Informative ordeals in healthcare: Prior authorization of drugs in Medicaid*

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Abstract

Health insurers frequently impose supply-side policies in the form of 'prior authorization' to manage healthcare spending. Prior authorization requires providers to fill out paperwork before treatment is eligible for coverage. The stated purpose of these policies is to reduce healthcare spending by encouraging the use of lower-cost treatments of similar quality, and to ensure treatment complies with established guidelines. However, there are concerns that prior authorization may discourage needed care. Using all-payer claims data from Massachusetts in 2009-2013, we estimate the effect of prior authorization on the use of specific drugs in MassHealth, the state Medicaid fee-for-service program. Using difference-in-differences estimation, we compare Medicaid beneficiaries affected by changes in prior authorization requirements to individuals in plans of a major commercial insurer unaffected by these policy changes. We find that prior authorizations lead to large reductions in utilization of drugs that have clear substitutes. These reductions are fully offset by increases in utilization of cheaper but equally effective drugs. However, when clear substitutes are not available, there are reductions in utilization that do not lead to substitution to similar drugs. Prior authorization reduces both high- and low-value use of drugs, suggesting that it is not well targeted.

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1 Introduction

Prescription drugs have become an increasingly important part of healthcare spending in the U.S. (Tichy et al., 2023). From 1980 to 2022, real per capita spending on prescription drugs in the U.S. has increased more than sixfold for both private and public payers, amounting to over $422 billion or almost one tenth of total healthcare spending in 2022 (Centers for Medicare and Medicaid Services, 2024b). This increase in drug spending has been a major concern for policymakers (Cubanski et al., 2023; Congressional Budget Office, 2022), particularly as 3 in 10 adults in the U.S. report being unable to afford their prescription drugs due to cost (Mulcahy et al., 2024).

This paper asks how supply-side policies affect prescription drug spending and patient outcomes. Economic theory suggests that, if consumers are fully rational and not liquidity constrained, optimal policy for managing drug spending should focus on the demand side through increasing cost-sharing, copays, or otherwise increasing the price that the patient is responsible for paying for drugs they receive (McGuire, 2011). Under the standard model of optimal health insurance design, such policies optimally trade off the benefits of risk protection from insurance and the increase in utilization due to moral hazard. However, in practice, concerns over financial barriers to healthcare access have led to a push towards reducing cost-sharing and towards supply-side utilization management policies. In fact, the share of spending on prescription drugs paid by patients has decreased from 57% in 1990 to 15% in 2018 (Congressional Budget Office, 2022). Furthermore, recent evidence suggests that demand-side policies and increased cost-sharing may harm patients and increase mortality (Chandra et al., 2021).

One of the most common supply-side policies for reducing spending is 'prior authorization', where providers are required to fill out paperwork in advance to obtain approval from the insurer. The stated goal of prior authorization policies is to reduce healthcare spending by ensuring treatment complies with established guidelines and targets use of treatments to those most likely to benefit (America's Health Insurance Providers, 2020). Use of prior authorization has been rising over time (Brot-Goldberg et al., 2023; Kyle et al., 2023) and is the second biggest administrative burden for providers behind billing (Casalino et al., 2009). Prior authorization requirements are generally imposed on new, high-cost, on-patent drugs (Kyle and Song, 2023) but also remains in effect for many older drugs as well. In Medicaid, where legally all drugs must be covered by the program, prior authorization is used for up to 70% of branded drugs.[1]

Theoretically, prior authorization requirements for a given drug unambiguiously reduce utilization and spending on that drug in two ways. First, providers are less likely to prescribe the drug subject to prior authorization due to the ordeal costs imposed through the prior authorization process. Second, prior authorization policies give the insurer discretion in approving and denying coverage, which can lead to a reduction in the utilization of the restricted drug if the denial rate is non-

[1] Authors' calculation using MMIT data. Conditional on being included in the drug formulary, the share of drugs that have prior authorizations in Medicare and private insurance range between 25%-35%.

zero. However, the overall effect on spending and utilization is ambiguous and depends on whether prior authorization diverts utilization to relatively cheaper or more expensive drugs, to other more expensive non-pharmaceutical care (e.g. ED care, inpatient care) or to no treatment at all. The effect of prior authorization on patient outcomes is similarly ambiguous depending on the relative efficacy of the drugs patients substitute to when the drug subject to prior authorization is restricted.

Prior authorization requirements may also improve the targeting of drugs to patients most likely to benefit either through the provider or the insurer side. On the provider side, if providers have different thresholds for prescribing low-value vs. high-value care, imposing the same ordeal cost for both types of care may disproportionately reduce low-value care. Alternatively, if patient-provider matching is such that providers who are more willing to undergo the administrative ordeal for treatments also disproportionately see patients who are more likely to benefit from those treatments, prior authorization may improve targeting. On the insurer side, to the extent that the prior authorization form is an "informative" ordeal and reveals information about the patient benefit from treatment to the insurer, the insurer can then use their discretion to deny coverage to patients less likely to benefit from the drug.

We empirically investigate these theoretical predictions and examine the effect of prior authorization requirements in the context of prescription drug use in MassHealth, the Massachusetts fee-for-service Medicaid program during 2009-2013. We use the Massachusetts All Payer Claims Database (APCD) to measure drug utilization during this period. We use a difference-in-difference design to evaluate the effect of adding a new prior authorization requirement on a drug on spending and targeting of drugs to patients most likely to benefit. In our empirical approach, we compare 'treated' beneficiaries enrolled in MassHealth with 'control' beneficiaries enrolled in Blue Cross Blue Shield of Massachusetts (Blue Cross Blue Shield MA) plans.[2] We compare outcomes for drugs that were never subject to prior authorization in our control group but that transition from no or partial prior authorization to complete prior authorization in our treatment group. We match beneficiaries in Mass Health with beneficiaries in Blue Cross Blue Shield MA based on demographics, enrollment duration, and prior utilization.

We find that imposing a new prior authorization requirement on a drug reduces use of that drug by 58%. However, this reduction is not uniform across all drugs. We estimate larger decreases in utilization for drugs that have more easily available alternatives. When prior authorization is placed on a branded drug with an unrestricted generic active ingredient, utilization of the branded drug decreases by almost 70%. Similarly, when prior authorization is placed on a particular dosage, formulation, or route of administration of an active ingredient when other forms of the drug are unrestricted, utilization of the restricted drug falls by almost 60%. In both cases, these decreases are fully offset by increases in utilization of cheaper equally effective drugs with the same active ingredient. This implies that in some situations, prior authorization requirements can be effective

[2]MassHealth and Blue Cross Blue Shield MA plans are the two largest insurers in Massachusetts, with almost 45% of all Massachusetts residents ever enrolled in one of the two plans during our data.

in reducing spending on drugs without harming patient outcomes.

However, when prior authorization is placed on all brands, formulations, and dosages of an active ingredient, utilization of the restricted drug falls by 15% and this decrease is not offset by increases in utilization of other drugs in the same therapeutic class as the restricted drug, thus indicating that some patients forgo care and substitute towards no pharmaceutical treatment when the drug they are prescribed is subject to prior authorization.

We then investigate whether prior authorizations disproportionately reduce high-value vs. low-value use of drugs. We define use as high-value when it is consistent with the Food and Drug Administration's (FDA) indication for the given drug, i.e., 'on-label' use. Uses of drugs in populations or diseases that have not been approved by the FDA ('off-label' uses) are defined as low-value care. We find that prior authorization reduces both high-value and low-value care. Off-label use of drugs falls by 42% and on-label use falls by 65% due to prior authorizations. Conditional on receiving the drug, the proportion of patients receiving the drug for an off-label use does not change after prior authorizations have been implemented, suggesting that prior authorizations do not disproportionately target low-value care.

We also empirically test whether the large reductions observed due to prior authorizations are due to provider or insurer behavior, as suggested by theory. Using prior authorization removals as a test for whether insurer decisions drive utilization reductions, we find that part of the effect that we attribute to prior authorizations is due to insurer discretion in approving or denying coverage since we observe a discrete increase in utilization as soon as prior authorization of a drug is removed. However, after the initial increase in utilization, there is gradual adoption of the drug, suggesting that provider behavior, likely through learning over time which drugs no longer have prior authorizations, also plays a role in the utilization reductions we observe.

Our paper contributes to several literatures. Empirically, a large literature has shown that increased cost-sharing does indeed reduce utilization as predicted by the theory of optimal insurance design (Gaynor et al., 2007; Landon et al., 2007; Newhouse and the Insurance Experiment Group, 1993).[3] However, these reductions occur at the expense of both low and high-value care, even harming patient outcomes (Brot-Goldberg et al., 2017; Chandra et al., 2021). Similar to the cost-sharing literature, we find that supply-side policies do lead to reductions in spending and utilization, but also appear to reduce both low and high value care. Our paper also shows that not all prior authorization policies equally impact patient outcomes – certain types of prior authorizations, such as those implemented on branded drugs where generic alternatives are available, may reduce spending while not harming patient outcomes. However, restricting entire active ingredients without available substitutes may lead to reductions in care that are not offset by increases in other drugs.

We also contribute to work on administrative costs in health (Casalino et al., 2009; Cutler and

[3]For a thorough review of the empirical literature on cost-sharing for drugs and health care more broadly, see McGuire (2011) and Cutler and Zeckhauser (2000).

Ly, 2011; Gottlieb et al., 2018) and the effects of provider-facing ordeals, including work by Dunn et al. (2023) on claims denials, auditing Medicare claims in the context of soft spending limits (Shi, 2022),and prescription monitoring (Alpert et al., 2020). Prior authorization, and utilization management more generally, can be thought of as an alternative to price-based rationing through copays. Our paper is the first to examine the causal effect of prior authorizations and in particular, prior authorizations in Medicaid where the legal requirement to cover all drugs makes prior authorizations much more widely used than in other settings.

