NBER WORKING PAPER SERIES

THE FEASIBILITY OF USING BAYH-DOLE MARCH-IN RIGHTS TO LOWER DRUG PRICES: AN UPDATE

Lisa Larrimore Ouellette
Bhaven N. Sampat

Working Paper 32217
http://www.nber.org/papers/w32217

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
March 2024

This paper updates and extends previous analyses conducted together with Frank Lichtenberg (Sampat and Lichtenberg 2011), and with Maya Durvalsula and Heidi Williams (Durvasula, Ouellette, and Williams 2021). We thank Robert Cook-Deegan, Daniel Hemel, and Ken Shadlen for comments on a previous draft, and Daniel Gross for his work and insights on the Government Patent Register (Gross and Sampat 2024). Sampat acknowledges a grant from the National Institute of Healthcare Management (NIHCM) which helped support the data collection and cleaning effort. The datasets used for these analyses are available at https://doi.org/10.7910/DVN/VI93T9. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

The Feasibility of Using Bayh-Dole March-In Rights to Lower Drug Prices: An Update
Lisa Larrimore Ouellette and Bhaven N. Sampat
NBER Working Paper No. 32217
March 2024
JEL No. I18,O3

ABSTRACT

In December 2023, the Biden-Harris Administration released a proposed framework for exercising government "march-in" rights on high-priced taxpayer-funded drugs. While both proponents and critics of the new rules view them as having broad scope, march-in rights can be exercised only on patents that result from federally funded research, and they can enable generic entry only if all patents on a drug were public-sector patents. In this paper, we examine the feasibility of using march-in rights to lower pharmaceutical prices by examining patents on drugs approved by the U.S. Food and Drug Administration (FDA) from 1985 to 2022. Our primary analyses focus on the 883 new molecular entities with at least one patent listed in the FDA's Orange Book since 1985. While 9 percent of these drugs have a public-sector patent, only 2.5 percent have only public-sector patents. While the new march-in rules could be a tool to lower prices for a few drugs, their overall impact on prices or expenditures will likely be limited. In addition to the updated analyses, we provide links to the data used in the analyses.

Lisa Larrimore Ouellette
Stanford Law School
559 Nathan Abbott Way
Stanford, CA 94305
ouellette@law.stanford.edu

Bhaven N. Sampat
Arizona State University
Consortium for Science, Policy, and Outcomes
1800 I Street NW, Suite 300
Washington, DC 20006
and NBER
bhaven.sampat@asu.edu

A data repository is available at https://doi.org/10.7910/DVN/VI93T9

Introduction

The high price of many prescription drugs in the United States is an issue of ongoing and bipartisan concern. In December 2023, as part of a suite of initiatives to address this issue, the Biden-Harris Administration released a proposed framework for exercising government rights in taxpayer-funded drugs with high prices (White House 2023; NIST 2023). In particular, if a drug's price makes it inaccessible to the U.S. public, the framework would allow agencies to exercise "march-in" rights on public-sector patents, effectively granting compulsory licenses for those patents to generic drugmakers.

Reactions to the proposed march-in framework were swift and heated. The White House's announcement was both commended as a way to "curb[] the ability of pharmaceutical companies to jack up the price of drugs taxpayers helped pay to develop" (Warren 2023), and excoriated as "a body blow to the world's best innovation system" (Allen 2023) that will ultimately "harm Americans' health" (Zinberg 2023).

The poster child for the potential impact of march-in reform has been the prostrate cancer drug Xtandi, which can cost as much as $190,000 per year. Xtandi is marketed through a collaboration between the private pharmaceutical firms Astellas and Pfizer, who currently own exclusive rights to Xtandi's three patents. But all three patents were based on taxpayer-funded research: they were originally filed by the University of California based on research by UCLA scientists under grants from the U.S. Army and National Institutes of Health (NIH). In March 2023, the NIH refused a petition to "march in" on Xtandi's patents, viewing the high list price as insufficient given that the drug was "widely available to the public on the market" (NIH 2023). Concern over this decision helped spur the Biden-Harris Administration's new proposed rules, under which price alone could be a sufficient justification for marching in and facilitating generic entry (NIST 2023).[2]

In commending the march-in proposal, legislators have cited Xtandi and suggested that the same logic would apply broadly, noting that "[a]ccording to one study, every new drug approved between 2010 and 2016 benefited in part from federal funding" (Warren 2023). Indeed, many studies have shown that the federal government contributes substantially to drug development (e.g., Sampat and Lichtenberg 2011; Cleary et al. 2018). Xtandi is highly unusual, however, in the government's ability to use march-in rights.

The march-in rights under consideration were established through the 1980 Bayh-Dole Act. Before 1980, federal R&D funding agencies had inconsistent policies on whether universities and other federal grant recipients could patent inventions created under these grants (Mowery

[2] The draft framework does not specify how to determine *when* a high price could trigger march-in. The framework says march-in may be warranted when a price is "not reasonable," when it "unreasonably limit[s] availability of the invention," or when it is "extreme and unjustified given the totality of the circumstances." The only concrete suggestion of how an agency might tell that a price is unreasonable is if there is a "steep price increase in response to a disaster, but the framework also notes that "extreme" initial prices may also be unreasonable.

et al., 2004). The Bayh-Dole Act created a uniform policy allowing these taxpayer-funded inventions to be patented. The stated goals in the statutory text at 35 U.S.C. § 200 include "promot[ing] the utilization of inventions arising from federally supported research or development" as well as "ensur[ing] that the Government obtains sufficient rights in federally supported inventions to meet the needs of the Government and protect the public against nonuse or unreasonable use of inventions."

Those rights retained by the federal government include the right under 35 U.S.C. § 203 to "march-in" to issue additional licenses to the patent "upon terms that are reasonable under the circumstances," including if the government determines that the contractor is not taking "effective steps to achieve practical application" of the invention or "to alleviate health or safety needs."

In practice, march-in rights have never been exercised, although federal agencies have successfully used the threat of march-in to spur companies to make voluntary price reductions (Knowledge Ecology International 2024). The NIH has received several petitions to march in on high-priced drugs. In most cases, as with Xtandi, it has rejected those petitions on the grounds that march-in was never meant to apply to prices (e.g., NIH 2004). There is considerable legal debate about whether march-in was meant to apply only in cases of failed commercialization (NIH 2004; Rabitschek and Latker 2005) or can be triggered by price and affordability considerations as well (Arno and Davis 2000). The Biden Administration's new framework shifts the federal government's stance on the appropriate use of march-in authority.

Our analyses here do not address this contentious legal question. Instead, we approach feasibility from an empirical perspective. While both proponents and critics of new march-in rules sometimes describe them as having broad scope, march-in rights can be exercised only on patents that result from federally funded research, and they can enable generic entry only if all patents on a drug were federally funded. In this paper, we examine the feasibility of using march-in rights to lower drug prices by examining patents on all 883 patented drugs approved by the U.S. Food and Drug Administration (FDA) from 1985 to 2022. We update previous work on these issues (Sampat and Lichtenberg 2011; Durvasula, Ouellette, and Williams 2021), bringing these analyses up-to-date, and we extend the work to explicitly examine the interaction between public-sector and other drug patents, and how this varies over drug product life-cycles.

Previous Research

Numerous papers have examined the role of the government in pharmaceutical innovation by examining patents in the FDA's Orange Book, a public data source that provides information on patents associated with marketed drugs (Durvasula et al. 2023).

Sampat and Lichtenberg (2011) found that for new molecular entities approved between 1988 and 2005 with at least one Orange Book patent, 9 percent had a public-sector patent, which they defined to include patents with government-interest statements or a public-sector assignee.

The shares of drugs with at least one public-sector patent were higher for priority-review drugs (17.4 percent), one measure of drug importance, than standard-review drugs (3.1 percent).[3] However, Rai and Sampat (2012) noted considerable underreporting of government-interest statements in patent documents; many patents listed in an NIH database (NIH RePORTER, see below) that should have had government-interest statements do not. Others have noted that government-interest statements have sometimes been disclosed through "certificates of correction" not available through the USPTO's standard electronic patent databases (Love 2019). Accounting for these and other corrections, Durvasula et al. (2021) found that 8 percent of new molecular entities approved between 1981 and 2014 had a public-sector patent.

Other work has also examined the role of universities and public-sector research institutes in contributing to Orange Book listed patents (Sampat 2009; Stevens et al. 2011; Chatterjee and Rohrbaugh 2014; Kneller 2010; Nayak et al. 2019). For example, Nayak et al. (2019) found that 25 percent of drugs approved between 2008 and 2017 had "late-stage" contributions from a university or public-sector research institute, or a company spun off from public-sector research. But only half of these (12 percent of all drugs) had university- or public-sector-owned patents. (Only the subset of these based on extramural federal grants would be subject to march-in rights.)

Researchers have also used "bibliometric" approaches to document links between articles acknowledging NIH funding and FDA-approved drugs (Sampat and Lichtenberg 2011; Cleary et al. 2018). Sampat and Lichtenberg (2011) report that over half of priority-review drugs in their sample cite back to NIH-funded publications, and Cleary et al. (2018) show that all drugs approved over the 2010–2016 period are linked to at least one NIH-funded publication, typically one focused on the drug target. These figures are often referenced in arguments for march-in (Federal Trade Commission 2024; Warren 2023; Kilpatrick 2022; Scott 2019).

