inverse probability weighting, yielding a weighted average of the dynamic effects of pharmacy closures. This approach is identified and effectively controls for both time-invariant and patient-invariant confounders like the canonical event study.

This approach has several advantages over alternative methods of estimating an event study in settings with only eventually treated units. An event study with two or more reference periods is identified in settings without never-treated units, but such an approach imposes assumptions on the effects in the reference periods. The stacked event study approach does not impose such assumptions and, like the canonical event study, dynamic events are estimated relative to a single period. Recently, several researchers have raised concerns that event study estimates with staggered treatment designs and heterogeneous treatment effects may not fall within the convex hull of group-specific effect estimates due to the presence of negative weights (see Wing et al. (2024) for a review). In the stacked event study approach, each cohort-specific event study only has one treatment period, which precludes the possibility of these problematic negative weights. Finally, relative to a single-regression stacked event study approach, the current approach is computationally efficient and feasible with limited computing resources[5].

In addition to the stacked event study, I also estimate an analogous stacked difference-in-difference estimator, which represents overall causal effects of pharmacy closures. The approach is the same, except that we only estimate one coefficient per cohort, as shown in (3). As before, the cohort-level coefficients are aggregated via inverse probability weighting.

$$y_{ipt} = \beta \text{Pharmacy Closed}_{ip} 1(t \geq 0) + \gamma_i + \gamma_t + \epsilon_{ipt} \tag{3}$$

[5]The single-regression stacked event study, in which the econometrician estimates the canonical event study equation with an additional set of time-by-cohort fixed effects on a stacked dataset of all the individual cohorts, would directly estimate the aggregated event study coefficients and have fewer assumptions on effect homogeneity and cohort sample sizes. Alternative estimators like Sun and Abraham (2021) and Callaway and Sant'Anna (2021) are based upon this approach. However, this approach is computationally expensive, particularly on large datasets such as those used in this study.

4 Results

4.1 Pharmacy and Prescription Drug Use

In our sample, 82,151 patients experienced a primary pharmacy closure at one of 8,101 retail/community pharmacies. Figure 4 shows four event studies, estimated via Equation 2, examining the effect of pharmacy closure on pharmacy and prescription drug use. The analogous difference-in-difference estimates are shown in Table 1. Panel A shows that the days of prescription supply significantly decrease in response to primary pharmacy closure; the average patient-month reduces their number of prescription days by around 1.9 on a mean of 126, representing a 1.5% decline. The share of patients who visit any pharmacy in a given month is 82% in our sample and significantly decreases by 3 percentage points (3.7% decrease) in response to primary pharmacy closure. The total number of pharmacy trips per patient decreases by approximately 1%, while fills decrease by 5%.

The dynamics shown in these event studies reveal some interesting patterns. For example, the share of patients who visit a pharmacy is temporarily elevated just before the pharmacy closes. This is consistent with an anticipation period, which seems feasible in this setting. Patients who are informed that their primary pharmacy is imminently closing may visit the pharmacy to stockpile medications before their access to pharmaceuticals decreases. Additionally, the effect on days of supply exhibits a zig-zag pattern after the closure of the pharmacy, which could be consistent with the usage of 90-day prescriptions. The effect seems weakest every third month after closure, which could be the month that patients who turn to 90-day prescriptions after primary pharmacy closure complete their fills.

These event studies also enable us to test the parallel trends assumption. The days of supply event study provides clear evidence in favor of parallel trends. Leading up to the closure, all coefficients are either not significantly different from zero or only marginally significant, indicating that the treatment and control group followed similar trajectories in the outcome after accounting for the fixed effects. After the closure, however, almost all coefficients are significantly less than zero, suggesting that the trajectories of treated and control patients diverged strongly at the time of the closure. The event study for the patients' likelihood of visiting any pharmacy provides less clear but no less compelling evidence in favor of parallel trends. Due to the anticipation period, the trajectories of the treatment and control group (conditional on the fixed effects) diverge three periods before the pharmacy closure. However, in this anticipation period, the treated group's likelihood of visiting a pharmacy increases relative to the control group, which contrasts with the effect after the closure. Therefore, in this case, anticipation likely attenuates the estimated effect.

