IMPLICATIONS OF THE 2017 FDA REAUTHORIZATION ACT ON PEDIATRIC CANCER DRUG DEVELOPMENT: AN INDUSTRY PERSPECTIVE

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DISCLOSURE INFORMATION

ONCOLOGY ADVISORY COMMITTEE, PEDIATRIC SUBCOMMITTEE JUNE 2018

LISA L. BOLLINGER, M.D.

I have the following financial relationships to disclose:

I work full time for Amgen

I will not discuss off label use and/or investigational use in my presentation.

BPCA AND PREA WORK TOGETHER

- **Intended to work together to maximize information in labeling on dosing, safety, and efficacy for products that may be used in children**
  - **Even if studies are negative/uninterpretable, study information still placed in labeling because information is deemed critical**
- **Not mutually exclusive**
  - **Therapies with required studies under the Pediatric Research Equity Act (PREA) are eligible for exclusivity under the Best Pharmaceuticals for Children Act (BPCA)**

PEDIATRIC ONCOLOGY STUDIES
NOT PERFORMED UNDER PREA OR BPCA

- **FDA has required post marketing commitments outside of PREA.**
- **Examples include:**
  - **2000, Aresenic Trioxide (Trisenox) – Acute promyelocytic leukemia**
  - **2001, Imatinib mesylate (Gleevec) – Ph+ Leukemias**
  - **2006, Panitumumab (Vectibix) – solid tumors**
- **Before 2017, submissions with Orphan Drug Designation (ODD) were exempt from PREA requirements**

TARGETED THERAPIES

- **Since early 2000s, improved knowledge of tumor biology is informing treatment**
- **Precision medicine has delivered more targeted therapies**
  - **Impact on unmet medical need large,**
  - **Populations with greatest potential to benefit are smaller**
- **Products may qualify for ODD**
  - **Critical regulatory pathway for development of medicines**

PEDIATRIC TARGETS

- **Remarkable progress has been made in our understanding of the genomic landscapes of pediatric cancers**
- **Products approved for use in adult cancers can provide a health benefit for pediatric patients**
- **Despite the lack of a PREA requirement, these products are studied in the pediatric population**
- **Not always performed for regulatory review nor product labeling**

SAMPLING FROM DRUGS@FDA APPROVAL LETTERS

- **Approximately 77 new BLAs or NDAs, approved since 2012**
  - **26 applications waived,**
    - **Disease did not occur or was rare in the pediatric population**
  - **50 applications exempt**
    - **Orphan designation**
  - **One had no clear information**
- **Clinicaltrials.gov search**
  - **Of 77 above, 48 have pediatric studies (62.3%)**
  - **Regulatory utility of studies unknown (intended for submission)**

CHANGES IN PEDIATRIC LEGISLATION UNDER FDARA

- **BPCA:**
  - **No changes**
- **PREA:**
  - **Requires evaluation of new molecularly targeted drugs and biologics “intended for the treatment of adult cancers and directed at a molecular target substantially relevant to the growth or progression of a pediatric cancer.”**
  - **Elimination of the PREA exemption when the application is for a orphan designated cancer drug being studied in adults**

LEGISLATIVE CHANGES BRING NEW OPPORTUNITIES

- PREA now allows industry an early opportunity to discuss pediatric studies with the FDA
- Smaller study populations will require the development innovative study designs
- It is a chance for closer collaboration between NCI, COG, other collaboratives, FDA, Industry, and Advocacy groups
- Independent regulatory review of data and availability in labeling may increase access for patients

LEGISLATIVE CHANGES COME WITH CHALLENGES

WHAT MOLECULES SHOULD BE STUDIED?
THE “LISTS”

- **Legislation requires lists**
  - **May represent an opportunity for stakeholders to come together to discuss emerging science**
  - **Intended to limit regulatory uncertainty, but nonbinding**
  - **Therapies must be individually assessed for appropriate conditions**
    - **This could change over time as more information becomes available**