This paper is organized as follows. Section 2 describes the setting, data, and construction of the sample. Section 3 describes our empirical approach. Section 4 shows summary statistics on the beneficiaries and drugs in our sample. Section 5 shows our main results, and the final section concludes.

2 Setting and data

2.1 Medicaid

Medicaid is a joint federal and state program offering healthcare coverage to eligible low-income individuals, children, and pregnant women across the United States. It provides insurance for roughly 25% of the U.S. population, covering over 70 million people, with children making up 47% of enrollees (Centers for Medicare and Medicaid Services, 2024a). In 2018, Medicaid represented 9.5% of the federal budget (Centers for Medicare and Medicaid Services, 2024d). Federal law mandates coverage for certain groups, including low-income children, pregnant women, and individuals receiving Supplemental Security Income. The Affordable Care Act expanded eligibility for children to those at or below 138% of the federal poverty level (FPL), and allowed states to expand coverage to adults below 138% of the FPL, though several states opted not to implement this expansion (Center on Budget and Policy Priorities, 2021).

Medicaid covers a wide range of health services. Mandatory services, as required by federal guidelines, include hospital services (inpatient and outpatient), physician services, lab and X-ray services, nursing facility care, home healthcare, and certain screenings and preventive services for children (Centers for Medicare and Medicaid Services, 2024c). While prescription drug coverage is an optional benefit under federal Medicaid law, all states currently provide some coverage for prescription drugs to Medicaid-eligible individuals (Centers for Medicare and Medicaid Services, 2024e) States have flexibility in designing their Medicaid drug coverage policies, including determining which drugs are covered, the copay amoubt, and establishing preferred drug lists (Kaiser Family Foundation, 2019). To manage costs, states may negotiate drug prices, utilize managed care plans, or apply rebate programs while ensuring access to necessary medications (Kaiser Family Foundation, 2020).

2.2 Medicaid in Massachusetts (MassHealth)

Our paper focuses on MassHealth, the Massachusetts' state-administered Medicaid program. During our data period (2009-2013), all Massachusetts residents at or below 150% of the federal poverty line were eligible for MassHealth. Beneficiaries eligible for Medicaid can choose to enroll either in a fee-for-service (FFS) plan and or a managed care plan, of which there were several during our data period. The FFS plan is directly managed and administered by the state and providers who accept this plan are directly paid by the state. Managed care plans are private insurance plans that contract with the state to provide Medicaid benefits.

In the period we study, managed care plans were responsible for maintaining their own formularies, so we restrict to beneficiaries in the FFS plan[4]. In the period we study, MassHealth FFS copays for most drugs were $2-3.65 per prescription. From July 2010, copays for some classes of drugs, including antihyperglycemics, antihypertensives and antihyperlipidemics were set even lower, at $1 per prescription. There was also a cap on total prescription drug payments of $200 that rose gradually over the period.

2.3 Prior authorization policies in MassHealth and Blue Cross Blue Shield

Because copayment rates are set low and there is little differentiation between drugs ('tiering'), the primary way in which MassHealth can direct drug use is through use of prior authorization requirements, as well as excluding drugs from the formulary. However, Medicaid is legally required to cover all drugs and include them on their formulary, so the only drugs that are excluded are those whose manufacturers do not agree to provide rebates to the state, who have been discontinued by the manufacturer, or approval has been revoked by the FDA. Therefore, exclusion of drugs from the formulary is rare in MassHealth. On the other hand, Blue Cross Blue Shield of Massachusetts (Blue Cross Blue Shield) is not legally required to cover all drugs and can exclude drugs from their formulary. Blue Cross Blue Shield can also impose tiered copayments, which can be used to direct drug use. Furthermore, MassHealth explicitly states that all prior authorization requests are evaluated on the basis of medical necessity only.

2.4 Utiization data

We use the Massachusetts All-Payer Claims Database (APCD) for the years 2009-2013 to capture detailed information on patient characteristics, plan enrollment, and drug utilization. The APCD contains comprehensive demographic data and plan enrollment information, such as the payer, enrollment dates, and other coverage details, for all individuals insured through payers that provide coverage for Massachusetts residents and employees. This data includes both medical and pharmacy claims, offering insight into patients' medical encounters with information on diagnoses, procedures, physician-administered drugs, and drugs prescribed in medical settings. Pharmacy

[4] As of 2023, the formularies have been unified between FFS and managed care plans, although they may differ for drugs covered under the medical benefit component of the plan

claims specifically capture only those drugs that have been filled by patients, ensuring that the data reflects actual medication utilization. We do not observe insurer denials for pharmacy-filled drugs.

Drugs in the pharmacy claims data are recorded at the National Drug Code (NDC) level, a standardized system used in the U.S. to identify drug products. The NDC is a unique, 10- or 11-digit number that specifies the drug manufacturer, product, and package size, allowing precise identification of each medication's type, dosage, and form (e.g., tablet, liquid, injectable). This level of detail enables analyses of specific drug utilization patterns, including the identification of drugs subject to prior authorization requirements down to the level of dosage.

2.5 Prior authorizaton data

We collect data on prior authorization changes in MassHealth using the MassHealth drug lists and formularies for 2009-2013 obtained from Massachusetts's Executive Office of Health and Human Services. The lowest level at which MassHealth can implement a prior authorization is at the brand-ingredient-dosage-formulation level. For example, one of the changes in MassHealth's formulary requires a prior authorization for the active ingredient methylphenidate, with the brand name Concerta, extended-release formulation, 27mg dosage. However, MassHealth can also impose a prior authorization on any combination of brand name, active ingredient, dosage, or formulation. Examples include a prior authorization implemented on all formulations, dosages, and brands for norfloxacin, a prior authorization placed only on ketoprofen injection, or a prior authorization placed on buspirone 30mg tablet.

We similarly collect data on prior authorization changes from the 2023 Blue Cross Blue Shield of Massachusetts formulary. Unlike MassHealth, we cannot exactly observe the dates at which prior authorizations were implemented in Blue Cross Blue Shield. However, we observe whether a drug was subject to prior authorization at any time between 2009 and 2023.[5] Therefore, we exclude from our sample any drugs that were ever subject to prior authorization in Blue Cross Blue Shield during 2009-2023.

Our measures of drug utilization include both pharmacy and physician-administered drugs. We use the Redbook data to map drug names to National Drug Codes (NDCs), which allows us to identify drugs with prior authorization changes in the APCD pharmacy claims. We manually map HCPCS codes to drug names to identify physician-administered drugs in the medical claims.[6] The vast majority of utilization in our data comes from prescription drugs rather than physician-administered drugs.

[5] We do not observe drugs that were part of retired prior authorization policies. However, since Blue Cross Blue Shield defines policies often at the drug class level, a retired policy would mean that prior authorizations were removed from all drugs in a given class, which is rare.

[6] In some cases, over-the-counter drugs and products for compounding (e.g., powders) may be subject to prior authorization. We do not include these drugs in our analysis since their utilization is difficult to track and observe completely.

2.6 Sample

Our APCD data includes data from private insurers, MassHealth, and Medicare Advantage, but not traditional Medicare. Since we cannot observe Medicare enrollees' complete enrollment, medical, and prescription history in our data, we exclude patients aged 65 or older from our analysis.[7] Furthermore, for those covered under Medicare Advantage, the same formulary may not apply to those younger than 65, even though the listed payer is the same.[8]

Table 1: Sample selection

	MassHealth (Treated)	BCBS (Control)
Patients with some prescription drug coverage in 2009-2013	2,265,974	2,863,883
Patients younger than 65 in 2009-2013	2,070,213	2,694,489
Patients that lived in MA in 2009-2013	2,048,189	1,809,169
Patients with 12 months of medical enrollment before any period of prescription drug coverage in 2009-2013	1,707,651	1,468,841

Note. Data comes from the Massachusetts All-Payer Claims Database for 2009-2013. Blue Cross Blue Shield stands for Blue Cross Blue Shield of Massachusetts.

Table 1 shows the steps of our sample selection process and the number of patients included in each step. We begin by finding all patients ever enrolled in prescription drug coverage provided *only* by MassHealth fee-for-service or Blue Cross Blue Shield of Massachusetts during 2009-2013.[9] Approximately 2.3 million MassHealth enrollees and 2.9 million Blue Cross Blue Shield patients had prescription drug coverage only through MassHealth or Blue Cross Blue Shield, respectively, at some point during 2009-2013, which covers almost 80% of the MA population in 2013.[10] As discussed earlier, we drop enrollees 65 or older during all periods of prescription drug coverage by MassHealth or Blue Cross Blue Shield. Furthermore, because payers are not required to report claims to the APCD for enrollees living outside of Massachusetts, we also drop patients who were not Massachusetts residents during all periods of prescription drug coverage by MassHealth or Blue Cross Blue Shield.

Lastly, and most importantly, we require that every period of prescription drug coverage by MassHealth or Blue Cross Blue Shield during 2009-2010 be preceded by at least 12 months of medical coverage by any payer. This criterion ensures that we have enough medical history to

[7] This implies that we also would exclude those dually eligible under Medicare and MassHealth; however, the primary payer for prescription drug coverage for the dually eligible is typically Medicare, which we do not observe in the data.

[8] For example, the Blue Cross Blue Shield formulary does not apply to "Medicare Advantage, Medex, direct-pay products such as Managed Major Medical, Comprehensive Managed Major Medical, and certain Managed Blue for Seniors plans".

[9] The MassHealth formulary data we collect applies to MassHealth fee-for-service but not necessarily managed care. As a result, our sample excludes those insured through MassHealth managed care. During our sample period, the majority of MassHealth enrollees belonged to fee-for-service.

[10] While some physician-administered drugs may be covered under medical coverage instead of prescription drug coverage, the vast majority of claims for drugs in our sample are prescription drugs.

identify on- and off-label use of drugs and effectively restricts our time period to 2010-2013.

