U.S. FOOD & DRUG ADMINISTRATION

REPORT

Estimating Cost Savings from New Generic Drug Approvals in 2018, 2019, and 2020

Authors:
Ryan Conrad, PhD
Kristin Davis, JD
Lukas Glos, MA
William Liu, PhD

U.S. Food & Drug Administration
Center For Drug Evaluation and Research
10903 New Hampshire Avenue
Silver Spring, MD 20993
FDA.GOV

Estimating Cost Savings from New Generic Drug Approvals in 2018, 2019, and 2020
August 2022

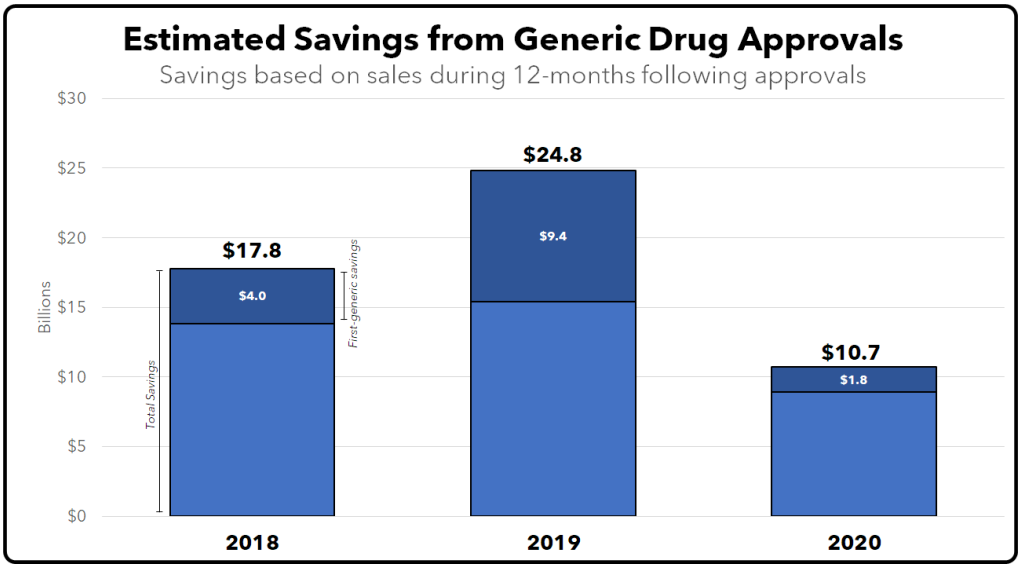
Access to affordable medicines remains a significant public health priority for FDA, and competition from generic drugs can help lower drug prices and improve access for American patients and consumers.

This study estimates savings associated with the 2,400 new generic drug applications approved by FDA in 2018, 2019, and 2020. Previous FDA research shows the relationship between generic competition and drug prices, with market entry of just a few generic competitors yielding generic prices well below the brand price.[1]

This work builds on this previous research, further explaining the relationship between generic drugs, competition, lower drug prices, and consumer savings. We estimate total savings accrued during the twelve-months following each generic drug approval. We also highlight savings estimates for first-generic approvals – these are generic products that are the first generic versions approved for the brand product. First-generics often yield substantial cost savings.

Generic drugs approved in 2018 yield annual savings of $17.8 billion, with $4.0 billion from first-generic approvals. Savings from 2019 approvals amount to $24.8 billion, with $9.4 billion coming from first-generic approvals. Savings from 2020 approvals are estimated at $10.7 billion, with first-generic approvals contributing $1.8 billion. Over all three years, first-generic approvals account for 29% of the total savings.

Figure 1. Estimated savings from generic drug approvals.



Variations in yearly savings are primarily due to the mix of products for which generics were approved in those years. For example, high priced, large-market products tend to yield more savings when new generics enter compared to products with smaller markets. Total savings from new generic approvals in years where more of these high-revenue products are approved can be significantly larger than in years when relatively few high-revenue products have generic

[1] For example, see these FDA studies on the relationship between competition and pricing and on savings generated from generic drug approvals in 2017.

approvals. The timing of these first-generic approvals is often dictated by patent expiry dates of the brand product.

