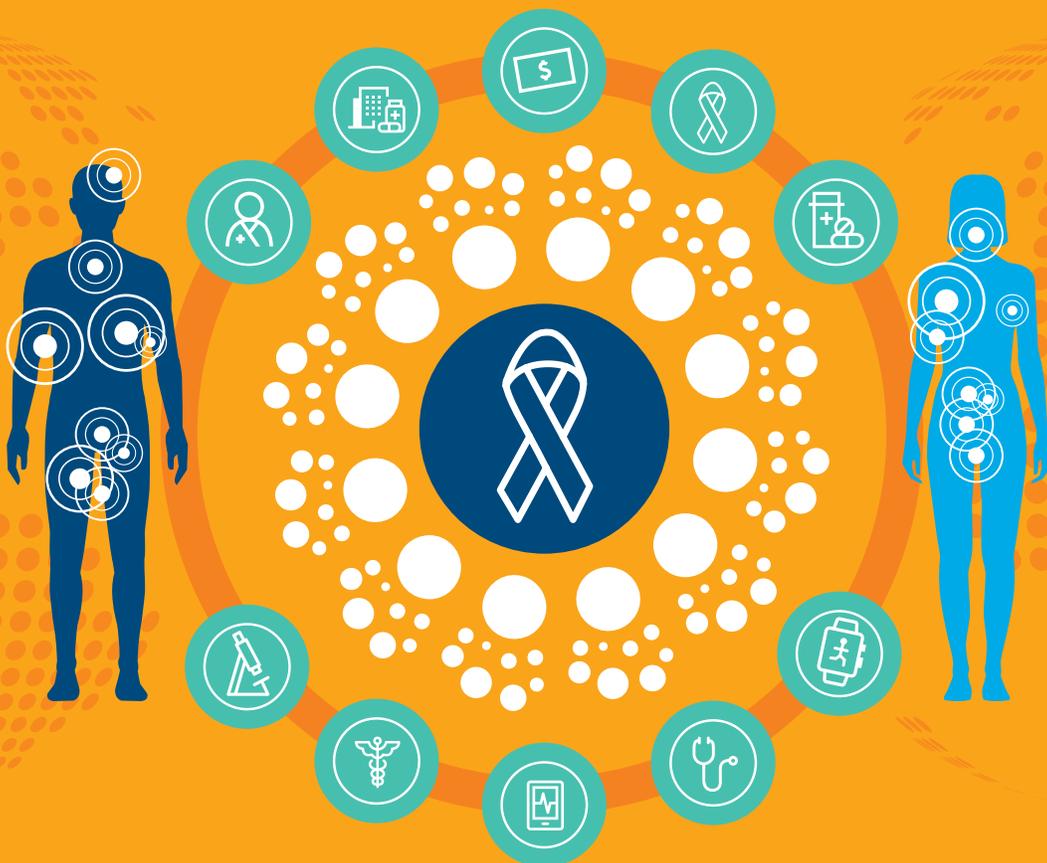


MAY 2018

# Global Oncology Trends 2018

Innovation, Expansion and Disruption



# Introduction

Treatments for cancer have been advancing at an accelerated pace in recent years, offering notable improvements in clinical benefit, as well as increased specificity through selection according to biomarkers, or through engineered cell or gene therapies. Global spending on cancer therapies and supportive care drugs now exceeds \$133 billion, as the value of these medicines is recognized and a greater share of drug budgets is allocated to these products. Over the next five years, this amount is projected to reach \$180–200 billion.

The number and quality of medicines currently in clinical development raise the prospects of continued advances, while also challenging payers to discern value and fund access to treatments. The surge in innovation also brings new dimensions of complexity, even as the availability of predictive biomarkers and diagnostic tests can help bring a more precise course of treatment to an individual patient. There are also a number of disruptive technologies that will reshape healthcare and cancer specifically, including data science that incorporates artificial intelligence and real-world data, as well as advances in patient engagement through mobile apps.

In this year's report, we highlight advances in cancer therapeutics, the use of these drugs and the amount spent on them globally, the pipeline of therapeutic innovation and associated clinical trial activity, and the outlook through 2022. Our research and this report are intended to provide an evidence base that can be used in discussion about the broader implications for patients and their families, providers and their institutions, public and private payers at local and national levels, as well as supranational organizations.

The research included in this report was undertaken independently by the IQVIA Institute for Human Data Science as a public service, without industry or government funding. The contributions to this report of Reto Bazzani, Amrita Bhandari, Paul Cariola, Beyat Christen, Nick DeFabis, Purvi Dev-Vartak, Paul Duke, Bernie Gardocki, Onil Ghotkar, Jeff Hodge, Dr. Saurabh Kumar, Julia Levy, Graham Lewis, Mary Liu, Einstein Lubrin, Stacy Mecham, Kim Mehle, Siohbhan Palmer, Melissa Pirolli, Joe Purvis, Sam Riches, Durgesh Soni, Alan Thomas, Peter Wagner, Terri Wallace, Dan Winkelman and many others at IQVIA are gratefully acknowledged.

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## **MURRAY AITKEN**

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# Executive summary

## ADVANCES IN CANCER THERAPEUTICS

Over the past five years, 61 cancer drugs, each approved in one or more tumors, have impacted the treatment of 23 different cancer types. The rise of immuno-oncology since the first launches in 2014 has been largely centered on the PD-1 and PD-L1 mechanisms, so-called checkpoint inhibitors, which have broad efficacy across solid tumors and are used across 23 different tumor types.

Of the 14 New Active Substance cancer therapeutics launched in 2017 alone, all of them were targeted therapies and 11 of them were granted Breakthrough Therapy designation by the FDA - demonstrating potential for substantial improvement over existing therapies on one or more clinically significant endpoints. The range of clinical benefits from this new group of medicines includes several with total remission rates above 50%, and significant extensions of overall survival, as well as some with incremental survival benefits in tumors where those rates were already extremely high.

In addition to the benefits of individual drugs, the approach of using multiple drugs in a treatment regimen is being extended to include multiple immuno-oncology checkpoint inhibitors in combination regimens, though this use is currently limited primarily to metastatic melanoma patients. Across a number of major tumor types, patient treatment protocols are based on the identification of biomarkers which are re-defining cancer into more precise categories, with improved response rates, better outcomes and more tolerable treatments. Next-generation therapeutics are also beginning to include gene and cell therapies, such as CAR-T drugs, which engineer a patient's own T-cells to fight their cancer, and are associated with significant rates of remission in tumors with otherwise poor prognoses.

## CANCER TREATMENTS USE AND SPENDING LEVELS

Global spending on cancer medicines - both for therapeutic and supportive care use - rose to \$133 billion globally in 2017, up from \$96 billion in 2013. Supportive care remained largely unchanged at \$23.6 billion down \$100 million over five years, providing an early sign of the potential savings from biosimilars, which are expected to be available for several important cancer therapeutics by 2022. Growth in spending slowed in 2017 to 12.1% in the United States and 12.5% globally, on a constant dollar basis. A drop in growth from new medicines following a low number of approvals in 2016 was the major factor slowing growth in the United States in 2017, while in other markets, uptake of medicines and increased use of existing brands drove growth in 2017. Spending on cancer drugs in the United States has doubled since 2012 and reached almost \$50 billion in 2017, with two-thirds of the growth tied to use of drugs launched within the past five years. Outside the United States, oncology costs exceeded \$60 billion in 2017, driven by new product launches and increased use of existing brands.

Spending on cancer medicines is heavily concentrated with the top 35 drugs accounting for 80% of total spending, while over half of cancer drugs have less than \$90 million in annual sales. List prices of new cancer drugs at launch have risen steadily over the past decade, and the median annual cost of a new cancer drug launched in 2017 exceeded \$150,000, compared to \$79,000 for the new cancer drugs launched in 2013. Most cancer drugs - including those with high annual costs - are used by relatively few patients, with about 87% of drugs being used by fewer than 10,000 patients in 2017. Price increases following a new drug's launch in the United States have moderated to 4.7% on average in the past two years, on an invoice price basis, and rebates, discounts and other price concessions averaged 6% across all branded cancer drugs relative to invoice prices. These price concessions are estimated to average 23% of WAC price in 2017.

Only patients in the United States, Germany and United Kingdom have access to more than 40 of the 55 oncology medicines initially launched between 2012 and 2016 due to manufacturers not filing for regulatory approval, delays or denials of approval, or manufacturers awaiting the results of reimbursement negotiations prior to launching the drug in the country. Newer medicines launched within the past five years account for 30% of all oncology drug spending across developed markets, while more than half of spending across pharmerging markets is for drugs that were first launched more than 20 years ago. The number of oncologists available to treat patients varies three-fold relative to population across developed countries, potentially impacting access to care. The uptake of new immuno-oncology PD-1 and PD-L1 inhibitors also varies across countries, with the U.K.'s use per million of population at one-third the level of the United States. Use of personalized medicine biomarker tests is increasing for patients with several tumor types, though the use of these tests continues to be lower than guidelines recommend.

Faced with a continuing stream of new and highly effective treatments emerging from research, payers around the world took actions in 2017 to address rising expenditure on oncology medicines through a range of new approaches to purchasing and to the negotiation of reimbursement levels with manufacturers. The number of health technology assessments has doubled in the past five years across 20 countries, with fewer than half of these assessments resulting in a positive recommendation in 2017, and very few reaching consistent recommendations across countries, highlighting the varied thresholds and approaches in use.

For patients in the United States, final out-of-pocket costs for cancer medicines will vary significantly based on drug choice, manufacturer prices, and insurance plan design. While outpatient drug costs can carry high

costs for payers, the patient responsibility averages less than \$500 per year for commercial plans, and for retail drugs, the extensive use of coupons helps offset patient out-of-pocket costs.

## PIPELINE AND PROSPECTS FOR CLINICAL DEVELOPMENT

More than 700 cancer drugs are in late-stage development – up over 60% from a decade ago. Over one-third of trials are using biomarkers to stratify patients, pointing to even more personalized (and effective) cancer treatments in the future. The pipeline of immunotherapies is particularly active and includes almost 300 molecules with 60 separate mechanisms being evaluated in Phase I or Phase II clinical trials, which is a significant jump from the four mechanisms of such drugs in Phase III trials or under regulatory review. These immunotherapy trials are being conducted across 34 different tumor types, indicating the broad-based application of this new approach to cancer treatment.

While many efforts are in place to accelerate the time taken to bring a new cancer medicine to patients, the 2017 new drug approvals had a median time since patent filing of 14 years, slightly faster than in 2013. In Japan, long a country with significant delays before new medicines would launch, government initiatives over the past decade have roughly halved both the average development times for new molecules and regulatory approval times. Just over half of the New Active Substances launched globally from 2012 to 2016 were launched in Japan by 2017, all within four years of their global launch. Almost 700 companies or organizations have one or more oncology drugs in late-stage development, representing a remarkably diverse set of entities pursuing advances in this area, and 14 of the world's largest pharmaceutical companies have at least one-third of their late-stage R&D activity focused on oncology.

Clinical trial success rates for Phase I and III have reached approximately 66% and 73% respectively in 2016, while Phase II trials – including those that are combined Phase I and Phase II – remain at about 30%. Across all trials and phases, the average duration has declined over the past five years and the number of patients per trial is lower in 2017 than in 2013 for Phase II and Phase III trials. The upper quartile of patient enrollment in clinical trials has increased from 58 to 75 over the past five years for Phase I trials, but declined for Phase II and Phase III trials. Patient enrollment rates – measured as average patients per site per month – have almost doubled since 2012 yet remain low at an average of 0.38 patients per site per month across all Phase I-III trials, and are even lower for trials enrolling patients with biomarker stratification.

## OUTLOOK THROUGH 2022

Advances in technology and the use of information will act as driving forces that will impact oncology treatment and costs over the next decade. This would include advances in drugs and medical devices, as well as real-world data, artificial intelligence and mobile apps to drive better patient engagement. While each of these areas will see advances individually, they will also have some multiplicative effects that begin to reshape prognoses for patients, the way care is delivered and how much it costs.

In pharmaceuticals, the rise of immuno-oncology, cell and gene therapies are generating significant early clinical results, while other small molecule mechanisms such as RNA interference (RNAi), and inhibitors of dozens of other pathways with small molecule drugs are in development and show promise. In medical technology, surgical robots, 3D bio-printing of tissues and improved medical imaging all promise to enhance cancer care, though how widely adopted they will become remains unclear. The exploding volumes of real-world data shows the prospect of finding expanded

use in regulatory submissions, better tracking patients with open cancer registries, and enabling artificial intelligence to help with diagnosis, treatment selection, and even drug discovery.

The ubiquity of mobile apps across many countries, and the growing body of evidence that apps can improve diagnosis, treatment, adherence and other aspects of patient engagement in cancer, is driving greater adoption and usage. Apps are even helping providers understand the increasingly complex landscape of treatment options and best practices, including tools to help non-oncologists play their part in diagnosis and referrals to specialists.

The growing availability of real-world evidence will result in a growing number of uses as all stakeholders look to improve their decision-making on the appropriate use of oncology medicines and management of costs, though to date payers have been more focused on clinical trial data in cancer.

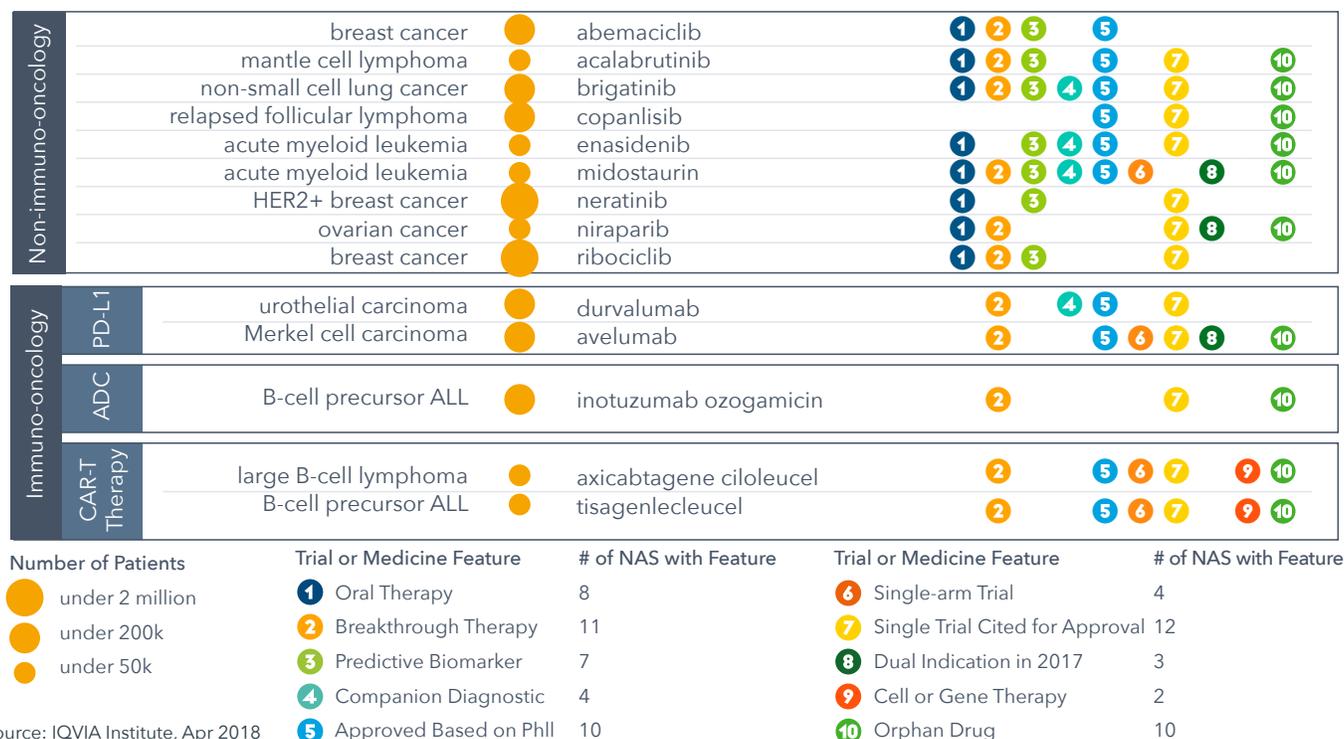
The global market for oncology therapeutic medicines will reach as much as \$200 billion by 2022, averaging 10–13% growth over the next five years, with the U.S. market reaching as much as \$100 billion by 2022, averaging 12–15% growth.

## Advances in cancer therapeutics

- In 2017, 14 New Active Substance cancer therapeutics were launched; all of them targeted therapies and 11 of them identified as breakthrough therapies, demonstrating potential for substantial improvement over existing therapies on one or more clinically significant endpoints.
- The new medicines launched in 2017 included significant clinical advances and contributions to patient overall survival across a range of tumors and mechanisms.
- Over the past five years, there have been 76 indication approvals for 61 New Active Substances, with some treating multiple tumor types. These include treatments for 23 different tumor types.
- Immuno-oncology PD-1 and PD-L1 inhibitors, first launched in 2014, have seen rapid uptake with patients in the United States, as the number of drugs and the tumor types for which they are approved has increased significantly.
- In 2017, PD-1 and PD-L1 inhibitors were used to treat patients with 23 different tumor types, of which the primary use is lung cancer.
- The immuno-oncology checkpoint inhibitors are also being used in combination regimens, though this is currently limited primarily to metastatic melanoma patients.
- Across a number of major tumor types, patient treatment protocols are based on the identification of biomarkers, which are re-defining cancer into more precise categories.
- Next-Generation Biotherapeutics, including gene and cell therapies, are now available, bringing a new type of treatment option to patients.

# All 14 new active substances launched in 2017 for oncology were targeted therapies, and more than half had breakthrough status

Chart 1: Oncologic New Actives Substances (NAS) Launched for the First Time in the United States in 2017



- All 14 NAS launched in 2017 for oncology were targeted therapies: those therapies that block the growth progression and spread of cancer by interfering with specific molecular targets.<sup>1</sup>
- Of the 14 NAS in oncology, seven were associated with predictive biomarkers. Precision medicines are having a significant impact on the treatment of cancer, as patients are being stratified into specific groups via predictive biomarkers that can identify patients with a greater chance of responding to a therapy.
- Continued development and availability of immuno-oncology (I/O) therapies have created a paradigm shift in the standard of care of many types of cancer by offering substantial efficacy for a subset of patients. In 2017, there were five I/O NAS and all received Breakthrough Therapy designation.
- Increasingly, new cancer medicines are for smaller patient populations, with 10 out of 14 therapies targeting orphan indications.
- Eight of the therapies were oral rather than infused or injected, thus decreasing the burden on patients to receive care at an infusion center or hospital.
- The remaining six therapies were biologics, including two novel cell-based therapies: axicabtagene ciloleucel and tisagenlecleucel. These two therapies are the first available chimeric antigen receptor (CAR) T-cell immunotherapies in the United States.

Chart notes: A New Active Substance (NAS) is a new molecular or biologic entity, or combination where at least one element is new; includes NAS launches in the United States in 2017 regardless of the timing of FDA approval. Patient estimates are based where possible on disease prevalence. ADC = antibody-drug conjugate; ALL = acute lymphoblastic leukemia; AML = acute myeloid leukemia. Both midostaurin and niraparib were approved simultaneously for multiple indications (midostaurin for AML and systemic mastocytosis and niraparib for recurrent epithelial ovarian, fallopian tube, or primary peritoneal cancer), while avelumab received approval first for Merkel cell carcinoma followed by urothelial carcinoma in 2017. Abemaciclib received regulatory approval for breast cancer in combination with fulvestrant based on results from a Phase III study and as a monotherapy based on a Phase II study.

# The new medicines launched in 2017 included significant clinical advances across a range of tumors and mechanisms

Chart 2: New Active Substances Launched in 2017 and Summary of Clinical Benefits

MOLECULE	INDICATION	TRIAL	APPROVAL TRIAL PHASES	SUMMARY
abemaciclib*	breast cancer (monotherapy)	MONARCH 1	Phase II	19.7% of patients experienced complete or partial shrinkage of their tumors for a median of 8.6 months, with abemaciclib as a stand-alone treatment
	breast cancer (with fulvestrant)	MONARCH 3	Phase III	Use with an aromatase inhibitor improved progression-free survival vs. aromatase inhibitors alone (not reached vs. 14.7 months), with objective response rate of 59%
acalabrutinib	mantle cell lymphoma	ACE-LY-004 MCL	Phase II	Overall response rate of 81% and a complete response rate of 40% measured 15 months after treatment
brigatinib	non-small cell lung cancer	ALTA	Phase II	Patients with NSCLC and baseline brain metastases had over a 50% response rate and an average progression free survival time of 15.6 months
copanlisib	relapsed follicular lymphoma	CHRONOS-1	Phase II	Indolent lymphoma patients no longer responding to standard of care experienced 294 progression free days and those with aggressive lymphoma experienced 70 days
enasidenib	acute myeloid leukemia	AG221-C-001	Phase I/II	Median overall survival among relapsed/refractory patients was 9.3 months, and for the 19.3% of patients who attained complete remission (n=34), overall survival was 19.7 months. IDH-DS (isocitrate dehydrogenase differentiation syndrome) occurs in 12% of patients but is effectively managed with corticosteroids
midostaurin**	acute myeloid leukemia	NCT00651261	Phase III	Among patients with AML and a FLT3 mutation, adding midostaurin to daunorubicin and cytarabine improved overall survival and event-free survival by 22%
	systemic mastocytosis	CPKC412D2201	Phase II	The rate of confirmed complete remission plus incomplete remission by modified Valent criteria was 38% for aggressive SM and 16% for SM with associated hematologic neoplasm
neratinib	HER2+ breast cancer	ExteNET	Phase III	Add-on therapy for one year after trastuzumab treatment improved rates of disease free survival by 2.3–2.5%
niraparib	ovarian cancer	NOVA	Phase III	Significantly prolonged median progression-free survival: 21.0 vs. 5.5 months in the gBRCA cohort, 12.9 months vs. 3.8 months in non-gBRCA HRD+, and 9.3 months vs. 3.9 months in the overall non-gBRCA cohort
ribociclib	breast cancer	MONALEESA-2	Phase III	Objective response rate of 42.5% when added to letrozole vs. 28.7% letrozole and placebo and 9.3 months longer median progression free survival (25.3 months)
durvalumab	urothelial carcinoma	Study 1108	Phase I/II	In patients with locally-advanced or metastatic urothelial carcinoma of the bladder, the objective response rate was 17.0%, 14.3% of all evaluable patients achieved partial response and 2.7% achieved complete response
avelumab	Merkel cell carcinoma	JAVELIN Merkel 200	Phase II	31.8% objective response rate including 22.7% (20/88) partial and 8/88 complete responses
inotuzumab ozogamicin	B-cell precursor ALL	INO-VATE ALL	Phase III	The rate of complete remission was higher with inotuzumab ozogamicin (80.7%) than with standard therapy (29.4%)
axicabtagene ciloleucel	large B-cell lymphoma	ZUMA-1	Phase I/II	Objective response rate of 82% with complete response in 54% of cases. After 15.4 months, 42% had continued response, and 40% complete response
tisagenlecleucel	B-cell precursor ALL	ELIANA	Phase II	Overall remission rate of 81% at three months, with overall survival of 90% at six months and 76% at 12 months

Source: IQVIA Institute analysis of trials used as the basis for FDA approval of relevant drugs, see References for details of the trials used: references 2-17.

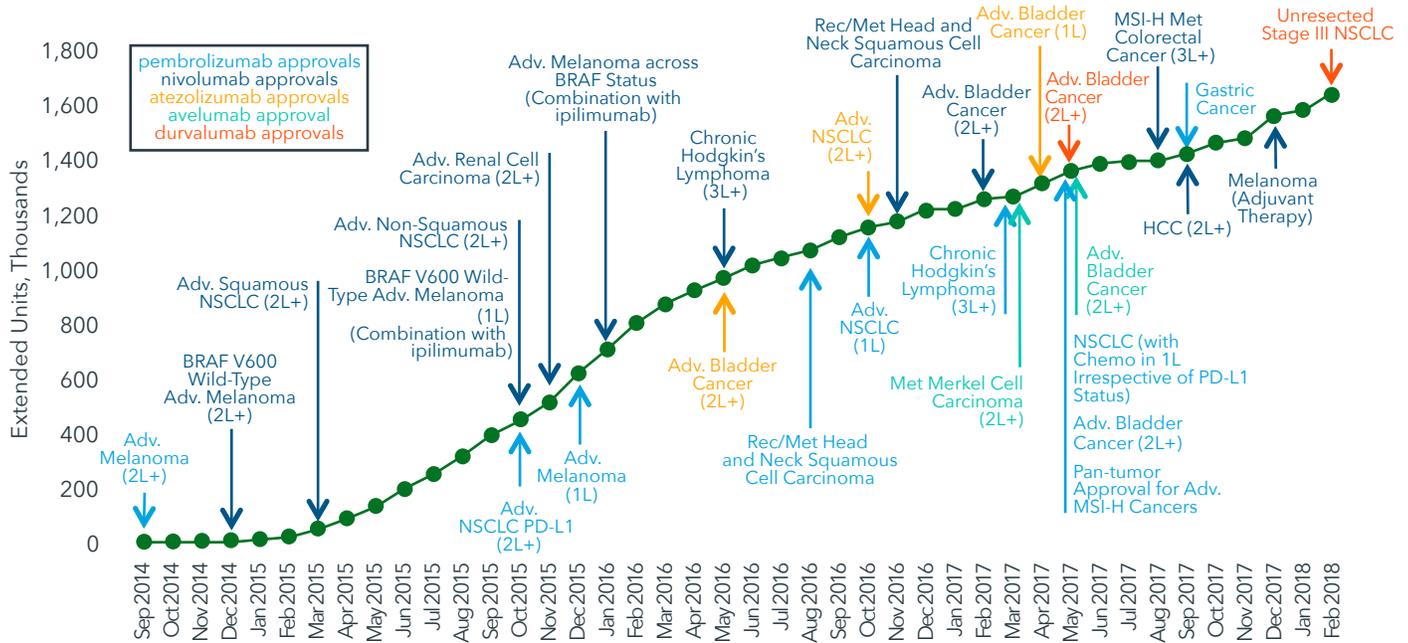
- Of the 14 NAS launched in 2017 for cancer treatments, seven were approved from a Phase II trial and three from a Phase I/II, reflecting the improvements in efficacy compared to current standards of care, or absence of treatment options.
- For these medicines approved from earlier Phase I/II trials, the key endpoints considered were response rates and remission rates, which were often significant, especially in advanced disease where other treatment options remain limited.
- Two CART-T therapies, axicabtagene ciloleucel and tisagenlecleucel, brought complete remission to aggressive B-cell lymphomas at significant rates.
- For all of these medicines, ongoing trials and real-world evidence studies will add further evidence of the impact of these drugs on overall survival relative to other treatment options.