Our final sample contains 1.7 million individuals enrolled in MassHealth and 1.5 million patients individuals enrolled in Blue Cross Blue Shield at some point during 2009-2013 and satisfying our sample selection criteria. Individuals may have multiple continuous periods of prescription drug coverage that satisfy our sample selection criteria, all of which are included in our analysis.

2.7 Data on approved ages and indications

We use the same methods for determining off-label use as in Ristovska (2023). We map each drug with a prior authorization policy change in MassHealth's formulary to its active ingredient. We then create a crosswalk between active ingredients and all indications and ages approved by the Food and Drug Administration (FDA) as of March 2023 using the MicroMedex database, which is one of the statutorily named medical compendia by Centers for Medicaid and Medicare Services (CMS).[11] We consider all indications approved for an active ingredient as on-label, even if they were approved for a specific formulation, route of administration, or dosage, and not the entire active ingredient. Such a definition may underestimate the actual off-label use; however, such disparate indications based on formulation, dosage, or route of administration are rare. Since MicroMedex does not list dates of approval, following Berger et al. (2021), we manually review the Drugs@FDA records for our sample drugs to determine the indication and dates of approval for each disease and age pair.

Indications can be quite detailed (e.g., use for treatment-naive vs. experienced patients, disease sub-types). We map indications to coarser diseases that can plausibly be mapped to ICD-9-CM diagnosis codes, which we use to identify diseases in the data.[12] Since multiple indications can be mapped to the same disease, and approved age ranges across indications may differ, we take the broadest possible age range as approved for each disease (across indications), which may also lead to an underestimate of off-label use.

2.8 Defining FDA-approved and unapproved (off-label) uses

The APCD pharmacy claims do not list what uses each drug was prescribed for. Thus, to identify uses for which a drug might be prescribed, we use ICD-9-CM diagnosis codes reported in the APCD medical claims for individuals in our sample. Based on our sample selection criteria, each individual has at least 12 months of medical claims data preceding any drug claims included in our analysis. We base our on-label/off-label classification on the medical claims data preceding each drug claim.

For a drug claim to be classified as FDA-approved, it must satisfy the following criteria: (i) the individuals associated with the drug claim must have been diagnosed with an indicated disease

[11] For off-label use to be approved by MassHealth, the healthcare provider must list a reference to an academic paper or medical compendium supporting the off-label use.

[12] This method of mapping drugs to indications and dates of approval closely follows methods used by Berger et al. (2021).

prior to the date the prescription was filled, and (ii) the drug must be FDA-approved for the indicated disease for the patient's age at the time the drug claim was filled.[13] This implies that there are four types of off-label use that we can observe in the data: (1) prescriptions to individuals never diagnosed with the indicated disease, (2) prescriptions to individuals diagnosed with the indicated disease *after* the prescription was filled, (3) prescriptions to individuals diagnosed with an eventually indicated disease before FDA approval for that indication, and (4) prescriptions to individuals diagnosed with an indicated disease but associated with an age not approved by the FDA at the time of the prescription. The vast majority of off-label prescriptions are for a disease that is not approved by the FDA.

Active ingredients can be indicated for multiple diseases. If a prescription is determined to be on-label for any indication, we classify it as on-label for all indications.

2.9 Prior authorization changes

Table 2 summarizes the prior authorization policy changes in MassHealth and shows the number of drugs and active ingredients affected by each policy change. Drugs are uniquely identified by combinations of active ingredient, brand name, formulation, and dosage. We map around 700 prior authorization policy changes in MassHealth's formulary for 2009-2013 to drug identifiers in the APCD data.[14] These changes affect 2800 unique drugs and 467 unique active ingredients.

In the MassHealth formulary, a drug can be unrestricted (i.e., not subject to prior authorization) or restricted in several ways. One way is by imposing what we call a "full" prior authorization, meaning that every use of the drug requires the submission of a prior authorization form. Another common way to restrict the use of a drug in the MassHealth formulary is based on quantity prescribed, i.e., require a prior authorization form to be submitted if the quantity prescribed exceeds a certain amount, typically if it exceeds 30, 60, or 90 units for a 30 days' supply. Somewhat rarer are requirements that the healthcare provider submits a prior authorization form if the drug is used for a specific gender, age, or in a specific setting (e.g., in a hospital vs. outpatient vs. pharmacy setting). Lastly, a drug can be entirely excluded from the MassHealth formulary, in which case MassHealth does not cover it.

The prior authorization policy changes we consider in our analysis include transitions from no prior authorization required to full prior authorization required and vice versa. This excludes most of the MassHealth prior authorization policy changes from our sample. One-third of the exclusions come from dropping new drugs that enter the MassHealth formulary. For these drugs, the policy change of entering the formulary effectively corresponds to a *relaxing* of the prior authorization policy since they go from not being covered at all to requiring prior authorization for coverage. The remaining

[13] While we include both prescription drug claims and medical claims associated with physician-administered drugs in our analysis, for conciseness, we refer to filling a prescription when talking about both pharmacy drugs and physician-administered drugs.

[14] We could not match 53 changes to drug identifiers in the data. The majority of these are powders used for compounding.

third of prior authorization policy changes we exclude mainly involve changes in whether a drug is subject to quantity restrictions. We exclude such policy changes for two reasons. First, it is difficult to confidently identify quantities subject to prior authorization in the claims data. Second, cases where the quantities of a drug exceed the threshold imposed by the prior authorization are rare. We further exclude drugs affected by multiple policy changes and drugs that we cannot map to indications, which excludes a small share of sample events.

Table 2: Prior authorization changes in MassHealth

	All	Main sample	Guideline sample
PA changes	419	402	399
Newly approved drugs	194	185	183
Newly approved drugs → full PA	145	138	136
Newly approved drugs → partial PA	22	21	21
Newly approved drugs → no PA	27	26	26
Events among restricted drugs	37	37	37
full PA → partial PA	13	13	13
full PA → no PA	24	24	24
Events among partially restricted drugs	44	44	44
partial PA → full PA	17	17	17
partial PA → partial PA	25	25	25
partial PA → no PA	2	2	2
Events among unrestricted drugs	144	136	135
no PA → partial PA	26	24	24
no PA → full PA	118	112	111
Brands only	47	47	46
Dosage/formulation/route only	34	29	29
Entire active ingredient	37	36	36

Note. Includes data on all changes in prior authorization policies (prior authorization) for MassHealth in 2009-2013 that can be mapped to drug identifiers in the APCD data.

In the Blue Cross Blue Shield formulary, we observe whether a drug was subject to any restriction, such as step therapy, prior authorization, or lack of coverage during 2009-2023. However, we cannot observe changes in the details of the restrictions, such as whether only certain ages, genders, or settings were subject to the prior authorization policy. As discussed before, we do not observe when the policy change occurred. In order to obtain a sample of drugs where a prior authorization policy change occurred in MassHealth but not in Blue Cross Blue Shield, we excluded drugs that were subject to any prior authorization policy in Blue Cross Blue Shield at any point during 2009-2023. This criterion may over-exclude drugs as we exclude drugs that may have been subject to prior authorization requirements only after our data ends.[15] However, this ensures a clean control group unaffected by prior authorization requirements. As a result, we further exclude approximately 100

[15]We also do not know which drugs have been subject to quantity-based restrictions in Blue Cross Blue Shield and when. However, as mentioned previously, these account for a small share of claims.

prior authorization policy changes affecting drugs that may have been subject to prior authorization in Blue Cross Blue Shield.

Our final sample of 170 events affects 573 unique drugs (which we refer to as sample drugs moving forward) and 140 active ingredients. In 23 of these events, the drug was subject to a prior authorization, which was removed during the span of our data. For example, ramipril capsule, used to treat hypertension and heart failure, was subject to a prior authorization for any use of the drug but transitioned to no prior authorization required during the span of our data. While these events can be used to examine whether there is a symmetrical response for the removal of prior authorizations as for addition or prior authorization requirements, we focus on the addition of prior authorizations as the results for removal of prior authorizations are too noisy. 62 events include the addition of prior authorization for any use of a branded drug. Typically, these occur when a generic becomes available. In 43 events, prior authorization was added on a specific formulation or dosage. For instance, we observe MassHealth add a prior authorization on phenytoin 100 mg/4 ml only, which is used to treat epilepsy. Lastly, 42 events include the addition of prior authorization on all brands, formulations, and dosages for a specific active ingredient, such as ambrisentan, used to treat pulmonary hypertension.

3 Empirical approach

In our setting, treatment occurs at the drug level, defined as unique combinations of active ingredient, brand name, dosage, and formulation.[16] Each drug in MassHealth (our treatment group) is subjected to a prior authorization at different point in time. In our control group (Blue Cross Blue Shield), the drugs included in the sample were never subjected to prior authorization.

To estimate the causal effect of changes in prior authorization policy on outcomes of interest, we use a stacked difference-in-difference approach:

$$Y_{itd} = \sum_{k=-4}^{k=6} \beta_k \mathbb{1}(t - T_d = k) MassHealth_{it} + \delta_{p(i,t)d} + \delta_{dt} + X_i + \varepsilon_{itd}$$

where i identifies patients, t is calendar time (quarter), d identifies drugs, and $p(i,t)$ determines the plan individual i was in at time t.[17], and δ_{dt} represents fixed effects for drug by calendar time. X_i represents controls for patient characteristics: fixed effects for 5-year age bins by gender, whether the patient had any emergency room (ER) visit in 12 months prior to t, and whether the patient had any hospitalization in 12 months prior to t. The ER and hospitalization controls capture time-varying differences in disease severity and utilization patterns across enrollees.

[16] We use this definition of a drug for both pharmacy-filled drugs and those administered in a medical setting, e.g., by a physician.

[17] Drugs can be subjected to multiple "events", i.e., multiple changes in prior authorization status. For ease of notation, we have used d to denote drugs in the above equation but in reality the unit of analysis is event, i.e., any change in prior authorization status for a given drug d.