In addition to total savings, this report also highlights the importance of price reductions associated with generic drug approvals. We observe many instances where, within a year of the first-generic approval, prices fall by more than 75% compared to the brand price. For some of these products that serve smaller patient populations, total savings are modest. However, for the patients relying on these drugs, these price reductions are meaningful and can increase their access important medicines.

1. Data and Methods

We identify all new generic drug applications that were fully approved by FDA in 2018, 2019, and 2020.[2] In some cases, these approvals are the first ever generics for the drug product. These first-generic approvals can yield relatively large price declines when they enter into markets with only a brand drug and no existing generic producers. In other cases, new generic approvals enter markets with robust competition from previously approved generic drugs. These approvals may be associated with modest price reductions but the additional competition they provide helps in sustaining low drug prices.

For each newly approved generic drug we identify the NDA number of the brand drug that is the reference listed drug (RLD), along with ANDA numbers of all other previously approved generics sharing this RLD.[3] These sets of bioequivalent brand (NDA) and generic (ANDA) drug applications define what we refer to as a "drug product" throughout this work, representing all approved applications of each drug product.[4]

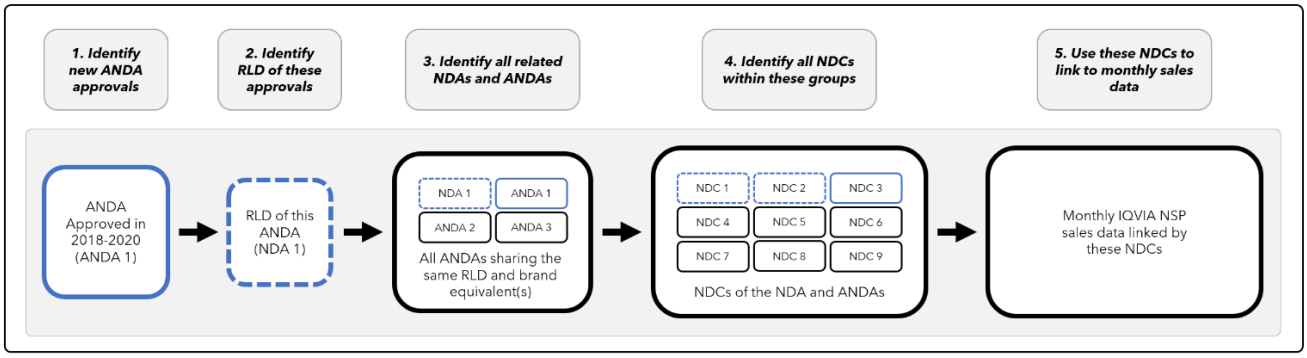
Price and market share can vary widely among competing producers of the same drug product. For example, a brand drug may be priced ten-times that of a generic equivalent, yet the generic may hold ninety percent of the market share. Given these variations within the same product we do not consider prices set by individual producers of newly approved generic equivalents. Instead, we compute a single average price for each drug product. This average price is calculated by taking the combined total dollar sales of all brand and generic equivalents of each drug product and dividing by the total unit sales for the product.

This price measure is a weighted average accounting for within-product differences in price and market share between all competing brand and generic producers of the same drug product. This computed price represents the average market price of each drug product, considering the market share and price of each individual producer. This price is computed each month, starting from the ANDA approval month and covers the following twelve calendar months.

[2] Abbreviated new drug applications (ANDAs) are identified using FDA's Approved Drug Products with Therapeutic Equivalence Evaluations (commonly known as the Orange Book).
[3] Brand drugs are approved via new drug applications (NDAs); generic drugs are approved via abbreviated new drug applications (ANDAs). A Reference Listed Drug (RLD) is an approved drug product to which an ANDA applicant must show, among other things, that its proposed generic equivalent is bioequivalent. A drug company seeking approval to market a generic product must refer to an RLD in its ANDA.
[4] For this work we consider different strengths to all be the same drug product. For example, pregabalin capsules of 25mg and 50mg are considered the same drug product despite being of different strengths.

The IQVIA National Sales Perspective (NSP) database is our source of prescription drug sales data.[5] We use the national drug code (NDC) numbers associated with each NDA and ANDA to identify the correct products in the NSP database. All dollars are inflation-adjusted to a January 2021 base using the Consumer Price Index (CPI) from the Bureau of Labor statistics, allowing for consistent comparisons across time. The logical process used to identify our sample is summarized in Figure 2.