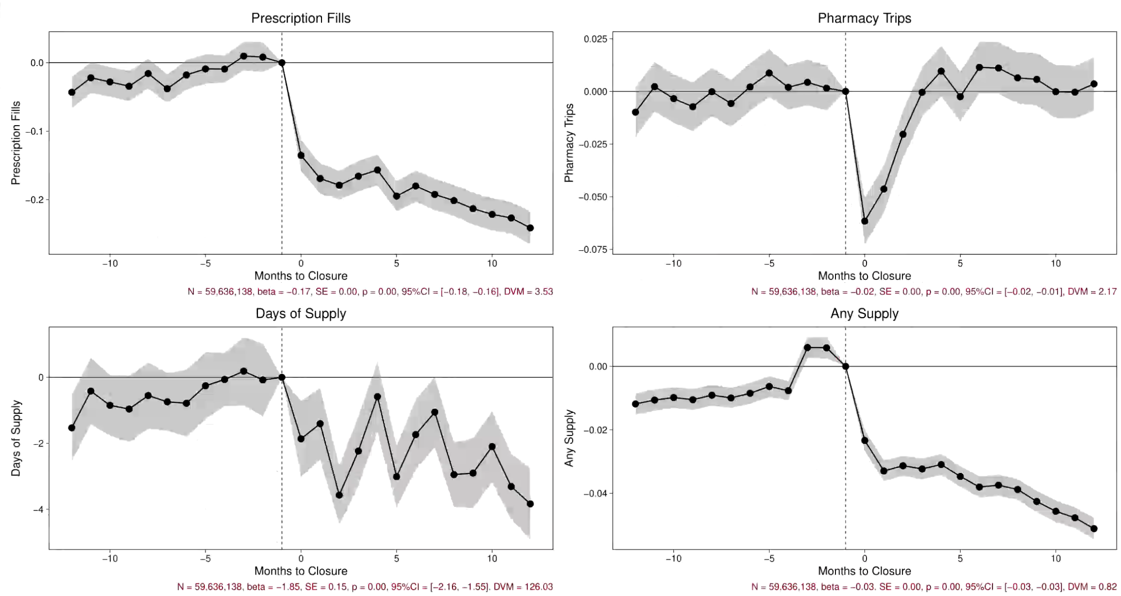

Figure 4: Effect of Primary Pharmacy Closure on Prescription Drug Use

	Prescription Fills (1)	Pharmacy Trips (2)	Days of Supply (3)	Any Supply (4)
Pharmacy Closure	-0.170***	-0.020***	-1.850***	-0.030***
	(0.000)	(0.000)	(0.150)	(0.000)
Dep. Var. Mean	3.530	2.170	126.030	0.820
Observations	59,636,138	59,636,138	59,636,138	59,636,138

Note: Standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05

Table 1: Effect of Primary Pharmacy Closure on Prescription Drug Use: Coefficient Estimates

4.2 Adaptation

The combination of a 5% decrease in fills but only a 1.5% decrease in days of supply implies that patients increase the days of supply per prescription. Indeed, we find significant evidence that patients substitute from 1-month (28-31 day) prescriptions to 3-month (84-93 day) prescriptions. Following a closure, patients decreased their number of 1-month prescriptions by 0.21 per month and increased their number of 3-month prescriptions by 0.05 (Table 2 and Figure 5). This suggests that nearly three quarters of the decline in days of supply from fewer 1-month prescriptions was offset by an increase in 3-month prescriptions.

Patients also increased their use of mail-order pharmacies in response to a pharmacy closure. Throughout our sample, only 3% of patients used a mail-order pharmacy in a given month. This increased by 1 percentage point after primary pharmacy closure.