PRIORITIZATION IS REQUIRED

- **Many products share same molecular target, studies could be competing for the same small pool of patients**
  - **Recruitment in pediatric trials difficult**
  - **Pediatric studies often international by nature**
    - **Requires some level of harmonization**
- **On going surveillance of pipelines required to ensure that the most promising therapies are studied first**
  - **FDA and NCI are often aware of pipelines across companies**
  - **Convert deferrals to waivers as appropriate**

SAFETY REQUIREMENT

- **Safety information for any product is critical to assure that benefit out weighs risk**
  - **Inherent risks for patients participating in clinical studies**
    - **Recent adult examples of studies of immunotherapies in combination with other drugs that were placed on hold while safety concerns examined**
  - **Previous studies in pediatrics (including non-oncology) have identified adverse events unique to or amplified in the pediatric population**
    - **Some toxicities difficult to identify from adult studies and/or nonclinical studies**

REGULATORY STABILITY

- **Intent of legislation was not to provide prescriptive directions for implementation, and lists do not provide certainty**
- **As science advances, it will be incumbent upon the FDA to more clearly define what therapies will have study requirements**
- **Regulatory certainty is an ideal that is hard to realize, and Business uncertainty is not sustainable**
  - **Must know what study requirements will be for a given therapy over time**

PEDIATRIC STUDY COST

- **While not the primary driver, must be assessed for business**
- **$1 million - $35 million for studies (depending on source)**
  - **JAMA Intern Med. 2017;177(11):1569-1575 Li JS, Eisenstein EL, Grabowski HG, et al. Economic Return of Clinical Trials Performed Under the Pediatric Exclusivity Program. JAMA : the journal of the American Medical Association. 2007;297(5):480-488.**
  - **Exclusivity seen by many companies to off set the cost of studies**

CONCLUSIONS

- **We have been here before**
  - **More than 20 years ago, people said pediatric studies could not be conducted.**
    - **Now there are 728 products with pediatric information in label, largely from studies**
- **There will be challenges prioritizing products to study**
  - **The best minds are poised to solve the challenges presented by the new legislation**
- **The new requirements may provide an opportunity for collaboration across industry, academia and government**

Investigator Perspectives on New Agent Prioritization and Challenges with Multiple Same in Class Agents

Pediatric Oncology Subcommittee of the Oncologic Drugs Advisory Committee

Elizabeth Fox, MD

20 June 2018

Children's Hospital of Philadelphia℠

Disclosure Information

Elizabeth Fox, MD

Consultant (travel compensation only) from: Bayer, Bristol Myers Squibb

Institutional research support for clinical trials from: Novartis, Ignyta, Merck

Data Safety Monitoring Board (compensated): Helsinn Therapeutics

All data in this presentation is publically available and referenced. My interpretation of data and opinions are not intended to reflect opinions of my institutional or cooperative group affiliations or trial sponsors.

I will discuss the following off label use and/or investigational use in my presentation: atezolizumab, cabozantinib, entrectinib, larotrectinib, nivolumab, pazopanib, pembrolizumab, vismodegib

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Research to Accelerate Cures & Equity for Children Act

FDARA 2017 Title V

- Mandates earlier discussion of the pediatric plan for an oncology drug or biological product directed at a specific molecular target in cancer that is germane to children
- Agents classified as relevant, non-relevant or other
- Opportunity for collaboration among US government agencies, EMA/PDCO, global pharmaceutical industry, academic investigators, and patient and policy advocates