Figure 2. Data identification process.



Savings estimates depend on both the price decline observed after new generic drug approvals and the unit sales of the product in each month. A baseline price is computed for the six-months prior to the ANDA approval. For products that had first-generic entry, the baseline price includes only brand sales prior to generic entry as no generics were yet on the market. If generics are already approved, the baseline price includes sales of all generic equivalents along with the brand equivalent. This baseline price is computed similarly to the monthly weighted average product price described earlier, except we combine sales for the six-months prior to the generic drug approval. Using six-months rather than a single month helps to mitigate any month-to-month price variations. The baseline price for each product does not change over time.

Using the monthly product price and the baseline price we can estimate savings associated with price reductions from new generic drug approvals. Monthly savings for each drug product are calculated by first taking the difference of the baseline price and the observed price, and then multiplying this price difference by the units sold in the given month.

Generally speaking, savings for product i in month t are estimated as:

$$Savings_{i,t} = Units_{i,t} * (Price_{i,base} - Price_{i,t})$$

Total savings for a given product i are computed by summing each monthly savings estimate for the product over the full twelve-months of follow-up:

$$Savings_i = \sum_{t=1}^{12} Savings_{i,t}$$

Finally, we can calculate total savings for each of the 2018, 2019, and 2020 approval cohorts by summing these product-level savings from all products (N_Y) in the given year:

[5] See this IQVIA NSP fact sheet (pdf) for a complete description of the data.

$$Savings_Y = \sum_{i=1}^{N_Y} Savings_i$$

The Technical Appendix explains in more detail how these price measures and savings estimates are computed, including a discussion on how drug products that have multiple ANDAs approved throughout the year are handled.

2. Results

FDA fully approved exactly 2,400 ANDAs during 2018, 2019, and 2020. Sales data are available for RLD product families representing 2,251 of these ANDAs.[6,7] Following each ANDA approval for 12-months we estimate yearly savings.[8] Table 1 summarizes these results.

Table 1. Summary of yearly generic drug approvals and savings, 2018-2020.

	2018	**2019**	**2020**
ANDAs fully approved	810	836	754
ANDAs with available sales data	755	788	708
Unique Drug Products with sales data	413	430	404
Total 12-month savings for ANDA approvals (billions)	**$17.8**	**$24.8**	**$10.7**

Estimates of the total 12-month savings vary considerably for each of these three years. Generic drug approvals in 2018 yielded about $17.8 billion in savings; 2019 approvals yielded about $24.8 billion in savings; and 2020 approvals yielded an estimated $10.7 billion in savings. Much of this year-to-year variation is due to the specific products for which generic equivalents are approved in each year. For example, the significant increase in savings in 2019 compared to 2018 or 2020 was largely driven by the approval of a handful of high-revenue products serving large patient populations that subsequently experienced substantial price declines upon generic entry. As we discuss later, some of these large-market generics are observed to contribute savings of over $1 billion each for their given approval cohort.

To better understand the specific markets with new generic approvals, we consider if the ANDAs are first-generics for the product, and if the product was initially approved as a new molecular entity (NME).[9] First-generics, and especially first-generics of NME products, are often associated with significant price reductions relative to the brand equivalent. A careful examination of savings

[6] Sales data are limited to prescription drugs; over-the-counter products are excluded. NSP data also may exclude certain products with limited distribution and low revenue.
[7] Because we identify sales from all ANDAs and NDAs in each product family, generics approved in the study period need not actually enter the market to be included in the sample data as sales from these other sponsors in the product family are included.
[8] All dollars in this report are inflation adjusted to a January 2021 base period.
[9] In general, brand drugs are approved as either new molecular entities (NMEs) or follow-on products. NMEs are products for which the active pharmaceutical ingredient (API) has never previously been used in an approved drug. Follow-on products contain APIs that are used in previously approved drugs, but the product is different from the originator (e.g., a new extended-release capsule containing an API that that was previously only approved as an immediate release tablet).

from these first-generics in each year helps to further describe factors that can drive variation in yearly savings estimates

Table 2. *Summary of yearly first-generic approvals and savings, 2018-2020*

	2018	2019	2020
Drug products with first-generic approvals	42	60	46
12-month savings from first-generic approvals (billions)	**$4.0**	**$9.4**	**$1.8**
NME drug products with first-generic approvals	22	32	15
12-month savings for NME first-generic approvals (billions)	**$2.7**	**$7.1**	**$1.1**