However, as Sampat and Lichtenberg (2011) and Ledley and Cleary (2023) note, these bibliometric linkages may be important for certain policy questions (including the social returns to public research funding), but they are not relevant for march-in. For march-in, the share of drugs with public-sector patents is what is relevant, irrespective of any other upstream contributions (Ledley and Cleary 2023; Sampat and Lichtenberg 2011). As noted above, march-in rights can enable generic entry only if *all* patents on a drug are federally funded.

Our analyses in this paper bring our previous work (Sampat and Lichtenberg 2011; Durvasula et al. 2021) to date and directly consider this question.

[3] Under standards created in 1992, the FDA generally will designate a drug for "priority review" if it would provide a "significant improvement" in safety or efficacy in addressing serious conditions.

Data

FDA Compilation of New Molecular Entities Approvals (1985–2022)

We began with a list of all new molecular entities approved from 1985–2022, drawn from a compilation by the FDA (U.S. Food and Drug Administration 2023). Over this period, the FDA approved 1,002 distinct new drug applications (NDAs) for new molecular entities, corresponding to 1,002 unique active ingredients. This data source also includes information on the application number, approval year, applicant, and whether the approval was through the FDA's priority review process. In previous analyses, including studies of the role of public funding in drug development, whether a drug received priority review has been used as a rough proxy for the clinical importance of drugs (e.g., Sampat and Lichtenberg 2011).

Orange Book Patent Data

Next, we collected patent data from the FDA's Orange Book. Since the 1984 Hatch-Waxman Act, NDA applicants have been required to report patents covering these drugs to the FDA, which lists them as part of a document colloquially called the Orange Book (Durvasula et al. 2023). Since each version of the Orange Book includes only unexpired patents at the time of publication, we relied on a compilation of archival Orange Book listings from 1985–2016 (Durvasula et al. 2023), which includes information from print editions from 1985–1999, and the Electronic Orange Book from 2000–2016. We updated this dataset to 2023, appending information from Electronic Orange Book listings from 2017–2023. Specifically, we appended the last Electronic Orange Book file available each year through the Internet Archive: 12/2017, 12/2018, 11/2019, 9/2020, 8/2021, 10/2022, and 10/2023.

Note that we collected data on drugs approved until 2022, but we consulted Orange Book patent listings for these drugs through 2023 (to give the FDA time to record patents on recently approved drugs). Over the 1985–2023 period, there are 9,860 unique patents in the Orange Book. Not all of these correspond to the NMEs in our sample. Of the 1,002 NMEs approved between 1985 and 2022, 883 had at least one Orange Book patent. These NMEs linked to 4,748 patents (of which 4,497 were unique).

PatentsView Patent Data

As a first step in determining patents for which government march-in rights would apply, we downloaded several files from the U.S. Patent and Trademark Office (USPTO) PatentsView Database (USPTO 2024b). The first file includes the raw text of government-interest statements in all patents issued since 1976. The Bayh-Dole Act mandates that patent holders who received government funding include "government-interest statements" in their patents.[4]

[4] More precisely, federal grants and other funding agreements must contractually require grant recipients to include this information in patent applications (35 U.S.C. § 202(c)(6); 37 C.F.R. § 401.14(f)). Some agencies also required reporting before Bayh-Dole as well, though this was haphazard and uncommon.

We downloaded the USPTO assignee file from PatentsView, to track patents where title is held by the NIH (or other government agencies). In addition to data on government rights and ownership, we also collected information from PatentsView on the application dates for each patent in our dataset, which we use to assess when government-funded patents and other patents for the drugs in our sample were filed.[5]

USPTO Certificates of Correction

Previous writing (Love 2017; Durvasula, Ouellette, and Williams 2021) has found cases where a government-interest statement is not included when a patent issues but is added later in a post-issuance "certificates of correction." Unfortunately, these certificates of correction are not available from PatentsView (or any other machine-readable database we know of) but are viewable in the image PDFs of patent documents. We obtained the USPTO Certificate of Correction "Authority File," a listing of all patents with Certificates of Correction (USPTO 2024a). We merged this file with all 9,860 patents in the FDA's Orange Books from 1985–2023. Of these, 3,142 (32 percent) had a certificate for correction. Not all Certificates of Corrections are focused on government-interest statements, so we had to search patent text for these. We downloaded and digitized the full PDFs of each of all Orange Book patents with Corrections from the USPTO. Then, we searched the Certificate of Corrections for any additional government-interest statements. Only 62 of the 3,142 Orange Book patents with Certificates of Correction had government-interest statements listed in these Corrections. Our approach captured those on Gleevec and Spiriva and those identified in previous investigations of this issue (Love 2017; Love 2019).

RePORTER / iEdison Data on NIH-funded patents

Since grantees sometimes fail to disclose patents in government-interest statements (Rai and Sampat 2012), we also collected data from the NIH RePORTER database on all patents resulting from NIH-funded grants or contracts (NIH 2024).

The Government Patent Register (Executive Order 9424 Conveyances)

As Gross and Sampat (2024) explain, Executive Order 9424, signed by President Franklin D. Roosevelt in 1944, created the Register of Government Interest in Patents to track government-funded patents. While these records were originally maintained as a series of Index Cards at the USPTO assignment branch, modern register data are maintained in the USPTO's Patent Assignment Database (UPAD). Marco et al. (2015) suggest many government-interest patents are reported via Executive Order 9424 that don't have government-interest statements. UPAD also includes data on patents reassigned to the government, which may pick up some government-assigned patents beyond those originally assigned to a government agency. Here we use the Gross and Sampat (2024) updated "Government Patent Register" which consolidates the historical Government Register and UPAD information.

[5] We use the actual filing date (as recorded on the front page of the patent) here. An alternative measure of the timing of an application would be the "effective" filing date, which would account for filing dates of any earlier priority applications, and which is generally the relevant date for calculating patent expiration (Durvasula et al. 2023).

Manual Review of University Patents

As a final safeguard for completeness, we reviewed the PDFs of all university-assigned patents that did not have government-interest statements (in PatentsView data or Certificates of Correction), were not in RePORTER, or patents with government rights in the UPAD/Government Patent Register. We did the same for any patents (mostly old ones) where PatentsView lacked assignee information.

Methods

We defined a “public-sector” Orange Book patent as any patent with a government-interest statement (in the original text, Certificate of Correction, or through manual review), with a government assignee, in NIH RePORTER, and/or with government rights per the UPAD/Register. Based on these data, we calculated:

1. The share of patents in the Orange Book that are public-sector patents, and how they are captured through the various sources above.

2. The share of drugs with *any* public-sector patent in the Orange Book, how this varies across priority-review and standard-review drugs, and how this is changing by year of FDA approval. For exposition, we divide approval years into seven cohorts: 1985–1989, 1990–1994, 1995–1999, 2000–2004, 2005–2009, 2010–2014, 2015–2022.

3. The share of drugs where *all* patents in the Orange Book are public-sector patents, how this varies across priority-review and standard-review drugs, and how this is changing by approval year cohort.

4. For drugs with at least one public-sector patent, how often that patent is the first filed patent on the drug.

We also provide the raw drug-patent level data for NMEs as a new public dataset. While most of our analyses are for NMEs, we also provide a broader dataset of all NDAs with Orange Book patents for future analyses and briefly summarize the NDA-level results in the final section of the paper.

Results

Patent-Level Analyses

Our first set of analyses focuses on the share of Orange Book patents for our drug sample that are public-sector patents. There are 4,748 patents for the drugs. Of these, 4,497 are unique, since patents are sometimes listed for multiple NMEs.

Of the 4,497 unique patents, 3.1 percent (138) have a government-interest statement in the original patent text. Given concerns about under-reporting (Rai and Sampat 2012), we also compared information from other sources. Table 1 shows that of the 138 patents with government-interest statements, 54 percent were reported in iEdison and listed in NIH RePORTER:

Table 1: Government-interest statements vs RePORTER

	RePORTER?		
	no	yes	Total
Government-interest?			
no	4,334	25	4,359
yes	63	75	138
Total	4,397	100	4,497

One-quarter of patents in NIH RePORTER have government-interest statements. This suggests the different sources have complementary information about public-sector patents.

However, if we look at government-interest statements not only in the original patents, but also those reflected in Certificates of Correction, in Table 2, we find that nearly all patents in RePORTER have government-interest statements. But given the difficulty in accessing information in Certificates of Correction (requiring downloading, converting to searchable text, and searching), RePORTER data remains important for capturing the full set of public-sector patents. Table 2 also shows that 61 percent of Orange Book patents with government-interest statements are in RePORTER, but nearly 40 percent are not. Reviewing the 64 missing patents by hand, we found that of these some were from other agencies, but the majority reflected NIH grants and should have been included in RePORTER.

Table 2: Government-interest statements (including Certificates of Correction) vs RePORTER

	RePORTER?		
	no	yes	Total
Government-interest (with CoC)			
no	4,333	2	4,335
yes	64	98	162
Total	4,397	100	4,497

Next, we compared the government-interest data (including information reported through Certificates of Correction) to information in the Government Patent Register/UPAD data. Consistent with Marco et al. (2015), Table 3 shows differences in what is reported in the two sources. Less than half of patents with government-interest statements are reported in the Government Patent Register/UPAD, and 18 percent of patents disclosed through the assignments data do not have government-interest statements.