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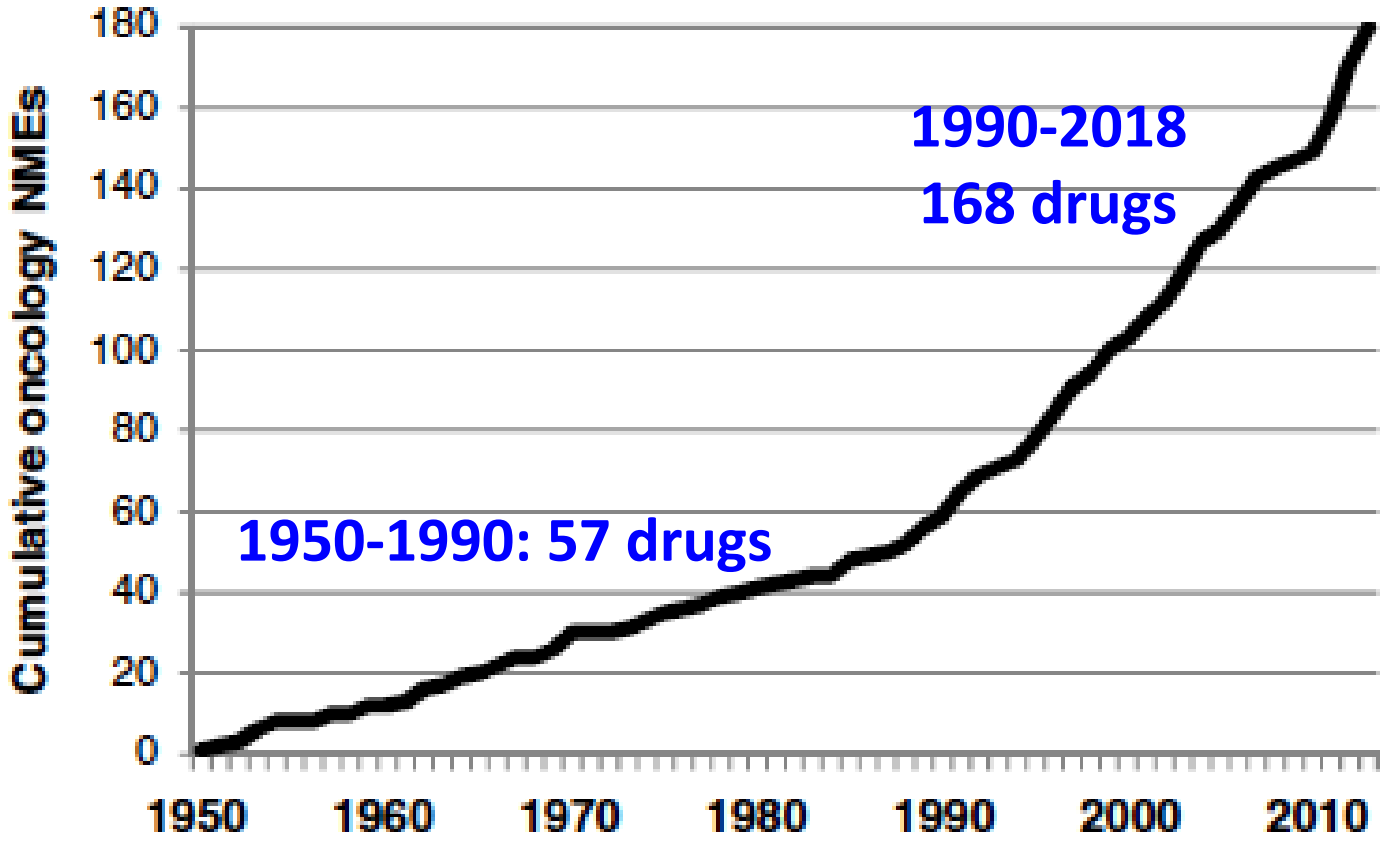
Oncology Drug Approvals



Decade	Total NME	Annual Average
1951-1960	11	1.1
1961-1970	17	1.7
1971-1980	11	1.1
1981-1990	18	1.8
1991-2000	44	4.4
2001-2010	49	4.9
2011-2018	**75**	**10.7**