	Mail Order Days Supply	Any Mail Order Fills	Number 28-31 Day Prescriptions	Number 84-93 Day Prescriptions
	(1)	(2)	(3)	(4)
Pharmacy Closure	0.010***	0.010***	-0.210***	0.050***
	(0.000)	(0.000)	(0.000)	(0.000)
Dep. Var. Mean	0.030	0.030	2.510	0.450
Observations	59,636,138	59,636,138	59,636,138	59,636,138

Note: Standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05

Table 2: Effect of Primary Pharmacy Closure on Prescription Length: Coefficient Estimates

4.3 Heterogeneity

Public discourse surrounding pharmacy closures often focuses on potentially disparate impacts on disadvantaged communities. Indeed, we find that disadvantaged communities were most affected by the pharmacy closures. While primary pharmacy closure caused a 0.58 prescription drug day decrease in White patients, the effects on Blacks, Asians, and Native Americans were almost eight times stronger (Table 3 and Figure 6). Hispanics were particularly strongly affected; the average Hispanic patient decreased their prescription pill days by over 12 days per month in response to a pharmacy closure.

Disabled patients and those with end-stage renal disease also experienced a much greater

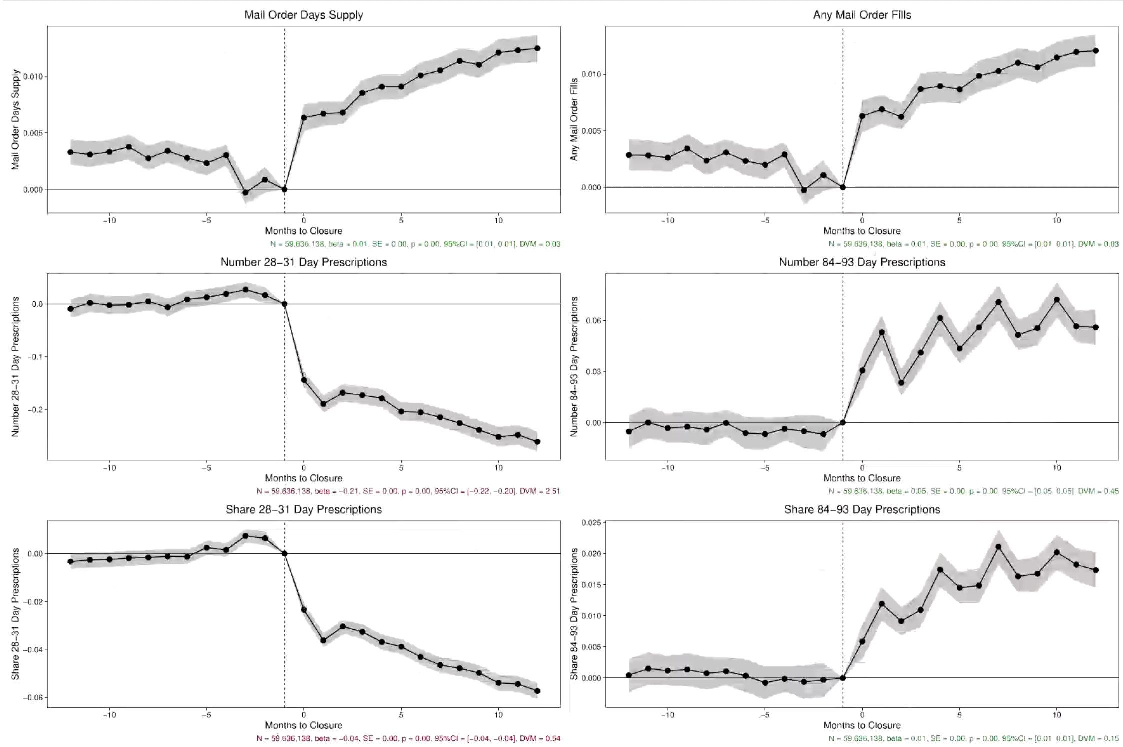

Figure 5: Effect of Primary Pharmacy Closure on Prescription Length

decline in days of supply than patients enrolled in Medicare for old age (Table 4 and Figure 7). Those originally enrolled in Medicare due to disability or end-stage renal disease decreased their prescription days of supply by 4.5 days of supply per month and 14.8 days of supply per month, while those enrolled due to age decreased their prescription drug use by only 0.73 days of supply per month. This heterogeneity is further reflected by age group (Table 5 and Figure 8). Those enrolled in Medicare under the age of 65 – who are necessarily enrolled in Medicare due to either disability or end-stage renal disease – experience the greatest declines in days of prescription supply. Interestingly, the effect appears to attenuate with age; those in the oldest age group seem to be the least affected.