Chart notes: \*abemaciclib received simultaneous approval with and without fulvestrant; \*\*midostaurin received simultaneous approval for and systemic mastocytosis.



# The sustained uptake of checkpoint inhibitors demonstrate their remarkable clinical profile and continued expansion of indications

Chart 4: Immuno-Oncology PD-1 and PD-L1 Inhibitor Uptake in the United States



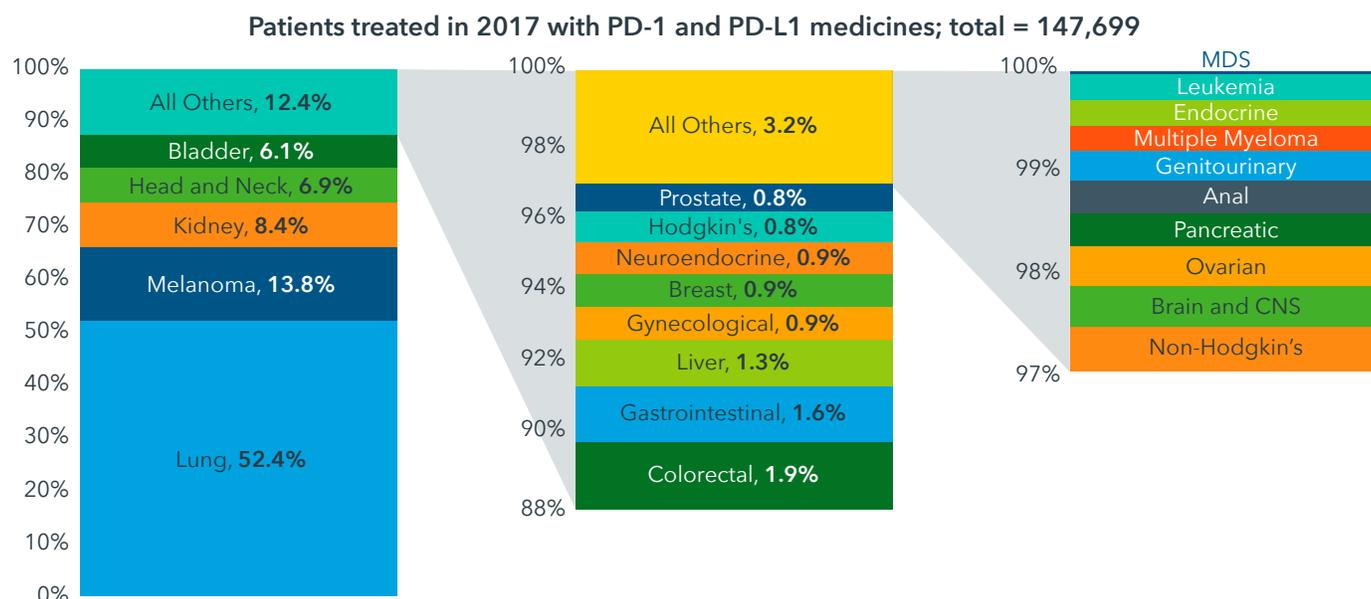
Source: U.S. FDA, IQVIA, National Sales Perspectives, Feb 2018; IQVIA Institute, Apr 2018

- Programmed cell death protein 1 (PD-1) inhibitors represent a paradigm shift in the treatment of cancer. The immune system has the ability to find and destroy tumor cells, however, some tumors elude this response by disrupting immune checkpoint signaling pathways involving PD-1 and its ligands (PD-L1 and PD-L2). Treatment with anti-PD-1 agents in tumors that over-express PD-1 stimulate a patient’s immune system against the cancer. These agents are associated with durable response in multiple cancer types.
- Following the launch of ipilimumab in 2011 (an anti-CTLA4 therapy) two highly anticipated anti-PD-1 therapies launched at the end of 2014 for the treatment of melanoma (pembrolizumab in September and nivolumab in December).
- The PD-L1 inhibitor atezolizumab was approved in May 2016 for bladder cancer and in October 2016 for non-small cell lung cancer.
- Avelumab was approved in March 2017 for metastatic Merkel cell carcinoma, a rare and highly aggressive type of skin cancer. That same year, the drug received an additional approval for advanced or metastatic urothelial carcinoma (bladder cancer).
- Durvalumab, another PD-L1 inhibitor, received approval for PD-L1 advanced or metastatic urothelial carcinoma in 2017 and advanced or metastatic urothelial carcinoma in 2018.
- In May 2017, pembrolizumab was granted accelerated approval for patients with unresectable or metastatic solid tumors identified as having a biomarker referred to as microsatellite instability-high (MSI-H) or mismatch repair deficient (dMMR). This was the first approval of this kind for patients whose cancers have a specific genetic feature.<sup>18</sup>

Chart notes: Met = metastatic; rec/met = recurrent/metastatic; 1L+ = 1st line; 2L+ = 2nd line; HCC = hepatocellular carcinoma.

# Checkpoint inhibitors are being used across many different tumor types

Chart 5: PD-1 and PD-L1 Inhibitor Treated Patients by Tumor Type in the United States



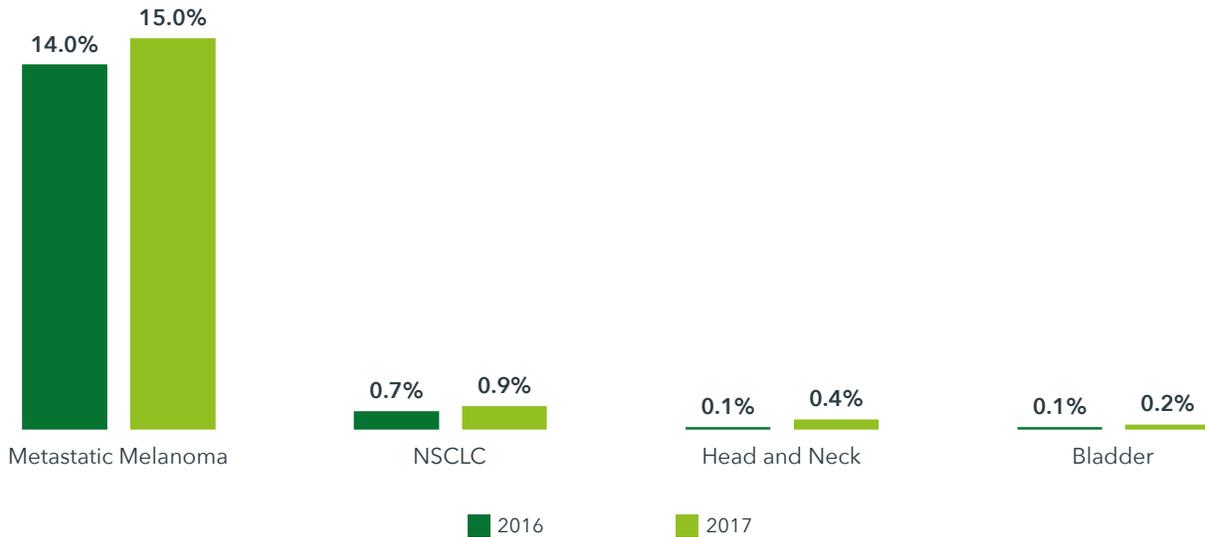
Source: IQVIA Oncology Anonymized Patient Level Data (APLD) sourced from longitudinally linked medical and pharmacy healthcare claims, Feb 2018; IQVIA Institute, Apr 2018

- The PD-1 and PD-L1 checkpoint inhibitors are being used across more than 20 cancer indications; some oncologists use these prior to FDA approval of the indication, which is referred to as off-label usage.
- These checkpoint inhibitors are used most often in FDA-approved indications of lung, melanoma, kidney, head and neck and bladder cancers.
- Over half of the usage of these therapies is in lung cancer alone (52%). Nivolumab and pembrolizumab, which both target PD-1, can be used in lung cancer progression after chemotherapy, and pembrolizumab can be used in patients as a first-line treatment. Durvalumab, which targets PD-L1, is used in patients whose disease has not progressed following concurrent platinum-based chemotherapy and radiation.
- Other indications make up approximately 12% of the usage of PD-1 and PD-L1 inhibitors with colorectal cancer, gastrointestinal and liver cancers making up approximately 4.8% of that grouping.
- Although nivolumab and pembrolizumab have FDA approvals for Hodgkin’s lymphoma, the use of these therapies for this indication is extremely small compared to other uses, likely reflecting the rarity of the cancer, rather than the efficacy of the treatment.

Chart notes: Chart totals may not sum due to rounding.

# The use of multiple immuno-oncology checkpoint inhibitors in combination is becoming more common in melanoma

Chart 6: Percent of U.S. Patients Receiving a Regimen with Two or More Checkpoint Inhibitors



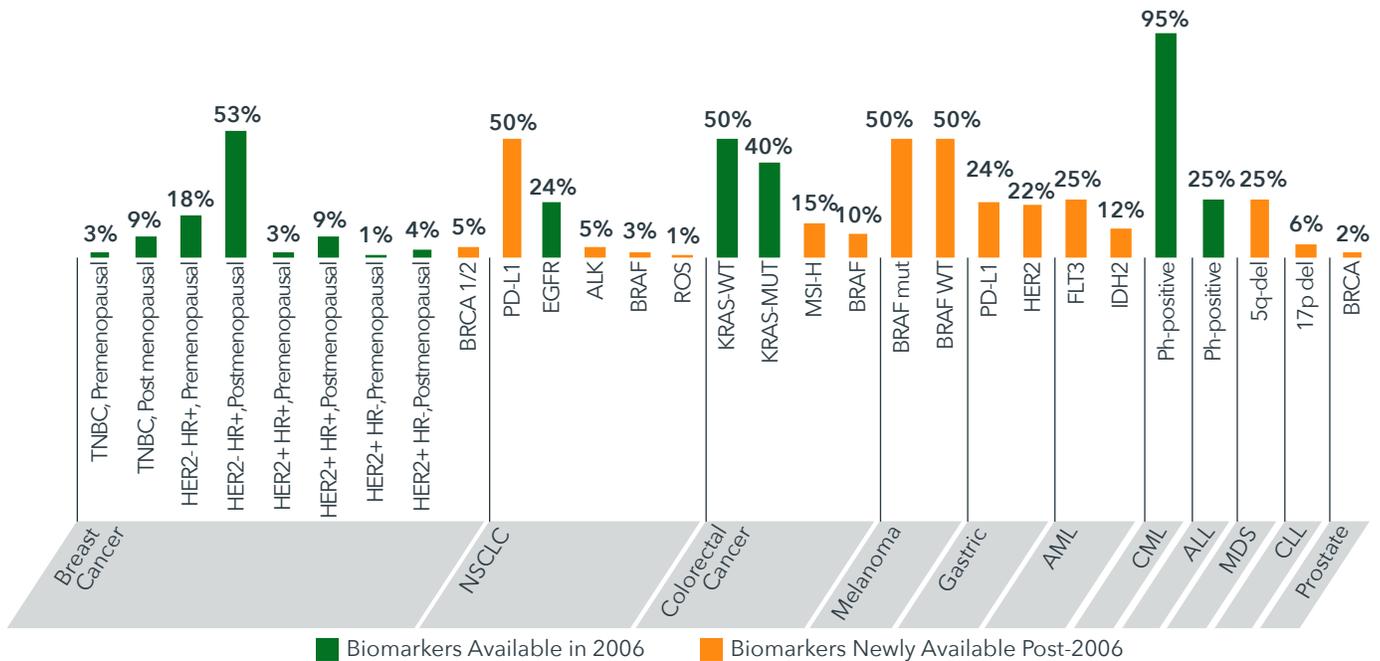
Source: IQVIA Oncology APLD, Dec 2017

- Ongoing clinical trials have begun to demonstrate improved results in some patients administered more than one novel medicine in a regimen.
- In cases where a tumor expresses multiple targets that can be addressed simultaneously, the overall results for the patient may be enhanced.
- The use of two or more immuno-oncology checkpoint inhibitors together in a regimen has begun to be called a 'doublet' or a 'triplet', but uptake across tumors has varied.
- Combined usage has occurred predominantly in metastatic melanoma, which was also the first indication approved for any of the checkpoint inhibitors, and as such, usage is more advanced.
- The use of a more intensive regimen would generally be reserved for patients non-responsive to the preferred regimens, or for those who are expected to be able to tolerate the effects of the combined regimens.
- As more clinical trials complete, there will likely be more tumors (and patients) where these doublets and triplets are used.
- Melanoma treatment has been transformed over the past five years, where poor prospects in advanced or metastatic disease had put intense focus on prevention and early detection. While these remain critical, the prospects for patients with advanced disease have improved dramatically.

Chart notes: NSCLC = non-small cell lung cancer.

# Biomarkers are being used to redefine cancer more precisely across several tumor types

Chart 7: Patient Incidence of Positive Biomarker Results Per Cancer by Biomarker Availability, 2017



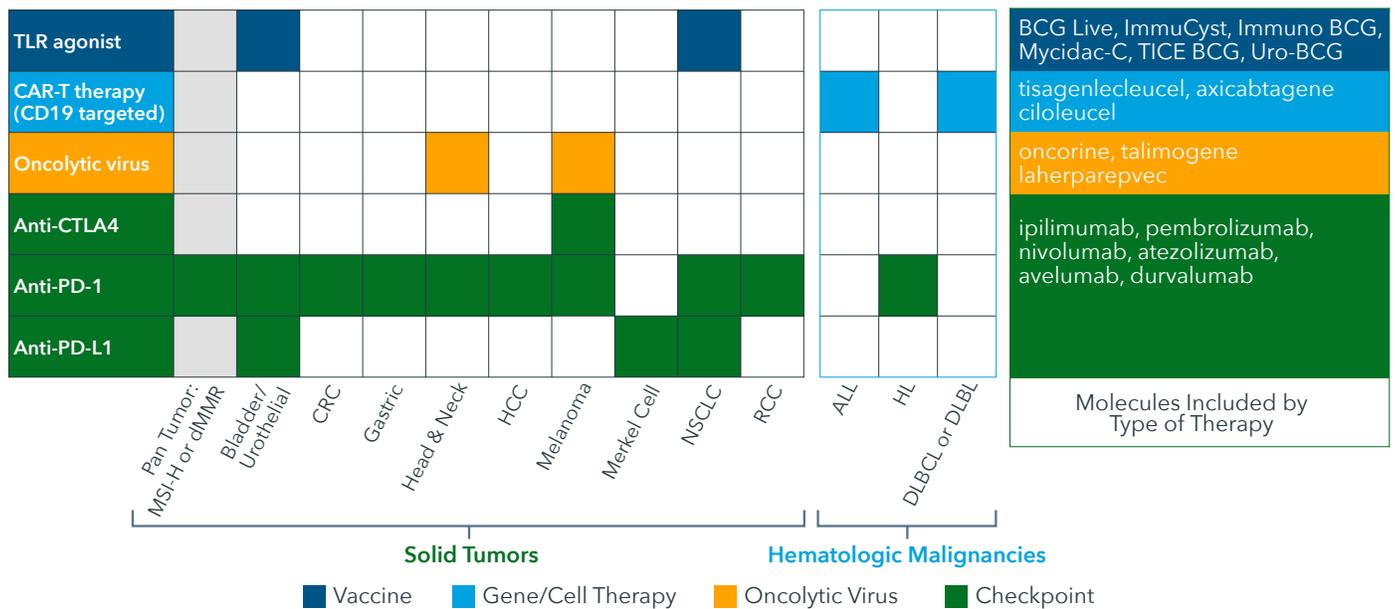
Source: FDA.gov and Drugs@FDA, Apr 2018; IQVIA, ARK R&D Intelligence, Apr 2018; IQVIA Institute, Apr 2018

- The use of biomarkers to target treatment improves patient outcomes by making earlier and more appropriate treatment selections, and the number of markers has increased dramatically in the past decade.
- Breast cancer was highly segmented even in the early 2000s, but the addition of the BRCA 1/2 genetic marker further isolates responders to specific treatments.
- The addition of PD-L1 expression across a range of tumors has enabled identification of responsive patient sub-populations, with more demonstrable clinical effects.
- Some tumors were previously treated with systemic treatments, but now have biomarkers and testing to help with treatment selection.
- The expansion in the number of biomarkers suggests that providers would need to run multiple tests, which adds some burden to the process, but clearly improves the outcomes for affected patients.

Chart notes: ALL = acute lymphoblastic leukemia; AML = acute myeloid leukemia; CLL = chronic lymphocytic leukemia; NSCLC = non-small cell lung cancer; MDS = myelodysplastic syndromes; C-met in NSCLC: Nearly 5% of all NSCLCs contain c-Met mutations.<sup>19</sup> NTRK in NSCLC: NTRK rearrangements represent the molecular driver of a subset of solid tumors, including 3% of non-small-cell lung cancers;<sup>20</sup> BRCA in breast cancer: Approximately 5% of unselected patients with breast cancer carry a germline BRCA mutation. Patients with a BRCA1 mutation are predisposed to triple-negative breast cancer, whereas patients with a BRCA2 mutation most often have tumors that express estrogen receptors.<sup>21</sup> KRAS mut/WT: Oncogenic activation of KRAS and BRAF is mutually exclusive and occurs in approximately 40% and 10% of all CRCs, respectively.<sup>22</sup> Melanoma PD-L1 expression helps to enrich the population of patients who benefit from anti-PD-1 therapy, but is not powerful enough to exclude patients from anti-PD-1 treatment.<sup>23</sup> Incidence is estimated.

# Immuno-oncology now encompasses a range of mechanisms with multiple medicines available across a range of tumor types

Chart 8: Approved Checkpoint Inhibitors and Next-Generation Biotherapeutics by Mechanism of Action and Tumor Type Approvals



Source: Tang J, Shalabi A, Hubbard-Lucey VM. Comprehensive analysis of the clinical immuno-oncology landscape. Ann Oncol. 2018 Jan 1;29(1):84-91. IQVIA Institute, Apr 2018

- Immuno-oncology agents have drastically altered the treatment landscape of multiple tumor types that have FDA approval. These therapies work effectively in specific sub-groups of patients across multiple solid and blood-based tumors.
- A number of these agents, including the checkpoint inhibitors, have novel mechanisms of action and methods of delivery, including live viruses, vaccines and the chimeric antigen receptor (CAR) T-cell therapies, which involve a patient’s own T-cells genetically engineered using a virus to produce chimeric antigen receptors that target various tumor antigens.
- The current CAR T-cell therapies, tisagenlecleucel and axicabtagene ciloleucel, specifically target the B-lymphocyte CD19 antigen and have indications for the treatment of refractory B-cell acute lymphoblastic leukemia and diffuse large B-cell lymphoma.
- These second-generation CAR-T therapies have been shown to be extremely effective; in one study, 27 of 30 patients (90%) with relapsed leukemia achieved remission.<sup>24</sup>

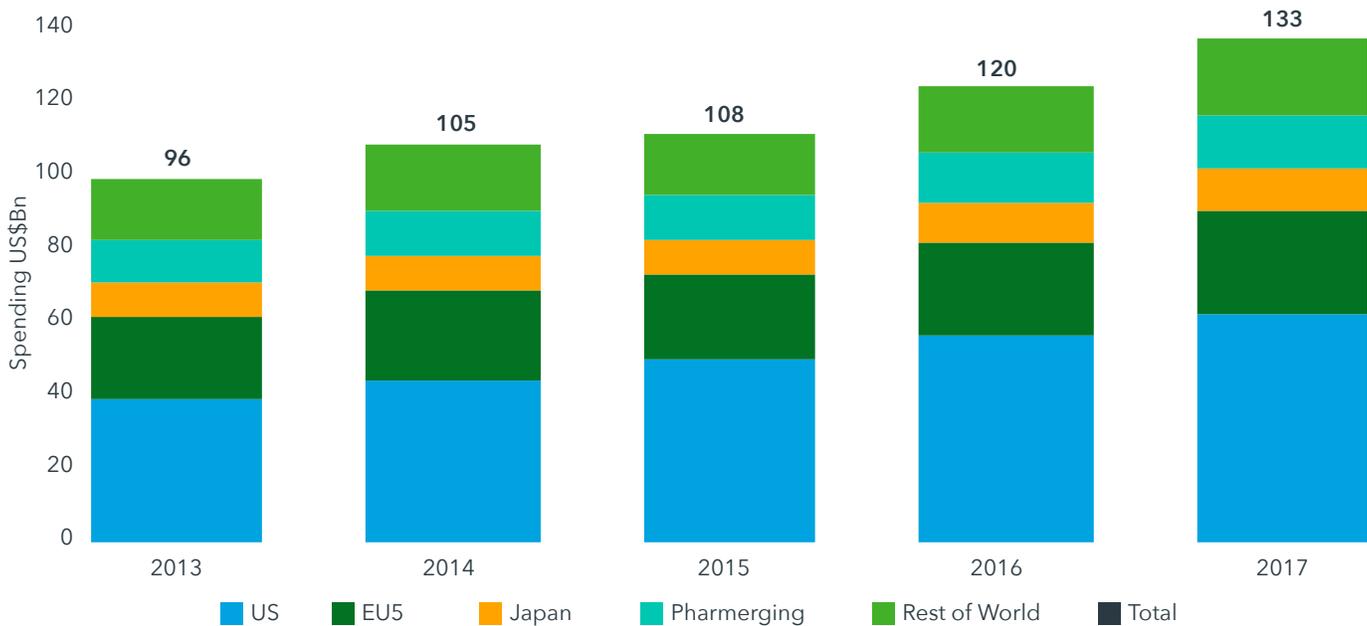
Chart notes: CRC = colorectal cancer; HCC = hepatocellular carcinoma; NSCLC = non-small cell lung cancer; RCC = renal cell carcinoma; ALL = acute lymphoblastic leukemia; HL = Hodgkin’s lymphoma; DLBCL = Diffuse large B-cell lymphoma.

## Use and spending levels for cancer treatments

- Global spending on cancer medicines – both for therapeutic and supportive care use – rose to \$133 billion in 2017, up from \$96 billion in 2013.
- Growth rates for therapeutics – measured in constant dollars – slowed globally and across most regions in 2017, though they remained in double digits at 12.5% globally and 12.1% in the United States, down from 14.8% and 17.4%, respectively, in 2016.
- A drop in growth from new medicines following a low number of approvals in 2016 was the major factor slowing growth in the United States in 2017, while in other markets, uptake of medicines and increased use of existing brands drove growth in 2017.
- Spending on cancer therapeutic drugs in the United States has doubled since 2012 and reached almost \$50 billion in 2017, with two-thirds of the growth resulting from the use of drugs launched within the past five years.
- Outside the United States, oncology costs exceeded \$60 billion in 2017, driven by new product launches and increased use of existing brands.
- Spending on cancer medicines is heavily concentrated, with the top 35 drugs accounting for 80% of total spending, while over half of cancer drugs have less than \$90 million in annual sales.
- List prices of new cancer drugs at launch have risen steadily over the past decade and the median annual cost of a new cancer drug launched in 2017 exceeded \$150,000, compared to \$79,000 for the new cancer drugs launched in 2013, but most cancer drugs – including those with high annual costs – are used by relatively few patients – with about 87% of drugs being used by fewer than 10,000 patients in 2017.
- Only patients in the United States, Germany and United Kingdom have access to more than 40 of the 55 oncology medicines initially launched between 2012 and 2016, due to manufacturers not filing for regulatory approval, delays or denials of approval, or manufacturers awaiting the results of reimbursement negotiations prior to launching the drug in the country.
- The uptake of new immuno-oncology PD-1 and PD-L1 inhibitors varies across countries, with the U.K.'s use per million of population at one-third the level of the United States.
- Use of personalized medicine biomarker tests is increasing for patients with several tumor types, though the use of these tests continues to be lower than guidelines recommend.
- Payers around the world took actions in 2017 to address rising expenditure on oncology medicines through a range of new approaches to purchasing and to the negotiation of reimbursement levels with manufacturers.
- For patients in the United States, final out-of-pocket costs for cancer medicines will vary significantly based on drug choice, manufacturer prices, and insurance plan design.
- While outpatient drug costs can carry high costs for payers, the patient responsibility averages less than \$500 per year for commercial plans, and for retail drugs, the extensive use of coupons helps offset patient out-of-pocket costs.