Table 3: Government-interest statements (including Certificates of Correction) vs Government Register/UPAD

	In Register/UPAD?		
	no	yes	Total
Government-interest (with CoC)			
no	4,318	17	4,335
yes	84	78	162
Total	4,402	95	4,497

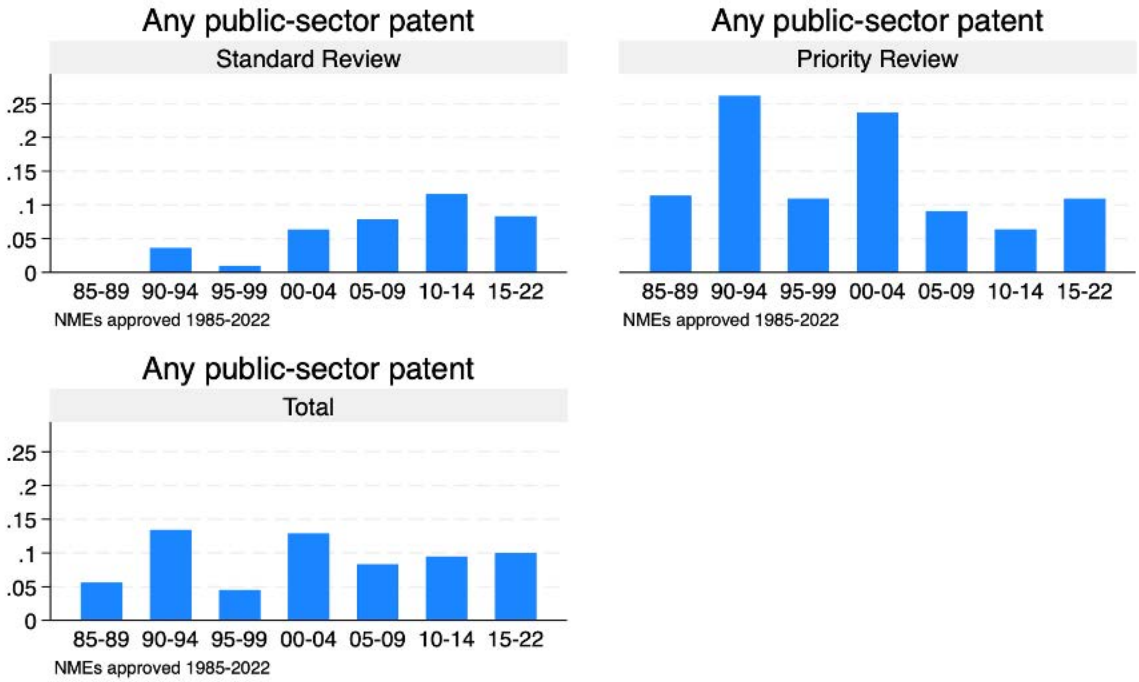
Note that some of the discrepancies between the assignments data and government-interest statements reflect patents assigned to the government. These need not necessarily have government-interest statements (though sometimes do) or be listed in RePORTER (primarily an extramural database) but may appear in the Register. We also found that of patents with public-sector assignees, only 13.6 percent have government-interest statements, 4.5 percent are in RePORTER, but the vast majority (86.4 percent) are in the Register/UPAD database.

Drug-Level Analyses

Next we turn to our main analyses, at the drug level. Overall, 64 of the 883 drugs have "public sector" patents based on raw government-interest statements, 70 when including certificates of correction, 70 when incorporating RePORTER, and 80 when including government assignees. The Register/UPAD database adds no additional drugs with at least one public-sector patent beyond these sources. The drugs with all public-sector patents are listed in Appendix Table A1, and the drugs with both public-sector and other patents are listed in Appendix Table A2.

Thus after combining information across the sources, we found that nine percent of the drugs (80/883) had at least one public-sector patent. The share was more than twice as high for priority-review drugs (13 percent) compared to standard-review drugs (5.6 percent), consistent with previous research (Sampat and Lichtenberg 2011; Durvasula, Ouellette, and Williams 2021). Figure 1 shows some fluctuation over time in these shares, but no obvious trend.

Figure 1: NMEs with any public-sector patent, by priority review status and approval year

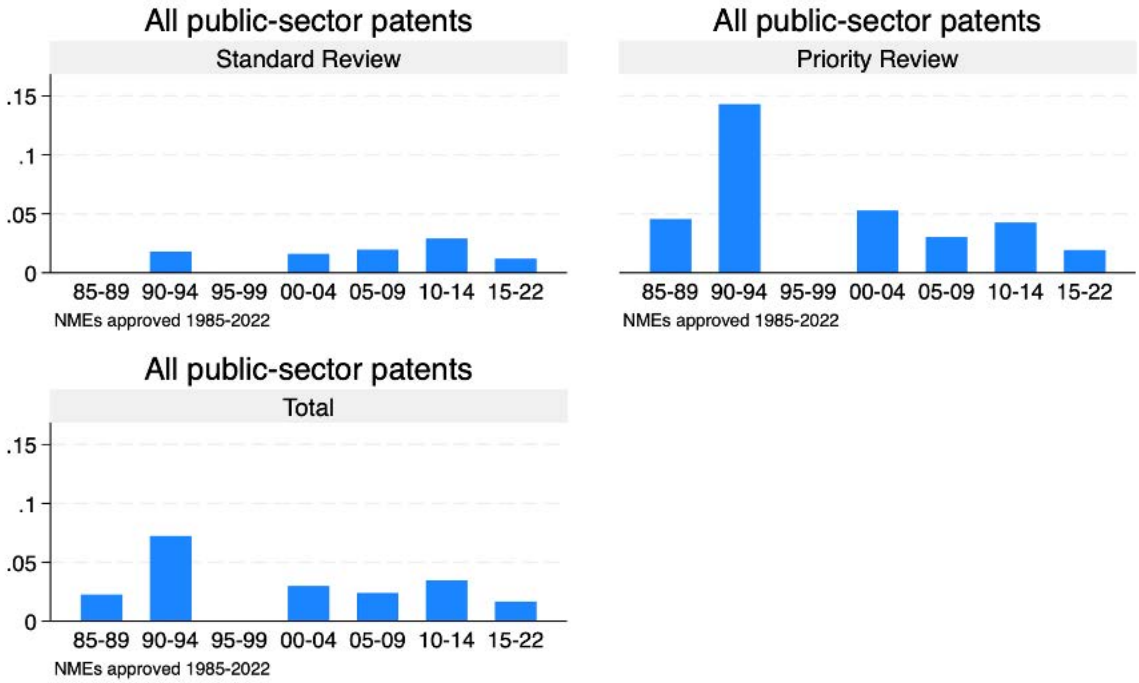


To enable generic competition through march-in alone, all patents must be public-sector patents. Overall, this is true for only 22 drugs in our sample, about 2.5 percent of the 883. The 2.5 percent is an upper bound because our public-sector patents include those assigned to the government, which are governed not by Bayh-Dole but rather by the separate Stevenson-Wydler Act, to which the draft march-in framework does not apply.[6] This share is slightly higher

[6] Stevenson-Wydler encourages patenting of inventions developed at federal laboratories, such as intramural research at NIH research institutes, as well as inventions developed under a cooperative research and development agreement (CRADA) between a federal laboratory and a private company (35

for priority-review drugs than standard-review drugs (3.9 vs 1.3 percent). Figure 2 shows the shares over time:

Figure 2: NMEs with all public-sector patents, by priority review status and approval year



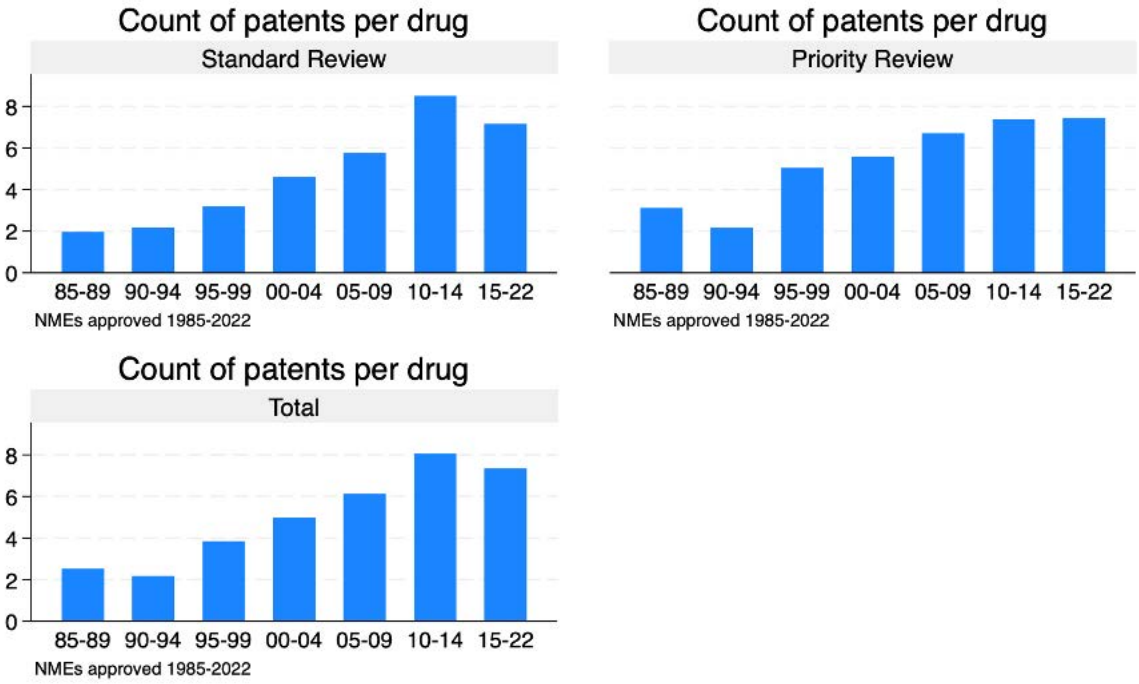
The Role of Secondary Patents

The low share of drugs where all patents are public-sector patents reflects that in most cases, there are multiple patents per drug. Across the sample, there are an average of 5.4 patents per