Drug Disc Today 19: 1831-5, 2014

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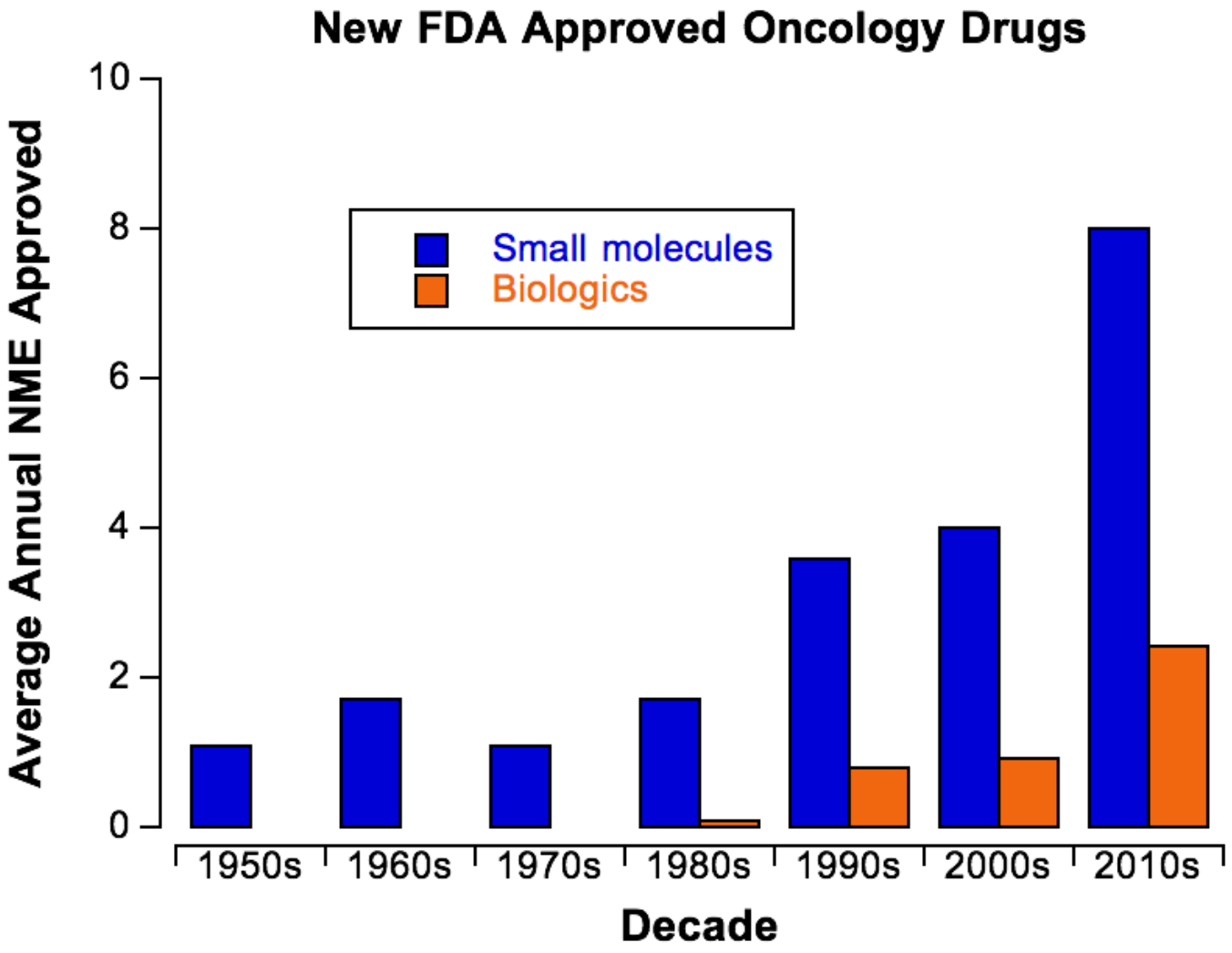
Anticancer Drugs



Generic Name Stem	Mechanism of Action
-tinib	Tyrosine kinase inhibitor
-anib	Angiogenesis inhibitor
-ciclib	Cyclin-dependent kinase inhibitor
-zomib	Protesome inhibitor
-lisib	PI3 kinase inhibitor
-parib	PARP inhibitor
-stat	Enzyme inhibitors
-ase	Enzyme
-kin	Interleukin (-leukin is IL-2)
-mab	Monoclonal antibody
-leucel	Cell therapy
-stim	Colony stimulating factors
-tide	Peptide