# Cancer medicine spending - both therapeutic and supportive care - rose to \$133 billion globally in 2017, up from \$96 billion in 2013

Chart 9: Global Oncology Therapeutic and Supportive Care Spending, US\$Bn, 2013–2017



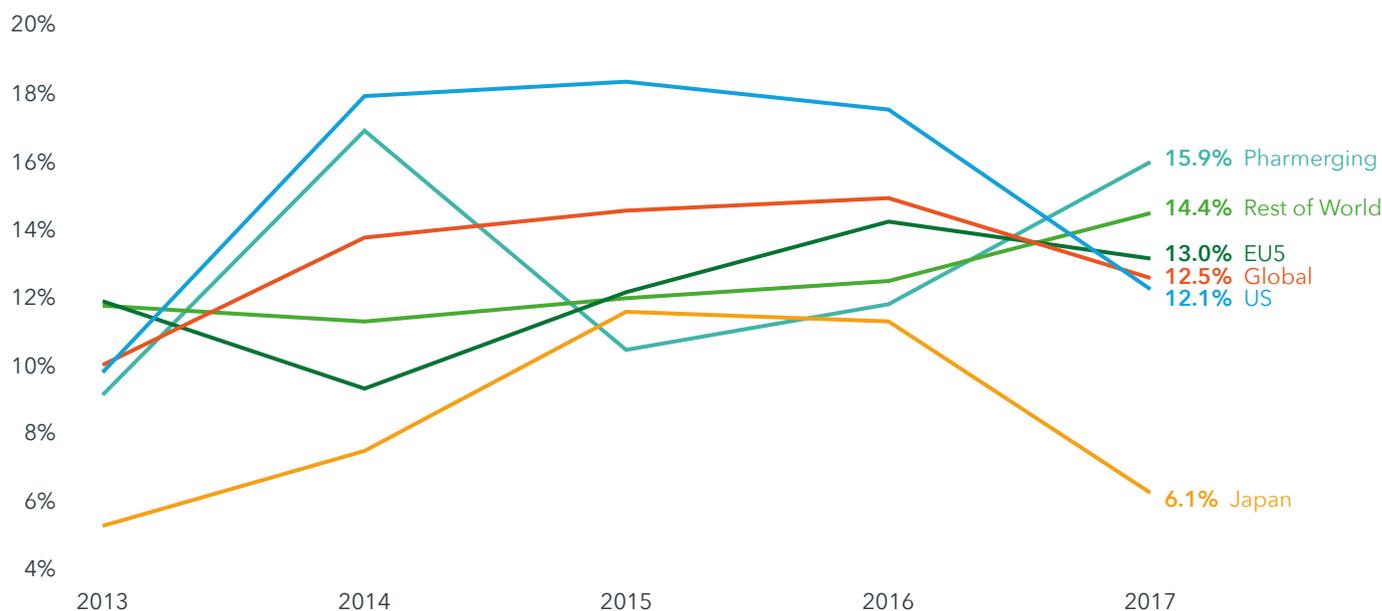
Source: IQVIA MIDAS; IQVIA Institute, Dec 2017

- Cancer medicine spending rose to \$133 billion globally including all types of therapeutic and supportive care medicines.
- Spending continued to be focused in the major developed markets, with the United States, EU5 and Japan accounting for 74% of spending, up from 72% in 2013.
- U.S. spending has risen from \$38 billion in 2013 to \$61 billion in 2017, and accounts for 46% of global spending, up from 39% in 2013.
- Supportive care spending was almost unchanged over five years, dropping \$100 million from \$23.7 billion in 2013 to \$23.6 billion in 2017. This now represents 18% of spending globally in 2017, down from 25% in 2013
- as innovative therapies and supportive care volumes have increased, but biosimilars and small molecule patent expiries have reduced supportive care costs.
- Biosimilars of erythropoietins (erythropoietin alfa), and GM-CSF drugs (filgrastim) are already widely available, especially in Europe, reducing costs in supportive care as many cancer patients receive them to boost red or white blood cell counts in response to common side effects of cancer treatments.
- Biosimilars of therapeutic oncologics are expected to reach many markets by 2022, including rituximab, trastuzumab, bevacizumab and others.

Chart notes: Therapeutic oncologics include those classified by EphMRA (European Pharmaceutical Market Research Association) as cytotoxics in the L1 or L2 classes, as well as radiotherapeutics (V3C) and specific molecules classified elsewhere but used primarily in cancer (lenalidomide, aldesleukin, pomalidomide). Supportive care includes anti-nauseants and cancer detox agents (A4A and V3D), erythropoietins (B3C), GM-CSF white blood cell boosters (L3A), other interferon therapies used in cancer (L3B excluding multiple sclerosis drugs), and bisphosphonates used to prevent bone metastases (M5B4).

# Oncology spending growth slowed to 12.5% in 2017, down from 14.8% in 2016

Chart 10: Growth Rates for Global Oncology Therapeutic Medicines Spending, 2013–2017



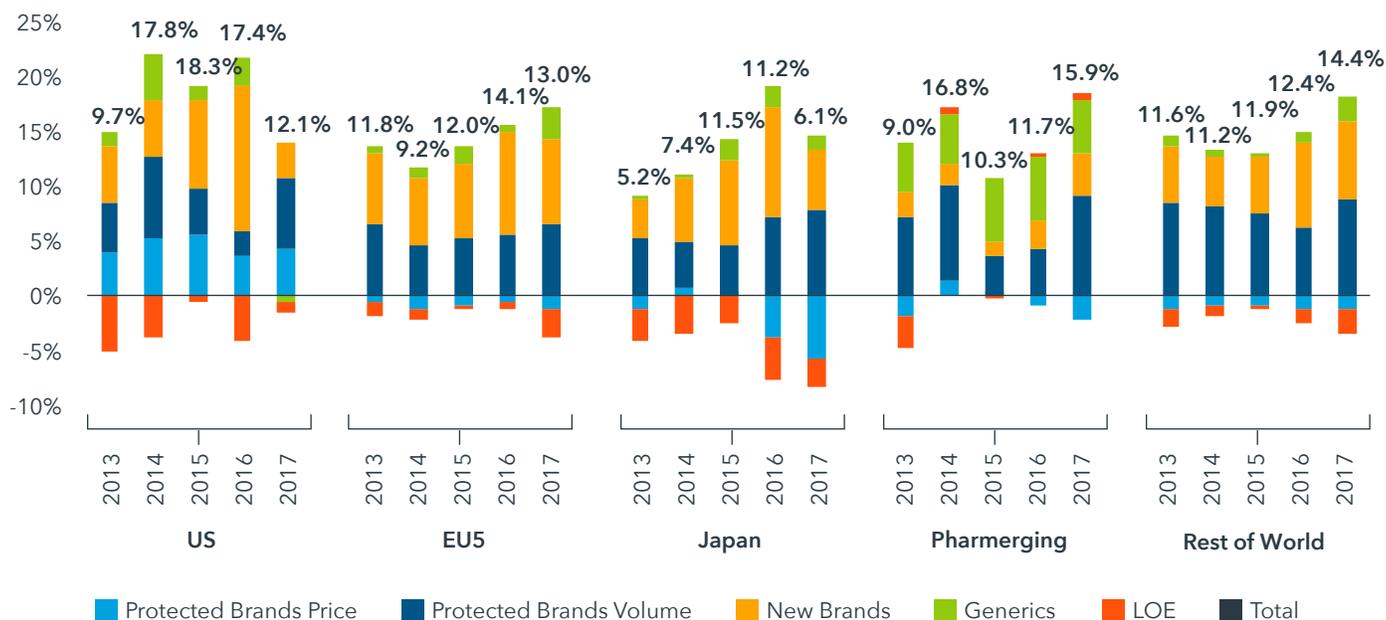
Source: IQVIA, MIDAS, Dec 2017

- Growth rates - measured in constant dollars - slowed globally and across most regions in 2017, though they remained in double digits at 12.5% globally and 12.1% in the United States.
- Growth in the rest of the world has been driven generally by volume and increased usage of medicines, often a few years later than first adopted in developed markets.
- Spending growth in the five major European markets reached 13.0% in 2017, down slightly from 14.1% in 2016, but higher than prior years.
- Japan spending grew the slowest among the developed markets, as the wide usage of innovative immuno-oncology treatments exceeded company forecasts and triggered government (MLHW) price cuts.
- U.S. spending growth had been far higher than other countries from 2014 to 2016, and slowed to 12.1% in 2017, down 5.3 percentage points from 2016, as the growth from some earlier launches slowed, few products were launched in 2016, and increasing numbers of medicines are for niche populations.

Chart notes: Therapeutic oncology only.

# New medicines growth sets developed markets trend, while brand volume and generics drive trend in pharmerging

Chart 11: Oncology Therapeutic Spending Growth by Product Segment, 2013–2017



Source: IQVIA, Midas, Dec 2017; IQVIA Institute, Apr 2018

- The United States was the largest driver of slower global growth in 2017, as the contribution from new brands – drugs with less than two years on the market – dropped from 12.9% in 2016 to 3.0% in 2017.
- Brands launched in the United States in 2014–2016, which are included in the protected brands segment in 2017, continue to contribute to growth, as overall protected brand volume increased from 2.1% in 2016 to 6.4% in 2017.
- Growth in Europe slowed, as some cancer medicines faced losses of exclusivity and new brands contributed 7.4% to growth compared to 9.0% in 2016.
- Japan growth was nearly halved, dropping from 11.2% to 6.1%, as price cuts affected branded products including newly launched products if they exceeded agreed volume forecasts.
- In pharmerging markets, growth accelerated from 11.7% to 15.9% driven mostly by volume growth of branded products.
- In other countries around the world, including a mix of developed and low-income countries, growth increased primarily through greater volume use of branded products, and generics.

Chart notes: Product segments are mutually exclusive in each period. New brands are defined as those on the market for less than eight quarters for any quarterly period in the year. Protected brands are defined as those products with patent protection still in force, which are not new. Price growth is the impact on growth of changes to invoice prices tracked in IQVIA audits if volume is held constant. Volume growth is the impact on growth if prices are held constant. LOE (loss of exclusivity) is defined as the growth for branded products after they lose exclusivity, typically after patent expiry. Generics include all non-original products including unbranded generics and non-original branded products such as branded generics or company branded products.

# Spending on cancer drugs in the United States has doubled since 2012, reaching almost \$50 billion in 2017

Chart 12: U.S. Oncology Therapeutic Market Spending and Growth by Segment



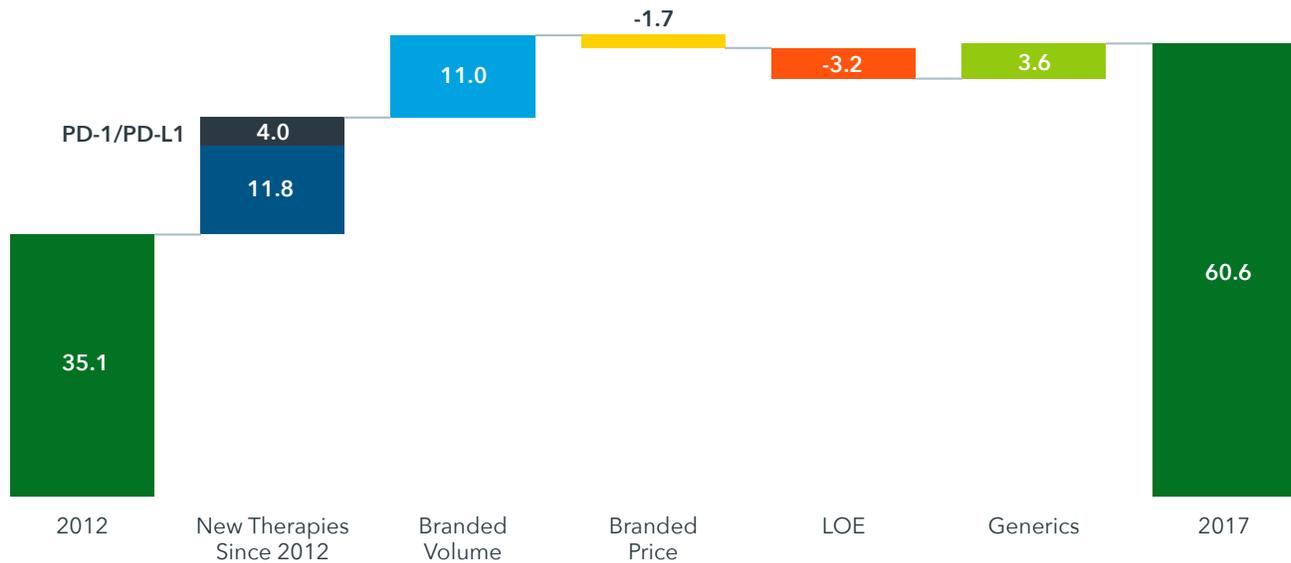
Source: IQVIA, MIDAS, Q4 2017; IQVIA Institute, Apr 2018

- Spending on cancer drugs in the United States has doubled since 2012 and reached almost \$50 billion in 2017, with over 75% of the growth from the use of drugs launched within the past five years.
- The total cost of oncology medicines rose by \$25.1 billion to \$49.8 billion in the United States between 2012 and 2017.
- Two-thirds of the growth in U.S. oncology costs in the last five years can be attributed to the uptake of innovative medicines launched since 2013.
- PD-1 and PD-L1 inhibitors account for one-fifth of the growth.
- The costs for older protected brands increased due to both wider usage and increasing prices on an invoice basis.
- The loss of patent exclusivity for some older brands contributed to \$4.3 billion in lower brand costs.
- The \$1.3 billion increase in generic costs equates to 5% of oncology cost growth between 2012 and 2017.

Chart notes: Product segments are mutually exclusive in each period. New brands since 2012 show the total 2017 spending for all new branded products launched since the end of 2012. Branded volume and branded price are based on protected brands, which are defined as those products with patent protection still in force, and in this analysis exclude all branded products that are new since 2012. New PD-1 and PD-L1 products have been shown separately. Price growth is the impact on growth of changes to invoice prices tracked in IQVIA audits if volume is held constant. Volume growth is the impact on growth if prices are held constant. LOE (loss of exclusivity) is defined as the growth for branded products after they lose exclusivity, typically after patent expiry. Generics include all non-original products including unbranded generics and non-original branded products such as branded generics or company branded products.

# Outside the United States, oncology costs exceeded \$60 billion in 2017, driven by new products and increased volume of existing brands

Chart 13: Oncology Therapeutic Market Spending and Growth by Segment Outside the United States, Constant US\$Bn



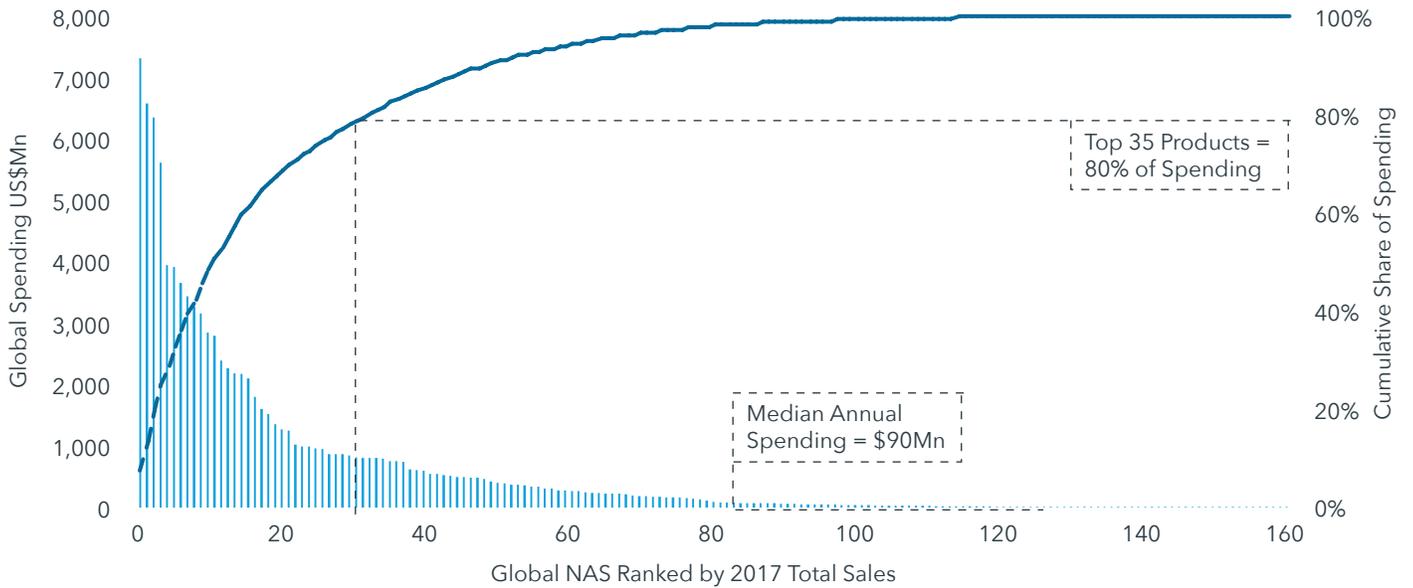
Source: IQVIA, MIDAS, Q4 2017; IQVIA Institute, Apr 2018

- Outside the United States, oncology costs exceeded \$60 billion in 2017, driven by new product launches and increased volume use of existing brands.
- Outside the United States, oncology costs increased by \$25.5 billion to \$60.6 billion between 2012 and 2017.
- The uptake of new brands resulted in \$15.8 billion in increased costs in other countries with a third from PD-1 and PD-L1 inhibitors.
- Greater use of older brands, due to increasing numbers of patients receiving treatment, as well as lengthening treatment durations, led to \$11.0 billion in cost growth in the past five years.
- Prices declined on average for older protected brands outside the United States and contributed to \$1.7 billion of lower brand costs over five years.
- Loss of exclusivity for brands resulted in \$3.2 billion in lower costs of cancer medicines outside the United States.
- The \$3.6 billion increase in generic costs equates to 14% of oncology cost growth between 2012 and 2017.

Chart notes: Product segments are mutually exclusive in each period. New brands since 2012 show the total 2017 spending for all new branded products launched since the end of 2012. Branded volume and branded price are based on protected brands, which are defined as those products with patent protection still in force, and in this analysis exclude all branded products that are new since 2012. New PD-1 and PD-L1 products have been shown separately. Price growth is the impact on growth of changes to invoice prices tracked in IQVIA audits if volume is held constant. Volume growth is the impact on growth if prices are held constant. LOE (loss of exclusivity) is defined as the growth for branded products after they lose exclusivity, typically after patent expiry. Generics include all non-original products including unbranded generics and non-original branded products such as branded generics or company branded products.

# Spending on cancer medicines is heavily concentrated with the top 35 drugs accounting for 80% of total spending

Chart 14: Global Markets Number of Oncologic Medicines Available and Average Spending per Product



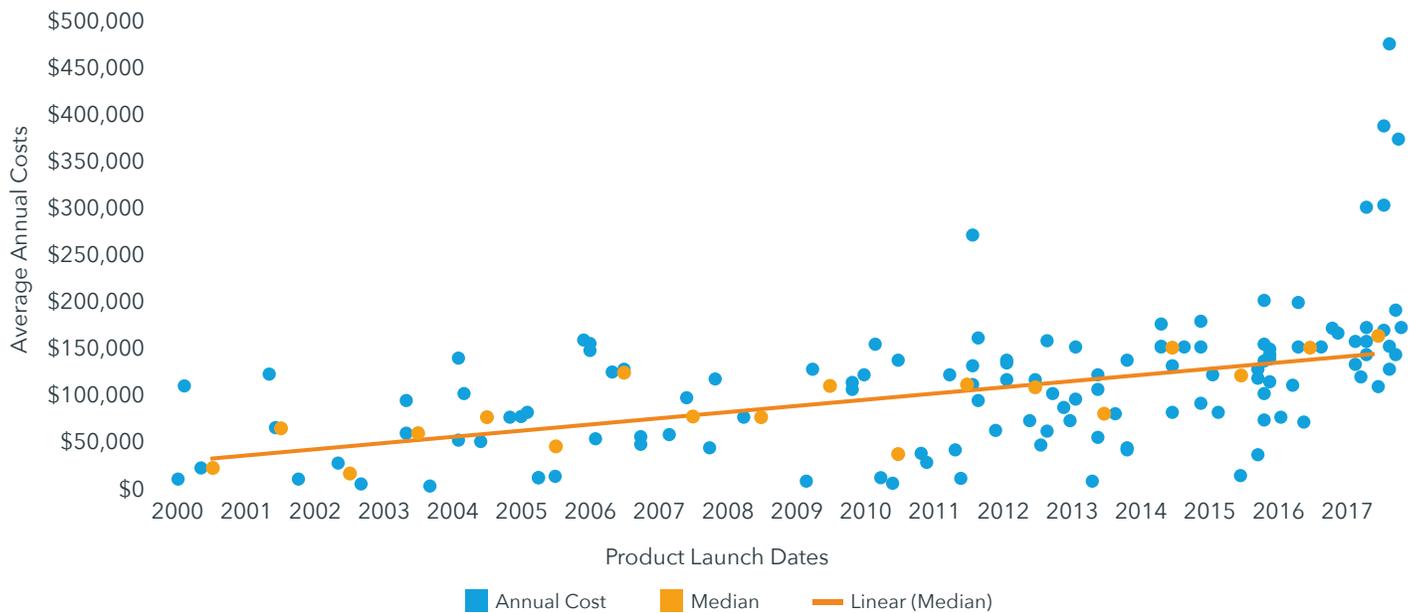
Source, IQVIA MIDAS, Dec 2017

- Spending on cancer medicines is heavily concentrated with the top 35 drugs accounting for 80% of total spending, while over half of cancer drugs have less than \$90 million in annual sales.
- Those products with less than \$90 million in sales account, in aggregate, for only 2% of oncology spending as they are often older and available as generics at lower costs.
- Those medicines with the highest spending are used widely across countries, are generally newer brands, and often have multiple approved indications.
- Of cancer medicines in use around the world, 80% generated less than \$1 billion per year for the companies that produce them, and 72% less than \$500 million.

Chart notes: Each oncology therapeutic treatment is depicted, including spending for originators and other marketers of those medicines in all markets.

# All drug launches in 2017 earned list prices above \$50,000 per year and the median exceeded \$150,000 per year

Chart 15: Average Annual Costs For Oncology Products by Launch Year in the United States



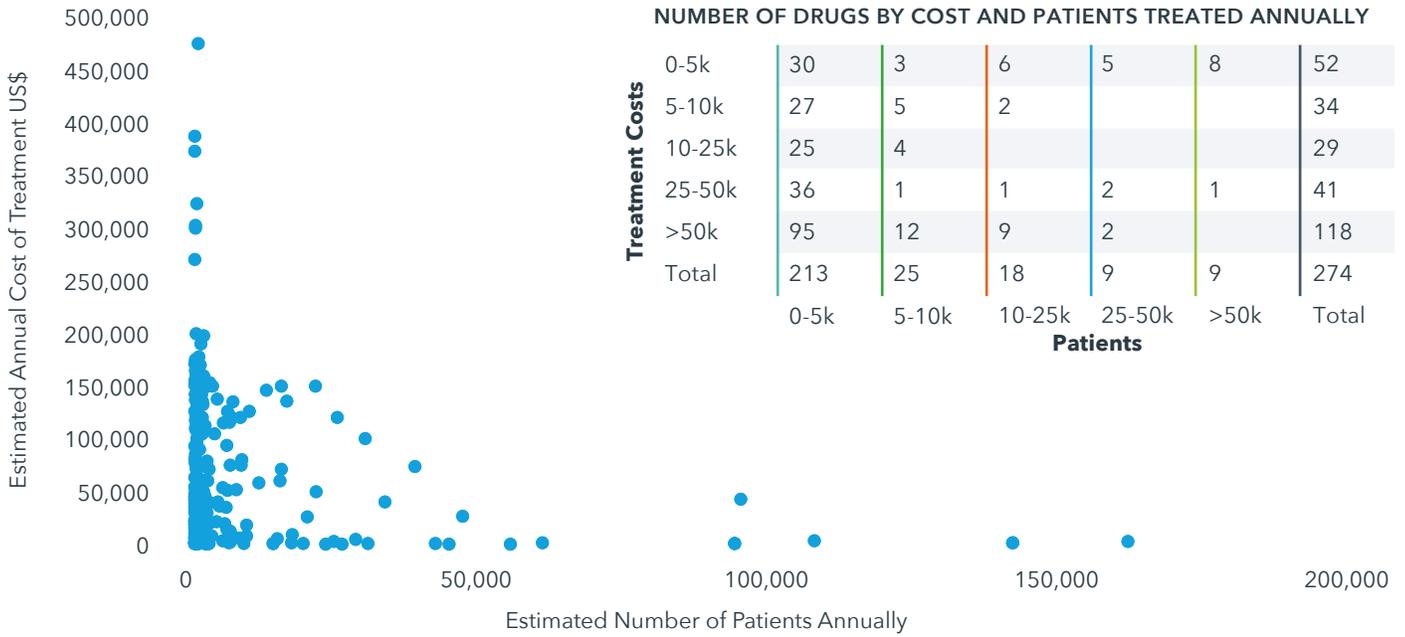
Source: IQVIA Institute, Apr 2018

- The annual costs of new oncology brands in the United States are rising with the median costs now above \$160,000 in 2017, up from \$79,000 in 2013.
- The introduction of some products with costs far above median costs has become more common.
- The mean cost for the new brands in 2017 (not shown) was over \$200,000.
- None of the new launches in 2017 had annual costs below \$100,000, compared to seven of 11 in 2013.
- In total, the 2017 launches treated fewer than 5,000 patients, reflecting the small populations they target, as well as the short time that has elapsed since launch for some products.
- The overall trend to more expensive treatments includes both a focus on smaller, more-focused sub-populations, and the significant clinical benefits brought by many new treatments (see Chart 2).

Chart notes: If published annual costs are available they have been included, and if not, annual costs were estimated based on IQVIA Institute interpretation of the most-common dosing in the approved label and available product unit pricing information.