First-generic approvals have an outsized contribution to total savings. During these three years, first-generics represent about 12% of the products with generic approvals yet they contribute about 29% of the total savings. This distribution is even more pronounced for first-generics of NME products. These represent about 5% of the products with ANDA approvals while contributing about 20% of the total savings.

a. Savings from 2018 approvals

There were 810 ANDAs approved in 2018. Of these, sales data for 755 ANDAs representing 413 unique drug products are available. Of these 413 products, 42 products had a first-generic ANDA approval. Of these 42 products, 22 are first-generic equivalents of brand drugs that are new molecular entities. Table 3 shows the top five products approved in 2018, ranked by total savings.

Table 3. Top five products by estimated 12-month savings, 2018 ANDA approvals.

Savings Rank	Product	Savings (Millions of $)	First ANDA?	RLD is NME?	Share of Savings
1	Sildenafil Citrate: Tablet	$1,633		✓	9.2%
2	Tadalafil: Tablet	$1,275	✓	✓	7.2%
3	Abiraterone Acetate: Tablet	$820	✓	✓	4.6%
4	Metformin Hydrochloride: Tablet ER	$666			3.7%
5	Sevelamer Carbonate: Tablet	$630			3.5%

The total savings from the 12-months following these 2018 ANDA approvals was $17.8 billion. As expected, a significant share of this total was generated by first-generic ANDAs. While savings for first-generic ANDAs amounted to nearly $4.0 billion (22% of savings) in 2018, $2.7 billion (15% of savings) were generated by first-generic ANDAs for products that are new molecular entities.

About one-fifth of the total savings from 2018 generic drug approvals were concentrated among three products. Specifically, of the $17.8 billion in savings about $3.7 billion in savings (21%) are from generic approvals for sildenafil citrate tablets, tadalafil tablets, and abiraterone acetate

tablets. All three products were equivalents of new molecular entities and two had ANDAs approved for the first time.[10]

Generic approvals for 14 out of the 413 unique products accounted for more than half of the total savings for all ANDA approvals in 2018. Eight of these products were generic equivalents of NMEs. Five of these 14 products had first-generic approvals.

b. Savings from 2019 approvals

In 2019 there were 836 ANDAs approved. Of these, sales data for 755 ANDAs representing 430 unique products are available. For these 430 products, 60 had a first-generic ANDA approved in 2019. Of these 60 products, 32 were generic equivalents of NME products. Table 4 shows the top five products approved in 2019, ranked by total savings.

Table 4. Top 5 products by estimated 12-month savings, 2019 ANDA approvals.

Savings Rank	Product	Savings (Millions of $)	First ANDA?	RLD is NME?	Share of Savings
1	Pregabalin: Capsule	$6,644	✓	✓	26.8%
2	Tadalafil: Tablet	$2,583		✓	10.4%
3	Abiraterone Acetate: Tablet	$1,400		✓	5.7%
4	Fluticasone Propionate, Salmeterol Xinafoate: Powder for inhalation	$1,347	✓		5.4%
5	Ranolazine: Tablet ER	$927		✓	3.7%

Based on the sales of all 2019 ANDA approvals over the 12-month period following each approval, total savings are estimated at $24.8 billion. A single product, pregabalin capsules, accounted for $6.6 billion of this total, about 27% of all generic savings from 2019 generic approvals. The top five products yield about $13 billion in savings, more than half of the total.

Interestingly, three of these five products were not first-generic approvals. The tadalafil, abiraterone, and ranolazine products all had first-generic equivalents approved prior to 2019, but these previous approvals had market entry delays. Although these approvals in 2019 are not technically first-generic approvals they did enter markets lacking robust competition. This demonstrates the importance of subsequent approvals in lowering prices and ultimately generating substantial savings for patients over time. In such cases, newly approved generics enter a market with limited generic competition after the expiration of 180-day patent challenge exclusivity which was blocking the approval and launch of new generics.

The top 50 generic products out of the 430 in 2019 account for nearly 90% of total savings, with 36 of these 50 products classified as either generic equivalents of an NME or first-generic approvals. These results again suggest that the large jump in total generic savings observed in 2019 relative to other yearly approval cohorts is likely attributable to high-revenue products with large price reductions, which are often substantial in the early stages of generic competition.