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Childhood Cancer Diagnosis (%)	Common Age Range
Acute Lymphoblastic Leukemia (20%)	< 8 y
Brain/ CNS Tumors (18%)	0-19 y
Hodgkin Lymphoma (8%)	10-19y
Non-Hodgkin Lymphoma (7%)	0-19 y
Acute Myeloid Leukemia (5%)	<2y; >12y
Neuroblastoma (5%)	<4 y
Bone: Osteosarcoma+Ewing Sarcoma (5%)	10-19y
Thyroid Carcinoma (4%)	15-19y
Wilms/Kidney (3%)	<5 y
Germ Cell Tumors (3%)	15-19y
Rhabdomyosarcoma (2%)	0-19 y
Retinoblastoma (2%)	< 1 y
Melanoma (2%)	>12y
Other (16%)	

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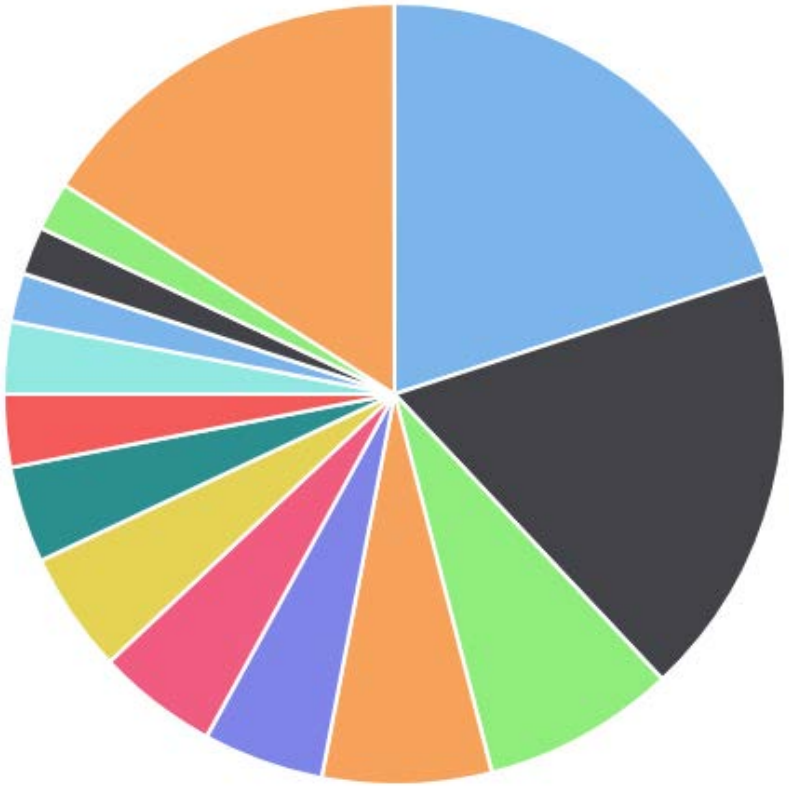
Each year **15,780 Children** in the US are diagnosed with **Cancer**



Adapted from
Siegel et al CA Cancer J Clin 2017

Single Agents, Same in Class

- Unique aspects of biomarker in cancers in children/adolescents (Strength on the Oncogenic Driver)
- Rare Tumors among Childhood Cancer
- Number of agents/trials in a rare patient population will depend on agent properties and efficiency of trial design
  - Endpoints (Safety, dosing, PK)
  - Biomarker/Companion Diagnostic
  - Disease specific response criteria

RACE for Children Act defines Cures as the Goal

- Majority of childhood cancers will require assessment of combinations
  - Disease specific backbone therapy (multimodality, cytotoxic)
  - Combinations of targeted agents for pathway inhibition
- Consideration of age distribution of specific cancers, histologic and molecular subtypes