$MassHealth_{it}$ is an indicator variable denoting whether patient i was enrolled in MassHealth's prescription drug program at time t (relative to being enrolled in Blue Cross Blue Shield' prescription drug program). T_d denotes the calendar time the prior authorization policy change occurred for drug d. Thus, α_0 identifies any time-invariant differences in outcomes between MassHealth and Blue Cross Blue Shield, and α_k identifies trends in Blue Cross Blue Shield outcomes over time and around the time when the policy change occurred in MassHealth.

The coefficients of interest are the set of β_k coefficients, which identify the effect of prior authorization policy changes on outcomes in MassHealth relative to Blue Cross Blue Shield for the same drug and calendar time for 4 quarters before the policy change and 6 quarters after the policy change, controlling for all other individual characteristics. We also report the estimates from the static difference-in-difference specification, where we replace the relative time fixed effects with a single dummy variable for whether the prescription occurred before or after the prior authorization policy change. We cluster standard errors at the drug level.

Our treated group is defined as everyone enrolled in MassHealth's prescription drug program at time t, living in MA at the time, younger than 65 at time t, and with 12 months of medical coverage by any payer at any time prior to t. Similar criteria define the control group, except that it includes everyone enrolled in Blue Cross Blue Shield's prescription drug program at time t instead of MassHealth. These definitions of our treated and control groups implicitly allow for individuals to switch plans endogenously due to the prior authorization policy change because we allow for the enrollee composition to change across time. To examine whether our results are driven by individuals switching plans as opposed to the direct restrictive effect of prior authorizations, we also estimate the effect of prior authorization policy changes on individuals who remain in the same plan throughout the study period (2009-2013).

A potential concern with the above approach is that MassHealth and Blue Cross Blue Shield enroll different patients. In addition to examining the pre-trends in our dynamic difference-in-difference specification as a check for differential trends between our treatment and control group, we also use a matched difference-in-difference specification using nearest-neighbor matching to match MassHealth enrollees to similar Blue Cross Blue Shield enrollees. We match treated individuals to controls based on 5-year age bins by gender, prior medical enrollment duration, and whether the enrollee had any ER or hospitalization visits in the 12 months prior. We do not control for race as it is infrequently reported in the APCD data. We control for prior medical enrollment to capture the fact that prescriptions to individuals with longer medical histories are more likely to be classified as on-label (since there is a longer time horizon for finding diagnosis codes for an indicated disease). We report the results from the unmatched difference-in-difference as a robustness check.

4 Summary statistics

Table 3 shows summary statistics on the use of sample drugs in the APCD data. Almost 800,000 patients have at least one drug claim for a sample drug in the data. More specifically, a quarter of the MassHealth enrollees and a quarter of the Blue Cross Blue Shield enrollees satisfying our sample criteria have at least one claim for a sample drug, indicating that these are relatively common drugs. We have approximately 8 million claims for sample drugs in our data among MassHealth and Blue Cross Blue Shield enrollees.

Table 3: Rates of use of sample drugs

	Total	MassHealth (Treated)	BCBS (Control)
Pats with at least one prescription for sample drug	790475	441013	354437
Number of sample drug claims	7586660	4503415	3083245
Number of sample drug claims, medical claims	20321	12116	8205
% off-label	19.3	16.2	23.7
% off-label, never dx	17.2	13.8	22.1
% off-label, dx after rx	1.8	2.1	1.5
% off-label, rx before approval	.1	.1	.1
% off-label, unapproved age	.2	.2	.1

Table 3 also shows that the rate of off-label use among our sample drugs is quite high – almost 1 in every 5 prescriptions is used off-label. The off-label use is particularly high in Blue Cross Blue Shield, reaching almost 25%. The vast majority of off-label prescriptions are among patients who have never been diagnosed with an indicated disease.

The drugs with the highest number of claims in our sample of prior authorization events are listed in Table 4. The highest-demand sample drug is a combination of buprenorphine and naloxone, which is approved to treat opioid dependence and is mostly used on-label. Four out of the ten most frequent sample drugs are mental health drugs, such as venlafaxine (approved for major depressive disorder, generalized anxiety disorder, panic disorder, and social phobia), quetiapine (approved for bipolar disorder, major depressive disorder, schizophrenia), escitalopram (approved for treatment of generalized anxiety disorder and major depressive disorder), and methylphenidate (approved for attention deficit hyperactivity disorder). The off-label share for these drugs also tends to be quite high. Among the remaining drugs listed in Table 4, doxycycline is an antibiotic, losartan is approved to treat cerebrovascular accidents, diabetic nephropathy, and hypertension, clobetasol is used to treat plaque psoriasis, and tamsulosin is approved for benign prostatic hyperplasia.

Table 5 shows the patient characteristics of our matched sample.[18] Patients in our sample are young – the average age in our sample is 24 – because MassHealth mostly enrolls children. Almost a quarter of the patients in our sample have had an ER visit in the past 6 months. While we see some

[18] See Appendix Table A1 for summary statistics on the unmatched sample.

Table 4: Top 10 drugs in sample with prior authorization events, by number of claims

Drug	Number of claims	% on-label	% off-label
buprenorphine naloxone	1079915	96.1	3.9
venlafaxine	789788	91.3	8.7
doxycycline	778567	92.1	7.9
quetiapine	709906	86.4	13.6
losartan	512155	95.2	4.8
clobetasol	371441	69.3	30.7
tamsulosin	351443	54.6	45.4
escitalopram	343546	86.5	13.5
methylphenidate	224319	79	21
prednisolone sodium phosphate	215721	90.9	9.1

statistically significant differences in prior medical enrollment and ER/hospital utilization between the treated (MassHealth) and control (Blue Cross Blue Shield), these are small in magnitude.

Table 5: Summary statistics

Characteristic	Treated mean	Control mean	Difference
Female, %	52.59	52.36	.22
Any ER visit, prior 6 months, %	24.21	20.71	3.5***
Any hospitalization, prior 6 months, %	5.59	4.82	.77***
Any ER visit, prior 12 months, %	37.93	36.94	.98
Any hospitalization, prior 12 months, %	9.90	9.18	.72*
Medical enrollment days at baseline	452.60	464.10	-11.6***
Age	24.20	23.70	.5
Num. ER visits, prior 6 months	0.60	0.40	.3***
Num. hospitalizations, prior 6 months	0.10	0.10	.1***
Num. ER visits, prior 12 months	1.20	0.70	.5***
Num. hospitalizations, prior 12 months	0.20	0.10	.1***
OOP, prior 6 months, $	107	293	-186***
OOP, prior 12 months, $	197	583	-386***
OOP pharmacy, prior 6 months, $	38	126	-88***
OOP pharmacy, prior 12 months, $	85	249	-164***
Spending, prior 6 months, $	3,136	2,829	306**
Spending, prior 12 months, $	6,287	5,612	675***
Spending pharmacy, prior 6 months, $	539	471	68*
Spending pharmacy, prior 12 months, $	971	892	79

Note. Treated individuals are matched to controls using nearest-neighbor matching based on 5-year age by gender bins, prior medical enrollment duration, and any emergency room (ER) visits or hospitalizations in the 12 months prior. Demographics, utilization, and spending were measured in the Massachusetts All-Payer Claims Database as of January 2010.

A vital difference arises when we look at spending, which we discuss now. We do not directly match on spending because MassHealth (and Medicaid more broadly) has almost no cost sharing by design, as compared to Blue Cross Blue Shield. Table 5 confirms this – out-of-pocket spending

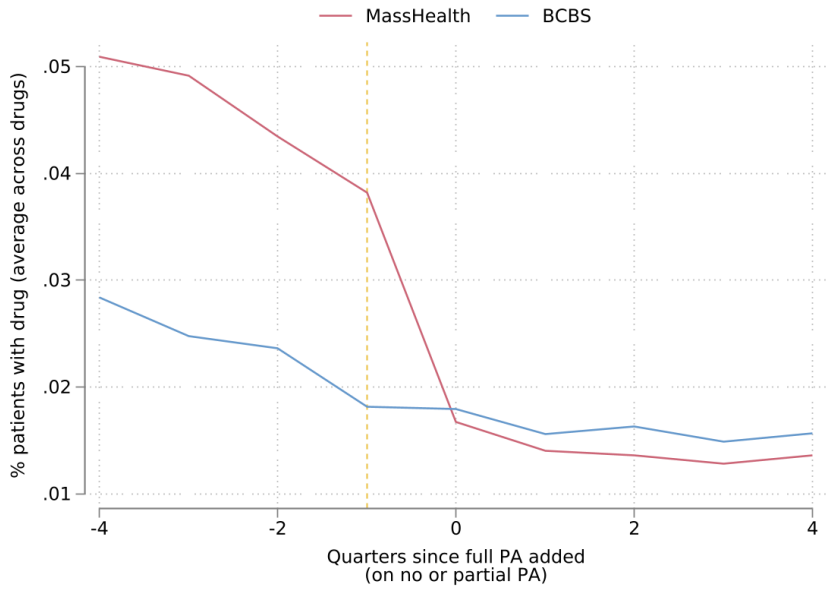
is much lower for MassHealth than Blue Cross Blue Shield, conditional on similar demographics and healthcare utilization. Additionally, prices for services and drug rebates may differ significantly between MassHealth and Blue Cross Blue Shield. As a result, we do not consider Blue Cross Blue Shield a good control group for assessing the effects of prior authorization on spending and focus our analysis on utilization instead.

5 Results

5.1 Effect of prior authorization on restricted drug

Figure 1 plots the raw drug utilization rates (measured as the share of patients taking the drug) over time as a function of time since the prior authorization was added in MassHealth but not in Blue Cross Blue Shield. Before the implementation of the prior authorization policy,there is a level difference in the drug utilization rates between our treatment and control group – the average drug was used almost twice as many times in MassHealth than in Blue Cross Blue Shield. However, as soon as the prior authorization policy is implemented, the drug utilization rates in MassHealth decrease to almost the same level as in Blue Cross Blue Shield.