# High treatment costs generally correspond to very low numbers of treated patients

Chart 16: Average Annual Costs and Estimated Patients in the United States in Thousands, 2017



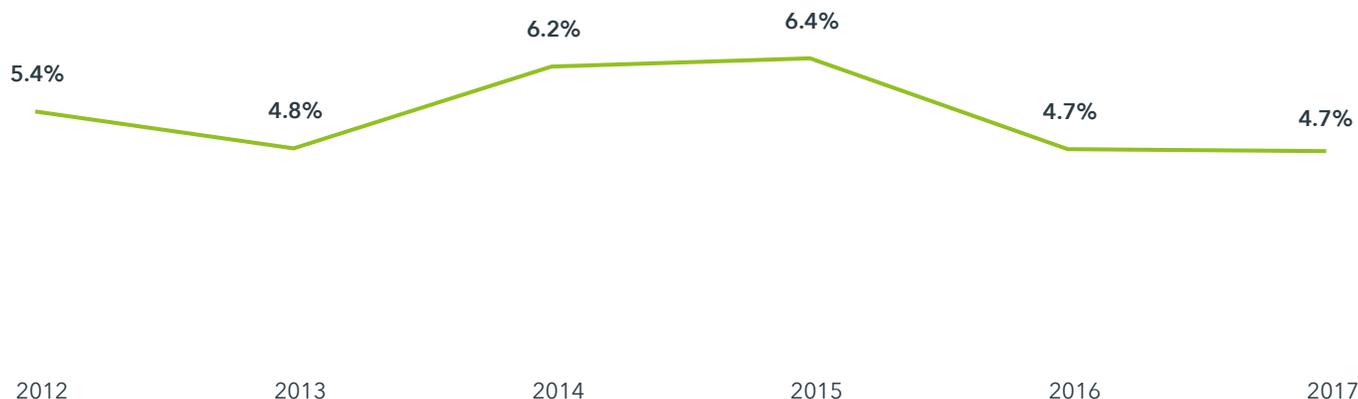
Source: IQVIA Institute, Apr 2018

- Most cancer drugs – including those with high annual costs – are used by relatively few patients, with about 87% of drugs being used by fewer than 10,000 patients in 2017.
- Generally high costs correlate with low numbers of patients, however there are some notable exceptions, where very effective treatments have patient populations of 10,000 to 50,000 and costs above \$50,000 per year, including trastuzumab, bortezomib, bevacizumab, lenalidomide, pertuzumab, enzalutamide, ibrutinib, pembrolizumab, nivolumab, and palbociclib.
- Of all drugs with above \$50,000 annual costs, 91% were used to treat fewer than 10,000 patients.
- While drug costs are an important part of cancer treatment, other costs including diagnostics, imaging, surgery and supportive care, can exceed therapeutic oncology drug costs for those patients.

Chart notes: If published annual costs are available they have been included, and if not, annual costs were estimated based on IQVIA Institute interpretation of the most-common dosing in the approved label and available product unit pricing information. Patient numbers are estimated in a number of ways depending on data availability. In some instances, IQVIA audited medicine spending divided by estimated cost per year is used to estimate patient numbers. In other cases, the number of doses per year are divided into the total number of doses audited by IQVIA. In this analysis, patients multiplied by annual costs for a product will generally equal overall audited sales. In some cases, IQVIA audits do not include full coverage of some products and these were adjusted based on company SEC filings, if available.

## Price increases following a new drug’s launch in the United States have moderated to 4.7% on average in the past two years

Chart 17: Average Invoice Price Increases for Protected Oncology Brands in the United States



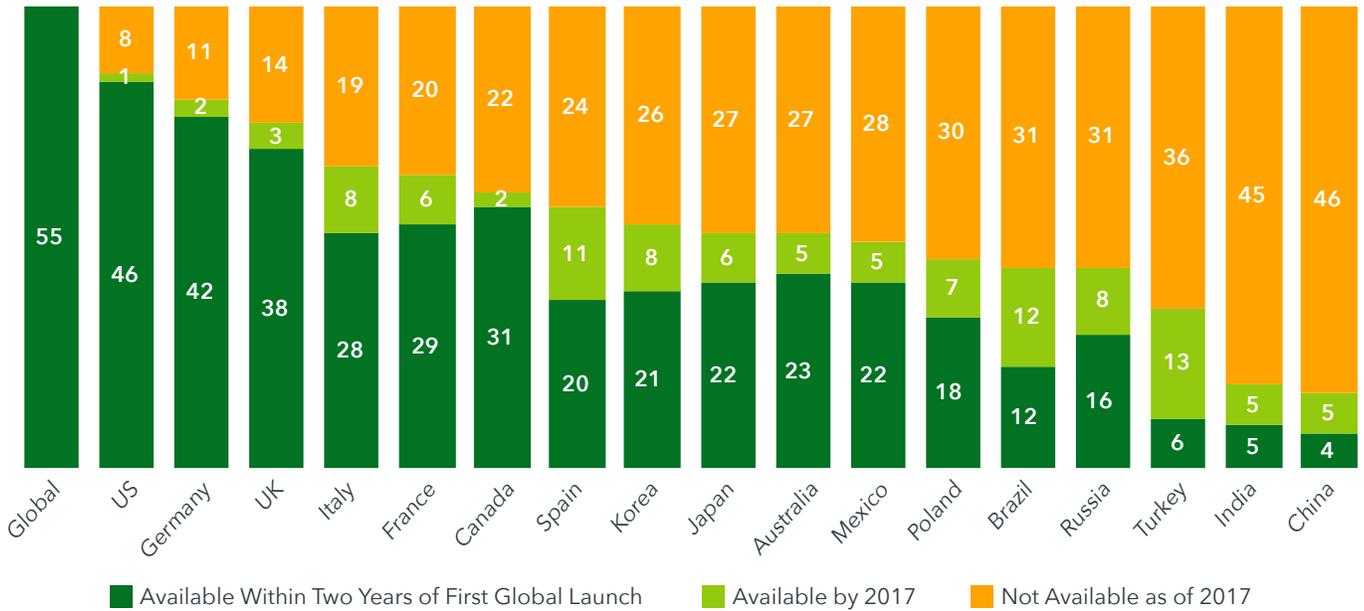
Source: IQVIA MIDAS, Dec 2017

- In the United States, manufacturer price increases can occur throughout the year and have averaged from 4.7% to 6.4% over the past six years.
- The level of price growth in the United States oncology market is substantially below that in the overall branded market, where prices increased 6.9% in 2017.
- These price increases are before the impact of any off-invoice discounts, rebates, or other concessions; though these discounts are understood to be modest in comparison to IQVIA’s audited invoice prices.
- Price increases following a new drug’s launch in the United States have moderated to 4.7% on average in the past two years on an invoice price basis, and rebates, discounts and other price concessions averaged 6% across all branded cancer drugs relative to invoice prices; these price concessions are estimated to average 23% of WAC price in 2017.
- Price concessions relevant for cancer medicines include the 340B drug discount program, Medicaid rebates, manufacturer coupons for pharmacy dispensed drugs, and other concessions manufacturers negotiate with intermediaries.

Chart notes: Invoice prices tracked in IQVIA audits reflect the average prices from wholesalers to their customers, and do not include discounts and rebates paid to the government, private payers, other intermediaries or the value of manufacturer funded coupons for patients. The 340B drug discount program entitles cancer centers to discounted drug purchases, some of which are reflected in IQVIA invoice prices, and some that are adjudicated separately. WAC = wholesale acquisition cost.

# Many new oncology medicines are not available beyond the largest developed markets

Chart 18: Year 2017 Availability of 55 Oncology Medicines First Launched Globally 2012–2016



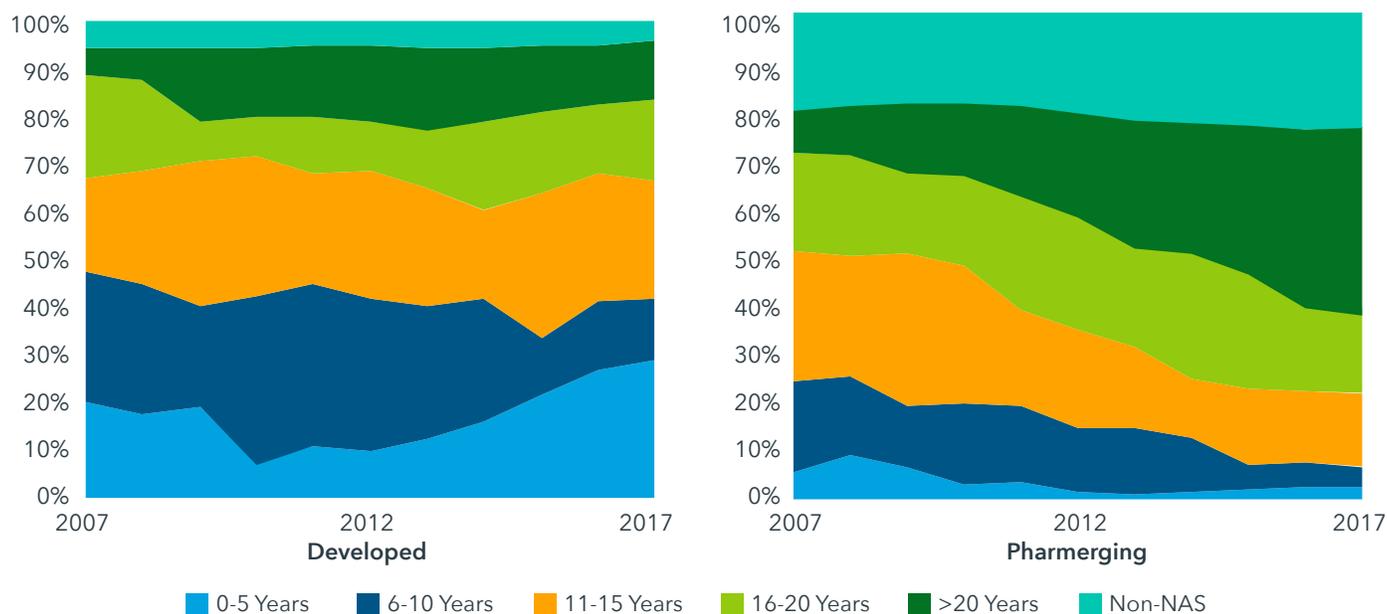
Source: IQVIA MIDAS, Dec 2017

- Only patients in the United States, Germany and United Kingdom have access to more than 40 of the 55 oncology medicines initially launched between 2012 and 2016, due to manufacturers not filing for regulatory approval, delays or denials of approval, or manufacturers awaiting the results of reimbursement negotiations prior to launching the drug in the country.
- Fewer than 20% of these medicines are available in most pharmerging markets.
- For those countries under the European Medicines Agency (EMA), which have fewer than 44 NAS available, these differences are due to either pending reimbursement reviews and negotiations or a company’s decision not to market an approved drug in that country.
- Germany has the most medicines available under EMA, with 44, in part because of ‘free pricing’ from launch, where a company can set their price, and then after a year a reimbursed price is determined through a health technology assessment (HTA).
- There are distinct national level processes for reviewing and negotiating reimbursement, often with varying HTA results by country. In single-payer countries, lack of reimbursement can influence whether a company chooses to launch.
- In Canada, three of the 22 medicines are pending, while the other 19 are not filed with Health Canada.
- In the United States, five medicines developed in pharmerging markets have not been filed, one has been withdrawn and two are pending.

Chart notes: Includes therapeutic new active substances (NAS) in oncology (excluding supportive care medicines) first launched globally between 2012 and 2016. Availability is based on sales appearing in IQVIA market audits in the period from launch to the end of 2017, regardless of reimbursement status. By assessing country availability at least a year after the last drug’s first launch, the analysis highlights differences that would not be present if filings had occurred simultaneously in all countries, if reviews were largely similar duration with the same results, and reimbursement or commercial considerations and incentives were similar across countries. All countries shown have coverage of both retail pharmacy and hospital settings to ensure comparable availability assessment for oncology products.

## New medicines account for a rising share of spending in developed markets, while most use in pharmerging markets is of older drugs

Chart 19: Oncology and Supportive Care Spending by NAS Global Launch Vintage and Region



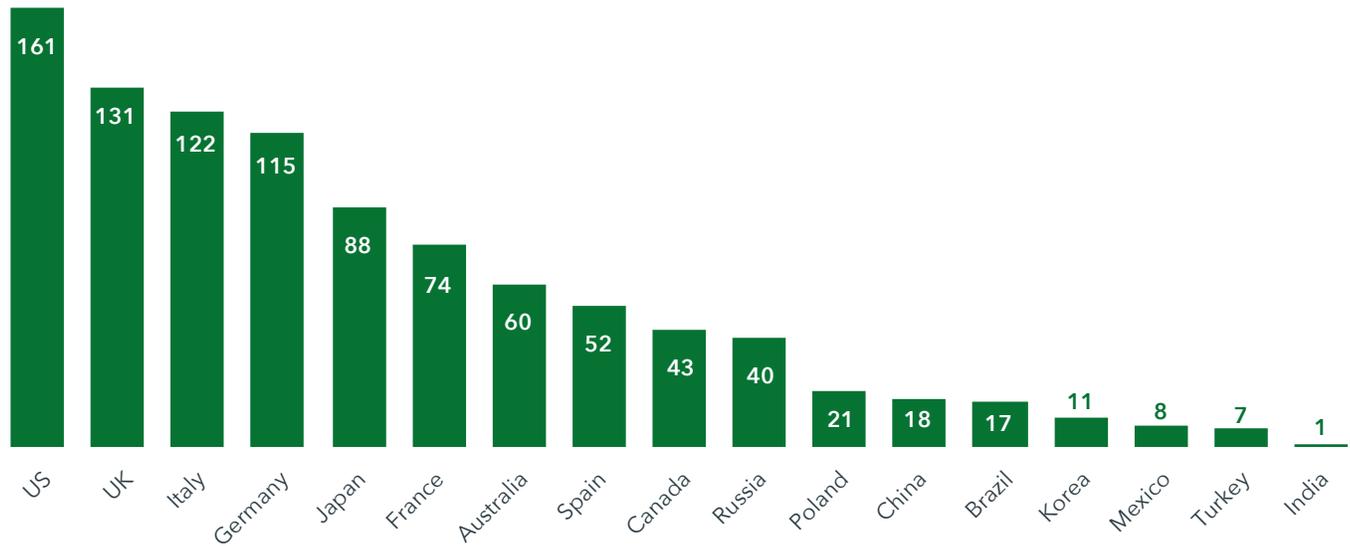
Source: IQVIA MIDAS, Dec 2017

- New Active Substances (NAS) in oncology are more rapidly adopted in developed markets than pharmerging markets.
- Newer medicines launched within the past five years account for 30% of all oncology drug spending across developed markets, while more than half of spending across pharmerging markets is for drugs that were first launched more than 20 years ago.
- The group of medicines launched between 6–10 years ago have begun to give way to newer medicines, while those launched 11–15 years ago (2002–2007) continue to be widely used in developed markets.
- Pharmerging markets have broadly not adopted newer oncology medicines, instead favoring the use of lower-cost treatments first introduced globally 20 years ago or more, which make up 54% of spending.
- Pharmerging markets access to newer medicines is generally limited, as over 80% of new drugs in the past five years are not yet available.
- The share of spending for global NAS launched 6–10 years ago are also less used in pharmerging markets, whereas those from 11–15 years ago are more widely available and have comparable shares in pharmerging markets to developed countries.

Chart notes: Spending on an invoice price basis.

## There are large variations in the number of oncologists across countries, potentially impacting access to care and outcomes

Chart 20: Oncologists per One Million of Population in Selected Countries, 2018



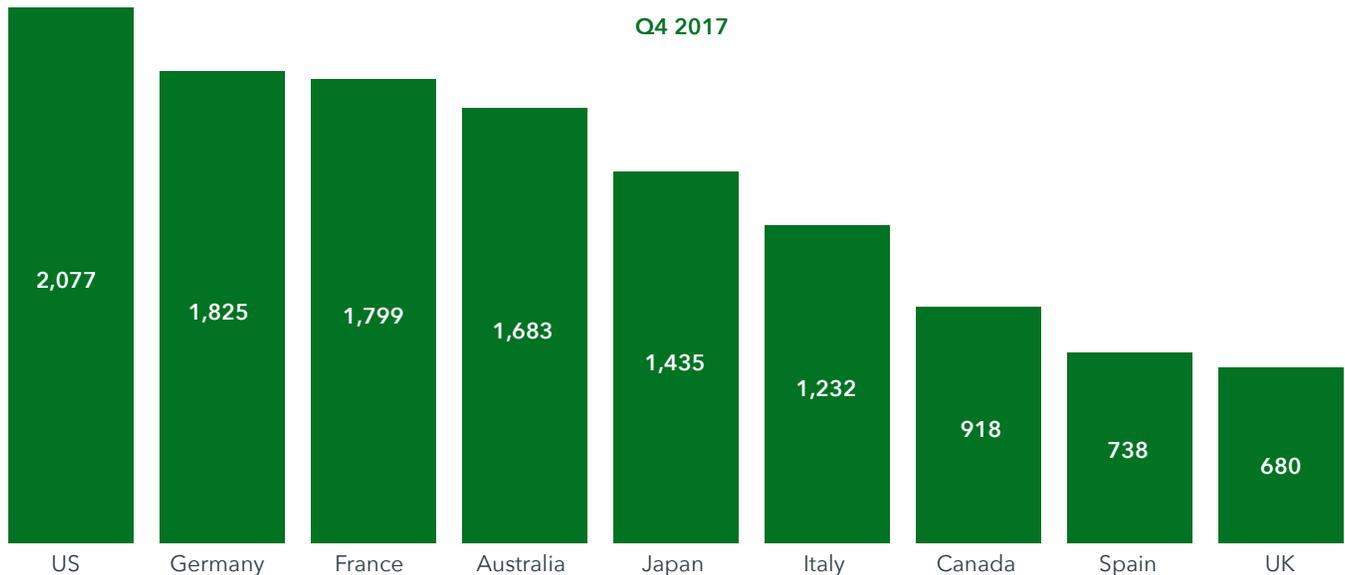
Source: IQVIA OneKey, Apr 2018

- The number of specialist oncologists per capita represents a potential limitation on patient treatment if patients face delays or constraints on their access to care.
- Constraints in access to care are unlikely to be a concern in major developed markets, where there are typically more than 50 oncologists per million people.
- There are some countries where high numbers of oncologists are present, as in Poland and Russia, but policymakers note significant issues in cancer care, however those issues are often related to the available budgets to support the most modern cancer care.
- In many pharmerging markets, there are very few oncologists, which reflects both budgetary limitations that make the specialty less lucrative or desirable for providers to pursue.
- While optimizing cancer care in each country is a complex balance of resources, delays in accessing treatment could result in worse outcomes particularly for those with advanced disease.

Chart notes: Oncologists were identified by related specialties, and in some countries by examining sub-specialties where oncology is not delineated distinctly. IQVIA OneKey validates provider specialty counts against government or medical association published statistics where published.

## The uptake of innovative medicines such as PD-1 and PD-L1 inhibitors varies three-fold across developed countries

Chart 21: Immuno-Oncology PD-1/PD-L1 Standard Units per Million of Population in Developed Markets



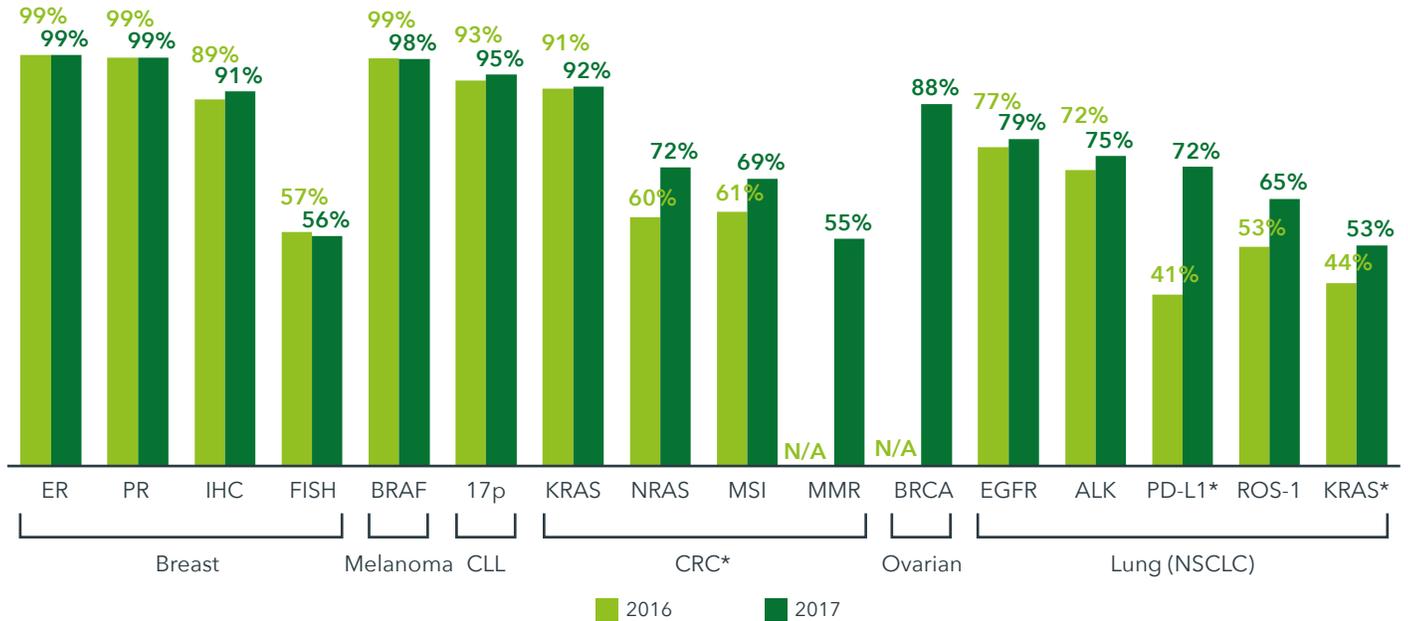
Source: IQVIA, MIDAS, Economist Intelligence Unit, Dec 2017

- The uptake of new immune-oncology PD-1 and PD-L1 inhibitors varies across countries, with use in the United Kingdom per million of population at one-third the level of the United States.
- Most I/O medicines were available in all developed countries for several years by the end of 2017, and variations in usage may be due to multiple factors including reimbursement, and variations in disease epidemiology for the approved uses.
- The extent to which clinical or reimbursement restrictions are placed on the use of these medicines in a country may be limiting their use.
- Countries that determine reimbursement and recommended use through health technology assessments, as in EU markets, generally have lower usage than the United States.

Chart notes: I/O drugs included were pembrolizumab, nivolumab, atezolizumab, avelumab and durvalumab.

# Use of predictive biomarker tests is increasing across tumor types, though it continues to be lower than guidelines recommend

Chart 22: Percent of Patients Tested for Biomarker by Cancer Type, 2016 and 2017



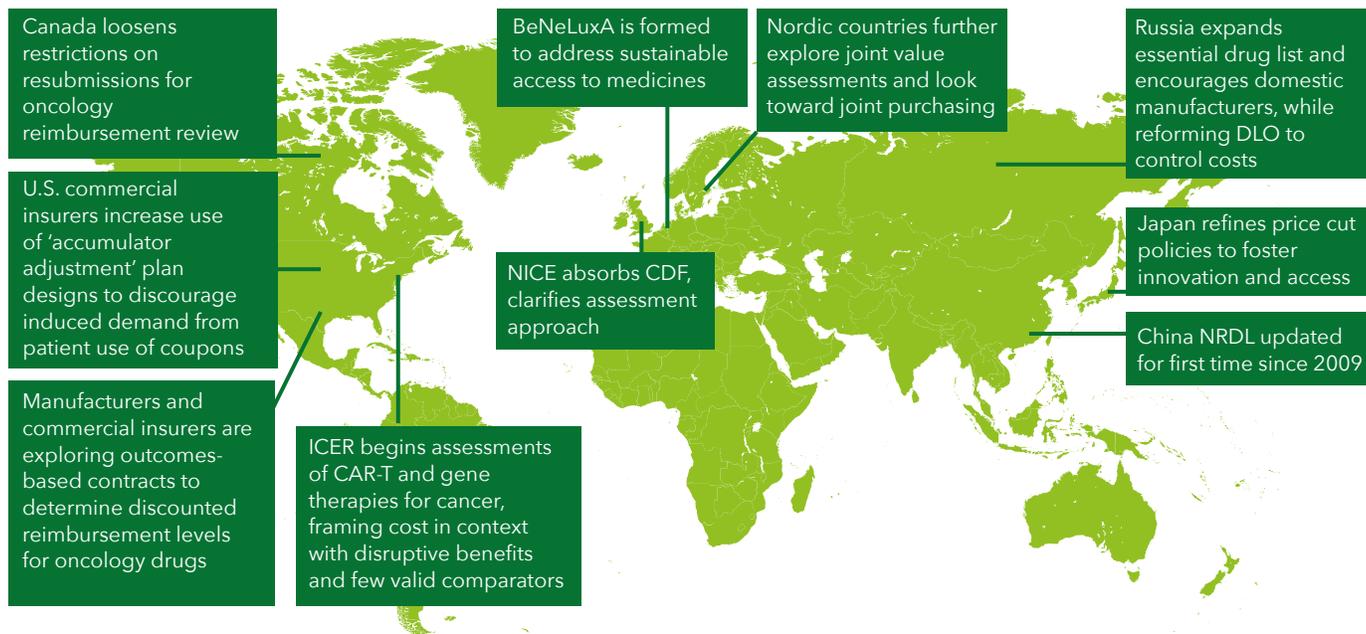
Source: IQVIA BrandImpact, IQVIA Institute, Apr 2018

- Surveyed oncologists note that the highest rates of biomarker testing in patients are for ER and PR breast cancers, BRAF mutations for melanomas and 17p mutations for chronic lymphocytic leukemia (CLL).
- The percentage of biomarker testing has increased since 2016, particularly in NSCLC.
- Guidelines recommend diagnostic testing of NSCLC patients with predictive biomarkers, in particular, EGFR and ALK. Survey results show that approximately 79% and 75% of patients in the survey received an EGFR biomarker test or ALK test, respectively, in 2017.
- Clinical practice guidelines for PD-L1 were revised in 2017 for NSCLC, which accounts for increased patient testing from 41% in 2016 to 72% in 2017.<sup>25</sup>
- Colorectal cancer (CRC) has seen an increase in biomarker testing corresponding to expanded approvals of the checkpoint inhibitors pembrolizumab and nivolumab in patients with tumors expressing high levels of microsatellite instability (MSI-H), or changes in one of the mismatch repair (MMR) genes.
- The use of the BRCA biomarker for ovarian cancer was also high in 2017, corresponding to the approvals of the poly (ADP ribose) polymerase (PARP) inhibitors olaparib, rucaparib, and niraparib in BRCA positive tumors.