U.S.C. §§ 3710-3710d). Patents owned by the NIH or other federal agencies are not subject to march-in or other rights retained by the federal government because the government already starts with title to the patents. Patents owned by an external CRADA partner are subject to march-in (15 U.S.C. § 3710a(b)(1)(B)-(C)), but are not covered by the draft framework.

drug (median = 4 patents per drug). And Figure 3 shows that the number of patents per drug has increased over time:

Figure 3: Average number of patents per drug, over time

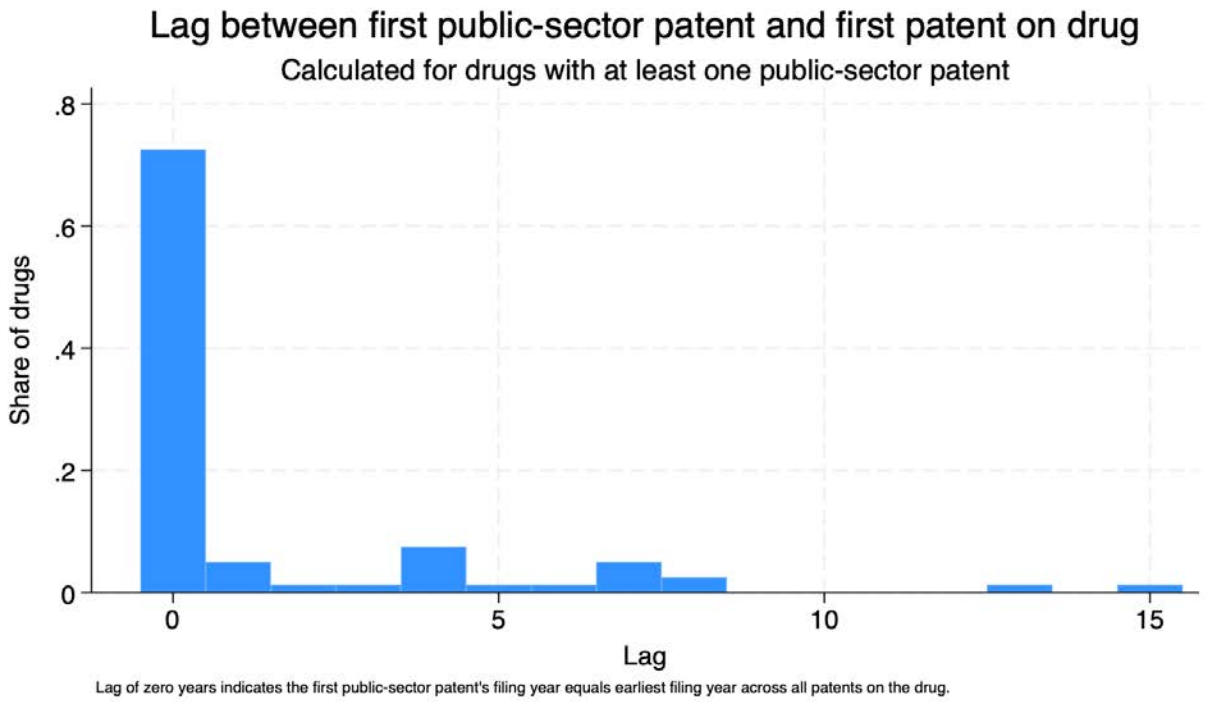


Previous research suggests that the growth in patenting over time reflects the accumulation of "secondary" patents, sometimes called "evergreening." While the overall share of drugs with public-sector patents is low, march-in could still be useful in contexts where the public sector has rights to the primary patents on the drug, since secondary patents are more vulnerable to being deemed invalid or non-infringed under the 1984 Hatch-Waxman Act's Paragraph IV challenge procedures (Hemphill and Sampat, 2011, 2012, 2013).[7]

While we have not coded patents as primary or secondary for this paper, we can also look at how often public-sector patents tend to be among the earliest patents filed on a drug. Previous research (Hemphill and Sampat 2011) shows that in most cases, drugs' primary patents tend to be the first filings. For the 80 drugs with at least one public-sector patent, Figure 4 shows the lag between the filing date of the first public-sector patent and the first patent filed on the drug:

[7] We also calculated how the share of public-sector patents on a drug varied across the sales distribution, using sales data collected for the the Hemphill and Sampat (2011) analysis of 119 NMEs with successful generic entry between 2000 and 2010. In the Hemphill-Sampat (2011) sample, 6 percent of drugs have a public-sector patent. While there is no clear association between whether a drug has any public-sector patent and sales, the share of public-sector patents was lowest in the top two sales quartiles, reflecting the propensity for drug companies to file additional patents is highest for top-selling drugs.

Figure 4: How often is the public-sector patent among the first filed?



For 72.5 percent of drugs with a public-sector patent, the public-sector patent is among the first filed patents.

NDA-Level Analyses

Following previous work, we calculated public-sector shares for new molecular entities (NMEs), not all new drug applications (NDAs). The latter set also includes line extensions for previously approved molecules. There are 9,860 unique patents in the Orange Book over this period, corresponding to 2,832 unique NDAs. Of the patents, 258 are public-sector patents. At the NDA level, 164 (5.8 percent) of the 2,832 NDAs had at least one public-sector patent, and 45 (1.6 percent) had all public-sector patents. Appendix Table A3 lists the 164 NDAs with at least one public-sector patent, with the bold and shaded rows indicating drugs with all public-sector patents.[8]

[8] In addition to the historical analyses, we calculated these figures for drugs that currently have at least one unexpired patent, using information from the November 2023 Orange Book, the last version used for our analyses. There are 1213 NDAs in this set, with 5633 patents that were in force as of November 2023. Of these NDAs, 45 have at least one unexpired public-sector patent, and for 16 NDAs (1.3 percent) all patents in force are public-sector patents. These 16 NDAs correspond to 14 drugs. In addition to Xtandi (enzalutamide), this set includes Amyvid (florbetapir f-18), Arakoda (tafenoquine succinate), Eysuvis (loteprednol etabonate), Folotyn (pralatrexate), Inveltys (loteprednol etabonate), Neuraceq (florbetaben f-18), Probuphine (buprenorphine hydrochloride), Tembexa (brincidofovir), Tpoxx

Discussion

Despite claims that price-based march-in would substantially lower pharmaceutical prices or seriously harm pharmaceutical innovation, our research suggests that march-in could apply to only a few drugs. Consistent with our prior work, we estimate that 9 percent of these 883 drugs have at least one public-sector patent. The share was more than twice as high for priority-review drugs (13 percent) compared to standard-review drugs (5.6 percent).

However, march-in rights can enable generic entry only if all patents on a drug are subject to Bayh-Dole. This is true for only 22 drugs in the 1985–2022 sample, about 2.5 percent of the 883 (see Appendix). This low share of drugs where all patents are subject to march-in reflects that in most cases, there are multiple patents per drug (Ouellette 2010). As noted above, this measure and others reported below are upper bounds because they capture not only Bayh-Dole patents, but also patents governed by the separate Stevenson-Wydler Act of 1980 (such as those owned by the NIH), to which the draft framework does not apply.

This paper focuses on patents on small-molecule pharmaceuticals. Our analysis and previous papers do not directly look at biologic drugs—disproportionately represented among high-cost drugs—due to the lack of public data about which patents cover these drugs. However, several accounts suggest there tend to be even more patents per drug for biologics, so the share of drugs with all public-sector patents would likely be even smaller. The draft framework is also intended to apply beyond healthcare. We suspect that for the same reasons, the public-sector share and scope for march-in would likely be low in "tech" fields like chips, electronics, and semiconductors, where patent-product ratios tend to be higher than in pharmaceuticals.

While the public sector funded all patents on only 2.5 percent of small-molecule drugs approved through 2022, our analysis also shows that when there is a public-sector patent, it is among the first filed patents on the drug nearly three-fourths of the time. This finding suggests the public sector may be more likely to have rights to stronger "primary" patents, and the private sector may hold weaker "secondary" patents. In these cases, march-in on the primary patent combined with curtailing of secondary patents—another Biden Administration priority—could increase the share of drugs where march-in was relevant to 9 percent (those where the public sector owns any patent).[9]

Note that the share of drugs where public-sector funds patents is considerably lower than commonly cited numbers on the share of drugs with some public-sector contributions (Cleary et al. 2018; Sampat and Lichtenberg 2011), including references to research showing that the public sector had some role in nearly all drugs (Cleary et al. 2018). For march-in, the share of

(tecovirimat), Vyndaqel (tafamidis meglumine), Vyondys 53 (golodirsen), Xenoview (xenon xe-129 hyperpolarized), and Zokinvy (lonafarnib).