Figure 1: Effect of adding prior authorization on % of enrollees taking restricted drug - raw trends

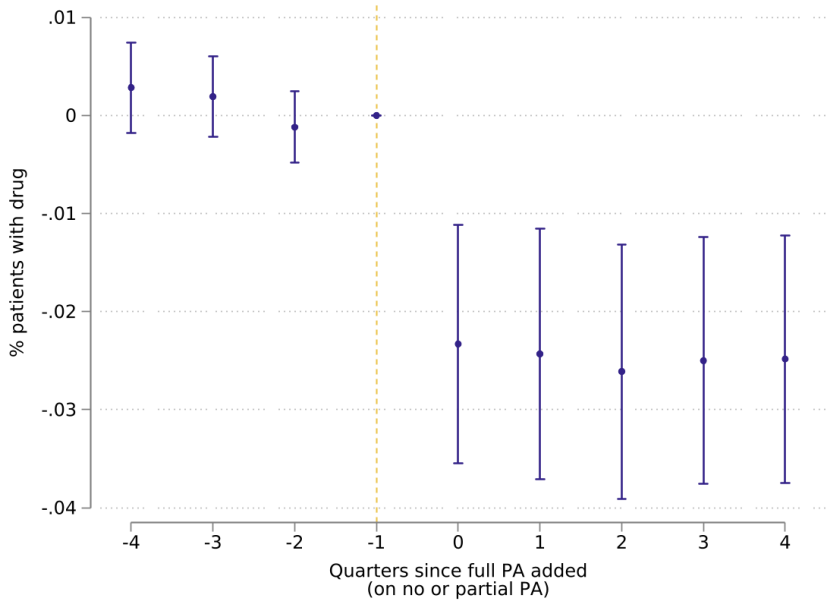


Note. This figure plots the percentage of beneficiaries in MassHealth and Blue Cross Blue Shield with any prescription for a drug in a quarter, averaged across drugs who had a prior authorization imposed in Masshealth but not in Blue Cross Blue Shield.

Assesing this more formally using our difference-in-difference framework, the average share of patients taking shows that adding a prior authorization requirement on a drug causes a significant and persistent decrease in the utilization of the drug. This decrease in utilization is immediate and

lasts throughout the entire post-policy period. Column 1 of Table A2 shows that this decrease is equivalent to a 58% decrease in the restricted drug's utilization relative to the pre-period utilization in MassHealth. Since our effects are driven by the sample drugs with the highest demand in the data, this indicates that there is a large decrease in drugs used to treat mental health disorders, opioid dependence, and a few other chronic conditions, as shown in Table 3.

Figure 2: Effect of adding prior authorization on % of enrollees taking restricted drug - difference-in-difference estimates



Note. This figure plots plots the coefficients from time dummies interacted with a dummy for enrolment in MassHealth from equation (1).

Appendix Figure A1 shows difference-in-difference results if we condition on individuals who have been enrolled in MassHealth or Blue Cross Blue Shield throughout the entire study period, effectively shutting down the endogenous plan switching channel for decreasing the utilization of drugs. We see slightly larger decreases in drug utilization if we condition on individuals who have never switched in or out of MassHealth and Blue Cross Blue Shield. However, the difference is only 5 percentage points relative to the case where we allow for endogenous plan switching shown in Figure 2, indicating that endogenous plan switching does not play a large role in the drug utilization reduction; rather, we seem to be picking up the direct effects of prior authorization on drug utilization. We also observe similar results if we use the non-matched sample in the difference-in-difference analysis (Appendix Figure A2), indicating that our results are not driven by the choice of matching procedure or controls.

We break down the effects of prior authorization based on whether the restricted drug is a branded drug, whether it is a specific dosage or formulation, or whether it is all products associated with an active ingredient. Figure 3 shows that the overall result masks significant heterogeneity. Prior

authorization reduces utilization of branded drugs by almost 70% relative to the pre-period average utilization in the control group. The reductions in utilization are smaller when the prior authorization is added to a specific dosage or formulation of the drug, at around 58%. However, Figure 4 shows that prior authorizations placed on an entire active ingredient reduce utilization by a precisely estimated 15%, which is much lower than the reductions in utilization for branded drugs or specific formul'ations.

5.2 Effect of prior authorization on substitution to other drugs

The prior authorizations where the brand name drug or an alternative formulation is restricted allow us to assess the substitution to drugs that may have the same active ingredient but be in a generic form (and thus cheaper) or alternative formulation (e.g., tablet instead of injection, which tends to be more expensive since it must be administered by a healthcare professional). Figure 5 shows the effect of imposing a prior authorization on a specific brand on the utilization of all drugs with that active ingredient. This figures indicates that when a specific brand of an active ingredient is restricted, even though we see a 70% decrease in the utilization of that brand, the total utilization of the active ingredient does not change, suggesting that all patients substitute to generic versions of the same active ingredient. Figure 6 shows the effect of imposing prior authorization on a specific dosage or route of administration on the utilization of all drugs with that active ingredient. Here we also observe the same results where there is almost full substitutions to other formulations with the same active ingredient as the restricted drug.

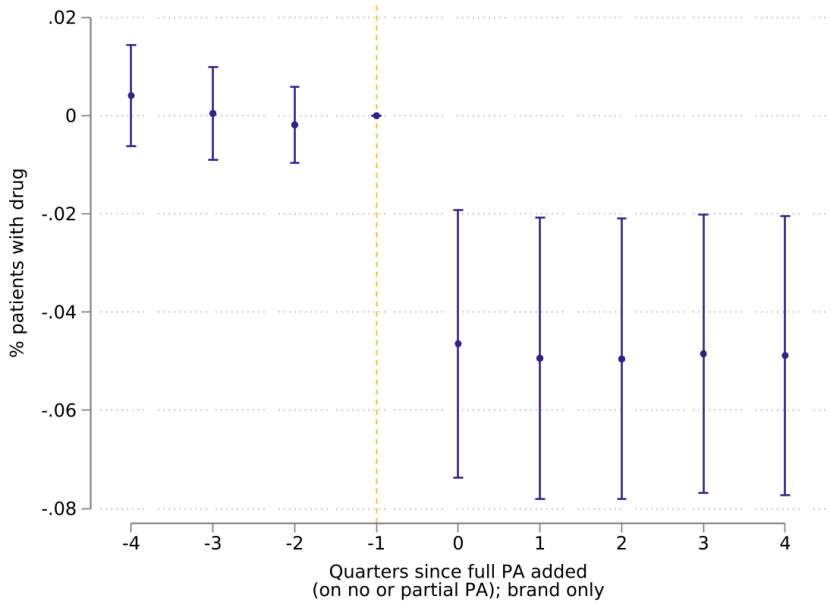
However, Figure 7 shows that when a prior authorization is placed on an entire active ingredient, the utilization of other active ingredients within the same therapeutic class (based on therapeutic class information in RedBook) does not change. Since we observe a 15% decline in utilization of the restricted drug but no change in the utilization of other similar drugs, that implies that some patients are forgoing needed treatment.

5.3 Effect of prior authorization on targeting

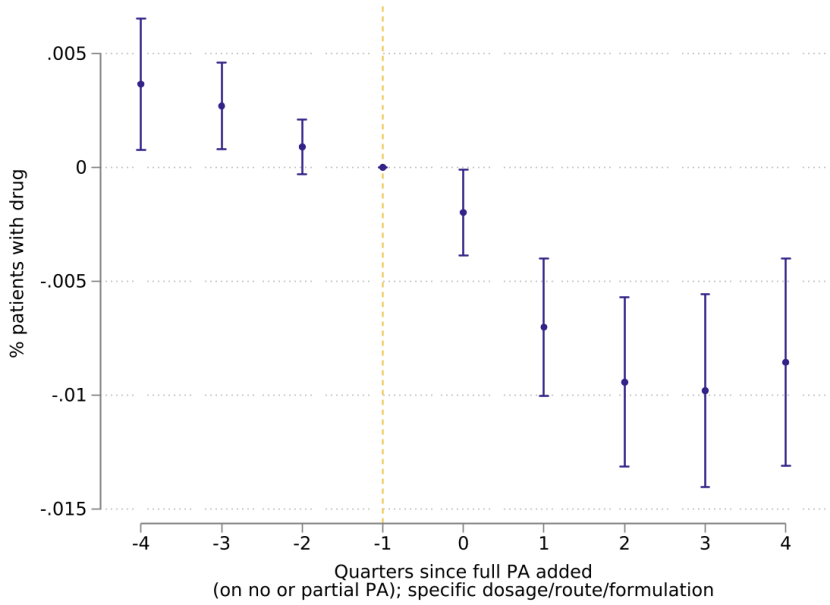
Figure 8 and Figure 9 separate the effect of prior authorizations on on-label vs. off-label uses of a drug. These results suggest that there is a reduction in both guideline-consistent on-label use and guideline-inconsistent off-label use of drugs as a result of prior authorizations. However, the decrease in off-label use is noisier and smaller in absolute magnitude. Columns 2 and 3 in Table A2 suggest that relative to the average drug utilization in MassHealth prior to the policy change, on-label use decreases by roughly 49% and off-label use decreases by 25%, suggesting that prior authorizations are more likely to decrease guideline-consistent use rather than off-label use. Appendix Figure A4–Figure A6 further that we see decreases in almost all types of off-label use, except for the use of drugs for conditions that are eventually approved by the FDA but are not indicated at the time the individual filled the prescription. Since prior authorizations typically require that citations supporting off-label use are included in the documentation submitted with

Figure 3: Effect of adding prior authorization on % of enrollees taking restricted drug