Chart notes: Reported as a percentage of knowledgeable respondents; 435 physicians were surveyed in 2017 and 425 in 2016; \* denotes percentage of metastatic. Number of patients covered in the survey: Lung = 16,000–22,000; Breast = 12,534; Melanoma = 2,600–2,900; Colorectal = 27,000–29,000; CLL = 7,800–7,900; Ovarian = 5,800–6,500. PD-L1 = programmed cell death receptor and its ligand; KRAS = gene coding K-Ras protein; FISH = Fluorescence in situ hybridization includes testing for estrogen receptor and HER2 protein; ROS-1 = a tyrosine kinase inhibitor encoded by ROS1; NRAS = gene coding N-Ras protein; ALK = gene coding ALK receptor tyrosine kinase; EGFR = gene coding epidermal growth factor receptor protein; IHC = immunohistochemistry test includes testing for estrogen receptor and HER2; 17p = a deleterious mutation found in some leukemias; BRAF = gene coding B-Raf; PR and ER are progesterone and estrogen receptors, respectively. Survey results for MMR started in 2017; Survey results for MSI started in 2016. BRCA and MMR not applicable in 2016 – not surveyed.

# Payers enacted several new provisions in 2017 to modify their approach to purchasing and reimbursement

Chart 23: Selected Purchasing and Reimbursement Actions Globally



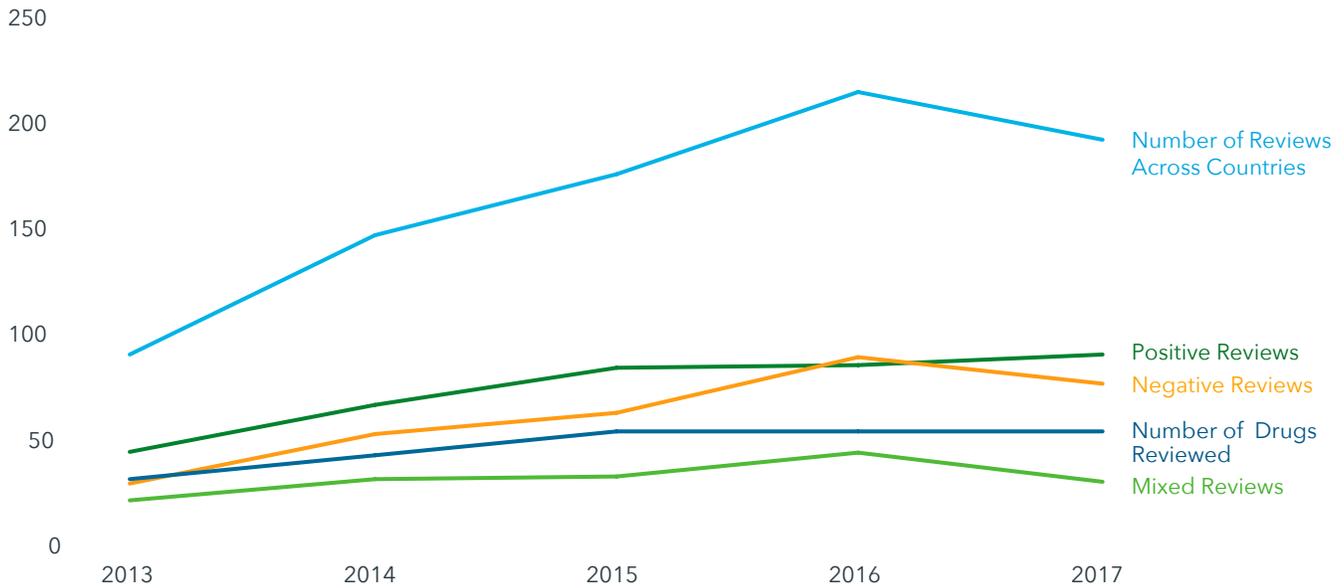
Source: IQVIA Institute, IQVIA PharmaQuery, Mar 2018

- Payers around the world took actions, in 2017, to address rising expenditure on oncology medicines through a range of new approaches to negotiate reimbursement levels with manufacturers.
- Most countries are addressing access to innovative medicines through some form of comparative effectiveness assessment or HTA.
- Many assessments enable negotiation of greater discounts based on a medicine's relative value.
- In most countries, savings achieved on medicines with lower value, through negotiated discounts, are a key way to support the incremental funding for higher-value innovative medicines. Another way payers address budget pressures is to capture savings from patent expiries of small molecules, or to reduce costs through the use of biosimilars.
- In many European markets, as well as Japan, increased generic utilization and aggressive uptake of biosimilars has created significant savings to enable greater spending on new innovative medicines.
- Savings in other therapy areas are also being balanced to reprioritize life-saving treatments in specialty, niche and orphan diseases, including many cancers.
- The wide availability and use of biosimilars in supportive care classes, such as erythropoietin alfa and filgrastim, represent important savings for payers, while the upcoming availability of biosimilars of rituximab, bevacizumab, and trastuzumab in Europe will generate significant savings by 2022.

Chart notes: ICER = Institute for Clinical and Economic Review; FDA = Food and Drug Administration; NICE = National Institute for Health and Care Excellence; CDF = Cancer Drugs Fund; NRDL = National Reimbursement Drug List; DLO = Dopolnitel'noe Lekarstvennoe Obespechenie, or the Programme for Supplementary Pharmaceutical Provision.

# More health technology assessments are being conducted per drug in oncology, while the results remain highly variable

Chart 24: Number of Health Technology Assessments Conducted in More than One Country and Summary Results



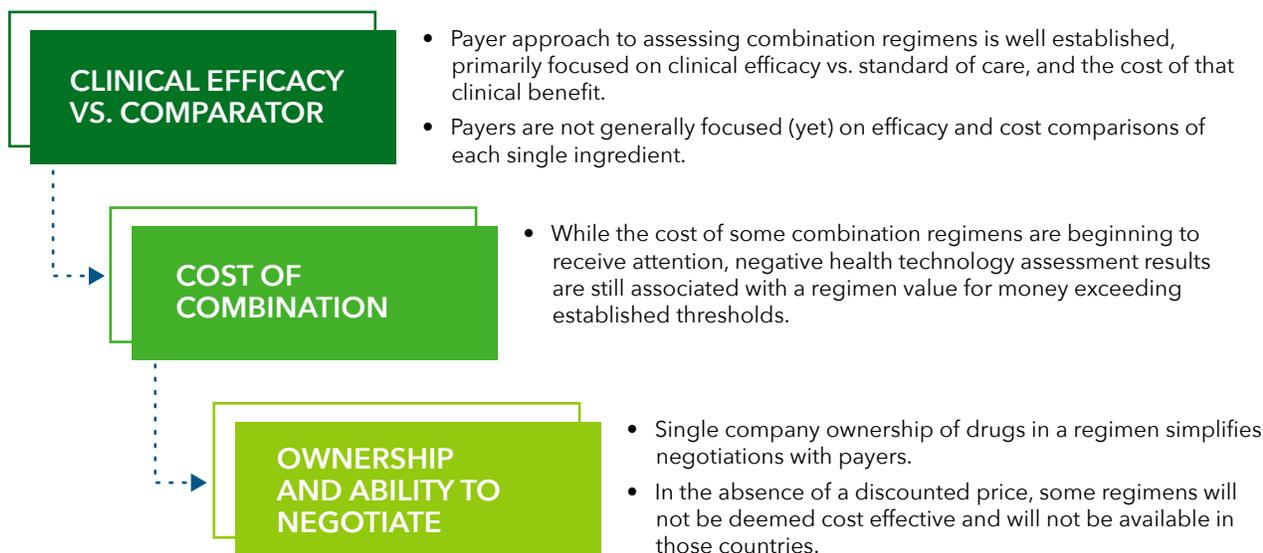
Source: IQVIA HTA Accelerator, Mar 2018

- For each oncology drug, four countries on average conduct health technology assessments, though the results of these assessments remain highly variable.
- In the 273 cases where more than one country reviewed the same medicine, two-thirds (604) of the 963 HTA reviews were positive or partly positive, but only 40 drugs had uniformly positive reviews (totaling 96 reviews), with the rest having at least one negative review.
- Only 17 drugs had all negative reviews across countries, for a total of 40 reviews.
- Countries have reached different HTA assessment decisions in 79% (216/273) of drugs, which reflects the disparate assessment methodologies and thresholds in use by various countries.
- In general, the HTA results for cancer drugs are more positive than those for other therapy areas, largely because of the clinical benefits, but this is offset by the influence of cost thresholds in many countries' HTA approaches.

Chart notes: Health technology assessments were counted only if assessments were conducted for a single drug across more than one country.

# Reimbursement for doublets in particular are triggering new approaches by payers

Chart 25: Reimbursement for Doublets

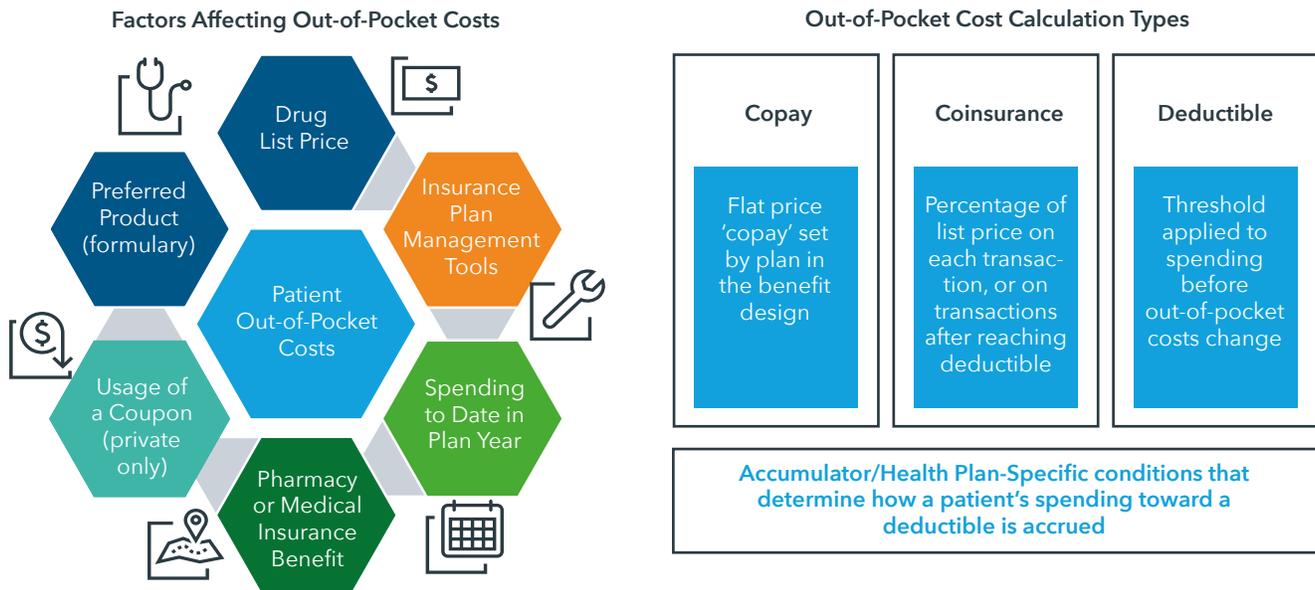


Source: IQVIA Real World and Analytics Solutions, Dec 2017

- As more is learned about the efficacy of immuno-oncology products, and more trials are completed demonstrating increased efficacy when two or even three medicines are used in combination, attention will eventually turn to the cost of such regimens.
- In most countries operating HTA, comparison to the standard of care is the primary mechanism by which the clinical value of an intervention is adjudicated.
- In the case of doublet or triplet combinations of I/O therapies, as they are becoming known, the comparison will only rarely be made against one of the single-ingredient drugs, as they are not yet the standard of care (SoC) in most tumors.
- In comparison to the SoC, the key element to understand the value for money of a combination is the clinical improvement, usually measured in cost per Quality Adjusted Life Years gained (QALY).
- To date, companies have been relatively willing to negotiate some discounts in return for the wider usage their medicines will receive. Only a few dozen combinations of novel targeted biologics are in wide use, and even fewer I/O doublets; these latter combinations will have the greatest impact for payers in the future.
- One significant challenge will be that most current and future I/O drugs that could be used together are owned by different companies and divided ownership complicates the payer’s negotiations.
- Few payers yet have a process in place to allocate benefit, and therefore negotiate with two or more parties simultaneously, and are left with the more blunt instruments of allowing access (or not).
- Concerns about the potential budget implications of doubling the cost of already expensive treatments are prompting governments and private insurers in the United States to look carefully at novel payment approaches including outcomes-based contracts.

# U.S. patients' final out-of-pocket costs vary significantly based on drug choice, manufacturer prices, and insurance plan design

Chart 26: Factors Influencing Patient Out-of-Pocket Costs for Cancer Medicines

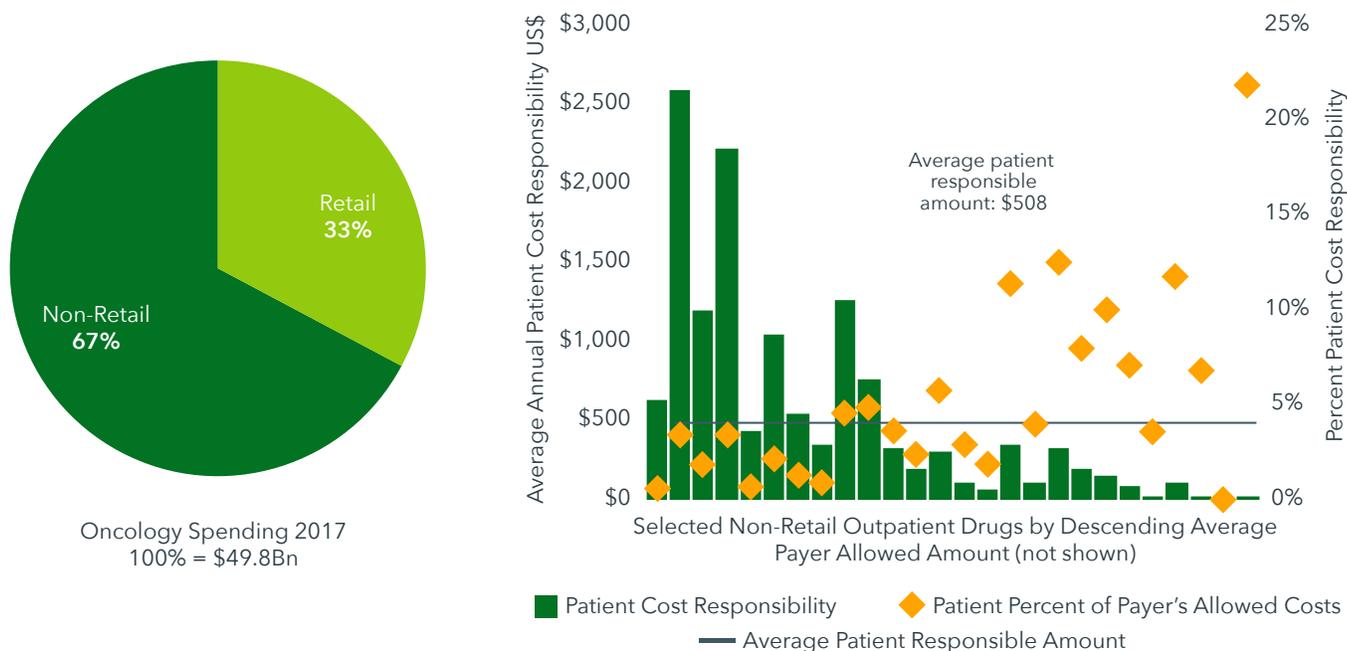


Source: IQVIA Institute, Apr 2018

- Costs for cancer treatments vary significantly for patients based on many factors including insurance type and provider decisions.
- The cost of a cancer diagnosis for a U.S. patient is driven by the type of insurance they have and the cost-sharing model it employs, with many privately insured patients having capped annual out-of-pocket costs.
- Patients with Medicaid are able to access cancer treatments that are covered by the Medicaid program in their state, which may not include some of the newest treatments, but which generally do not pass out-of-pocket costs on to patients.
- Medicare Part B includes coverage for medical services including drug infusions, but often comes with an uncapped 20% coinsurance rate unless patients purchase additional insurance to offset those out-of-pocket costs.
- If a drug is able to be dispensed to a patient at a pharmacy, as oral treatments are, Medicare Part D coverage would typically calculate a patient's cost based on their spending-to-date under the cost-sharing model often known as the 'donut-hole'.
- Privately insured patients may be able to offset some of their cost for pharmacy-dispensed drugs through manufacturer coupons, but plans with 'accumulator adjustment' provisions prevent those coupons from counting toward a patient's deductible, and coupons are illegal for those in government insurance plans.
- These complex and interactive variables determine the cost of a cancer drug for a patient and could vary for patients in the same plan with the same treatment based on their choice of provider, the pharmacy they use, or ongoing treatments for other chronic conditions.

# Oncology outpatient drugs can carry significant costs for payers, while patient costs average about \$500 annually

Chart 27: Annual Outpatient Oncology Costs for Selected Drugs by Patient Cost Responsibility and Percent of Total

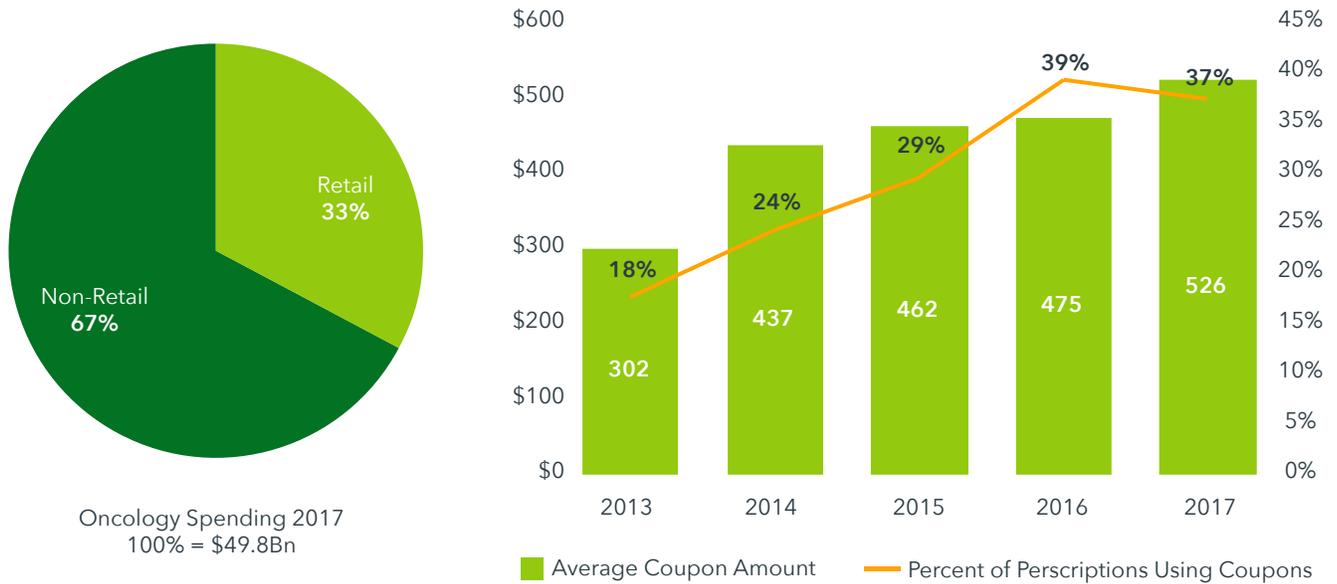


Source: IQVIA PharMetrics+ Dec 2017; MIDAS, Dec 2017

- Cancer medicines administered in clinics and hospitals account for two-thirds of spending, and are typically reimbursed through a patient’s medical insurance benefit.
- Most cancer treatments are administered on an outpatient basis, if the patient’s health status allows it, and while outpatient drugs can carry high costs for payers, the patient responsibility averages less than \$500 per year for commercial plans; still high enough to pressure some patients to delay or forgo therapy.
- For a segment of the most expensive outpatient cancer treatments, where some have annual costs in excess of \$100,000, patient responsibility averages less than 5% of total costs.
- For patients with a deductible, their exposure to cost can be much greater than the average other patients face, but as most deductible plans include capped out-of-pocket costs in the year, deductible plans can result in lower cost exposure in some cases.
- If a patient has a combined medical and drug deductible, their maximum costs could already have been reached with diagnostics and surgery for their tumor before their drug therapy has even begun.
- Out-of-pocket costs can represent a significant burden for some patients in the United States, but the exposure to cost is not uniform, and on average even though the drugs are high cost, the patient exposure is a small proportion of those costs.

# Oral oncology drugs can have significant costs for patients, and nearly 40% are using coupons to offset an average \$526 a month

Chart 28: Monthly Oncology Cost Reduction for Retail Pharmacy Claims Using Coupons and Percent Usage



Source: IQVIA, Formulary Impact Analyzer, Mar 2018; MIDAS, Dec 2017

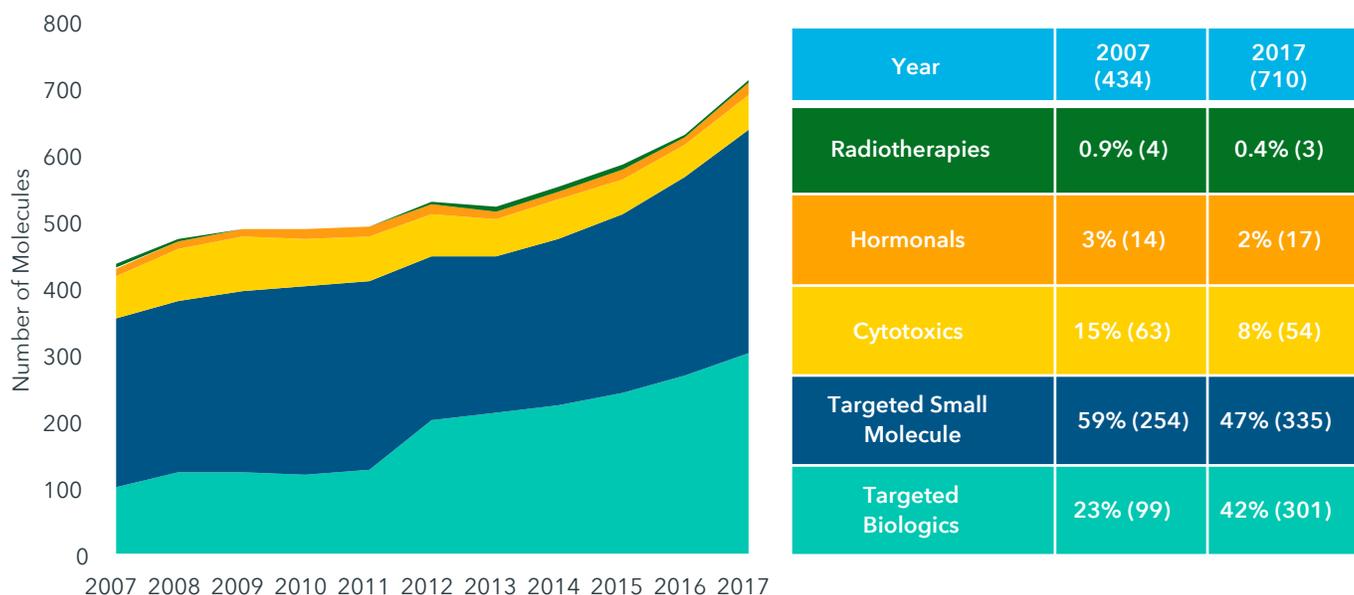
- Cancer medicines dispensed to patients in pharmacies include newer oral treatments, as well as older treatments to block hormonally activated tumors, and represent one-third of overall cancer spending in the United States.
- While some of these oral cancer therapies are generic and relatively inexpensive, some carry very high costs, which patients with high-deductible insurance plans or coinsurance cost-sharing models could face.
- For some of the most expensive oral cancer treatments, they could face costs of hundreds or thousands of dollars per prescription.
- For patients with commercial insurance receiving oral cancer medicines from pharmacies, coupons from manufacturers are dramatically reducing patient cost exposure, with 37% of prescriptions using a coupon with an average cost reduction of \$526.