[9] Other policies could also be used to adjust prices for a broader array of drugs, including allowing drug production "by or for the United States" under 28 U.S.C. § 1498 (Brennan et al. 2016), price-setting through government insurance like Medicare and Medicaid (Hemel and Ouellette 2023), or directly purchasing patented products as for COVID-19-related technologies (Ouellette 2024).

drugs with public-sector *patents* is what is relevant, irrespective of any other upstream contributions roles of public research (Ledley and Cleary 2023; Sampat and Lichtenberg 2011), or even late-stage contributions (Nayak et al. 2019). Moreover, as we noted, march-in alone, without other policy tools, would work only when *all* patents on a drug (or other technology) are public-sector patents.

However, our analyses also suggest significant underreporting of public-sector roles in patents in government-interest statements and in NIH RePORTER, though combining the two sources (and others discussed in the text) ameliorates this. We don't know the share of patents not reported to any source, and policies and empirical approaches to better assess these "unknown unknowns" seem important. Our instinct is that further corrections of under-reporting would not significantly change the basic picture, but investigation of this question is important going forward.

Our analysis has focused on the feasibility of using march-in rights, providing updated empirical evidence to go beyond previous assessments of feasibility that focused on issues like legislative intent and statutory interpretation (Arno and Davis 2000). We conclude with an observation on desirability. Both at the time of Bayh-Dole's enactment and today, policymakers have had little rigorous evidence about the impact of patent policy on the commercialization of federally funded inventions (Eisenberg 1996; Ouellette and Weires 2019). This is true both in general and for specific policy interventions such as price-related restrictions on patent rights. In our view, we lack evidence on the magnitude of the potential tradeoff between price-related restrictions and commercialization.[10] If "reasonable" price (however operationalized) were an explicit ground for potential march-in, would commercialization rates drop 1 percent? 50 percent? Not at all? Over 40 years after Bayh-Dole's enactment, we don't know. The fundamental evidence-building problem is that empirical progress depends on policy variation. Given the dearth of evidence on how any price-related restrictions on patent rights impact commercialization, it may be useful to think about approaches to implementing the march-in framework, or any changes in technology commercialization policy, in a way that enables evidence-based evaluation going forward.

[10] The evidence developed since 1980 is limited to a few anecdotes. There have not been significant efforts to limit Bayh-Dole patent rights based on pricing, but from 1989-95, the NIH attempted to impose price-related limits under the separate Stevenson-Wydler Act, which governs intramural research and collaborations between intramural laboratories and private firms. In particular, the NIH required "fair pricing" clauses in Cooperative Research and Development Agreements (CRADAs), or agreements to share government facilities and personnel (but not funding) with private-sector partners. The NIH said it abandoned this effort because drug companies refused to sign the new CRADAs but kept collaborating with government scientists, leading to confusion about the resulting IP ownership (Contreras 2020; Rohrbaugh and Wong 2021; Sarpatwari et al. 2020). But this thirty-year-old experience may not reflect public-private collaborations today, and it also reveals little about whether licensing of patents developed under federal grants would be markedly different if those patents came with additional price-related restrictions. Pre-Bayh-Dole anecdotes and statistics on commercialization rates when the government retained title to inventions (Eisenberg 1996) also do not inform the much narrower question of whether, to what extent, and under what conditions using march-in to ensure "reasonable" pricing would affect commercialization incentives.

References

Allen, Joseph P. 2023. “The Biden Administration’s Plan to Use March-in Rights to Address Drug Prices Would Kill Future World-Changing Innovations.” *STAT*. Dec. 15, 2023. https://www.statnews.com/2023/12/15/march-in-rights-bayh-dole-act-drug-prices-biden

Arno, Peter S., and Michael H. Davis. 2000. “Why Don’t We Enforce Existing Drug Price Controls? The Unrecognized and Unenforced Reasonable Pricing Requirements Imposed upon Patents Deriving in Whole or in Part from Federally Funded Research.” *Tulane Law Review* 75 (3): 631–693. https://www.tulanelawreview.org/pub/volume75/issue3/why-dont-we-enforce-existing-drug-price-controls

Brennan, Hannah, Amy Kapczynski, Christine H. Monahan, and Zain Rizvi. 2016. “A Prescription for Excessive Drug Pricing: Leveraging Government Patent Use for Health.” *Yale Journal of Law and Technology* 18: 275–354. https://yjolt.org/sites/default/files/kapczynski_18yjolt275_gk_0_0.pdf

Chatterjee, Sabarni K., and Mark L. Rohrbaugh. 2014. “NIH Inventions Translate into Drugs and Biologics with High Public Health Impact.” *Nature Biotechnology* 32: 52–58. https://doi.org/10.1038/nbt.2785

Cleary, Ekaterina Galkina, Jennifer M. Beierlein, Navleen Surjit Khanuja, Laura M. McNamee, and Fred D. Ledley. 2018, “Contributions of NIH Funding to New Drug Approvals 2010–2016.” *Proceedings of the National Academy of Sciences* 115 (10): 2329–2334. https://www.pnas.org/doi/abs/10.1073/pnas.1715368115

Contreras, Jorge L. 2020. “What Ever Happened to NIH’s ‘Fair Pricing’ Clause?” *Bill of Health*. Aug. 4, 2020. https://blog.petrieflom.law.harvard.edu/2020/08/04/nih-fair-pricing-drugs-covid19

Durvasula, Maya, C. Scott Hemphill, Lisa Larrimore Ouellette, Bhaven Sampat, and Heidi L. Williams. 2023. “The NBER Orange Book Dataset: A User’s Guide.” *Research Policy* 52 (7): 104791. https://doi.org/10.1016/j.respol.2023.104791

Durvasula, Maya, Lisa Larrimore Ouellette, and Heidi Williams. 2021. “Private and Public Investments in Biomedical Research.” *AEA Papers and Proceedings* 111: 341–345. https://doi.org/10.1257/pandp.20211105

Eisenberg, Rebecca. S. 1996. “Public Research and Private Development: Patents and Technology Transfer in Government-Sponsored Research.” *Virginia Law Review* 82 (8): 1663–1727. https://repository.law.umich.edu/articles/1224/

Federal Trade Commission. 2024. “Comment on Draft Interagency Guidance Framework for Considering the Exercise of March-in Rights.” February 6, 2024. https://www.ftc.gov/system/files/ftc_gov/pdf/2024.02.06March-InRightsComment.pdf

Gross, Daniel P., and Bhaven N. Sampat. 2024. “The Government Patent Register: A New Resource for Measuring U.S. Government-Funded Patenting.” NBER Working Paper No. 32136. https://www.nber.org/papers/w32136

Hemel, Daniel J., and Lisa Larrimore Ouellette. 2023. “Valuing Medical Innovation.”

Stanford Law Review 75 (3): 517–599. https://www.stanfordlawreview.org/print/article/valuing-medical-innovation/

Hemphill, C. Scott, and Bhaven N. Sampat. 2011. "When Do Generics Challenge Drug Patents?" *Journal of Empirical Legal Studies* 8 (4): 613–649. https://doi.org/10.1111/j.1740-1461.2011.01235.x

———. 2012. "Evergreening, Patent Challenges, and Effective Market Life in Pharmaceuticals." *Journal of Health Economics* 31 (2): 327–339. https://doi.org/10.1016/j.jhealeco.2012.01.004

———. 2013. "Drug Patents at the Supreme Court." *Science* 339 (6126): 1386–1387. https://doi.org/10.1126/science.1235857

Kilpatrick, Charlotte. 2022. "There's Already a Law on the Books That Could Lower Prescription Drug Prices — but No One's Using It." *Salon*. Feb. 11, 2022. https://www.salon.com/2022/02/11/theres-already-a-law-on-the-books-that-could-lower-prescription-prices-but-no-ones-using-it/

Kneller, Robert. 2010. "The Importance of New Companies for Drug Discovery: Origins of a Decade of New Drugs." *Nature Reviews Drug Discovery* 9: 867–882. https://doi.org/10.1038/nrd3251

Knowledge Ecology International. 2024. "Several March-in and Royalty Free Rights Cases, Under the Bayh-Dole Act." https://www.keionline.org/cl/march-in-royalty-free

Ledley, Fred D., and Ekaterina Galkina Cleary. 2023. "NIH Funding for Patents that Contribute to Market Exclusivity of Drugs Approved 2010–2019 and the Public Interest Protections of Bayh-Dole." *PLoS One* 18 (7): e0288447. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0288447

Love, James. 2017. "Errors in Patent Grants: More Common in Medical Patents." *Bill of Health*. October 21, 2017. https://blog.petrieflom.law.harvard.edu/2017/10/21/errors-in-patent-grants-more-common-in-medical-patents