The effects of pharmacy closure vary significantly not only by patient sample but by drug class. Drugs treating acid-related disorders and obstructive airway diseases, anti-inflammatory drugs, analgesics, antipsychotics, and anti-depressants are among the classes most significantly affected by closures; days of supply decreases significantly for each of these drug classes (Figure 9). Days of supply for other drug classes, such as antithrombotic agents, cardiac therapies, diuretics, and thyroid therapies, do not significantly decrease in response to a pharmacy closure.

	White (1)	Black (2)	Other (3)	Asian (4)	Hispanic (5)	Native American (6)
Pharmacy Closure	-0.580***	-4.770***	-5.690***	-5.990***	-12.220***	-5.020***
	(0.160)	(0.510)	(1.140)	(0.940)	(1.070)	(1.240)
Dep. Var. Mean	124.750	130.050	121.910	128.110	145.760	142.340
Observations	48,287,877	6,123,349	972,837	1,805,808	1,935,581	135,405

Note: Standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05

Table 3: Effect of Primary Pharmacy Closure on Days of Supply by Race: Coefficient Estimates

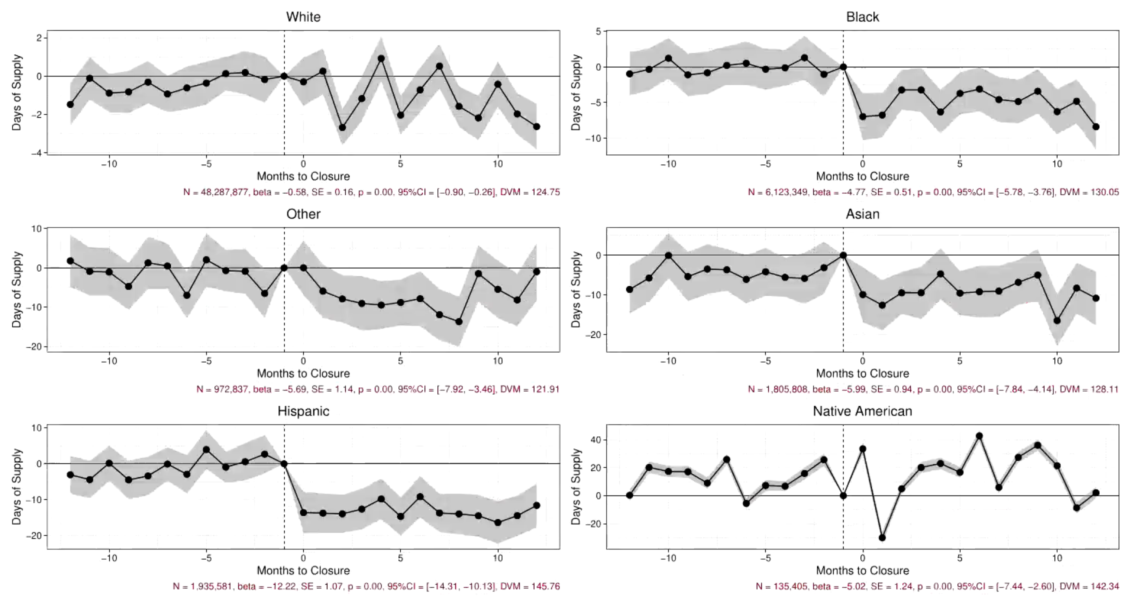

Figure 6: Effect of Primary Pharmacy Closure on Days of Supply by Race

4.4 Healthcare Services

Finally, we examine the effects of pharmacy closures on downstream health outcomes. The most compelling evidence of an effect is on the usage of home health services. Payments to

	OASI (1)	Disability (2)	ESRD (3)	Disability + ESRD (4)
Pharmacy Closure	-0.730***	-4.510***	-14.800***	-3.750*
	(0.170)	(0.330)	(1.710)	(1.610)
Dep. Var. Mean	118.230	144.710	154.720	159.070
Observations	42,339,605	16,730,460	163,193	386,720