[10] The first generic for sildenafil citrate tablets was approved with 180-day exclusivity in 2016, however its market entry was delayed until 2018. In this case, the $1.6 billion in savings is in large part due several subsequent ANDA approvals that occurred at the end of the first ANDA's exclusivity period.

c. Savings from 2020 approvals

FDA fully approved 754 ANDAs in 2020. Sales data representing 404 unique drug products corresponding to 708 of these ANDAs are available. Among these products, 46 had a first-generic equivalent approved in 2020. Of these 46 first-generic products, 15 were generic equivalents of an NME. Table 5 shows the top five products approved in 2020, ranked by total savings.

Table 5. Top 5 products by estimated 12-month savings, 2020 ANDA approvals.

Savings Rank	Product	Savings (Millions of $)	First ANDA?	RLD is NME?	Share of Savings
1	Dimethyl Fumarate: Capsule DR	$1,020	✓	✓	9.6%
2	Emtricitabine, Tenofovir Disoproxil Fumarate: Tablet	$812			7.6%
3	Pregabalin: Capsule	$540		✓	5.1%
4	Albuterol Sulfate: Aerosol	$371	✓		3.5%
5	Abiraterone Acetate: Tablet	$364		✓	3.4%

Total savings from price declines associated with these new approvals during the 12-months following each ANDA approval is estimated at $10.6 billion.

Savings from the 12-months following first-generic approvals are estimated at $1.8 billion (17% of savings), while the savings accrued from the subset of these first-generic approvals that are for NME products is estimated at $1.1 billion (10% of savings) during the 12-months following these first-generic approvals.

Estimates of total savings from generic drug approvals in 2020 are lower than savings in 2018 and 2019. This is primarily due to fewer large-market brand drugs experiencing initial generic entry in 2020. The product generating the most savings from approvals in 2020 was dimethyl fumarate delayed release capsules, whose 11 ANDA approvals in 2020 yielded $1.0 billion in savings. This is about 10% of the total savings from all 2020 generic approvals. The top 15 products in the 2020 cohort generated about 50% of the total savings from all 404 products.

In 2020, of the top 20 products ranked by savings only four were first-generics, and of these four only two were first-generics of an NME product. The rest of the products in the top 20 for sales were not first-generics. This finding highlights the role of subsequent generic approvals in improving patient access and continuing to lower prices and offer substantial cost savings after initial generic equivalents of drugs have already been approved.

3. Discussion

From 2018 through 2020, annual savings attributed to ANDA approvals in each respective year averaged $17.8B annually: $17.8 billion from 2018 approvals, $24.8 billion from 2019 approvals, and $10.7 billion from 2020 approvals. These variations are not directly related to the number of ANDAs approved each year, but rather due to differences in the specific products with generic approvals each year and the markets they entered. Several observations help to contextualize these yearly variations in total savings.

First-generic approvals contribute significantly to generic savings in each of these years. These results are summarized in the table below. In 2018, 42 products had first-generics approved leading to $4.0 billion in savings. These represent just 10% of the products with approvals that year, but 22% of the total savings. This trend is similar for the other years. In 2019 first-generics represent 18% of the total products with generic approvals but account for 38% of the total savings. In 2020 first-generics represent 11% of products with approvals yet account for 17% of the total savings.

Table 6. Share of savings associated with first-generic approvals.

	2018	**2019**	**2020**
Total Unique Drug Products	413	430	404
Total Savings	**$17.8**	**$24.8**	**$10.7**
Products with **First-Generics**	42	60	46
Savings	**$4.0**	**$9.4**	**$1.8**
Share of Total Products	*10%*	*14%*	*11%*
Share of Total Savings	*22%*	*38%*	*17%*

Most of the products in this sample with the largest total savings are high revenue products that also experienced large price declines after generic approvals. These are often products with first-generics allowing prices to fall from the brand-only monopoly price to a much lower price associated with competitive generic markets.

To help illustrate the outsized impact of first-generic approvals compared to other generic approvals on driving savings consider pregabalin capsules as an example: This product experienced a 95% price reduction during the first twelve-months of generic sales. First-generics were approved in July 2019. Prior to these ANDA approvals, the observed price of a 30-day supply was about $450. By July 2020 when generics were on the market for a full year, this price fell to about $23. Given the large patient population prescribed this drug, total savings during the year following these 2019 pregabalin capsule generic approvals amounted to just over $6.6 billion.