———. 2019. "Novartis, Dana Farber, Oregon Health & Science University Wait 18 Years to Disclose NIH Funding in Key Gleevec Patent." *Bill of Health*. October 11, 2019. https://blog.petrieflom.law.harvard.edu/2019/10/11/novartis-dana-farber-oregon-health-science-university-wait-18-years-to-disclose-nih-funding-in-key-gleevec-patent

Marco, Alan C., Amanda F. Myers, Stuart Graham, Paul D'Agostino, Kirsten Apple. 2015. "The USPTO Patent Assignment Dataset: Descriptions and Analysis." USPTO Economic Working Paper No. 2015-2. https://www.uspto.gov/sites/default/files/documents/USPTO_Patents_Assignment_Dataset_WP.pdf

Mowery, David C., Nelson, Richard R., Sampat, Bhaven N., & Ziedonis, Arvids A. 2004. *Ivory Tower and Industrial Innovation: University-Industry Technology Transfer Before and After the Bayh-Dole Act*. Stanford University Press. https://www.sup.org/books/title/?id=6652

National Institutes of Health (NIH). 2004. "March-in Position Paper in the Case of Norvir." https://www.techtransfer.nih.gov/sites/default/files/documents/policy/March-In-Norvir.pdf

———. 2023. “Decision on Xtandi March-in Request.” Mar. 21, 2023. https://www.techtransfer.nih.gov/sites/default/files/documents/pdfs/NIH_Decision_Xtandi_March-In_Request(2023)

———. 2024. “NIH RePORTER Patents File.” https://reporter.nih.gov/exporter/patents

National Institute of Standards and Technology (NIST). 2023. “Request for Information Regarding the Draft Interagency Guidance Framework for Considering the Exercise of March-in Rights.” 88 Fed. Reg. 85,593. Dec. 8, 2023. https://www.federalregister.gov/documents/2023/12/08/2023-26930/request-for-information-regarding-the-draft-interagency-guidance-framework-for-considering-the

Nayak, Rahul K., Jerry Avorn, and Aaron S. Kesselheim. 2019. “Public Sector Financial Support for Late Stage Discovery of New Drugs in the United States: Cohort Study.” *BMJ*. 367: l5766. https://doi.org/10.1136/bmj.l5766

Ouellette, Lisa Larrimore. 2010. “How Many Patents Does It Take To Make a Drug? Follow-On Pharmaceutical Patents and University Licensing.” *Michigan Telecommunications & Technology Law Review* 17 (1): 299–336. https://www.mttlr.org/wp-content/journal/volseventeen/ouellette.pdf

———. 2024. “IP and Public Research in Health Emergencies: U.S. Law and Best Practices.” WIPO Discussion Paper. https://ssrn.com/abstract_id=4505930

Ouellette, Lisa Larrimore, and Rebecca Weires. 2019. “University Patenting: Is Private Law Serving Public Values?” *Michigan State Law Review* 2019 (5): 1329–1387. https://ssrn.com/abstract_id=3443692

Rabitschek, John H., and Norman J. Latker. 2005. “Reasonable Pricing—A New Twist for March-in Rights Under the Bayh-Dole Act.” *Santa Clara High Technology Law Journal* 22 (1): 149–167. https://digitalcommons.law.scu.edu/cgi/viewcontent.cgi?article=1399&context=chtlj

Rai, Arti K., and Bhaven N. Sampat. 2012. “Accountability in Patenting of Federally Funded Research.” *Nature Biotechnology* 30 (10): 953–956. https://doi.org/10.1038/nbt.2382

Rohrbaugh, Mark L., and Jennifer Wong. 2021. “The NIH Experience with the Reasonable Pricing Clause in CRADAs FY1990–1995.” *National Institutes of Health*. https://www.techtransfer.nih.gov/sites/default/files/CRADA%20Q%26A%20Nov%202021%20FINAL.pdf

Sampat, Bhaven N. 2009. “Academic Patents and Access to Medicines in Developing Countries.” *American Journal of Public Health* 99 (1): 9–17. https://doi.org/10.2105/AJPH.2007.128769

Sampat, Bhaven N., and Frank R. Lichtenberg. 2011. “What Are the Respective Roles of the Public and Private Sectors in Pharmaceutical Innovation?” *Health Affairs (Project Hope)* 30 (2): 332–339. https://doi.org/10.1377/hlthaff.2009.0917

Sarpatwari, Ameet, Alison K. LaPidus, and Aaron S. Kesselheim. 2020. “Revisiting the National Institutes of Health Fair Pricing Condition: Promoting the Affordability of Drugs Developed with Government Support.” *Annals of Internal Medicine* 172 (5): 348–350. https://www.acpjournals.org/doi/abs/10.7326/M19-2576?journalCode=aim

Scott, Dylan. 2019. “How a Democratic President Could Reduce Drug Prices without Congress.” *Vox*. Nov. 25, 2019. https://www.vox.com/policy-and-politics/2019/11/25/20982374/2020-democratic-presidential-candidates-prescription-drug-prices

Stevens, Ashley J., Jonathan J. Jensen, Katrine Wyller, Patrick C. Kilgore, Sabarni Chatterjee, and Mark L. Rohrbaugh. 2011. “The Role of Public-Sector Research in the Discovery of Drugs and Vaccines.” *New England Journal of Medicine* 364 (6): 535–541. https://doi.org/10.1056/NEJMsa1008268

U.S. Food and Drug Administration. 2023. “Compilation of CDER New Molecular Entity (NME) Drug and New Biologic Approvals.” https://www.fda.gov/drugs/drug-approvals-and-databases/compilation-cder-new-molecular-entity-nme-drug-and-new-biologic-approvals

U.S. Patent & Trademark Office (USPTO). 2024a. “Certificates of Correction.” https://www.uspto.gov/patents/search/authority-files/certificates-correction

———. 2024b. “PatentsView.” https://www.uspto.gov/ip-policy/economic-research/patentsview

Warren, Elizabeth. 2023. “America—It’s Time to Tell the Government We’re Sick of Big Pharma’s Racket.” *Newsweek*. Dec. 14, 2023. https://www.newsweek.com/elizabeth-warren-americaits-time-tell-government-were-sick-big-pharmas-racket-opinion-1852487

White House. 2023. “FACT SHEET: Biden-Harris Administration Announces New Actions to Lower Health Care and Prescription Drug Costs by Promoting Competition.” Dec. 7, 2023. https://www.whitehouse.gov/briefing-room/statements-releases/2023/12/07/fact-sheet-biden-harris-administration-announces-new-actions-to-lower-health-care-and-prescription-drug-costs-by-promoting-competition

Zinberg, Joel. 2023. “Biden Decides to ‘March in’ on Drug Patents.” *Wall Street Journal*. Dec. 12, 2023. https://www.wsj.com/articles/biden-decides-to-march-in-on-drug-patents-price-control-biotech-research-3e327f6b

Appendix

Table A1. FDA-Approved New Molecular Entities (1985-2022) with all Public-Sector Patents

NDA	Drug	Public-Sector Patents (U.S. Patent No.)
19530	Ucephan	4284647
19836	Supprelin	4244946
19863	Geref	4517181, 4703035
19937	Adenocard	4673563
20038	Fludara	4357324
20044	Exosurf	4312860, 4826821, 5110806
20084	iobenguane Sulfate I 131	4584187
20134	Metastron	4861759, 5616566
20412	Zerit	4978655
21084	Serpacwa	5607979
21500	Emtriva	5210085, 5814639, 5914331, 6642245, 6703396, 7402588
21673	Clolar	4918179, 5384310, 5661136
21746	Surfaxin	5407914
22253	Vimpat	5654301, RE38551
22468	Folotyn	6028071, 7622470, 8299078
202008	Amyvid	7687052, 8506929
203415	Xtandi	7709517, 8183274, 9126941
204677	Neuraceq	7807135
208627	Tpoxx	7737168, 8039504, 8124643, 8530509, 8802714, 9339466
211996	Vyndaqel	7214695, 7214696, 8168663, 8653119
213969	Zokinvy	7838531, 8828356
214375	Xenoview	10583205, 11052161

Table A2. FDA-Approved New Molecular Entities (1985-2022) with Public-Sector and Other Patents

NDA	Drug	Public-Sector Patents	Other Patents
18936	Prozac	4035511, 4083982, 4971998	4018895, 4194009, 4314081, 4329356, 4590213, 4594358, 4626549, 4647591, 4683235, 5114976, 5744501, 6960577
19785	Cardiolite	4452774	4885100, 4894445, 4988827, 5324824
19829	Ceretec	4615876	4789736
19880	Paraplatin	4140707	4657927
20154	Videx	4861759, 5254539, 5616566	5880106
20199	Hivid	4879277	5028595
20212	Zinecard	5242901	4275063, 4963551
20262	Taxol	5496804, 6150398	5641803, 5670537, 6096331
20326	Neutrexin	4694007	4376858, 6017922
20408	Trusopt	4619939	4797413
20451	Photofrin	4649151, 4866168, 4932934, 5028621, 5145863	5438071
20597	Xalatan	4599353	5296504, 5422368, 6429226, 7163959
20659	Norvir	5541206, 5635523, 5648497, 5674882, 5846987, 5886036	5484801, 5948436, 6037157, 6703403
20819	Zemplar	5246925, 5587497, 5597815	6136799, 6361758
20845	Inomax	5485827, 5873359	5558083, 5732693, 5752504, 6125846, 8282966, 8291904, 8293284, 8431163, 8573209, 8573210, 8776794, 8776795, 8795741, 8846112, 9265911, 9279794, 9295802, 9408993, 9770570
20961	Vitravene	5264423, 5276019	4689320, 5442049, 5595978
21119	Visudyne	5798349	4833790, 4883790, 4920143, 5095030, 5214036, 5283255, 5707608, 5756541, 5770619, 6074666
21197	Cetrotide	4800191, 5198533	6319192, 6863891, 7605121