Note: Standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05

Table 4: Effect of Primary Pharmacy Closure on Days of Supply by Original Reason for Entitlement: Coefficient Estimates

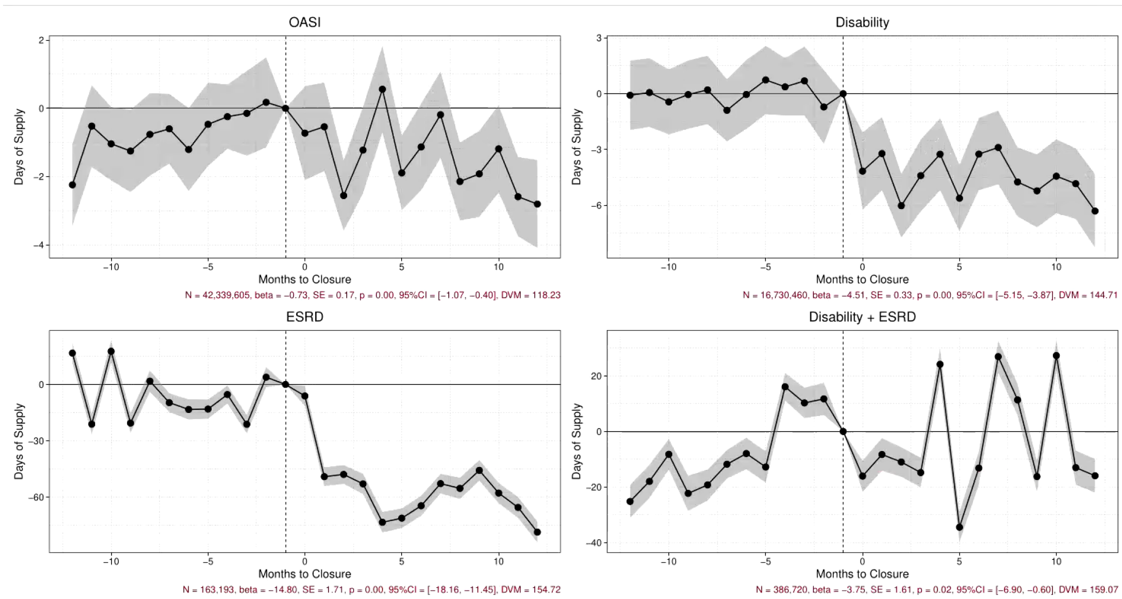

Figure 7: Effect of Primary Pharmacy Closure on Days of Supply by Original Reason for Entitlement

	Age 65-69 (1)	Age 70-74 (2)	Age 75-79 (3)	Age 80-84 (4)	Age 85-89 (5)	Age 90+ (6)
Pharmacy Closure	-3.180***	-0.270	0.090	0.220	-0.930	
	(0.330)	(0.320)	(0.360)	(0.420)	(0.510)	
Dep. Var. Mean	118.940	118.080	122.930	128.600	128.450	
Observations	8,357,905	12,729,616	10,640,246	7,854,573	5,061,816	

Note: Standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05

Table 5: Effect of Primary Pharmacy Closure on Days of Supply by Age: Coefficient Estimates