There are also many cases when subsequently approved ANDAs (i.e., ANDAs that are not first-generics) also lead to significant savings. For example, the first sildenafil citrate tablet generic was approved in 2016. But ANDAs approved for this product in 2018 yielded about $1.6 billion in savings. Because patent settlements and the 2016 generic approval's eligibility for 180-days of patent challenge exclusivity, the market for this product did not see large price declines until the exclusivity period expired in mid-2018 when a group of subsequent ANDAs were approved.

During the 180-day exclusivity period a 30-day supply of sildenafil citrate tablets was priced at about $185. Subsequent generics were approved in May 2018. By May 2019 the price of a 30-day prescription fell to about $21. This represents nearly a 90% reduction in price due to the approval of these subsequent generics. These new approvals yielded about $1.6 billion in savings after 12-months of sales.

We observe total annual generic savings to be highly concentrated among a small group of products. In 2018, the top ten products accounted for nearly 43% of total savings, while in 2019 and 2020, the top ten products accounted for 63% and 41% of total savings, respectively. These products play an outsized role in driving total savings, with many of these generic approvals being for first generics, generic equivalents of an NME, or both.

Although total savings are the focus of this work, another important consideration is savings at the patient level. Most of the total savings described in this work are concentrated among high-revenue products serving large markets. Yet patients using medicines with smaller revenues and serving smaller markets enjoy the benefit of price reductions even though such products contribute a relatively small share of total savings each year.

Generic entry into these markets had a relatively small impact on total savings, but individual patients using these medicines saw real and substantial benefits from the price reductions. Generic entry of such products often is met with little fanfare due to their smaller market sizes, but the impact generic competition for these products has on individual patients should not be overlooked when discussing the impact of generic drugs on improving access to care.

For example, 2018 generic approvals for albendazole tablets helped its price to fall by nearly 70%. Prior to these approvals a four-tablet course of treatment was priced at about $670. A year after these 2018 approvals the price had dropped to about $210. Because this drug is used for a relatively uncommon condition (specific parasitic infections) this price reduction yielded only about $80 million in savings. But individual patients requiring this drug saw the price of a course of treatment fall by about $460 after these generics were approved.

More examples of products with large price declines but modest total savings are shown in Table 7.

Table 7. Generic approvals with large price reductions, but modest total savings.

Approval Cohort	Drug Product	Price Decline after 12-Months	Annual Savings (millions)
2019	Pregabalin; Solution	89%	$9.0
2020	Nitazoxanide; Tablet	64%	$28.1
2020	Tavaborole; Topical Solution	94%	$48.1
2018	Azelaic Acid; Topical Gel	73%	$76.8
2018	Albendazole; Tablet	69%	$79.4
2020	Pyrimethamine; Tablet	69%	$90.3
2018	Naproxen Sodium, Sumatriptan Succinate; Tablet	64%	$92.7
2018	Arsenic Trioxide; Injectable	74%	$125.5
2019	Sildenafil Citrate; For Oral Suspension	65%	$147.9

To conclude, this work provides additional evidence showing the relationship between FDA-approved generics and reduced prescription drug spending. The mains results show tens-of-billions of dollars in annual savings at the economy-wide level from new generic approvals. Initial generic entry into markets previously controlled by only the brand product are of special importance, with first-generic approvals contributing about 30% of the total savings.

At the same time, individual patients often see real and substantial savings with generic drug entry, even if the specific medicine being used does not itself contribute substantially to total savings. These lower prices improve access to care, and this in turn is likely to lead to improved health outcomes as patients might be able to afford a medicine they otherwise could not.