NDA	Drug	Public-Sector Patents	Other Patents
21226	Kaletra	5541206, 5635523, 5648497, 5674882, 5846987, 5886036	5914332, 5948436, 6037157, 6232333, 6284767, 6458818, 6521651, 6703403, 7141593, 7432294
21320	Plenaxis	5843901, 6423686, 6455499	5968895, 6180608, 6699833
21335	Gleevec	6958335	5521184, 6894051, RE43932
21366	Crestor	7030152, 7964614	6316460, 6589959, 6858618, RE37314
21446	Lyrica	5563175, 6197819	6001876, RE41920
21481	Fuzeon	5464933	6133418, 6475491
21487	Namenda	5614560	5061703
21602	Velcade	6713446, 6958319	5780454, 6083903, 6297217, 6617317, 6747150, 7119080
21773	Byetta	5424286	6858576, 6872700, 6902744, 6956026, 7297761, 7521423, 7741269
21964	Relistor	6559158	8247425, 8420663, 8552025, 8822490, 9180125, 9492445, 9669096, 10376584
21976	Prezista	7470506, 8597876, 9889115	5583131, 5843946, 6037157, 6248775, 6335460, 6703403, 6987102, 7700645, 8518987, RE42889, RE43596, RE43802
21991	Zolinza	7399787, 7456219, 7652069, 7732490, 7851509, 8067472, 8101663	6087367, 8093295, 8450372, RE38506
21995	Januvia	6890898, 7078381, 7459428	6303661, 6699871, 7125873, 7326708
22271	Nesina	6890898, 7078381, 7459428	6150383, 6211205, 6303640, 6303661, 6329404, 7807689, 8173663, 8288539, 8697125
22474	Ella	9283233, 10159681, 10772897	8426392, 8512745, 8735380, 8962603, 9844510
201280	Tradjenta	6890898, 7078381, 7459428	6303661, 7407955, 8119648, 8178541, 8673927, 8846695, 8853156, 8883805, 9173859, 9486526, 10034877, 11033552
202207	Lymphoseek	6409990	9439985

NDA	Drug	Public-Sector Patents	Other Patents
203100	Stribild	5814639, 5914331, 6642245, 6703396	5922695, 5935946, 5977089, 6043230, 7176220, 7635704, 8148374, 8592397, 8633219, 8716264, 8981103, 9457036, 9744181, 9891239, 10039718
203137	Vizamyl	7270800, 8236282, 8691185	7351401, 8916131
205494	Cerdelga	6916802, 7253185	7196205, 7615573, 10888544, 10888547, 11458119
206488	Exondys 51	8486907, 9018368, 10781451, RE47751, RE47769	9243245, 9416361, 9506058, 10337003, 10364431, 10533174, RE48468
207561	Genvoya	5814639, 5914331, 6642245, 6703396	7176220, 7390791, 7635704, 7800788, 7803788, 8148374, 8633219, 8754065, 8981103, 9296769, 9891239, 10039718
207924	Olumiant	9089574, 9737469, 11045474	8158616, 8420629
208054	Axumin	5808146	9387266, 10010632, 10124079, 10716868, 10933147, 10953112, 10967077
209531	Spinraza	7838657, 8110560, 8361977, 10266822	6166197, 6210892, 7101993, 8980853, 9717750, 9926559, 10436802
209776	Vabomere	11376237	8680136, 9694025, 10172874, 10183034, 10561675, 11007206
209899	Zeposia	8481573, 8796318, 9382217	10239846
210251	Biktarvy	6642245, 6703396	7390791, 7803788, 8754065, 9216996, 9296769, 9708342, 9732092, 10385067, 10548846, 11744802
210450	Orilissa	6872728, 7056927, 7176211, 7179815, 7419983, 7462625	10537572, 10682351, 11344551, 11542239, 11690845, 11690854, 11707464
210557	Vyleesi	6579968	6794489, 9352013, 9700592, 10286034, 11590209
210922	Onpattro	8552171, 9193753	8058069, 8158601, 8168775, 8334373, 8362231, 8372968, 8492359, 8642076, 8741866, 8778902, 8802644, 8822668, 8895718, 8895721, 9234196, 9364435, 9567582, 9943538,

NDA	Drug	Public-Sector Patents	Other Patents
			9943539, 10240152, 11079379, 11141378
210951	Erleada	8445507, 8802689, 9388159, 9987261	9481663, 9884054, 10052314, 10702508, 10849888, RE49353
211109	Xerava	10961190, 11578044	8796245, 8906887
211970	Vyondys 53	9024007, 9994851, 10227590, 10266827, 10421966, 10968450, 10995337, RE47691	9416361, 10533174
213026	Amondys 45	8524880, 9447415, RE48960	9228187, 9416361, 9758783, 10287586, 10533174, 10781450
213378	Lybalvi	7262298, 7956187, 8252929	8778960, 9119848, 9126977, 9517235, 10300054, 10716785, 11185541, 11241425, 11351166, 11707466
214012	Leqvio	10590418	8106022, 8222222, 8232383, 8546143, 8809292, 8828956, 9074213, 9370582, 9708610, 9708615, 10125369, 10131907, 10266825, 10273477, 10669544, 10806791, 10851377, 11078485, 11530408
214200	Cosela	8598186, 8598197, 9487530, 9957276, 10085992, 10189849, 10189850, 10927120, 10966984, 11040042, 11717523	11529352
214793	Pylarify	8778305, 9861713, 10947197	8487129
215014	Empaveli	7888323, 7989589, 9169307	10035822, 10125171, 10875893, 11040107, 11292815, 11661441

Table A3. FDA-Approved New Drug Applications with at Least One Public-Sector Patent in the Orange Book (editions 1985-2023), with Bolded and Shaded Rows Indicating All Public-Sector Patents

NDA	Proprietary Name	Active Ingredient
18662	ACCUTANE	ISOTRETINOIN
20162	**ACTHREL**	**CORTICORELIN OVINE TRIFLUTATE**
22549	ADASUVE	LOXAPINE
19937	**ADENOCARD**	**ADENOSINE**
21316	ALTOPREV	LOVASTATIN
213026	AMONDYS 45	CASIMERSEN
202008	**AMYVID**	**FLORBETAPIR F-18**
210607	**ARAKODA**	**TAFENOQUINE SUCCINATE**
21937	ATRIPLA	EFAVIRENZ; EMTRICITABINE; TENOFOVIR DISOPROXIL FUMARATE
208054	AXUMIN	FLUCICLOVINE F-18
20727	BIDIL	HYDRALAZINE HYDROCHLORIDE; ISOSORBIDE DINITRATE
210251	BIKTARVY	BICTEGRAVIR SODIUM; EMTRICITABINE; TENOFOVIR ALAFENAMIDE FUMARATE
17954	**BRETYLOL**	**BRETYLIUM TOSYLATE**
22200	BYDUREON	EXENATIDE SYNTHETIC
21773	BYETTA	EXENATIDE SYNTHETIC
18874	CALCIJEX	CALCITRIOL
18312	CALDEROL	CALCIFEDIOL
19785	CARDIOLITE	TECHNETIUM TC-99M SESTAMIBI KIT
205494	CERDELGA	ELIGLUSTAT TARTRATE
19829	CERETEC	TECHNETIUM TC-99M EXAMETAZIME KIT
21197	CETROTIDE	CETRORELIX ACETATE
21673	**CLOLAR**	**CLOFARABINE**

NDA	Proprietary Name	Active Ingredient
202123	COMPLERA	EMTRICITABINE; RILPIVIRINE HYDROCHLORIDE; TENOFOVIR DISOPROXIL FUMARATE
214200	COSELA	TRILACICLIB DIHYDROCHLORIDE
20869	COSOPT	DORZOLAMIDE HYDROCHLORIDE; TIMOLOL MALEATE
21366	CRESTOR	ROSUVASTATIN CALCIUM
208215	DESCOVY	EMTRICITABINE; TENOFOVIR ALAFENAMIDE FUMARATE
18511	**DRAXIMAGE DTPA**	**TECHNETIUM TC-99M PENTETATE KIT**
22474	ELLA	ULIPRISTAL ACETATE
215014	EMPAVELI	PEGCETACOPLAN
21500	**EMTRIVA**	**EMTRICITABINE**
21896	**EMTRIVA**	**EMTRICITABINE**
210951	ERLEADA	APALUTAMIDE
206488	EXONDYS 51	ETEPLIRSEN
20044	**EXOSURF NEONATAL**	**CETYL ALCOHOL; COLFOSCERIL PALMITATE; TYLOXAPOL**
210933	**EYSUVIS**	**LOTEPREDNOL ETABONATE**
20038	**FLUDARA**	**FLUDARABINE PHOSPHATE**
22468	**FOLOTYN**	**PRALATREXATE**
21481	FUZEON	ENFUVIRTIDE
207561	GENVOYA	COBICISTAT; ELVITEGRAVIR; EMTRICITABINE; TENOFOVIR ALAFENAMIDE FUMARATE
20919	GEODON	ZIPRASIDONE MESYLATE
19863	**GEREF**	**SERMORELIN ACETATE**
20443	**GEREF**	**SERMORELIN ACETATE**
21335	GLEEVEC	IMATINIB MESYLATE
21588	GLEEVEC	IMATINIB MESYLATE
20637	GLIADEL	CARMUSTINE