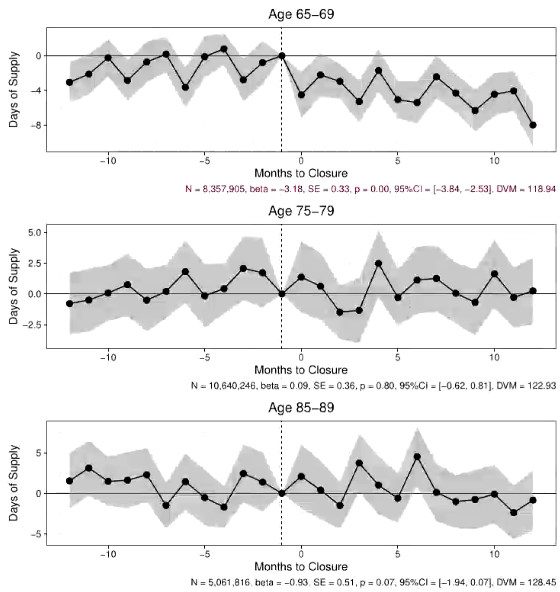

Figure 8: Effect of Primary Pharmacy Closure on Days of Supply by Age

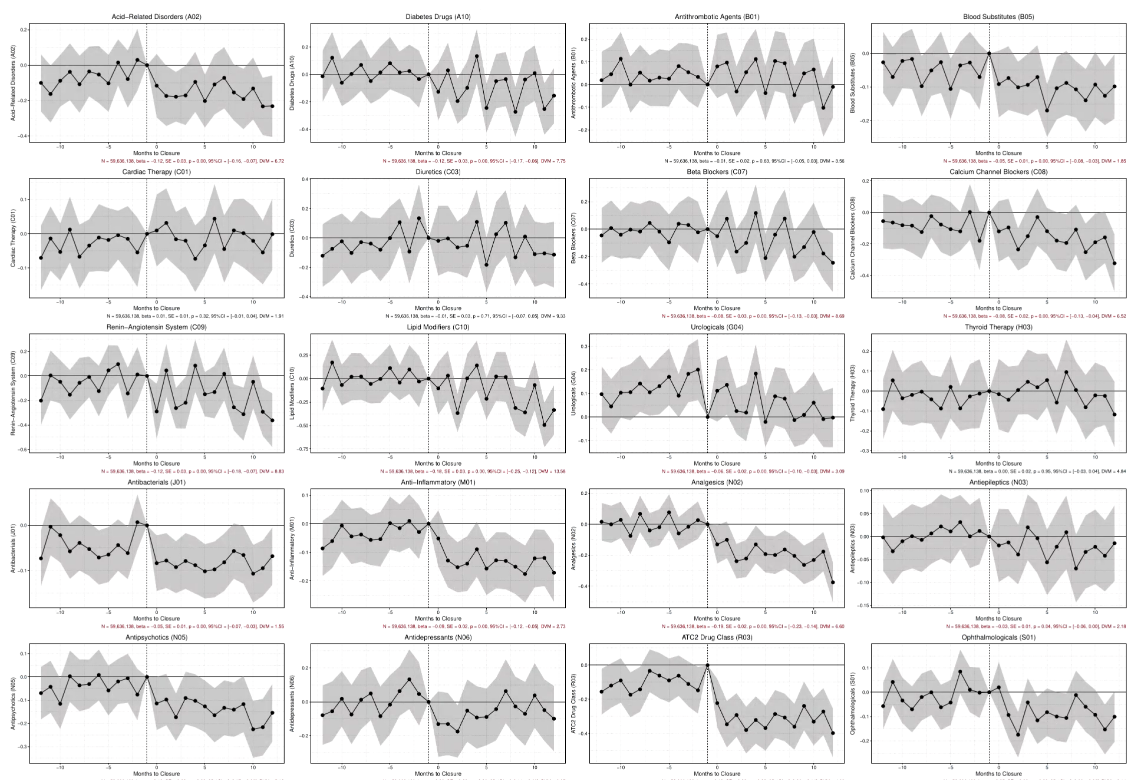

Figure 9: Effect of Primary Pharmacy Closure on Days of Supply by Drug Class

home health service providers increase by 6% relative to the sample mean (Figure 10 and Table 6). Payments to outpatient facilities, on the other hand, are much smaller.

The event studies for the other two forms of healthcare utilization are less interpretable (Figure 11 and Table 7). Inpatient spending remains mostly unaffected for virtually the entire study period but increases significantly in the last two months of the sample. Rather than a true effect, this is likely an artifact of the sample selection procedure. Each cohort includes treated patients, whose primary pharmacy closes at time t, and control patients, whose primary pharmacy closes after $t + 12$. We assign each patient to a pharmacy based upon their utilization within three months of that pharmacy's closure, and we restrict the sample to patients who are alive up until $t + 12$. Because of this, within each cohort, all control patients remain alive for at least nine months after $t + 12$, while treated patients may die immediately after $t + 12$. Consequently, at $t + 11$ and $t + 12$, treated patients could be nearing death while control patients, by definition, cannot. If inpatient hospitalizations increase near the time of death, that could explain the increase in inpatient spending near the end of the sample for treated relative to control patients. Hospice spending may suffer from a similar issue, in addition to a violation of the parallel trends assumption.