Technical Appendix

1. Data sources

This analysis uses several publicly available and proprietary data sources:

- FDA's Approved Drug Products with Therapeutic Equivalence Evaluations database (commonly known as the Orange Book): Identifies ANDAs approved in 2018, 2019, 2010, along with their reference listed drug (usually an NDA), along with other bioequivalent generic approvals (ANDAs). Includes approval dates[11]
- FDA's National Drug Code (NDC) Directory: Links ANDA and NDA numbers to their NDC product identifiers[12]
- IQVIA National Sales Perspectives: Sales volume ($) and quantity sold (units) at the drug product level, monthly.[13] Links to NDAs and ANDAs via NDCs.
- Bureau of Labor Statistics, Consumer Price Index: Used to inflation-adjust all dollar values, using a January 2020 base period.[14]

2. Methods

The analytic dataset was prepared using the following methodology:

- ANDAs approved in 2018, 2019, and 2020 are identified in the Orange Book.
- The reference listed drug (RLD) is identified for each of these ANDAs. The RLD is usually an NDA (brand drug) but can be an ANDA if the NDA is no longer marketed.
    - All other ANDAs sharing these RLDs are identified.
- NDC numbers for each of these NDAs and ANDAs are identified using NDC Directory.
- These NDC numbers linked to the IQVIA NSP dataset, and then aggregated to the drug product level, to identify monthly sales for each drug product.
- A monthly price for each product, equal to the total dollar sales divided by the total unit sales, is calculated for each month. All dollars are inflation adjusted to a January 2021 base.

From this analytic dataset we then calculate a baseline price for each product. This baseline price for each product market is calculated by taking the aggregate sales volume up to six months prior to the ANDA approval and dividing that value by the aggregate units sold:

- If the ANDA approval is the first generic equivalent ever approved for that market, the baseline period is six-months and will include sales of only the brand product
- If the ANDA approval was for a product for which there already existed generic approvals, the baseline period includes both branded and generic sales. In addition, the baseline period will only include the months prior to the approval in which the number of competitors was stable (unchanged), up to six months

[11] https://www.accessdata.fda.gov/scripts/cder/ob, data extracts downloaded May 2022.
[12] https://www.fda.gov/Drugs/GuidanceComplianceRegulatoryInformation/DrugRegistrationandListing/default.htm, data extracts downloaded May 2022.
[13] https://www.iqvia.com/locations/united-states/commercial-operations/essential-information/sales-information, data extracts downloaded May 2022.
[14] https://www.bls.gov/cpi/, data extracts downloaded May 2022.

- For each month after the approval an average "current" market price is calculated by dividing the aggregate sales volume of the market by the aggregate quantity sold of the market, per month. This includes all brand and generic sales for the given product
- Monthly cost-savings, per market, are calculated monthly, starting from the approval month, and continuing for 12-months.

Special calculations are used for the baseline price when there are multiple ANDAs approved for the same RLD in different months throughout the year:

- Multiple ANDAs sharing the same RLD are often approved at different times throughout a year.
- Savings for each ANDA are followed for 12-months, savings accrued during the overlapping 12-month periods of two ANDAs are not double counted.
- For example, savings from ANDAs sharing the same RLD approved in January 2020 and June 2020 will be calculated using sales data from January 2020 through July 2021
- The baseline price in place for the 12-months January 2020 through January 2021 is equal to the baseline price prior to the January 2020 approval.
- The baseline price in place for the 6-months from January 2021 through July 2021 is equal to the price in place prior to the July 2020 approval

Total overall savings are calculated by taking the sum of all monthly savings across all markets, aggregated by approval year cohorts.

The calculations used to measure prices and savings are formally written using the following notation: First, we define indices to track approval year cohorts, drug products, months elapsed since ANDA approval, the number of unique producers of each product, and the appropriate number of months used in calculation of the baseline prices. These are written as:

$Y = [2018, 2019, 2010]$. Index of approval year cohorts.

$i_Y = [1, 2, \dots, N]$. Index of drug products approved in year Y.

$t = [1, \dots, 12]$. Index of the twelve-months following an ANDA approval.

$p_{i,Y} = [1, 2, \dots, P]$. Index of producers making drug product i in year Y.

$a = [1, \dots, A_{i,Y}]$. Index of the months with an ANDA approved for product i in year Y. If ANDA approvals occur in only a single month, then $a = [1]$. If ANDAs for a product are approved every month of the year, then $a = [1, \dots, 12]$.

$b_{i,Y}^{a} = [-m, \dots, -1]$. Index of the months used to calculate the base-period price, for each of the A ANDAs approved for product i in year Y; $m \leq 6$. If no other ANDAs were approved during the six-months prior to this approval, then $m = 6$. But if, for example, another ANDA was approved three-months earlier then $m = 3$. This is necessary so that the base price is calculated during periods when there were no other ANDAs approved which could change the monthly prices.