NDA	Proprietary Name	Active Ingredient
206073	GLYXAMBI	EMPAGLIFLOZIN; LINAGLIPTIN
20076	HABITROL	NICOTINE
20199	HIVID	ZALCITABINE
20845	INOMAX	NITRIC OXIDE
22037	INTUNIV	GUANFACINE HYDROCHLORIDE
210565	**INVELTYS**	**LOTEPREDNOL ETABONATE**
20084	**IOBENGUANE SULFATE I 131**	**IOBENGUANE SULFATE I-131**
21884	**IPLEX**	**MECASERMIN RINFABATE RECOMBINANT**
22044	JANUMET	METFORMIN HYDROCHLORIDE; SITAGLIPTIN PHOSPHATE
202270	JANUMET XR	METFORMIN HYDROCHLORIDE; SITAGLIPTIN PHOSPHATE
21995	JANUVIA	SITAGLIPTIN PHOSPHATE
201281	JENTADUETO	LINAGLIPTIN; METFORMIN HYDROCHLORIDE
208026	JENTADUETO XR	LINAGLIPTIN; METFORMIN HYDROCHLORIDE
202343	JUVISYNC	SIMVASTATIN; SITAGLIPTIN PHOSPHATE
21226	KALETRA	LOPINAVIR; RITONAVIR
21251	KALETRA	LOPINAVIR; RITONAVIR
21906	KALETRA	LOPINAVIR; RITONAVIR
203414	KAZANO	ALOGLIPTIN BENZOATE; METFORMIN HYDROCHLORIDE
214012	LEQVIO	INCLISIRAN SODIUM
20517	LUPRON DEPOT	LEUPROLIDE ACETATE
20708	LUPRON DEPOT	LEUPROLIDE ACETATE
213378	LYBALVI	OLANZAPINE; SAMIDORPHAN L-MALATE
202207	LYMPHOSEEK KIT	TECHNETIUM TC-99M TILMANOCEPT
21446	LYRICA	PREGABALIN

NDA	Proprietary Name	Active Ingredient
22488	LYRICA	PREGABALIN
209501	LYRICA CR	PREGABALIN
21674	MENOSTAR	ESTRADIOL
20134	**METASTRON**	**STRONTIUM CHLORIDE SR-89**
22428	MOXEZA	MOXIFLOXACIN HYDROCHLORIDE
21487	NAMENDA	MEMANTINE HYDROCHLORIDE
22271	NESINA	ALOGLIPTIN BENZOATE
204677	**NEURACEQ**	**FLORBETABEN F-18**
20326	NEUTREXIN	TRIMETREXATE GLUCURONATE
22325	NEXTERONE	AMIODARONE HYDROCHLORIDE
20659	NORVIR	RITONAVIR
20680	NORVIR	RITONAVIR
20945	NORVIR	RITONAVIR
22417	NORVIR	RITONAVIR
208351	ODEFSEY	EMTRICITABINE; RILPIVIRINE HYDROCHLORIDE; TENOFOVIR ALAFENAMIDE FUMARATE
207924	OLUMIANT	BARICITINIB
210922	ONPATTRO	PATISIRAN SODIUM
213388	ORIAHNN (COPACKAGED)	ELAGOLIX SODIUM,ESTRADIOL,NORETHINDRONE ACETATE; ELAGOLIX SODIUM
210450	ORILISSA	ELAGOLIX SODIUM
217639	ORSERDU	ELACESTRANT DIHYDROCHLORIDE
22426	OSENI	ALOGLIPTIN BENZOATE; PIOGLITAZONE HYDROCHLORIDE
19880	PARAPLATIN	CARBOPLATIN
212937	PEDMARK	SODIUM THIOSULFATE
20451	PHOTOFRIN	PORFIMER SODIUM
21320	PLENAXIS	ABARELIX

NDA	Proprietary Name	Active Ingredient
205395	PREZCOBIX	COBICISTAT; DARUNAVIR
21976	PREZISTA	DARUNAVIR
202895	PREZISTA	DARUNAVIR
204442	**PROBUPHINE**	**BUPRENORPHINE HYDROCHLORIDE**
18936	PROZAC	FLUOXETINE HYDROCHLORIDE
214793	PYLARIFY	PIFLUFOLASTAT F-18
21964	RELISTOR	METHYLNALTREXONE BROMIDE
208271	RELISTOR	METHYLNALTREXONE BROMIDE
50790	RESTASIS	CYCLOSPORINE
18044	ROCALTROL	CALCITRIOL
21084	**SKIN EXPOSURE REDUCTION PASTE AGAINST CHEMICAL WARFARE AGENTS**	**PERFLUOROPOLYMETHYLISOPROPYL ETHER; POLYTETRAFLUOROETHYLENE**
215559	SOHONOS	PALOVAROTENE
209531	SPINRAZA	NUSINERSEN SODIUM
20657	SPORANOX	ITRACONAZOLE
20966	SPORANOX	ITRACONAZOLE
211243	SPRAVATO	ESKETAMINE HYDROCHLORIDE
209805	STEGLUJAN	ERTUGLIFLOZIN; SITAGLIPTIN PHOSPHATE
203100	STRIBILD	COBICISTAT; ELVITEGRAVIR; EMTRICITABINE; TENOFOVIR DISOPROXIL FUMARATE
19836	**SUPPRELIN**	**HISTRELIN ACETATE**
21746	**SURFAXIN**	**LUCINACTANT**
217171	SYFOVRE	PEGCETACOPLAN
210455	SYMTUZA	COBICISTAT; DARUNAVIR; EMTRICITABINE; TENOFOVIR ALAFENAMIDE FUMARATE
20262	TAXOL	PACLITAXEL
214460	**TEMBEXA**	**BRINCIDOFOVIR**

NDA	Proprietary Name	Active Ingredient
214461	TEMBEXA	BRINCIDOFOVIR
17675	**TENATHAN**	**BETHANIDINE SULFATE**
20898	THYROGEN	THYROTROPIN ALFA
50753	**TOBI**	**TOBRAMYCIN**
208627	**TPOXX**	**TECOVIRIMAT**
214518	**TPOXX**	**TECOVIRIMAT**
201280	TRADJENTA	LINAGLIPTIN
213436	TRUDHESA	DIHYDROERGOTAMINE MESYLATE
20408	TRUSOPT	DORZOLAMIDE HYDROCHLORIDE
21752	TRUVADA	EMTRICITABINE; TENOFOVIR DISOPROXIL FUMARATE
19530	**UCEPHAN**	**SODIUM BENZOATE; SODIUM PHENYLACETATE**
19981	**ULTRATAG**	**TECHNETIUM TC-99M RED BLOOD CELL KIT**
209776	VABOMERE	MEROPENEM; VABORBACTAM
21602	VELCADE	BORTEZOMIB
21267	VFEND	VORICONAZOLE
20154	VIDEX	DIDANOSINE
20155	**VIDEX**	**DIDANOSINE**
20156	**VIDEX**	**DIDANOSINE**
21183	**VIDEX EC**	**DIDANOSINE**
22253	**VIMPAT**	**LACOSAMIDE**
22254	**VIMPAT**	**LACOSAMIDE**
22255	**VIMPAT**	**LACOSAMIDE**
21119	VISUDYNE	VERTEPORFIN
20961	VITRAVENE PRESERVATIVE FREE	FOMIVIRSEN SODIUM
203137	VIZAMYL	FLUTEMETAMOL F-18
210557	VYLEESI (AUTOINJECTOR)	BREMELANOTIDE ACETATE

NDA	Proprietary Name	Active Ingredient
212161	VYNDAMAX	TAFAMIDIS
211996	**VYNDAQEL**	**TAFAMIDIS MEGLUMINE**
211970	VYONDYS 53	GOLODIRSEN
20597	XALATAN	LATANOPROST
208400	XATMEP	METHOTREXATE SODIUM
214375	**XENOVIEW**	**XENON XE-129 HYPERPOLARIZED**
211109	XERAVA	ERAVACYCLINE DIHYDROCHLORIDE
211950	XIPERE	TRIAMCINOLONE ACETONIDE
203415	**XTANDI**	**ENZALUTAMIDE**
213674	**XTANDI**	**ENZALUTAMIDE**
20819	ZEMPLAR	PARICALCITOL
21606	**ZEMPLAR**	**PARICALCITOL**
209899	ZEPOSIA	OZANIMOD HYDROCHLORIDE
20412	**ZERIT**	**STAVUDINE**
20413	**ZERIT**	**STAVUDINE**
21453	ZERIT XR	STAVUDINE
20212	ZINECARD	DEXRAZOXANE HYDROCHLORIDE
213969	**ZOKINVY**	**LONAFARNIB**
21991	ZOLINZA	VORINOSTAT