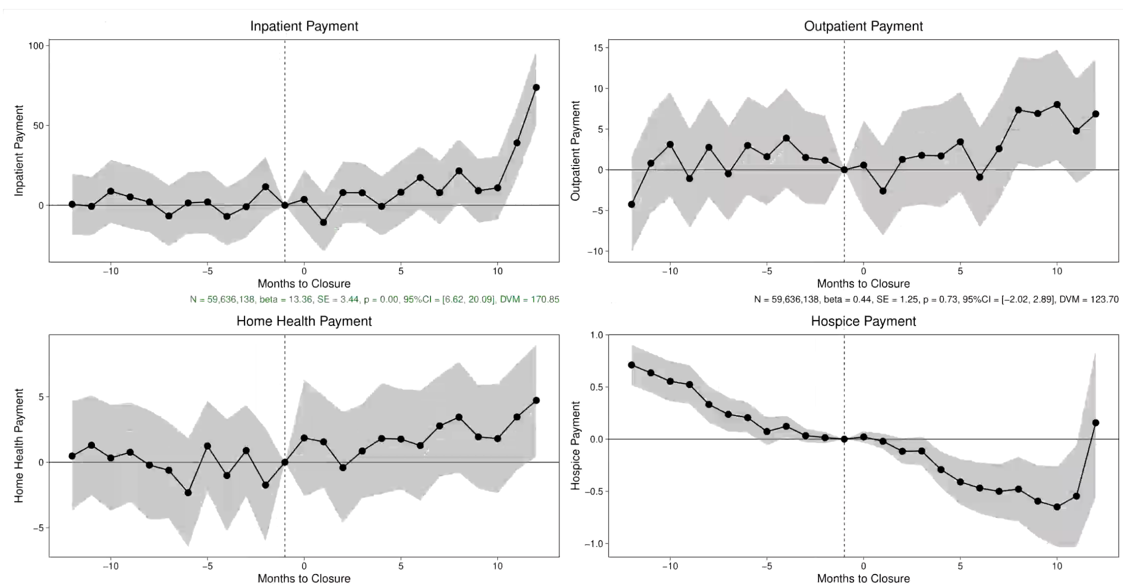

Figure 10: Effect of Primary Pharmacy Closure on Healthcare Service Payments

	Inpatient Payment	Outpatient Payment	Home Health Payment	Hospice Payment
	(1)	(2)	(3)	(4)
Pharmacy Closure	13.360***	0.440	2.370***	0.610*
	(3.440)	(1.250)	(0.590)	(0.250)
Dep. Var. Mean	170.850	123.700	39.590	2.280
Observations	59,636,138	59,636,138	59,636,138	59,636,138

Note: Standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05

Table 6: Effect of Primary Pharmacy Closure on Healthcare Service Payments: Coefficient Estimates