## Pipeline of therapeutic innovation prospects

- The industry's pipeline reached an historic high level of more than 700 molecules in late-stage development in 2017, up over 60% from a decade ago, and with almost 90% of the therapies being targeted treatments.
- Trials using biomarkers to stratify patients susceptible to response made up 34% of oncology trials in 2017.
- The pipeline of immunotherapy drugs is particularly active and includes almost 300 molecules with 60 separate mechanisms being evaluated in Phase I or Phase II clinical trials.
- These immunotherapy trials are being conducted across 27 different tumor types, indicating the broad-based application of this new approach to cancer treatment.
- While many efforts are in place to accelerate the time taken to bring a new cancer medicine to patients, the 2017 new drug approvals had a median time since patent filing of 14 years, slightly faster than in 2013.
- In Japan, government initiatives over the past decade have roughly halved the average development times for new molecules and regulatory approval times, contributing to just over half of the New Active Substances launched globally from 2012 to 2016 being approved within four years of their global launch.
- Almost 700 companies or organizations have one or more oncology drugs in late-stage development, representing a remarkably diverse set of entities pursuing advances in this area and 14 of the world's largest pharmaceutical companies have at least one-third of their late-stage R&D activity focused on oncology.
- Clinical trial success rates for Phase I and III have reached 66% and 73%, respectively, in 2016, while Phase II trials - including those that are combined Phase I and Phase II - remain at about 30%.
- Across all trials and phases, the average trial duration has declined over the past five years, and the average number of patients per trial is lower in 2017 than in 2013 for Phase II and Phase III trials.
- The upper quartile of patient enrollment in clinical trials has increased from 58 to 75 over the past five years for Phase I trials, but declined for Phase II and Phase III trials.
- Patient enrollment rates - measured as average patients per site per month - have almost doubled since 2012 yet remain low at an average of 0.38 patients per site per month across all Phase I-III trials, and even lower for trials enrolling patients with biomarker stratification.

# The pipeline of new medicines in late phase development exceeded 700 molecules, an increase of over 60% since 2007

Chart 29: The Pipeline of Late Phase Oncology Molecules, 2007-2017



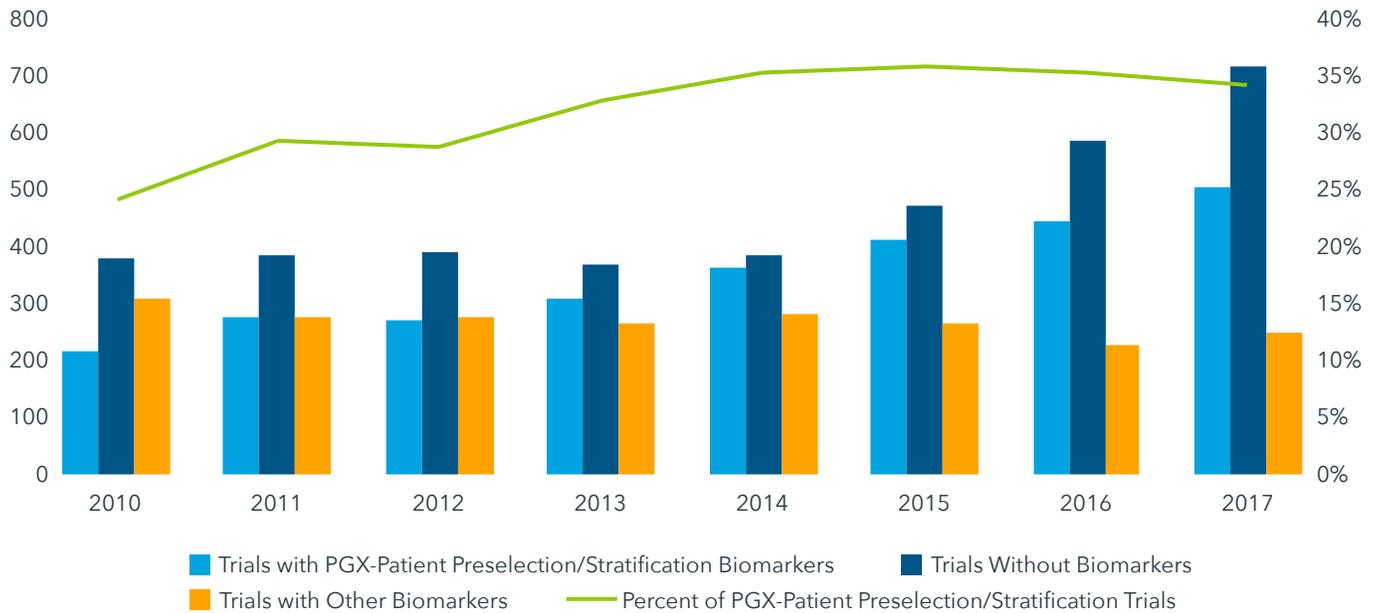
Source: IQVIA, ARK R&D Intelligence, Dec 2017; IQVIA Institute, Mar 2018

- Over 90% of pipeline oncology treatments are targeted therapies including small molecules and biologics.
- Targeted biologics began to increase in late phase development starting in 2012, when a range of immunotherapies began to emerge from pre-clinical and Phase I trials into Phase II and later trials.
- Increasingly breakthrough therapies are being identified earlier, and some are being approved based on a single combined Phase I/II trial.
- The increasing numbers of medicines in the pipeline is particularly notable because of the range of mechanisms being explored, the numbers of companies involved and the rate at which the research is progressing.
- In addition to the distinct molecules in research, many oncologics are being studied for multiple tumor targets, and in combination with other drugs in multiple regimens.
- Very few recent approvals have come from older types of mechanisms such as systemic cytotoxic chemotherapies, hormonal treatments, or radiotherapy drugs, but some of these continue to be researched.

Chart notes: Late phase pipeline includes trials in Phase II or higher for the most advanced indication. Phase I/II trials are included as Phase II.

# Trials using biomarkers to stratify patients susceptible to response made up 34% of oncology trials in 2017

Chart 30: Number and Percent of Oncology Trials by Biomarker Type, Phase I-III, 2010–2017



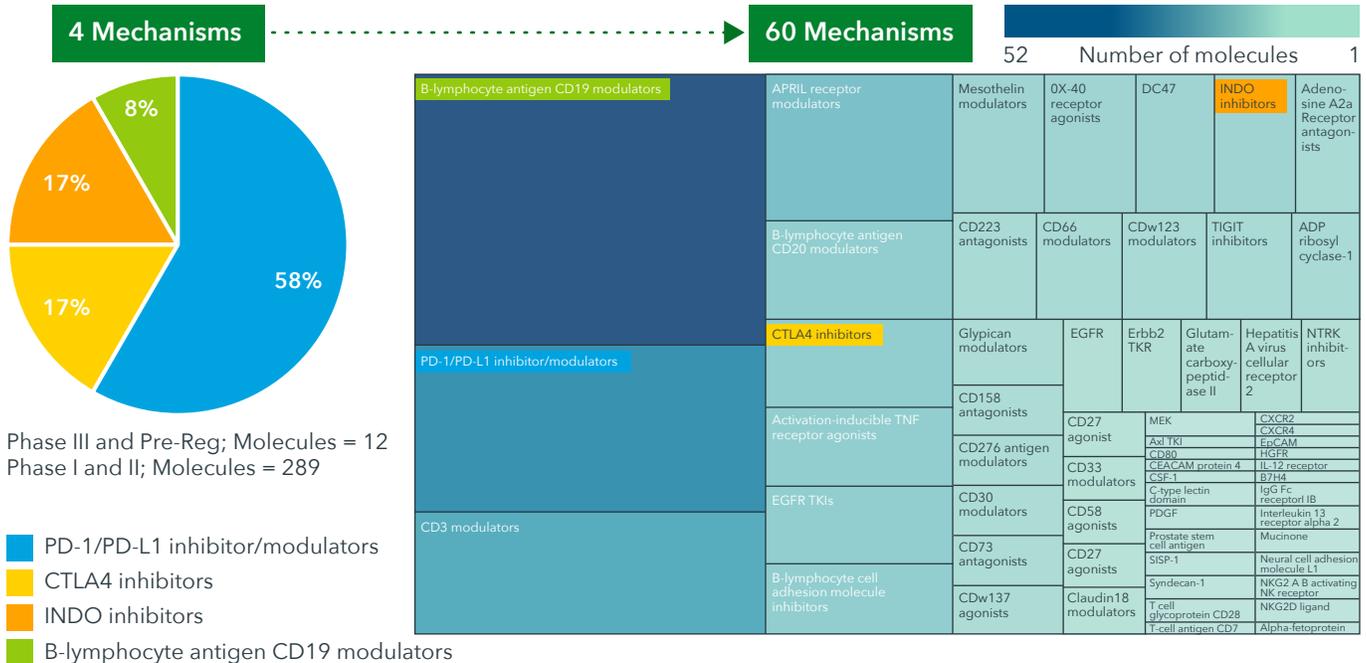
Source: Trialtrove, Pharma Intelligence, Apr 2018; IQVIA Institute, Apr 2018

- The total number of biomarker trials (including both trials with PGX and Other Biomarkers) was 754 in 2017, up from 672 in 2016, however, overall these account for a lower percentage of trials: 45% in 2017, as compared with 47% in 2016.
- The decline in the percentage of biomarker trials, during a time when trial numbers are increasing, may reflect a large influx of checkpoint inhibitor trials that include unselected patients due to the lack of data to indicate whether efficacy is related to any biomarker.
- The number of trials tagged as having pharmacogenomic (PGX) patient preselection/stratification, i.e., incorporating pharmacogenomic and/or pharmacogenetic analysis, has increased since 2010.
- These trials included the use of genomic biomarkers for patient selection or stratification, and the selection of patients for a trial (or a cohort in a trial) based on shared molecular profiling/genetic marking, and most tightly tie to trends in precision medicine trials.
- The percentage of trials tagged as PGX-patient preselection/stratification grew from 24% in 2010 to 34% in 2017, as trials are increasingly pre-selecting patients to be susceptible to a particular drug effect.

Chart notes: Citeline’s Trialtrove’s dataset was used to create a year over year analysis for the number of biomarkers in oncology trials. Biomarker trials were identified using the following trial tags: biomarker/efficacy, biomarker/toxicity, PGX-biomarker identification/evaluation, PGX-pathogen, PGX-patient preselection/stratification. Trials were industry only and interventional. Terminated and planned trials were excluded. Trials with healthy volunteers were excluded.

# Next-generation immunotherapies in development include 60 mechanisms of action

Chart 31: Immunotherapy Pipeline by Phase and Mechanisms of Action



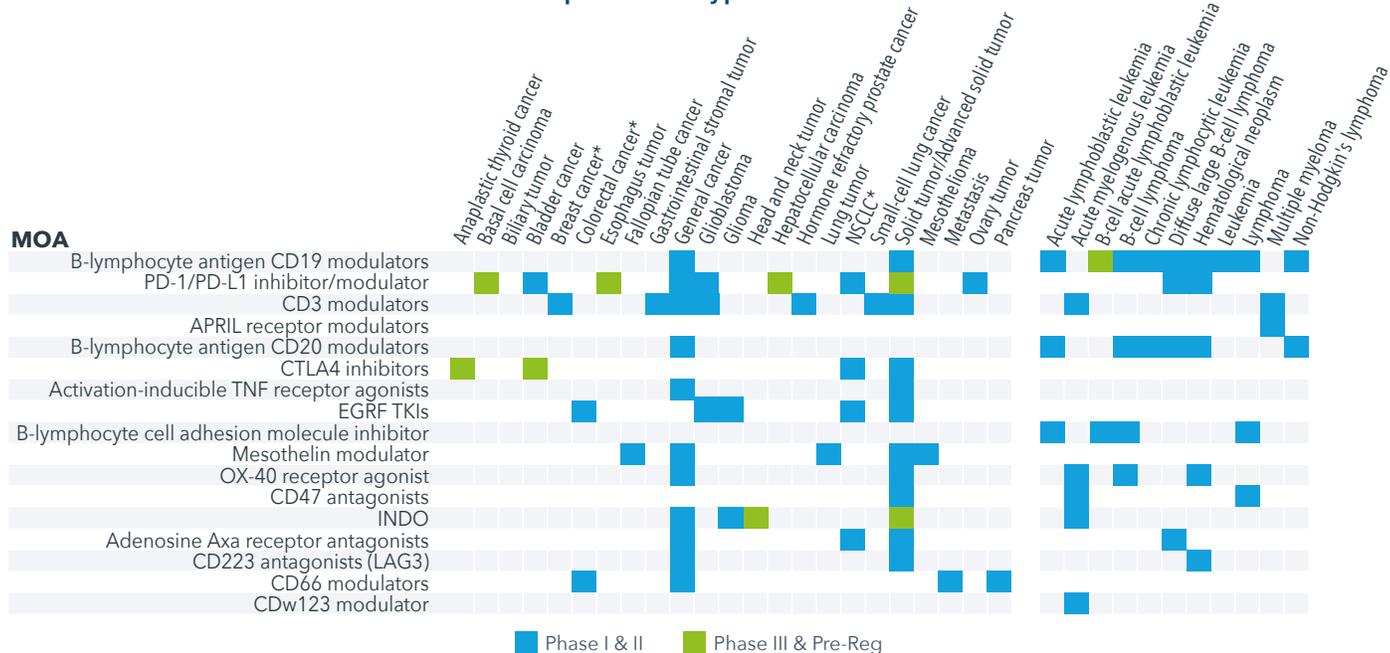
Source: Clarivate Analytics Cortellis, Apr 2018; IQVIA Institute, Apr 2018

- Over 300 immuno-oncology therapies are in development with their highest status of development in phases I, II, III or pre-registration. Therapies were identified with a primary mechanism of action, although many molecules combined mechanisms.
- Although the identified late-stage pipeline contains only four mechanisms for immuno-oncology, the early stage pipeline contains 60 mechanisms.
- The most popular mechanisms such as anti-CTLA4, anti-PD-1, anti-PD-L1 and CD19 modulators (e.g., the current target of approved CAR T-cell therapies) made up a significant portion of emerging therapies. Combined, anti-PD-1, anti-PD-L1 and CD19 modulators made up almost a third of Phase I and II trials.
- CD3 modulators (such as the already launched CD19/CD3-targeted bispecific antibody therapy, blinatumomab) made up 8% of Phase I and II trials.
- The pipeline also includes next-generation checkpoint inhibitors, such as anti-CD223 (LAG-3) therapies.
- Indoleamine-pyrrole-2,3-dioxygenase (INDO/IDO) inhibitors made up 17% of Phase III/Pre-registration trials and about 2% of Phase I and Phase II trials. These therapies, though initially promising, have recently demonstrated failures in late-stage trials.

Chart notes: Data query included immuno-oncology therapies sorted by highest status. Diagnostic molecules were not included. Sponsors include industry and non-industry. For molecules with multiple mechanisms, the first listed mechanism was chosen. PD-1 = Programmed cell death protein 1; PD-L1 = Programmed death-ligand 1; INDO = Indoleamine-pyrrole-2,3-dioxygenase inhibitor; CTLA4 = cytotoxic T-lymphocyte-associated protein 4; APRIL = A proliferation-inducing ligand; TKIs = tyrosine kinase inhibitors; EGFR = Epidermal growth factor receptor; TIGIT = T-cell immunoreceptor with Ig and ITIM domains.

# A wide array of immuno-oncology drugs, some with novel mechanisms, are in development across multiple tumor types

Chart 32: Select Mechanisms of Action for Multiple Tumor Types



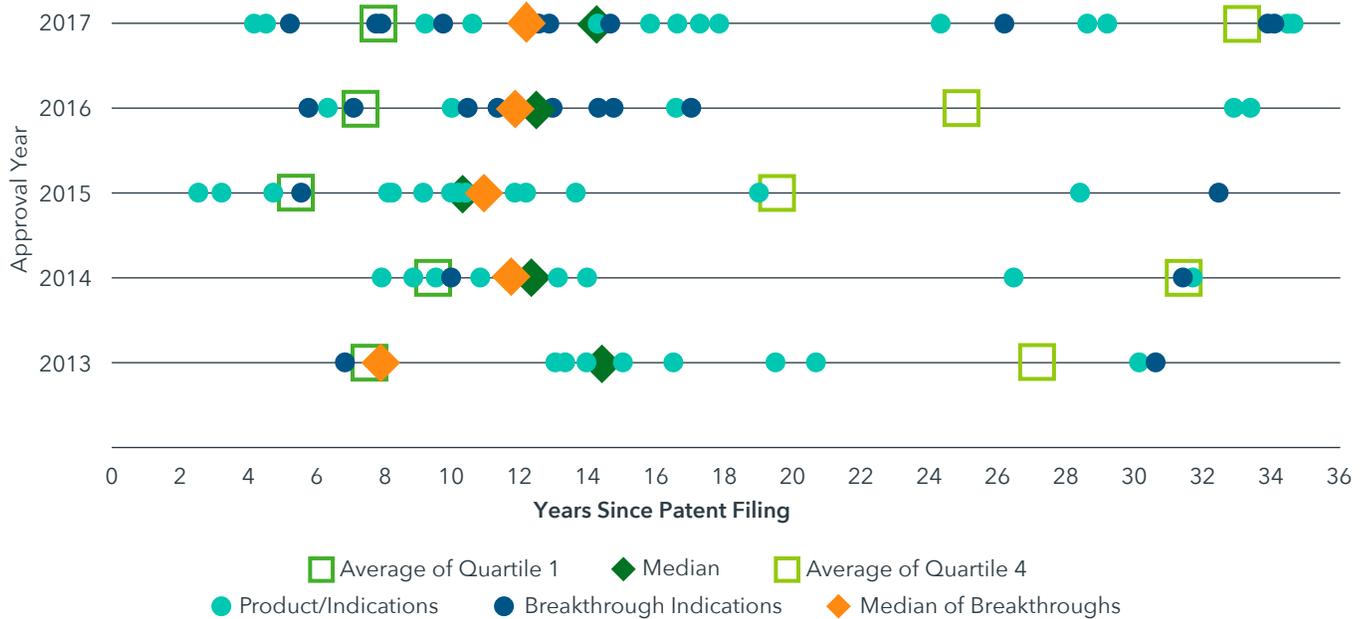
Source: Clarivate Analytics Cortellis, Apr 2018; IQVIA Institute, Apr 2018

- The immuno-oncology pipeline not only has a diverse number of mechanisms, but also boasts a significant number of indications in development.
- CD19 modulators and PD-1 and PD-L1 inhibitors cover the widest swath of diseases, together targeting over 18 cancer types.
- From 2013 to 2017, there have been 15 breakthrough oncology therapies that have yet to launch, although 18 therapies were designated with Fast Track status in 2017.
- Immuno-oncology combination therapies, such as nivolumab plus ipilimumab, are also common and target multiple diseases. In 2017, there were 145 trials tagged as immunotherapy + immunotherapy combination therapies.
- Notably some immuno-oncology mechanisms are demonstrating benefit across solid tumors and leukemias and lymphomas, which has generally been rare in earlier generations of oncologic treatments.

Chart notes: Data query included immuno-oncology therapies sorted by highest status. Diagnostic molecules were not included. Sponsors include industry and non-industry. For molecules with multiple mechanisms and disease, the first listed mechanism or disease was chosen. PD-1 = Programmed cell death protein 1; PD-L1 = Programmed death-ligand 1; INDO = Indoleamine-pyrrole-2,3-dioxygenase inhibitor; CTLA4 = cytotoxic T-lymphocyte-associated protein 4; APRIL = A proliferation-inducing ligand; TKIs = tyrosine kinase inhibitors; EGFR = Epidermal growth factor receptor; \* includes metastatic.

# Efforts to accelerate the time to bring a new cancer medicine to patients have had some success

Chart 33: Median Time from Patent Filing to Approval in the United States



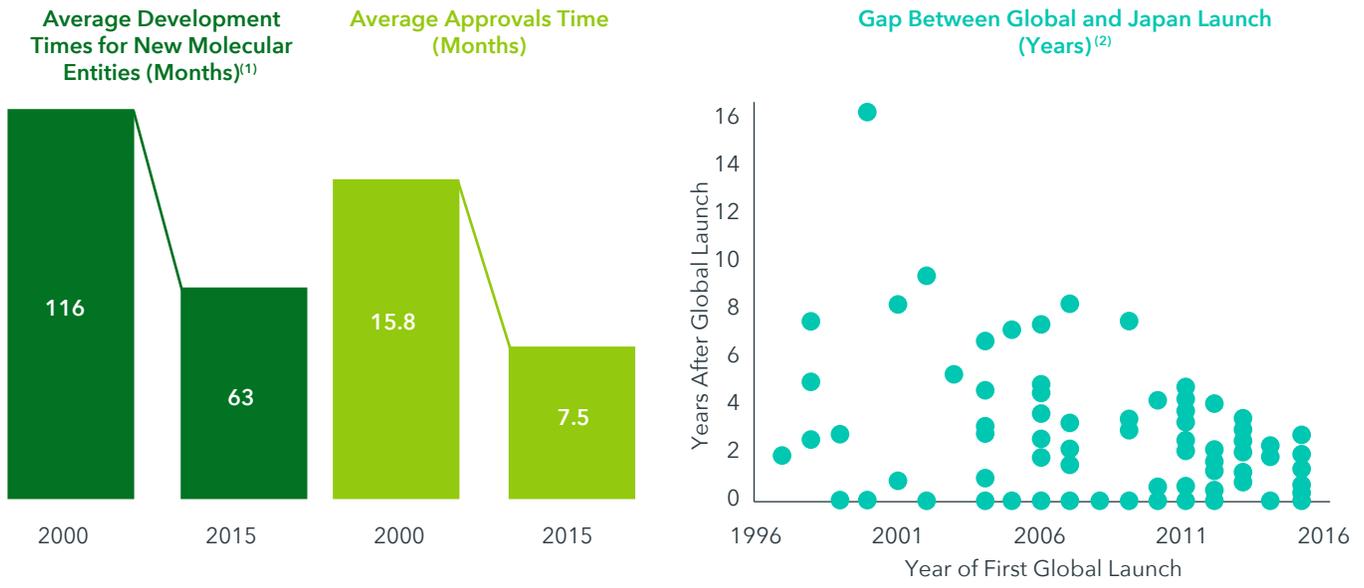
Source: IQVIA, ARK R&D Intelligence, Feb 2018; IQVIA, ARK Patent Intelligence, Mar 2018; Drugs@FDA, Feb 2018; IQVIA Institute, Mar 2018

- While many efforts are in place to accelerate the time it takes to bring a new cancer medicine to patients, 2017 new drug approvals had a median time since patent filing of 14.25 years, only slightly faster than the 14.38 years in 2013, and slower than the prior three years.
- Breakthrough Therapy designations are one mechanism to speed drug availability, but since the introduction of the designation in 2013, many of the drugs were already in late phase trials and were arguably not substantially accelerated in their approval.
- These Breakthrough Therapy designations were granted, on average, 11 months before approval in 2014, 16 months in 2015, 18 months in 2016, and 17 months in 2017, with the more recent years representing a shift to the intended acceleration of approvals.
- If breakthrough status were granted earlier in development, applicants and the FDA could have options to adapt trial design, and potentially approve some medicines based on very strong early clinical data, which occurred for 10 of the 14 new active substances launched in 2017.
- Notably, none of the approvals in less than five years from patent filing were breakthrough drugs, but median time to approval for breakthrough drugs is on average 1.86 years faster than overall oncology drugs.

Chart notes: First patent filing for a medicine compared to FDA approval for a specific indication, some medicines have multiple indications included in the analysis.

# Government initiatives in Japan over the past decade are driving earlier launch timelines and faster patient access to key therapies

Chart 34: Japan Oncology Development and Approval Times and Gap Between Global and Japan Launch



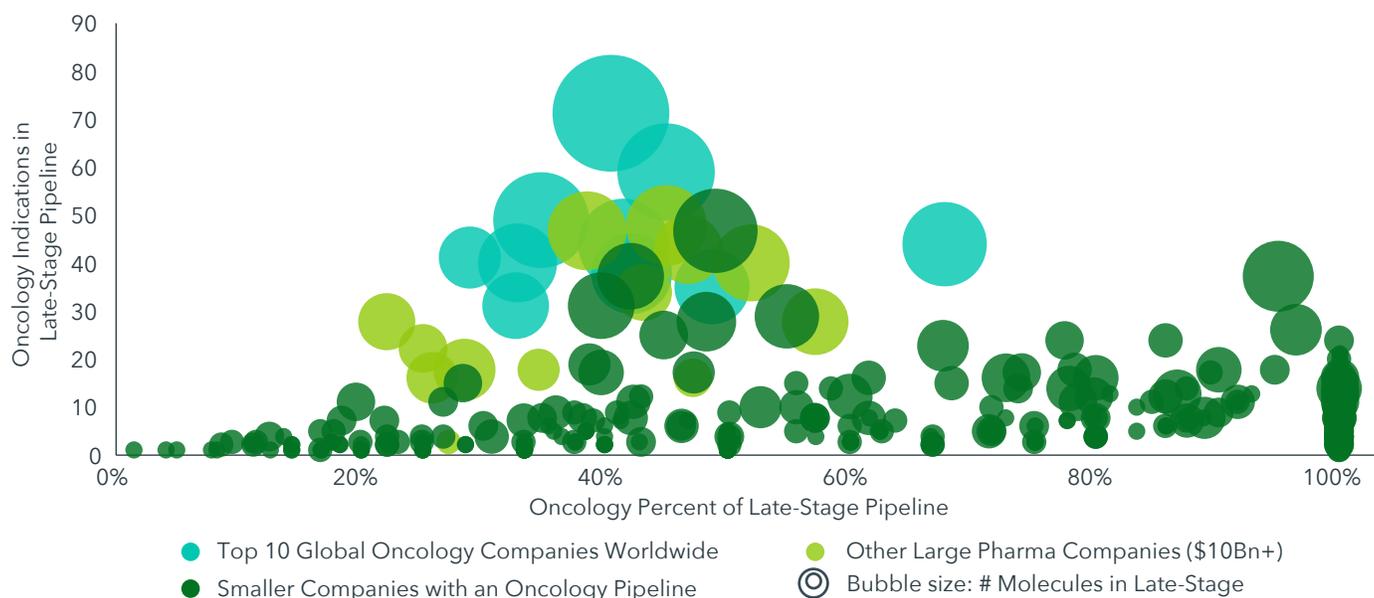
Source: IQVIA Solutions Japan. Japan Thought Leadership Team analysis

- In Japan, government initiatives over the past decade have roughly halved both the average development times for new molecules and regulatory approval times, contributing to more drugs being approved in Japan within four years of their global launch.
- Japanese regulators prefer clinical trials to be conducted in a relevant population, but development times have dropped nearly in half, as have review times for submitted applications.
- Of the 55 global NAS launched from 2012 to 2016, 28 (51%) have launched in Japan through the end of 2017, compared to 38% (10 of 26) from 2007 to 2012, and 29% (11 of 28) from 2002 to 2006.
- While Japan still lags in terms of availability of NAS compared to other countries, just over half of the NAS launched globally from 2012–2016 are available in Japan, as of 2017, with all of those taking less than four years after global launch to reach the market.
- For oncology products reaching the Japanese market, the lag from global launches has dropped from 49 months from 1997–2006 to 26 months from 2007–2016.
- More oncology medicines are reaching the Japanese market earlier, and older global launches are also reaching patients to a greater degree than previously.