(a) Prior authorization added on brand

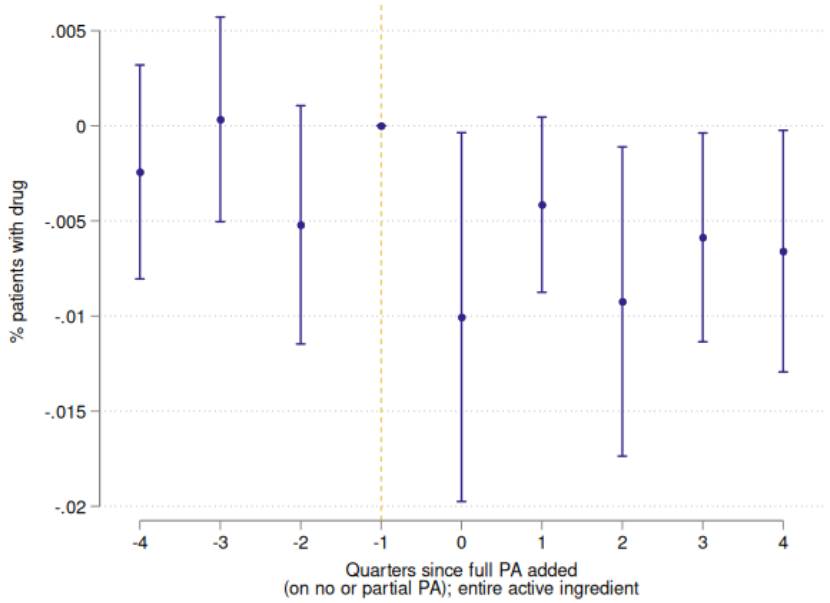


(b) Prior authorization added on dosage/route/formulation



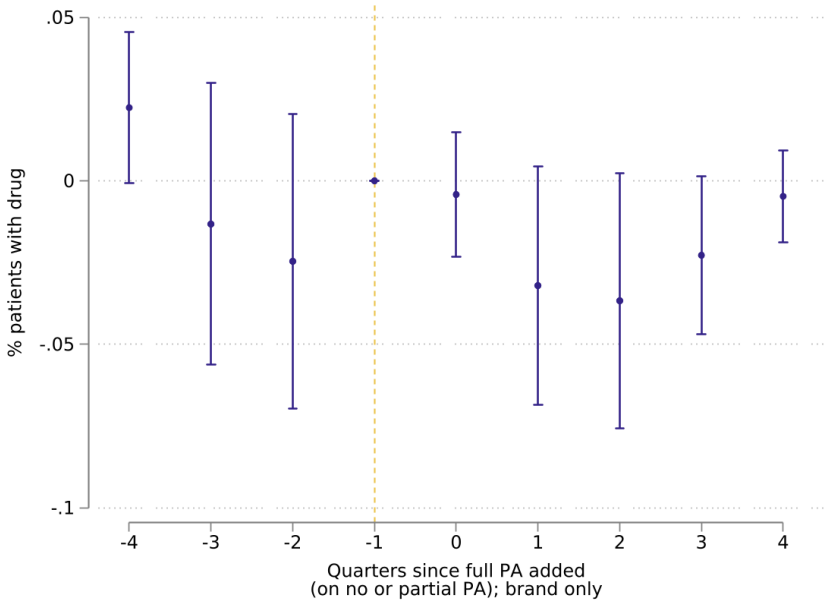
Note. This plot shows the event study coefficients (time dummies interacted with a MassHealth dummy) from equation (1) for (a) events where a prior authorization requirement was added to the branded version of the drug only and (b) events where a prior authorization requirement was added to a specific dosage, route or formulation of the drug only.

Figure 4: Effect of adding prior authorization on % of enrollees taking restricted drug when entire active ingredient is restricted



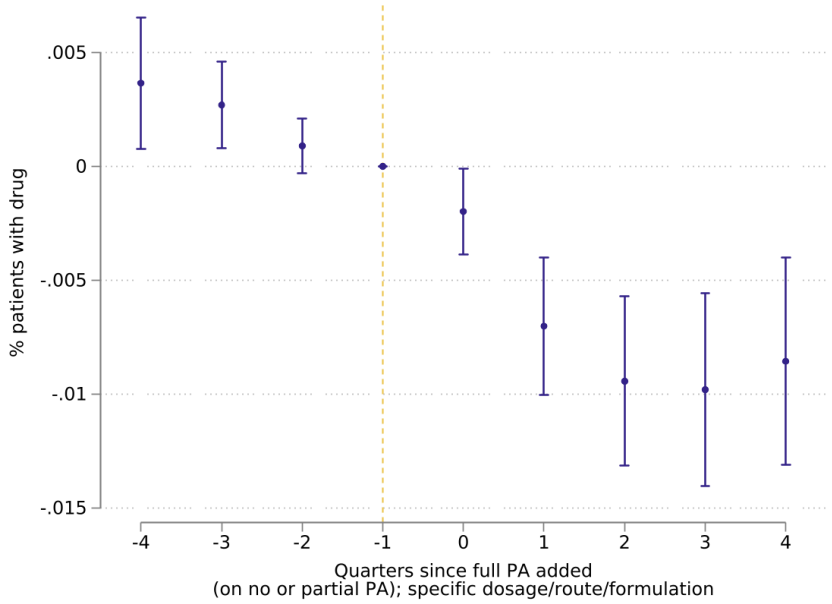
Note. This plot shows the event study coefficients (time dummies interacted with a MassHealth dummy) from equation (1) for events where a prior authorization requirement was added all products of a specific active ingredient.

Figure 5: Effect of adding prior authorization on a branded drug on % of enrollees taking any drug with the same active ingredient



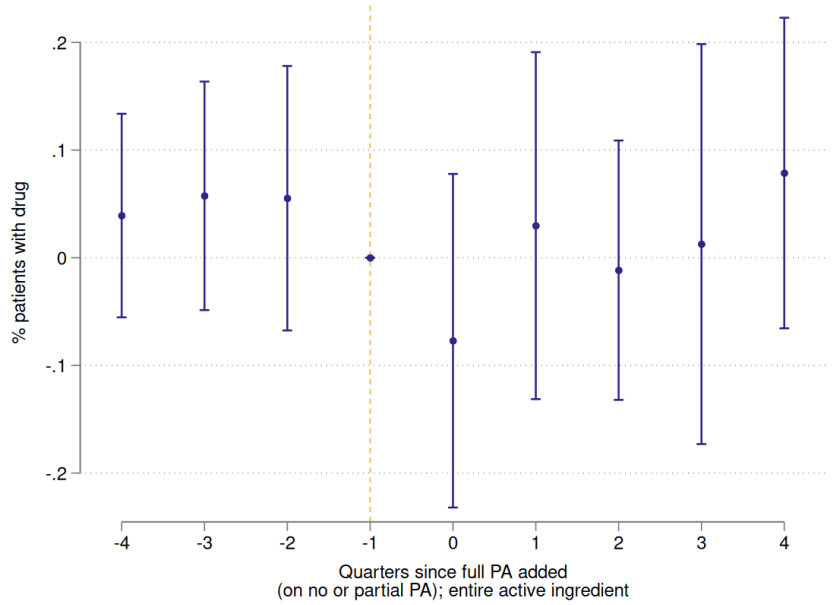
Note. This plot shows the event study coefficients (time dummies interacted with a MassHealth dummy) from equation (1) for events where a prior authorization requirement was added on branded drugs.

Figure 6: Effect of adding prior authorization on a specific dosage, formulation or route on % of enrollees taking any drug with the same active ingredient



Note. This plot shows the event study coefficients (time dummies interacted with a MassHealth dummy) from equation (1) for events where a prior authorization requirement was added on specific dosages, formulations, or routes of administration for drugs.

Figure 7: Effect of adding prior authorization on an entire active ingredient on % of enrollees taking any drug with the same therapeutic class as the restricted drug



Note. This plot shows the event study coefficients (time dummies interacted with a MassHealth dummy) from equation (1) for events where a prior authorization requirement was added on an entire active ingredient.

the form, these results suggest that prior authorizations may be an effective way of decreasing off-label use in cases where guidelines may not be supportive of the use since it might be easier to provide supportive evidence for an off-label use of a drug if the off-label use is soon-to-be approved by the FDA.

Figure 8: Effect of adding prior authorization on % of enrollees taking restricted drug as **on-label**

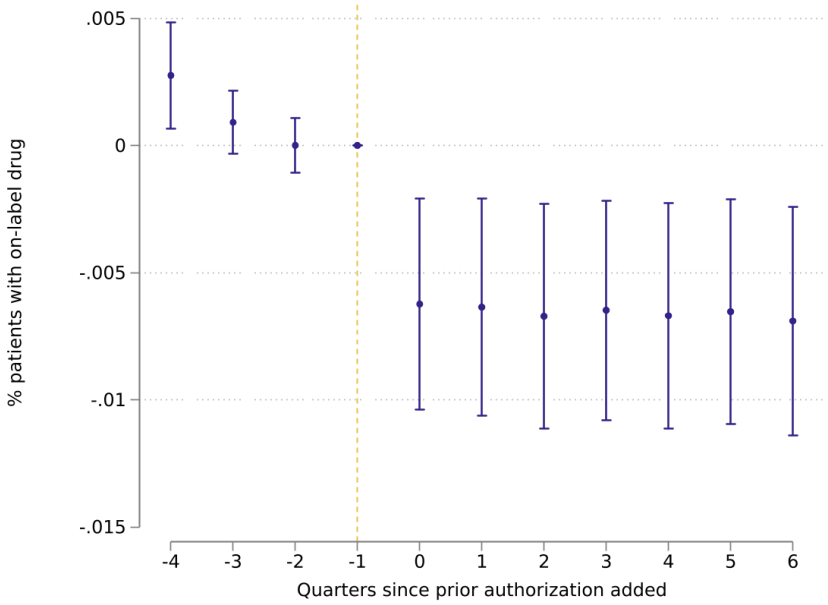
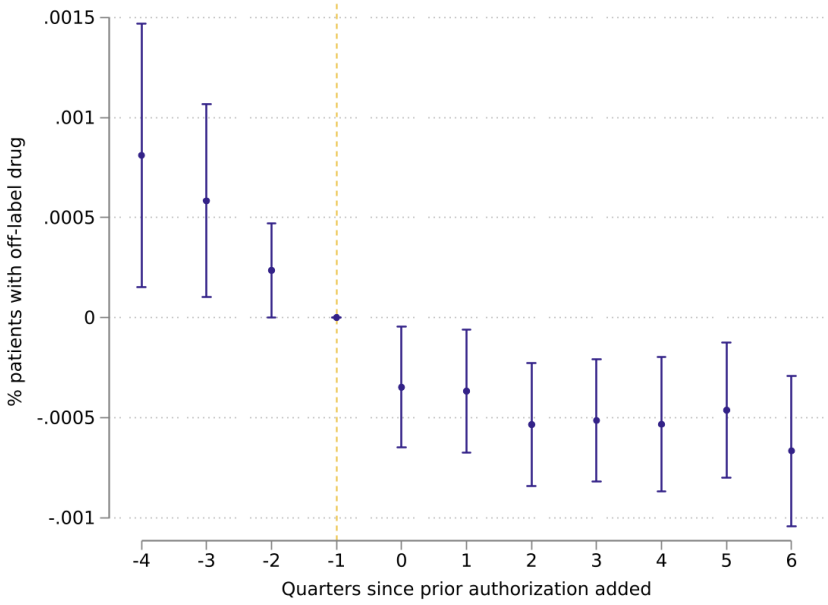