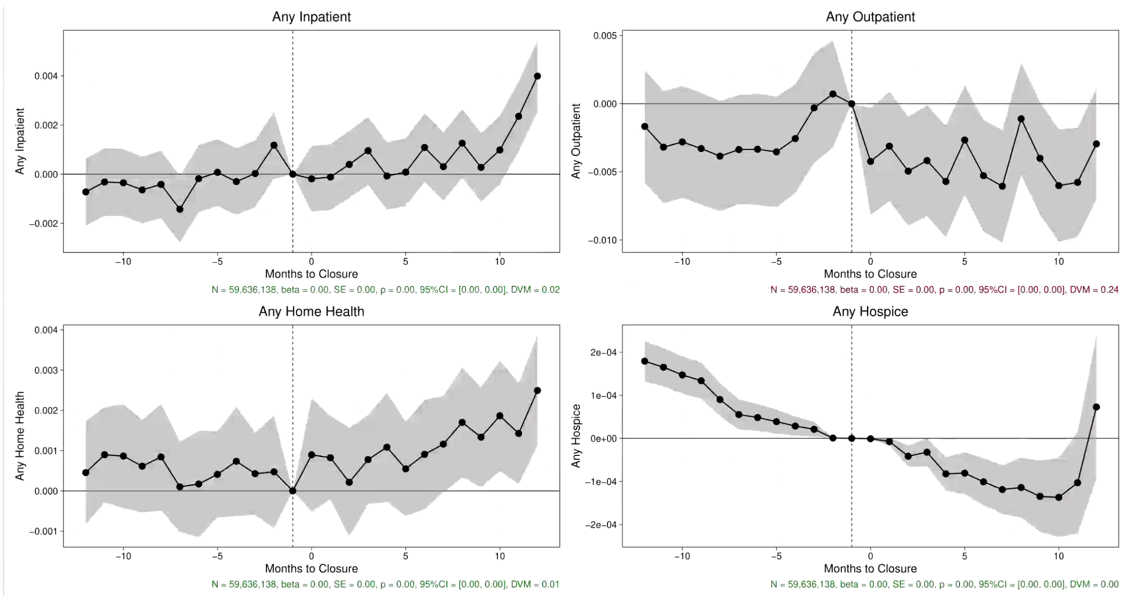

Figure 11: Effect of Primary Pharmacy Closure on Any Healthcare Service Use

	Any Inpatient	Any Outpatient	Any Home Health	Any Hospice
	(1)	(2)	(3)	(4)
Pharmacy Closure	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Dep. Var. Mean	0.020	0.240	0.010	0.000
Observations	59,636,138	59,636,138	59,636,138	59,636,138

Note: Standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05

Table 7: Effect of Primary Pharmacy Closure on Any Healthcare Service Use: Coefficient Estimates

5 Discussion

This paper provides the first comprehensive evaluation of the effects of pharmacy closures on patient health and healthcare utilization.

This study provides support for claims that pharmacy closures impact prescription drug access, particularly among disadvantaged communities. Prescription drug use consistently and significantly decreases following a primary pharmacy closure, and these effects are many times larger for minority and disabled patients than White and non-disabled patients.

However, this effect is, overall, small. Instead, there is notable evidence of patient adaptation. When a patient's pharmacy closes, their use of longer prescriptions and mail-order pharmacies increase dramatically and persistently. For example, the increase in 3-month prescriptions following a pharmacy closure compensates for approximately three quarters of the days of supply lost from a decrease in 1-month prescriptions. These findings indicate that many prescriptions not filled at a closing pharmacy will be filled elsewhere.

Ultimately, outpatient and inpatient healthcare spending are mostly unaffected. Several interpretations could be consistent with this finding. First, it is possible that patients are over-prescribed. While clinical trials for pharmaceutical drugs confirm a positive average treatment effect for all approved prescriptions, the marginal patient may be receiving less, if any, benefit from at least some medications. Inframarginal patients, who would suffer most from losing a prescription, may adapt to a pharmacy closure in order to continue receiving their necessary medications. Marginal patients, on the other hand, may cease using a prescription that may not have affected their health anyways. Our results concerning heterogeneity by drug class lend some credence to this hypothesis. Drugs that are less likely to lead to healthcare utilization if skipped, such as anti-depressants, and antipsychotics, are more responsive to pharmacy closures than drugs likely to increase healthcare utilization if skipped, such as cardiac and thyroid therapy.

Alternatively, it is possible that pharmacy closures affect patient health but that these effects do not flow into outpatient or inpatient spending. Medicare Claims data do not include direct information on patient health, and patients' daily experience with their health can deteriorate without a corresponding increase in inpatient or outpatient spending. It is additionally possible that these health consequences could impact inpatient or outpatient spending but with a lag extending beyond the study window.

6 Conclusion

The recent uptick and impending surge in pharmacy closures has raised concerns among policymakers and public health professionals about pharmaceutical access. Prescription drugs play a major role in modern medicine. Given that patients access prescription medications through pharmacies, pharmacy closures could have significant impacts on patient health and, potentially, the entire healthcare system. However, we find that, while statistically significant, the effect of a patient's primary pharmacy closure on their prescription drug use is minimal. Instead, patients successfully adapt and the consequences on downstream health outcomes are minimal.

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