Chart notes: (1) Development time is the period from initial protocol application to the approval date. (2) Based on single-molecule brand launches excluding launches if Japan was first country of launch.

## Over 700 companies are active in late-stage oncology R&D and 14 large companies have at least one-third of their focus on oncology

Chart 35: Company Late-Stage Pipelines, Number of Oncology Indications and Oncology Percent of Pipeline



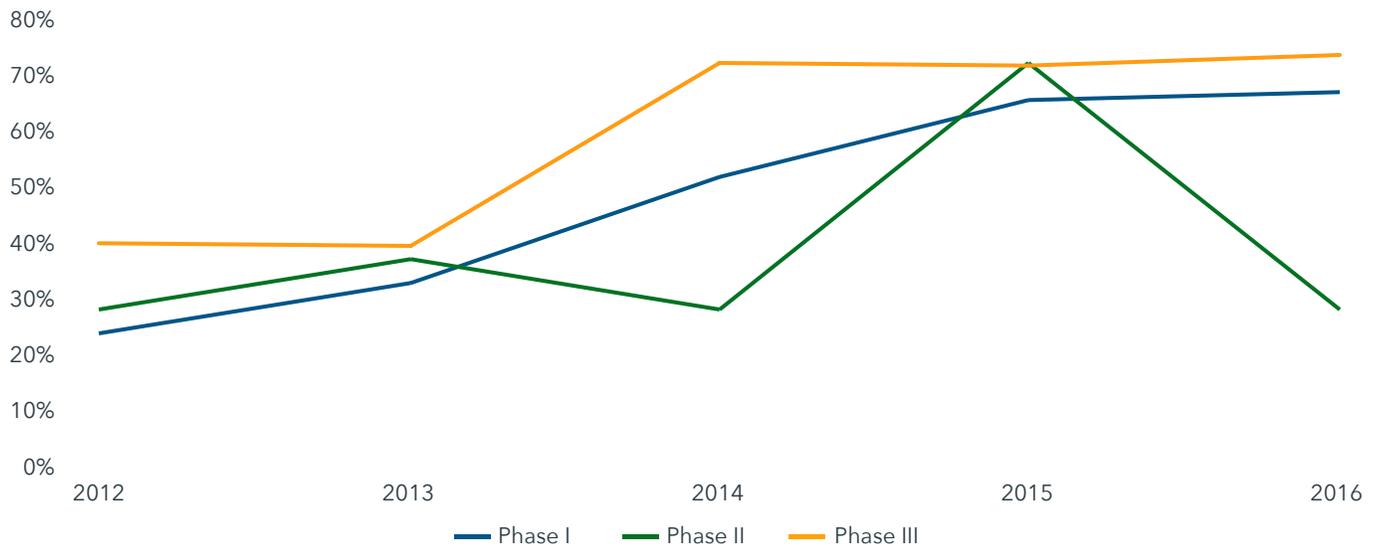
Source: IQVIA R&D Intelligence, Dec 2017; IQVIA Institute, Apr 2018

- Of the 710 compounds in late-stage development, many involve multiple companies participating in licensing, partnering, or co-development arrangements.
- Over 700 companies or organizations have one or more oncology drugs in late-stage development. This represents a remarkably diverse set of entities from academic centers and companies with a single drug candidate, to large companies with wide portfolios encompassing a range of tumors and treatments.
- The group of large companies with total corporate sales above \$10 billion, have relatively similar levels of focus in oncology, averaging just under 40% of their pipeline in oncology.
- The companies with the greatest focus in oncology have, on average, 18 molecules in late-stage development, with an average of two indications for each drug.
- Many smaller companies with a sole focus in oncology could eventually see their compounds or companies acquired by larger firms, but an increasing number of them are attempting to commercialize their innovations independently.
- The often niche character of cancer therapies is increasingly enabling smaller companies to market their medicines without requiring the partnership of larger established pharmaceutical companies.
- Of the 455 smaller companies with more than 90% of their pipeline in oncology, they are involved in 1,692 product-indications, which represents 43% of the overall cancer pipeline.

Chart notes: Companies depicted are those with active late-stage oncology programs.

## The rate of successful phase transitions has improved over time for Phase I and III, reaching 66% and 73% respectively in 2016

Chart 36: Oncology Trial Phase Transition Success Rate by Phase, 2012–2016



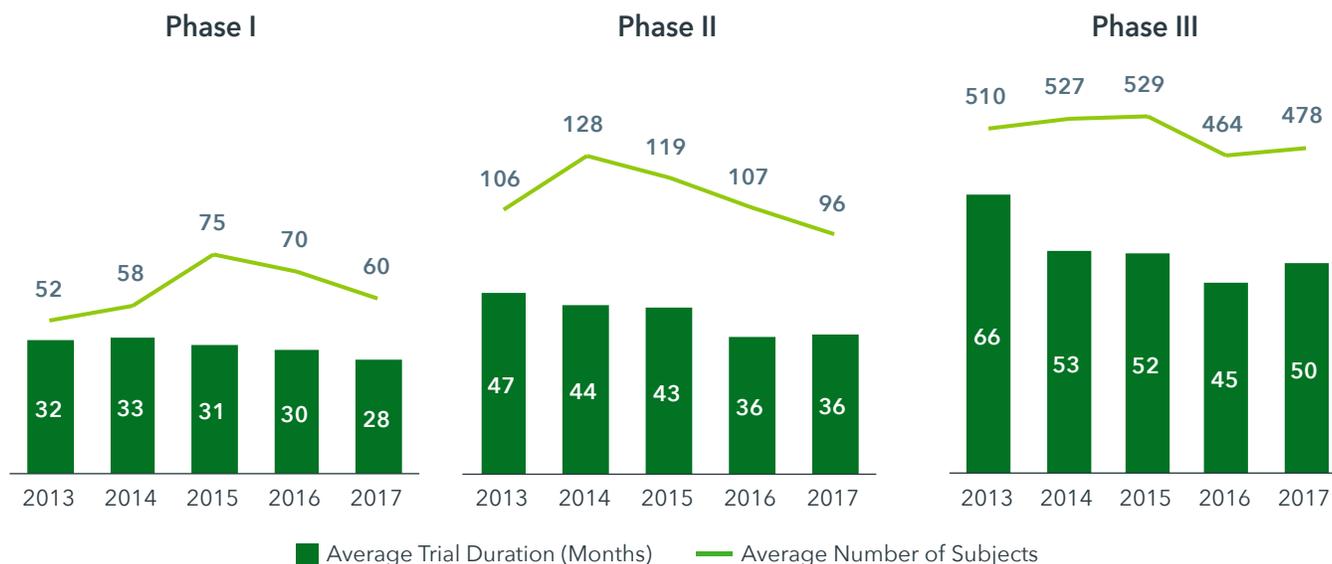
Source: IQVIA ARK R&D Intelligence, IQVIA Institute, Apr 2018

- Overall, the rate of successful phase transitions for Phase I trials and for Phase III trials has increased since 2012. In 2012, Phase I oncology trials had a 23% chance of success and increased to a 66% chance of success in 2016. Similarly, Phase III phase transitions have become more successful, with the rate increasing from almost 40% in 2012 to 73% in 2016.
- Phase II trials - including those that are combined Phase I and Phase II - remain at about a 30% success rate.
- The expectation is that as oncology trials have become more reliant on Phase I trials to test for efficacy and dosage in addition to safety, this has had a downstream, positive effect on later-stage Phase transition rates.
- Phase II trials, including combined Phase I/II trials, have more variable rates of success, partly due to new Breakthrough Therapy designations that accelerated a number of trials in 2015, some of which have since been approved earlier than they otherwise would have.

Chart notes: Phase II includes phases I/II, II, IIa, IIb. Phase III includes Phase II/III and III. Success rate based on 1,727 records. A successful outcome to a trial is defined as the commencement of a subsequent phase, or regulatory approval. Rates of successful phase shifts were calculated by dividing the number of phase advances by the total number of status changes including those which were discontinued, suspended, withdrawn or have had no active update to the records for more than three years. Trials were industry sponsored and interventional. Diagnostics, behavioral therapies, supplements, devices, and medical procedures were excluded.

## As late-stage trial duration has declined, so has the average number of enrolled patients

Chart 37: Mean Trial Duration and Patient Enrollment Shifts in Phase I and Phase III Trials (2013–2017)



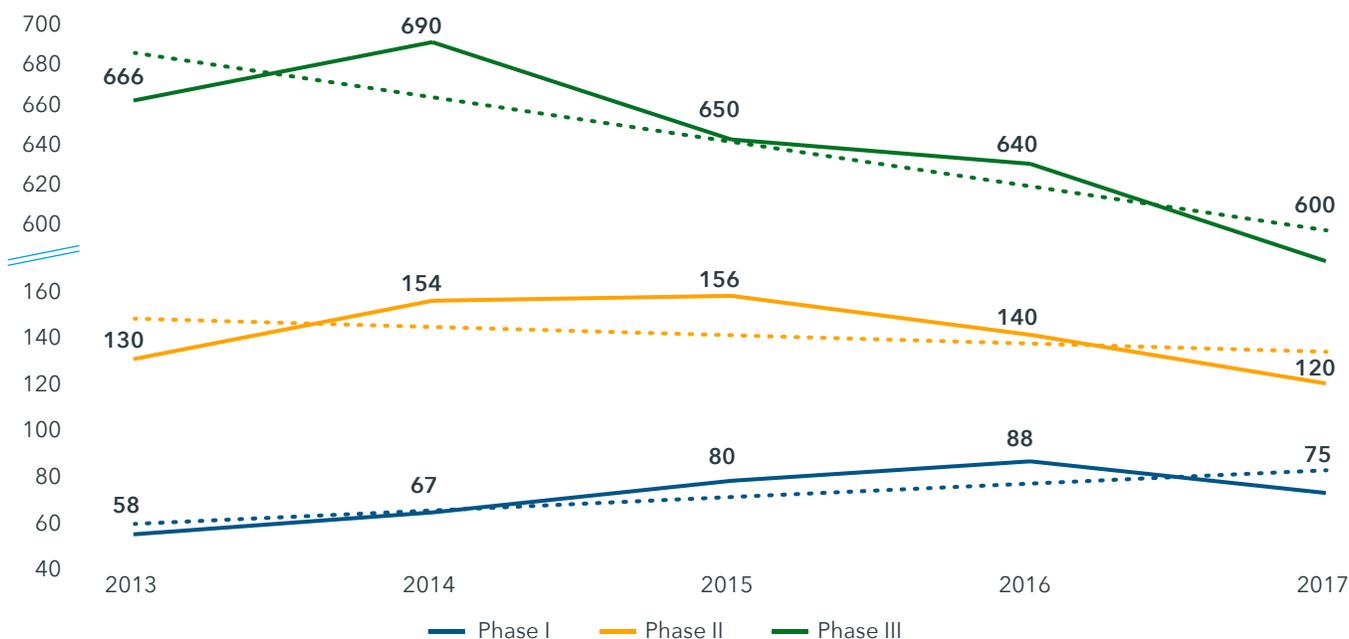
Source: Clarivate Analytics Cortellis, Jan 2018; IQVIA Institute, Apr 2018

- The past five years have seen a modest decline in the number of enrolled patients in Phase II and Phase III trials. The average number of subjects in Phase II trials has declined from a high of 128 in 2014 to 96 in 2017; similarly, in Phase III trials this number has declined from 510 in 2013 to 478 in 2017.
- That late-stage trials are including fewer patients speaks to the fact that with predictive biomarkers pre-selecting patients for response, the total number of patients needed to demonstrate efficacy is lower. In addition, the oncology pipeline is increasingly targeting more rare cancer types that may have a smaller patient pool, and more generally, oncology drugs are increasingly receiving accelerated approval, and trials for these drugs typically enroll a smaller number of patients.<sup>26</sup>
- At the same time, Phase I oncology trials have increased the number of patients that are enrolled. The growing number of targeted therapies in oncology and the increasing availability of predictive biomarkers is changing the clinical development pathway for Phase I oncology trials. Phase I trials have a greater focus on efficacy and an increased emphasis on pre-screening patients using pharmacogenomic testing for potential trial inclusion.<sup>27</sup>

Chart notes: Average reported is the mean. Phase II includes phases I/II, II, IIa, IIb. Phase III includes Phase II/III and III. Data for duration includes 3,341 trials; data for number of subjects includes 3,896 trials. Terminated and withdrawn trials were excluded from the analysis. Trials were industry sponsored and interventional. Diagnostics, behavioral therapies, supplements, devices, and medical procedures were excluded.

## Among the largest trials, patient enrollment counts declined over the past 5 years, except in Phase I trials

Chart 38: Upper Quartile Patient Enrollment per Phase 2013–2017



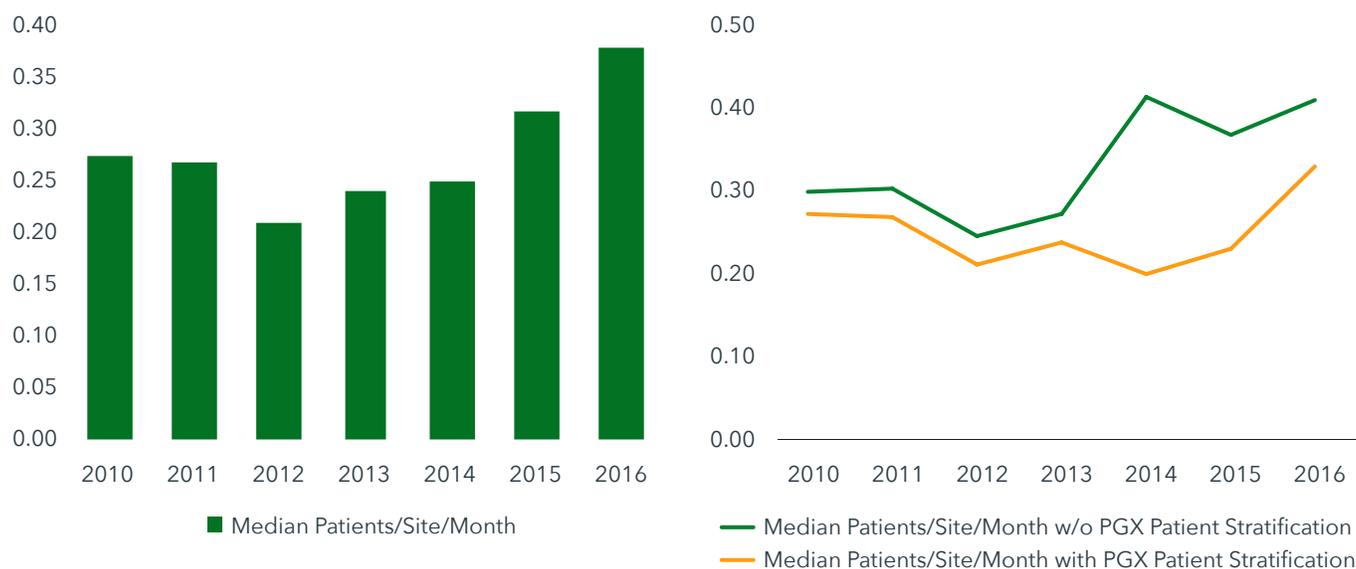
Source: Clarivate Analytics Cortellis, Jan 2018; IQVIA Institute, Apr 2018

- Phase I trials have grown since 2013 with the upper quartile (75th percentile) of patient enrollment at 88 patients in 2016 and 75 in 2017; compared to 70 and 60, respectively, across all oncology trials in those years.
- The number of subjects at the upper quartile for Phase III has declined sharply in oncology trials, indicating a shift of trial burden to Phase II and Phase I trials.
- The FDA is more often accepting oncology trials with large patient enrollment cohorts in Phase II or Phase I/II as the basis for approval. In 2017, there were 10 oncology NAS where the FDA-cited approval was based on data from Phase II or Phase I/II trials, such as Study 1108 for durvalumab (1,022 patients) and the ZUMA-1 study for axicabtagene ciloleucel (200 patients).<sup>28,29</sup>

Chart notes: Phase II includes phases I/II, II, IIa, IIb. Phase III includes Phase II/III and III. Data includes 3,896 trials. Terminated and withdrawn trials were excluded from the analysis. Trials were industry sponsored and interventional. Diagnostics, behavioral therapies, supplements, devices, and medical procedures were excluded. The upper quartile value can also be described as the 75th percentile, which splits the lowest 75% of data from the highest 25%.

# Enrollment for biomarker-selective trials are more challenging than traditional, oncology trials

Chart 39: Median Patient Enrollment Rates (Patients/Site/Month) for Phase I-III Oncology Trials



Source: Trialtrove, Pharma intelligence, Apr 2018; IQVIA Institute, Apr 2018

- The median value for patients per site per month was calculated from 2010 to 2016. Smaller values indicate slower patient enrollment and a greater difficulty in recruiting patients; larger values indicate more patients were recruited per month. The drop after 2011 corresponds to the influx of checkpoint inhibitor trials after ipilimumab that could have narrowed the overall patient population available for trials.
- From 2012 to 2016, there was an increase in patient enrollment rates suggesting that there were less constraints in recruiting. This corresponds, as well, to an increase in the overall number of oncology trials, which increased from just over 900 trials in 2010 to 1,260 in 2016 (see chart notes for types of trials included in this analysis).
- Of note, the median enrollment rates for trials tagged with PGX-patient preselection/stratified was 20% lower than those trials without patient preselection in 2016. This finding supports the idea that although testing with predictive biomarkers can pre-select patients for clinical trials, these patients are more difficult to find and the patient pool available is much smaller. For example, many anti-PD-1 trials require patients to be anti-PD-1 naïve prior to entry. Thus, as more of these therapies enter the pipeline and more are available in the market, there are fewer patients available and thus fewer being recruited.

Chart notes: Citeline’s Trialtrove’s dataset was used to create a year over analysis for the number of biomarkers in oncology trials. Biomarker trials were identified using PGX-patient preselection/stratification. Trials were industry only and interventional. Terminated and planned trials were excluded. Trials with healthy volunteers were excluded. Only trials with an actual completion date were included in the analysis for the patients per site per month; this filter was not included when counting the overall number of trials for oncology.

## Outlook for oncology

- Advances in technology and the use of information will act as driving forces that will impact oncology treatment and costs over the next decade.
- Mobile cancer apps are already available and being used by patients across a wide number of cancer types, albeit in small numbers.
- Cancer apps are being used across the patient journey from prevention to survivor support.
- Apps are also being incorporated into clinical trials as an adjunct to other interventions, or for validation purposes.
- Limited efficacy evidence has been published to date from clinical trials incorporating digital health tools in oncology, but 15 studies published in 2017 showed positive impact across a range of uses.
- The increased complexity and speed of treatment protocol evolution has prompted the development of a growing number of reference apps.
- The growing availability of real-world evidence will result in a growing number of uses as all stakeholders look to improve their decision-making in the appropriate use of oncology medicines and management of costs.
- The global market for oncology therapeutic medicines will reach as much as \$200 billion by 2022, averaging 10–13% growth over the next five years, with the U.S. market reaching as much as \$100 billion by 2022, averaging 12–15% growth.

# Significant advances in technology and use of information will impact oncology treatment over the next decade

Chart 40: Key Elements of Expected Technological Advances Impacting Oncology Treatment

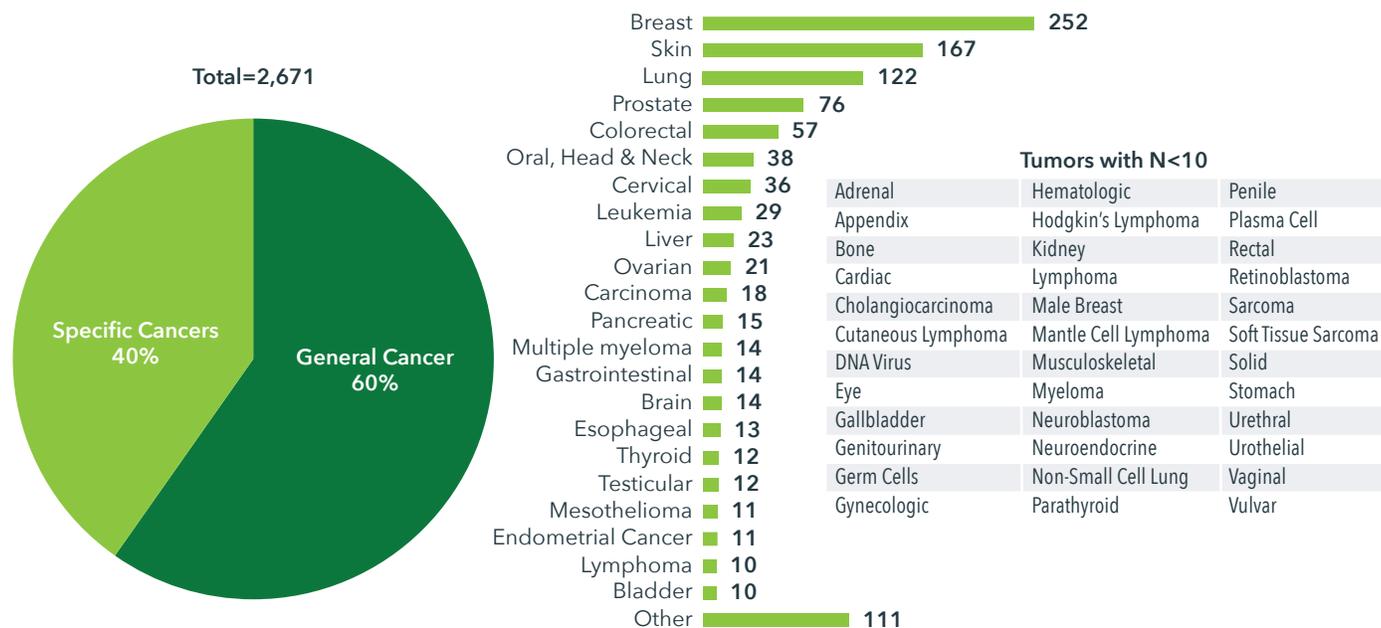
 Pharmaceuticals	 MedTech	 Artificial Intelligence	 Real-World Data	 Consumer Health
Immuno-Oncology Personalized / Stratified Therapies (Cell/Gene Therapy) Other New Small Molecule Mechanisms of Action	Surgical Robotics 3D Printed Implants Implanted Drug Delivery Devices Imaging	Clinical Diagnostics Drug Discovery Treatment Selection	Growing Use of RWE for Regulatory Expanded Use of Cancer Registries and Open Data Across Countries	Apps for Wellness and Condition Management Telemedicine / Virtual Physician Visits Connected Biometric Sensors

Source: IQVIA Real World and Analytics Solutions, Mar 2018

- Advances in biopharmaceuticals including immuno-oncology, cell and gene therapies and other promising small molecule mechanisms, as well as combination regimens are set to expand treatment options and improve outcomes dramatically in the next five years.
- For patients requiring surgical interventions, advances in non-invasive surgery with robots, and improved imaging technology could significantly reduce risk and complications.
- Developments in 3D printing including bio-printing of replacement tissues or organs could benefit some cancer patients.
- The pace of innovation in artificial intelligence, machine learning, and the expansion in the volume and quality of real-world healthcare data will change how researchers, payers, providers and patients assess the ever-expanding volumes of information.
- Tools are already helping providers with treatment selection and predictive analytics are helping sponsors to identify patient populations for clinical trials or treatment.
- The expansion of real-world evidence (RWE) and the ability to link across datasets enables analyses that are not possible in silos. For example, electronic medical record (EMR) data typically does not record a patient’s date of death, but inferences of mortality are made more accurate (for a subset of patients with linkable data) by combining EMR data with claims data, and can be verified with external demographic datasets, which include dates of death.<sup>30</sup>
- The potential uses of telemedicine/virtual patient visits are only beginning to be explored, but are of particular importance for patients who have been disabled by a recent surgery, are immunocompromised or who live in remote areas.
- Where patient psychology, behavior, and clinical guidance intersect, the growing use and evidence base for digital apps will add important value to patient treatment.