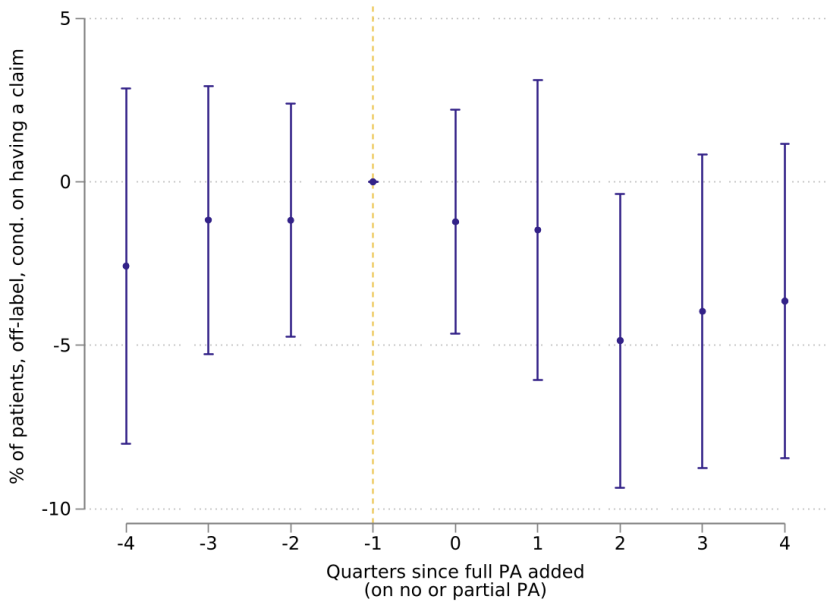
Figure 9: Effect of adding prior authorization on % of enrollees taking restricted drug as **off-label**



Given that both high-value and low-value care decrease, to assess targeting, we examine the effect of

prior authorizations on the share of prescriptions that are off-label conditional on making it through the prior authorization process. The results are shown in Figure 10. We see that the share of off-label prescriptions conditional on receiving the drug does not change after the prior authorization is added. This suggests that prior authorizations are not effective at targeting off-label use specifically

Figure 10: Effect of adding prior authorization on % of enrollees taking restricted drug as off-label conditional on receiving the drug



5.4 Who drives reductions in utilization: provider or insurer?

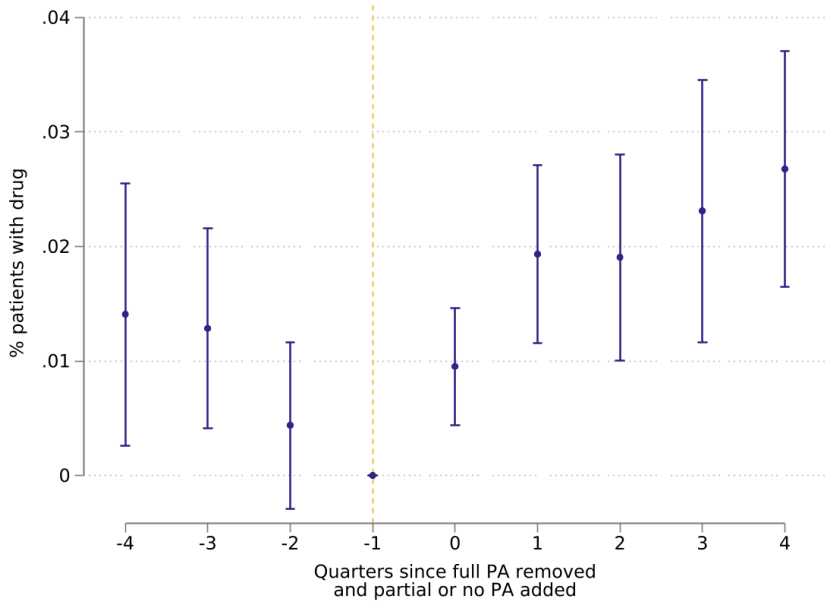
As discussed previously, utilization declines could be driven by either provider behavior (e.g., ordeal cost) or insurer discretion over approving or denying drugs requested through prior authorization. While we do not directly observe among our sample of drugs that were filled in pharmacy whether the insurer approved the request or whether the prescription was not written in the first place due to the provider being deterred due to ordeal costs, we use the removal or prior authorization requirements to test through which of these two channels we get utilization reductions from.

To help interpret our results from prior authorization, assume that all utilization reductions we observe are due to insurer denials and provider behavior is unaffected by prior authorization (e.g., they impose no ordeal costs). Under these assumptions, when a prior authorization is removed from a drug, we should see a discrete increase in utilization due to all prescriptions being approved by the insurer, which in the counterfactual are being denied.

However, Figure 11 shows that while there is a discrete jump in utilization in the initial quarter when a prior authorization is removed, the utilization rate continues gradually increasing after the initial increase in utilization. This suggests that both insurer and provider behavior are driving the

reductions in utilization we observe when prior authorizations are added.[19]

Figure 11: Effect of removing prior authorization on % of enrollees taking drug



6 Conclusion and discussion

Our findings suggest that supply-side policies, specifically prior authorization requirements, can be an effective way to manage health care spending for a public insurer who aims to minimize cost-sharing in order to reduce financial barriers to prescription drugs. Prior authorizations reduce prescription drug spending by limiting utilization of high-cost drugs and encouraging substitution towards cheaper, equally effective alternatives. However, more stringent prior authorizations that restrict all forms of a drug without easily available substitutes can lead to care gaps as patients forego treatment. We also show that despite aimed at reducing low-value care, prior authorizations reduce both low-value and high-value care indiscriminately, similar to demand-side cost-sharing mechanisms, leading to little to no improvements in targeting. Importantly, our study suggests that states can take a proactive role in managing health care spending and can be successful at it by strategically deploying prior authorizations to cases where more cost-effective substitutes are available.

[19] We remain agnostic over why provider behavior is affecting utiliztion. It could be learning over time which drugs have and do not have prior authorization, or ordeal costs, or no longer incorporating the probability of insurer denial in their decision making. All of these mechanisms are consistent with provider behavior driving the reductions in utilization.

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Appendix Tables and Figures

Appendix Table A1: Summary statistics, unmatched sample

Characteristic	Treated mean	Control mean	Difference
Female, %	52.59	49.68	2.9***
Any ER visit, prior 6 months, %	24.21	9.31	14.9***
Any hospitalization, prior 6 months, %	5.59	2.08	3.51***
Any ER visit, prior 12 months, %	37.93	16.75	21.17***
Any hospitalization, prior 12 months, %	9.90	3.98	5.92***
Medical enrollment days at baseline	452.60	503.70	-51.2***
Age	24.20	33.10	-8.9***
Num. ER visits, prior 6 months	0.60	0.20	.5***
Num. hospitalizations, prior 6 months	0.10	0.00	.1***
Num. ER visits, prior 12 months	1.20	0.30	.9***
Num. hospitalizations, prior 12 months	0.20	0.10	.2***
OOP, prior 6 months, $	107	280	-173***
OOP, prior 12 months, $	197	568	-372***
OOP pharmacy, prior 6 months, $	38	147	-109***
OOP pharmacy, prior 12 months, $	85	298	-213***
Spending, prior 6 months, $	3,136	2,054	1082***
Spending, prior 12 months, $	6,287	4,104	2183***
Spending pharmacy, prior 6 months, $	539	484	55***
Spending pharmacy, prior 12 months, $	971	962	9

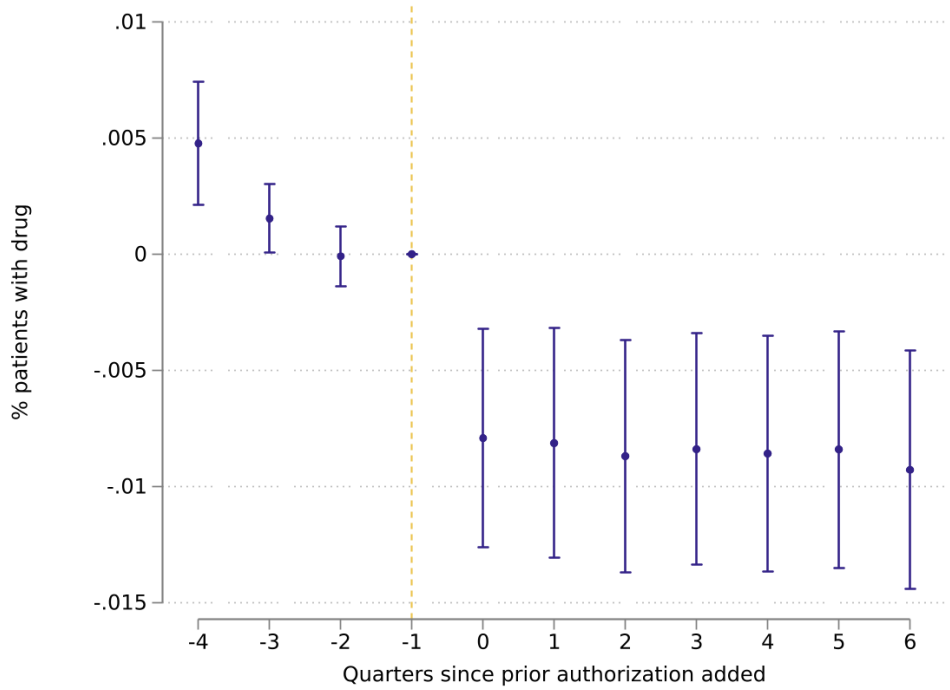
Demographics, utilization, and spending were measured in the Massachusetts All-Payer Claims Database as of January 2010.