Using this notation, we can then formally write the pricing and savings calculations as follows:

(1) The baseline price for ANDA approval A, for product i in year Y is calculated as:

$$Baseline\ Price = \widehat{Price}_{i,a,Y} = \frac{\sum_{b_{i,Y}^{a}=-m}^{-1}(DollarSales_{i_Y,b,Brand} + DollarSales_{i,b,Generic})}{\sum_{b_{i,Y}^{a}=-m}^{-1}(UnitSales_{i,b,Brand} + UnitSales_{i,b,Generic})}$$

This baseline price is composed of sales observed no more than six-months prior to the approval, i.e., $m \leq 6$. In the case of first-generic approval, the baseline price calculation uses only sales from the brand product, so the dollar and unit sales of the generic products are both taken as zero.

(2) The average price of for product i, in month t, in year Y is calculated as the sum of all sales from all P brand and generic producers of the product is calculated as:

$$Price_{i,t,Y} = \frac{DollarSales_{i,t,Y}}{Units_{i,t,Y}} = \frac{\sum_{p_{i,Y}=1}^{P}(DollarSales_{i,t,p,Brand} + DollarSales_{i,t,p,Generic})}{\sum_{p_{i,Y}=1}^{P}(UnitSales_{i,t,p,Brand} + UnitSales_{i,t,p,Generic})}$$

This does not need to be indexed by the ANDA approval a as this calculation is simply price observed in each month of the product.

(3) Savings for product i, in month t, in year Y after ANDA approval a is calculated as:

$$Savings_{i,a,t,Y} = Units_{i,t} * (\widehat{Price}_{i,a,Y} - Price_{i,t,Y})$$

(4) Savings from the twelve-months following ANDA approval a, for product i, approved in year Y is calculated as:

$$Savings_{i,a,Y} = \sum_{t=1}^{12} Savings_{i,a,t,Y}$$

(5) Total savings from all ANDAs approved in year Y is calculated as the sum of all product-level savings:

$$Savings_{Y} = \sum_{i=1}^{N_Y}\sum_{a=1}^{A_{i,Y}} Savings_{i,a,Y}$$

3. Approved indications of drug products mentioned in the report

Table A1. Drug products and indications, listed in order of appearance

Drug Product	**Indication***
Sildenafil Citrate: Tablet	Erectile dysfunction/Pulmonary arterial hypertension
Tadalafil: Tablet	Erectile dysfunction/Pulmonary arterial hypertension
Abiraterone Acetate: Tablet	Prostate cancer
Metformin Hydrochloride: Tablet ER	Diabetes
Sevelamer Carbonate: Tablet	Hyperphosphatemia
Pregabalin: Capsule	Peripheral neuropathy; Postherpetic neuralgia; Partial-onset seizures; Fibromyalgia; Neuropathic pain
Fluticasone Propionate, Salmeterol Xinafoate: Powder for inhalation	Asthma; Chronic obstructive pulmonary disease
Ranolazine: Tablet ER	Chronic angina
Dimethyl Fumarate: Capsule DR	Multiple sclerosis
Emtricitabine, Tenofovir Disoproxil Fumarate: Tablet	Human immunodeficiency virus
Albuterol Sulfate: Aerosol	Bronchospasm
Pregabalin; Solution	Peripheral neuropathy; Postherpetic neuralgia; Partial-onset seizures; Fibromyalgia; Neuropathic pain
Nitazoxanide; Tablet	Diarrhea caused by *Giardia lamblia or Cryptosporidium parvum*
Tavaborole; Topical Solution	Onychomycosis (fungal infection) of the toenails
Azelaic Acid; Topical Gel	Mild to moderate rosacea
Albendazole; Tablet	Certain tapeworms
Pyrimethamine; Tablet	Toxoplasmosis
Naproxen Sodium, Sumatriptan Succinate; Tablet	Migraine with or without aura
Arsenic Trioxide; Injectable	Acute promyelocytic leukemia
Sildenafil Citrate; For Oral Suspension	Erectile dysfunction/Pulmonary arterial hypertension

* Due to space limitations, abbreviated indications are listed. For full indication information, please check Drugs@FDA.