# Mobile cancer apps are available and being used by patients across a wide number of cancer types, albeit in small numbers

Chart 41: Mobile Cancer Apps by Cancer Sub-Type Targeted



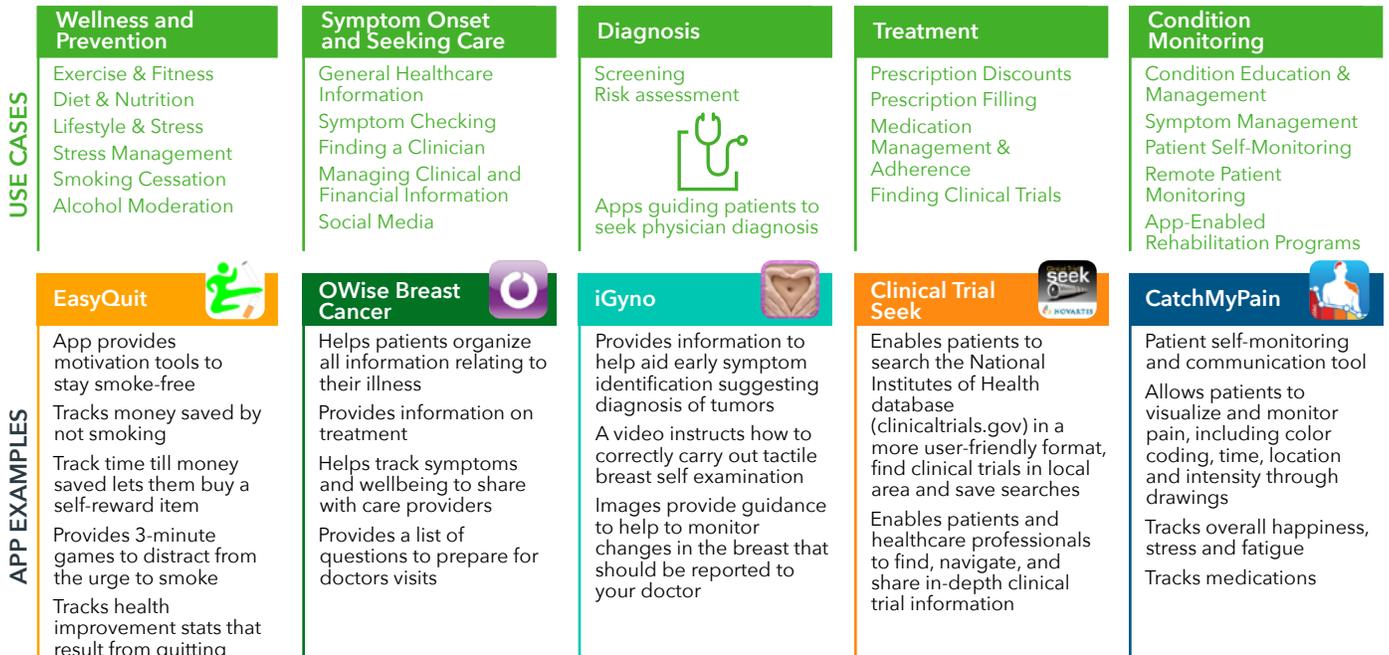
Source: AppScript App Database, May 2018

- Over 2,500 consumer apps self-define as relating to cancer, however many of these are only peripherally related or make unproven claims - e.g., yoga and naturopathic apps that claim to help prevent or cure cancer.
- Other apps are true consumer cancer apps. Among these, 40% (1,075 apps) are cancer-type specific and more closely serve cancer patient communities.
- Only 100 Android cancer apps (8% of 1,327 total), have over 5,000 installs. Of these, nearly a fifth focus on melanoma and help patients assess their melanoma risk, record photos of suspicious lesions to bring to their doctor, guide patients to dermatologist consults, prevent sun exposure, or support tele-dermatology.
- Only one app had over one million installs. It is a breast cancer prevention app called "Breast Cancer" that provides prevention tips, as well as answers to frequently asked questions in video format from a credible speaker: the president of Breastcancer.org.
- A third of all lung cancer specific apps (52/122) focus on prevention through smoking cessation.
- Apps that are pharmaceutical company sponsored provide information tied to specific medicines including treatment reminders, but also build support communities for patients and survivors, and track indicators of wellness or symptoms to share with physicians.
- Other tools include assistive communication apps for those with head or neck cancers and apps to reduce worry about non-cancerous lipomas or ovarian cysts.

Chart notes: Install data includes Android apps only. iOS data not available.

# Cancer apps stretch across the patient journey from prevention to survivor support

Chart 42: Digital Health Apps in the Oncology Patient Journey

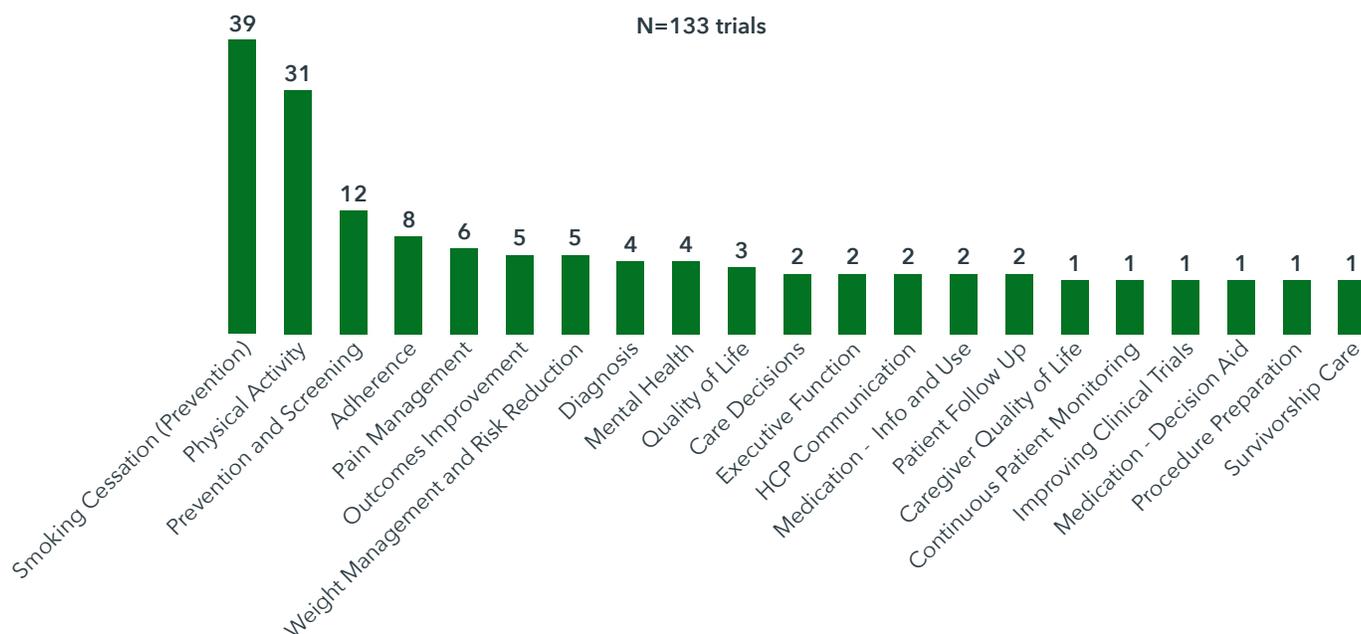


Source: AppScript App Database, May 2018

- Wellness and prevention apps in cancer encourage healthy people to avoid health risks, like tobacco, and encourage routine screenings; for survivors, these apps help to avoid future condition-associated harms. Patients that have received radiation may be encouraged to increase skin cancer checks and survivors of breast and endometrial cancers may be encouraged towards physical activity and weight loss to prevent poor outcomes.
- A number of apps help patients on their path to diagnosis by aiding in risk assessment and early symptom detection, as well as guiding patients to seek care and connect to physicians.
- Other apps help patients organize information for successful doctor visits, and help provide information to make interactions with the health system more productive.
- Condition monitoring apps in cancer both help patient self-monitoring and provide tools for physicians to more closely monitor patient performance status and symptoms outside the care environment.
- Treatment apps in cancer help patients monitor the drugs they are taking, encourage them to be adherent, as well as track associated symptoms.
- Following legal requirements, most leading cancer apps now position themselves as a means to accelerate diagnosis by facilitating information sharing with a physician.
- Some apps collect non-identified patient data to learn more about patient experience and improve cancer care. For example, CatchMyPain states it uses anonymized information from pain diaries to conduct research in cancer pain treatment.

## Apps are being incorporated into clinical trials for many reasons, such as supportive care or for treatment intervention or validation

Chart 43: Number of Oncology-Related Digital Health App Clinical Trials by Use, 2016–2017



Source: Clinicaltrials.gov, Feb 2017; IQVIA Institute, May 2018

- Digital health clinical trials relating to cancer care and prevention accounted for 15.4% (133 of 864) of all studies conducted last year globally, with 75% (100/133) of these trials conducted in the United States.
- A number of industry sponsored studies are intended to validate the effectiveness of digital health supported interventions, including melanoma detection apps and teledermatology to detect diagnose lesions, and apps to quit smoking,
- Some of the largest clinical trials being run (n>9,000) focused on reducing inefficient care and costs, including apps to promote adherence to guidelines and ASCO Choosing Wisely campaign. These include mobile apps for physicians, apps to prevent over-screening and over-treatment of young women for cervical pre-cancers, and reduce ineffective or unproven interventions for breast cancer.
- A wide range of patient quality of life questionnaires and scales are incorporated into trials including Posttraumatic Stress Disorder (PTSD) Checklist (PCL-5), Quality of Life Breast Cancer QLQ-BR23, the pediatric quality of life inventory (PedsQL), Brief Pain Inventory (BPI) and others pertaining to cancer related fatigue and frustration.
- Trials focusing on mental health addressed anxiety and distress/PTSD for patients undergoing care and were aimed at increasing physical activity to combat depression in survivors.
- Apps used for motivational purposes span uses, including motivating women in Argentina who have tested positive for HPV to present for cytological triage, and encouraging adherence to physical activity programs.

Chart notes: Active or recruiting before Sep 2017; includes trials for smoking cessation; probably understating the prevention ones affecting other cancer types.

# Clinical trials incorporating digital health tools in oncology have been limited, but show a range of positive impacts

Chart 44: Clinical Efficacy Studies Published on Oncology Apps in 2017 and Tools Used in These Trials



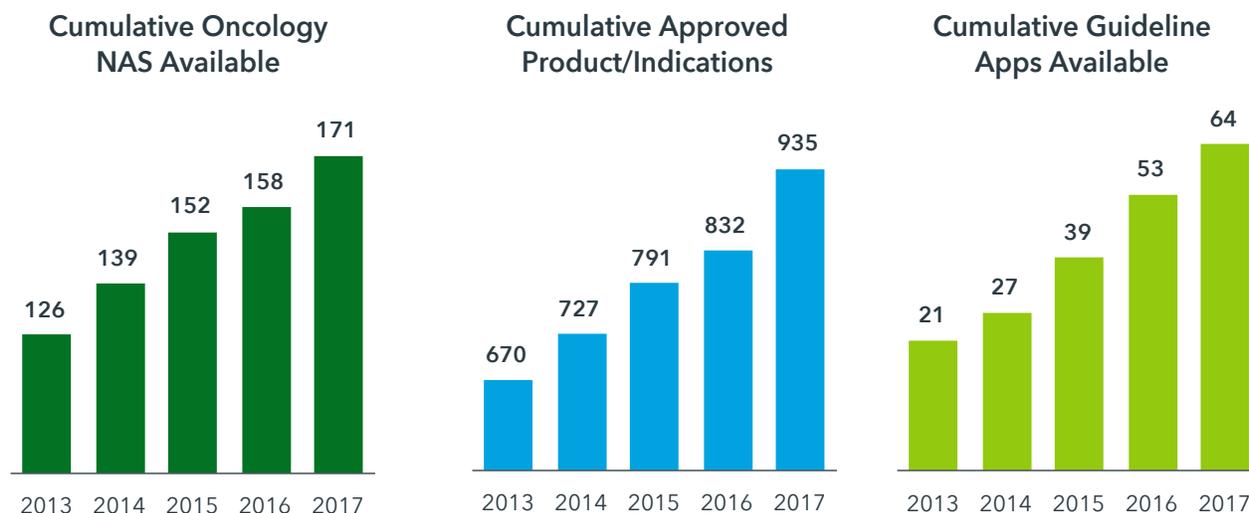
Source: IQVIA AppScript Evidence Database; Apr 2018; IQVIA Institute, May 2018

- There is a growing, but still limited, amount of published evidence related to the efficacy of mobile apps in cancer care, including those to support technology-based lifestyle interventions.
- In the past five years, 38 digital health efficacy studies have been conducted in oncology, including 15 publications in 2017, eight of which were randomized controlled trials (RCTs).
- The year 2015 was the first time more than five publications addressed oncology app efficacy.
- All studies published were positive, although two showed similar efficacy to standard of care.
- One app, MoovCare, a web-based monitoring application for lung cancer patients, published the first efficacy study to show improved overall survival (OS) and resource utilization. It did so by speeding relapse detection and enabling earlier palliative care initiation than a standard routine imaging follow-up.
- The majority of RCTs (n=4) focused on improving physical activity or weight in cancer survivors across a number of tumors including colon/rectal, endometrial, lung and childhood cancers. Two focused on reducing the risk for poor outcomes tied to obesity in endometrial and breast cancers.
- Accelerometers were used in interventions to improve physical activity and reduce fatigue.
- Endpoints often included patient quality of life measures such as fatigue, fear and pain; three studies focused on internet- or web- supported cognitive behavioral therapy to reduce these measures.
- The products tested in RCT trials include leaders in apps and sensors, but also text and telemedicine.
- Several interventions used telemedicine, social medial or other peer-based virtual support groups for motivation.

Chart notes: Withings Wi-Fi Scale used in one of the studies to send data to app was mapped to Nokia HealthMate as the likely receiving app.

## The growing complexity and rapid evolution of treatment protocols has prompted the development of reference apps

Chart 45: Oncology New Active Substances, Approved Product/Indications, and Medical Guideline Apps



Source: IQVIA, IQVIA Institute, ARK R&D Insight, IQVIA AppScript, Apr 2018

- The overall number of oncology NAS available globally increased from 126 to 171 in the past five years, with many of the drugs approved in multiple indications, and often in multiple combination regimens.
- The total number of approved indications for cancer drugs has risen from 670 to 935 over the past five years, with an average of five indications per NAS.
- In 2017, 102 new product-indications were approved for the first time around the world reflecting a significant acceleration in the number of treatment options available to clinicians and patients.
- The range of treatment options and appropriate use are often outlined in treatment guidelines from various clinical organizations, like ASCO or ESMO, or from a specific health system.
- Many of these bodies responsible for guidelines have begun to collate and disseminate their guidelines in easier-to-access formats like mobile apps.
- Clinicians continue to find it challenging to keep pace with the rapid evolution of oncology innovation, and are adopting mobile apps to help them keep up with the increasingly dynamic volumes of evidence.
- Non-oncology providers including primary care and nursing staff are increasingly becoming the consumers of apps to help them ensure the best outcomes for patients.

Chart notes: Oncology therapeutic NAS available globally by year summed cumulative including new medicines and reductions due to discontinued use of older medicines. Apps for medical professionals tracked in IQVIA Appscript.

# The significance of real-world evidence is intensifying across most developed markets, but local considerations remain paramount

Chart 46: Selected Factors Influencing Usage of Real-World Evidence in Developed Markets

COUNTRY	USAGE OF REAL-WORLD EVIDENCE
	<ul style="list-style-type: none"> <li>If overall survival (OS) data is not available at launch but due at a later date, payers are willing to provide preliminary reimbursement decisions at launch and reassess upon release of the additional real-world data (RWD):                             <ul style="list-style-type: none"> <li>[FR] A recent pricing agreement, implemented to balance access to innovative medicines with the need to control budget, stated a conditional price may be set when pricing cannot be reached under standard mechanisms, with a plan for review after real-world experience.</li> <li>[UK] The new Cancer Drugs Fund (CDF) process involves temporary funding while RWD is collected.</li> <li>[SP] Open data initiatives are providing RWD to multiple stakeholders and accelerating the advances in understanding of the value of medicines and the progression of disease, but have not yet changed the common supporting evidence in reimbursement decisions.</li> </ul> </li> </ul>
	<ul style="list-style-type: none"> <li>A new medicine launching without OS could be assigned to a reference price group, including older and even generic products, substantially lowering revenue, and ultimately providing incentives to delay launch if OS data could be generated.</li> <li>AMNOG assessments generally rely upon clinical trial data rather than RWE.</li> </ul>
	<ul style="list-style-type: none"> <li>The reimbursement authority's (AIFA) cancer registry is used to manage entry agreements, which adjust costs based on observed outcomes in managed entry agreements.</li> </ul>
	<ul style="list-style-type: none"> <li>Although stakeholders want more evidence of real-world patient outcomes, they are not aligned on the types and uses.</li> <li>Commercial insurers are regularly using RWE to identify patient populations and assess outcomes and value.</li> <li>Independent value assessment organizations, like the Institute for Clinical and Economic Review (ICER), use available RWE and clinical data to make their assessments but differ in their approaches from those taken by private payers and in government assessments.</li> </ul>
	<ul style="list-style-type: none"> <li>Japanese reimbursement decisions are generally not based on newer evidence types and instead rely on clinical trials.</li> <li>Evidence from head-to-head trials are preferred in Japan, followed by placebo-controlled, and then single-arm trials. Evidence is focused on whether the trial population is representative of the target real-world population for the drug, and if the reasons for the weaker trial design can be justified.</li> </ul>

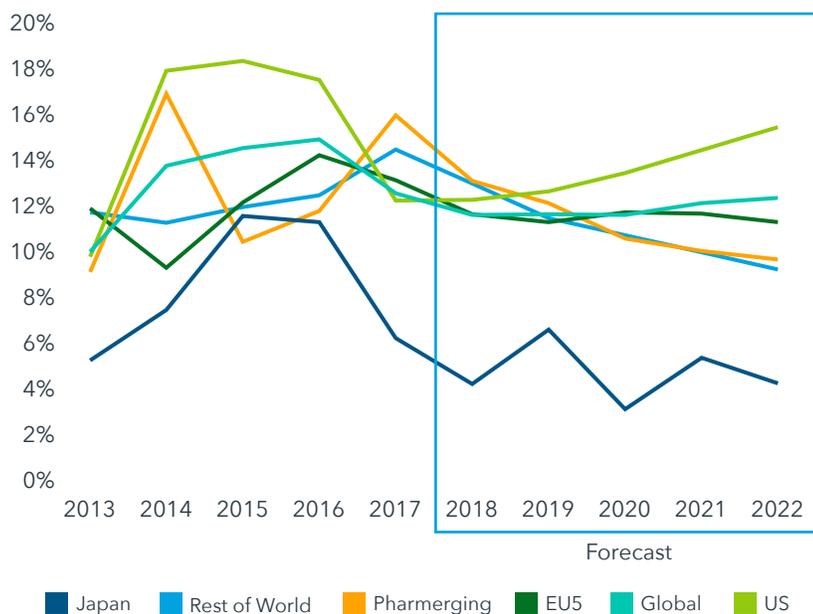
Source: IQVIA Real World and Analytics Solutions, Dec 2017

- The use of RWE in reimbursement decisions has been increasing across major developed markets.
- Although confirmation of clinical trial results is desirable, RWE is not yet considered as a sufficient substitute for clinical trial outcomes.
- Generally the lack of robust clinical trial evidence impacts reimbursement significantly.
- Most medicines seeking to confirm outcomes with RWE to date have had only incremental benefits.

Chart notes: AMNOG = Arzneimittelmarkt-Neuordnungsgesetz and is Germany's Pharmaceuticals Market Reorganisation Act; AIFA is the Italian Medicines Agency.

# Global oncology therapeutic medicines will reach as much as \$200 billion by 2022, averaging 10–13% growth over the next five years

Chart 47: Growth Rates for Global Oncology Therapeutic Medicines, Constant US\$, 2013–2022



	CAGR 2018-2022	Oncology Spending 2022
Global	10-13%	\$180-200Bn
US	12-15%	\$90-100Bn
EU5	10-13%	\$40-45Bn
Japan	3-6%	\$10-12Bn
Pharmerging	10-13%	\$18-20Bn
ROW	9-12%	\$24-26Bn

Source: IQVIA Institute, Dec 2017

- Global growth in oncology spending will reach nearly \$200 billion by 2022 with average growth of 10–13%.
- Growth will be led by the United States, driven by continued early adoption of new treatments and the significant number and clinical value of new pipeline products expected to launch in the next four years.
- The top five European markets are expected to experience slower growth, as budget pressures and wider use of health technology assessments limit cancer drug spending.
- Growth in the rest of the world has been driven generally by volume and the increased adoption and usage of medicines, often occurring a few years later than in developed markets.
- Japan is expected to see slower oncology spending growth with price control mechanisms in place, and further reforms to pricing rules to address complexities of multi-indication cancer products.
- Pharmerging markets have significantly less usage of cancer medicines than developed markets but are expected to grow to \$18–20 billion by 2022.
- Pharmerging markets are not expected to grow as much in oncology as developed markets due to slower forecasted economic growth.
- Patent expiries and biosimilar competition will contribute to lower costs but will be offset by increased prevalence, diagnosis rates and treatment rates.

Chart notes: Spending Growth in Constant US\$.

# Notes on sources

## THIS REPORT IS BASED ON THE IQVIA SERVICES DETAILED BELOW

**U.S. National Sales Perspectives (NSP)™** measures revenue within the U.S. pharmaceutical market by pharmacies, clinics, hospitals and other healthcare providers. NSP reports 100% coverage of the retail and non-retail channels for national pharmaceutical sales at actual transaction prices. The prices do not reflect off-invoice price concessions that reduce the net amount received by manufacturers.

**ARK R&D Intelligence™** is a drug pipeline database containing up-to-date R&D information on over 39,000 drugs in development worldwide. The database captures the full process of R&D, covering activity from discovery stage through preclinical and clinical development, to approval and launch. The information in Ark R&D Intelligence is manually curated by a team of scientifically trained analysts to ensure quality and relevance.

**ARK Patent Intelligence™** is a database of biopharmaceutical patents or equivalents in over 130 countries and including over 3,000 molecules. Research covers approved patent extensions in 51 countries, and covers all types of patents including product, process, method of use and others.

**MIDAS™** is a unique platform for assessing worldwide healthcare markets. It integrates IQVIA's national audits into a globally consistent view of the pharmaceutical market, tracking virtually every product in hundreds of therapeutic classes and provides estimated product volumes, trends and market share through retail and non-retail channels.

**BrandImpact™** uses a proprietary mobile research model and longitudinal network of more than 400 internet-enabled oncologists and is the only source of continuously-captured physician treatment decisions for the biopharmaceutical industry. The real-time data generated by its information panel of oncologists enables unique insights into physician behavior and the influences on that behavior.

**HTA Accelerator™** provides strategic insights into payer decision-making based on 25,000+ health technology assessments from 100 agencies and 40 countries. With additional clinical, regulatory and price information it sets the foundation for evidence-based insight generation.

**OneKey** a single reference data solution that delivers relevant, valuable content on nearly nine million healthcare professionals (HCPs) and 680,000 healthcare organizations (HCOs) and their affiliations in the U.S. OneKey is a global solution available in 100 countries.

**IQVIA AppScript App Database** provides global mobile patient health application data. The curated database provides information on widely available consumer mobile health apps and includes AppScript Scores, that provide a comprehensive assessment of app quality and may be predictive of a given app's value to the human health and the overall health system. As of April 2018 it included 403,526 apps; 199,086 in the AppStore and 204,440 in GooglePlay, with 20,843 apps in the AppScript Catalog of consumer health apps.

**AppScript Digital Health Evidence Database** is an internal-use dataset of peer-reviewed publications updated on a rolling basis, leveraging database search, as well as manual search methodologies. It enables App Clinical Maturity Assessment. As of April 2018 it included nearly 2,500 unique published studies of which over 900 efficacy studies are represented across dozens of app use categories.

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# About the Institute

The IQVIA Institute for Human Data Science contributes to the advancement of human health globally through timely research, insightful analysis and scientific expertise applied to granular non-identified patient-level data.

Fulfilling an essential need within healthcare, the Institute delivers objective, relevant insights and research that accelerate understanding and innovation critical to sound decision making and improved human outcomes. With access to IQVIA's institutional knowledge, advanced analytics, technology and unparalleled data the Institute works in tandem with a broad set of healthcare stakeholders to drive a research agenda focused on Human Data Science including, including government agencies, academic institutions, the life sciences industry and payers.

## Research Agenda

The research agenda for the Institute centers on 5 areas considered vital to contributing to the advancement of human health globally:

- Improving decision-making across health systems through the effective use of advanced analytics and methodologies applied to timely, relevant data.
- Addressing opportunities to improve clinical development productivity focused on innovative treatments that advance healthcare globally.
- Optimizing the performance of health systems by focusing on patient centricity, precision medicine and better understanding disease causes, treatment consequences and measures to improve quality and cost of healthcare delivered to patients.
- Understanding the future role for biopharmaceuticals in human health, market dynamics, and implications for manufacturers, public and private payers, providers, patients, pharmacists and distributors.
- Researching the role of technology in health system products, processes and delivery systems and the business and policy systems that drive innovation.

## Guiding Principles

The Institute operates from a set of Guiding Principles:

- Healthcare solutions of the future require fact based scientific evidence, expert analysis of information, technology, ingenuity and a focus on individuals.
- Rigorous analysis must be applied to vast amounts of timely, high quality and relevant data to provide value and move healthcare forward.
- Collaboration across all stakeholders in the public and private sectors is critical to advancing healthcare solutions.
- Insights gained from information and analysis should be made widely available to healthcare stakeholders.
- Protecting individual privacy is essential, so research will be based on the use of non-identified patient information and provider information will be aggregated.
- Information will be used responsibly to advance research, inform discourse, achieve better healthcare and improve the health of all people.

The IMS Institute is now the  
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