Appendix Table A2: Effect of adding prior authorization on % of enrollees taking restricted drugs

	(1)	(2)	(3)
	% taking focal drug	% taking focal drug on-label	% taking focal drug off-label
Post-period	-0.00217**	-0.00130*	-0.000797
	(0.00105)	(0.000783)	(0.000524)
MassHealth	0.00727***	0.00652**	0.000821*
	(0.00271)	(0.00254)	(0.000422)
Post-period * MassHealth	-0.00729**	-0.00661**	-0.000747*
	(0.00285)	(0.00268)	(0.000446)
Observations	11095378769	11095378769	11095378769
R-squared	0.064	0.066	0.010
Pre-period control group mean:	0.0165	0.0136	0.00296

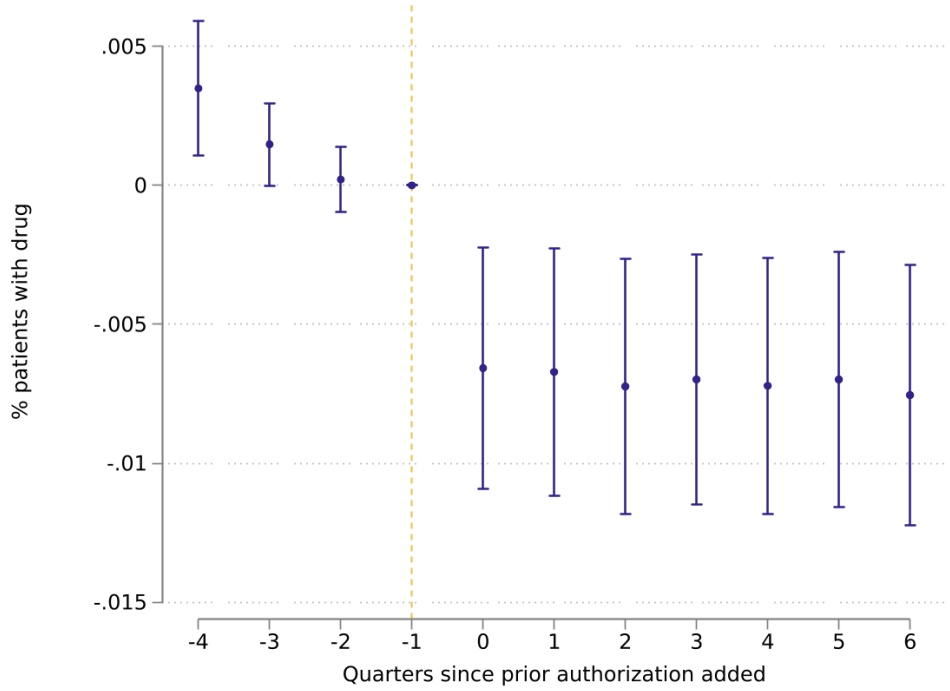
Note. Clustered standard errors in parentheses (clustered at drug level). *** p<0.01, ** p<0.05, * p<0.1

Appendix Figure A1: Effect of adding prior authorization on % of enrollees taking restricted drug



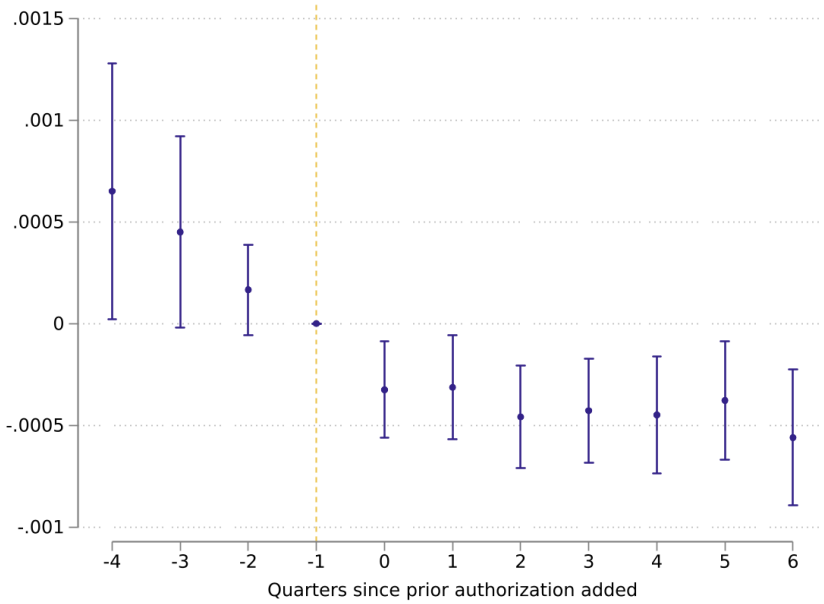
Includes everyone enrolled in MassHealth or Blue Cross Blue Shield for the entire data period (2009-2013). Treated (MassHealth) individuals are matched to control (Blue Cross Blue Shield) individuals using nearest neighbor matching.

Appendix Figure A2: Effect of adding prior authorization on % of enrollees taking restricted drug

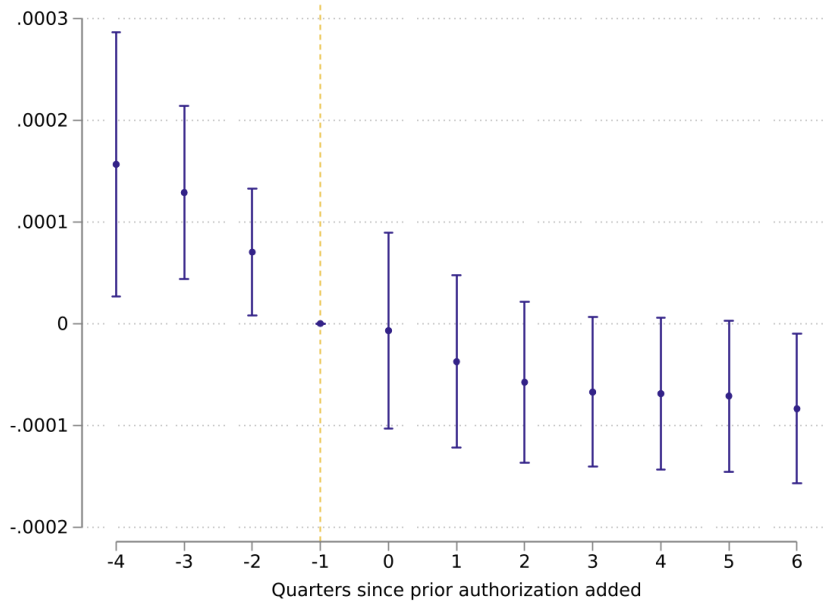


Includes everyone enrolled in MassHealth or Blue Cross Blue Shield at any point during the study period (2009-2013).

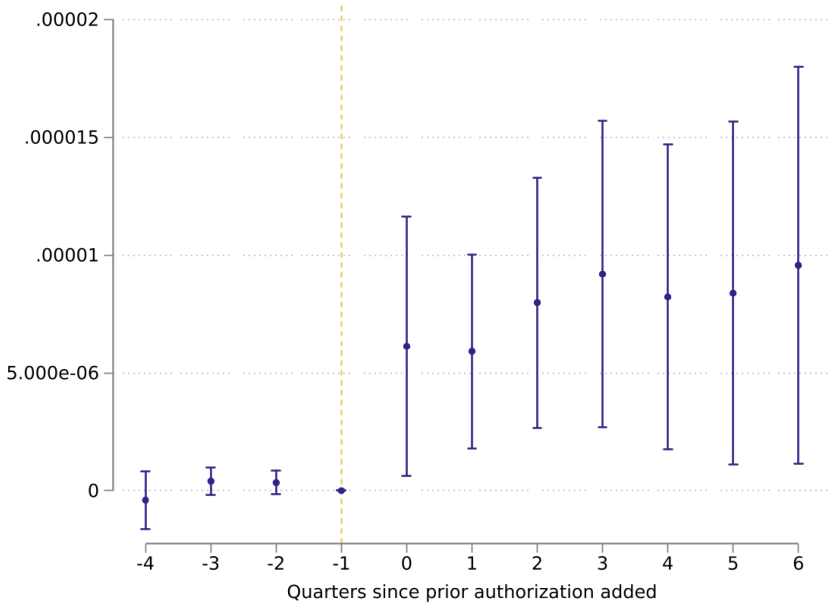
Appendix Figure A3: Effect of adding prior authorization on % of enrollees taking restricted drug as **off-label**, never diagnosed



Appendix Figure A4: Effect of adding prior authorization on % of enrollees taking restricted drug as **off-label**, diagnosed after prescription



Appendix Figure A5: Effect of adding prior authorization on % of enrollees taking restricted drug as **off-label**, prescribed before FDA approval



Appendix Figure A6: Effect of adding prior authorization on % of enrollees taking restricted drug as **off-label**, prescribed for an unapproved age