Prioritization

- Evidence of drug-target-response relationship
  - Less data from trials in adults
    - PKPD endpoints and modeling
    - PBPK models/assumptions
  - Biomarker Validation/Companion Diagnostics
  - Resources for Pediatric Cancer Specific Animal Models
- Toxicity profile
  - Developmental considerations; Juvenile toxicology
  - Severity and Reversibility
  - Combinations relevant to childhood cancer and additive toxicity
- Pharmacological properties and formulation
- Global Collaborations

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Preclinical Models: Prerequisite for Prioritization

- Selection of models with fidelity of the oncogenic drivers of disease
- Evaluation of biomarkers
- Drug distribution (CNS penetration)
- Validation of concentration thresholds and necessary duration of inhibition
- Demonstrate relationship between target inhibition and activity
- Clinically meaningful efficacy thresholds
- Evaluation of pathway redundancy, innate and acquired resistance
- Mechanistic rationale for synergy for combinations

Biomarkers

- Childhood cancer is rare disease, biomarker selection will further limit number of eligible patients
- Need for resources for assessment of agents in pediatric preclinical *in vivo* and *in silico* models
- Limited Re-Validation of Biomarker/Companion Diagnostics
    - Tumor Biopsies
    - Circulating Tumor DNA
- Relevance of single genetic aberrations and genomic signatures from carcinomas in adults
- Complexities of fusion transcripts and multiple fusion partners

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Checkpoint Inhibition in Childhood Cancer

	Atezolizumab	Nivolumab	Pembrolizumab
	Geoerger et al ASCO 2017	Davis et al ASCO2017	Geoerger et al ASCO 2017
N	74	46	66
Age (years)	14 (2-29)	13 (1-25)	13 (1-17)
PD-1/PDL-1 selection	No	No	Yes
Adverse Events	DLT Gr3 LFT; Gr4 DKA	No DLT	Gr3 ALT
Objective Response Rate	5% 2/9 HL; 1/11 EWS 1 MRT (unconfirm)	0% EWS, RMS, Osteo	6% 1 HL; 1ACC; 1GMB; 1 mesothelioma

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Checkpoint Inhibition in Childhood Cancer

Where we started:

- Enthusiasm from studies in adults and lack of preclinical models led to multiple large, multi-strata clinical trials
- Uncertainty of biomarker selection

What we learned:

- Single agent PD-1/PDL-1 inhibitors are tolerated for short durations
- Many children exposed, few with clinical benefit
- Multiple studies can simultaneously accrue when the effort is global

What we would like to know:

- HL cohorts included in trials in adults, can medical and pediatric centers collaboration can be realized?
- Can we define hyper-mutated cancers in children and will those children benefit?
- Will combinations work better?

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Dose Finding Trials in Childhood Cancer

Dose Escalation Trial	Dose Confirmation Trial
• Recommended Dose in Adults is MTD • Concern for toxicity: CNS, irreversible/serious organ damage • Myelosuppressive/impact of prior Tx • Highly variable PK, age related metabolism, or saturable CL • Untested formulation or schedule • Childhood cancer requires different target concentration • Rationale for early combination	• Recommended Dose in Adults is not MTD • Toxicology and Toxicity profile reversible • Non-myelosuppressive • PK is dose proportional, limited variability • Ability to deliver dose and similar schedule • Target inhibition across broad concentration or exposure range • Single agent or prior combination trial

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Challenges of Same in Class Comparison

	Larotrectinib	Entrectinib
Reference	Laetsch et al Lancet Oncology 2018	Desai et al ASCO 2018
Population	Biomarker enriched/selected	Solid tumor Dose Escalation; biomarker expansion
N	24 (17 fusion positive)	16 (3 fusion positive)
Median Age (years)	4.5	10
DLTs	increased ALT	pulmonary edema, fatigue, dysguesia, elevated creatinine
MTD	No	Yes
Pediatric RP2D	100 mg/m^2 BID (max 100 mg/dose)	550 mg/m^2 Daily
Adult RP2D	100 mg BID	600 mg/day (~350 mg/m^2)
Objective Response	14/15 patients with fusion positive tumors	3/3 patients with fusion positive tumors
Formulations	25 or 100 mg capsules; 20 mg/mL oral solution	100 and 200 mg capsules

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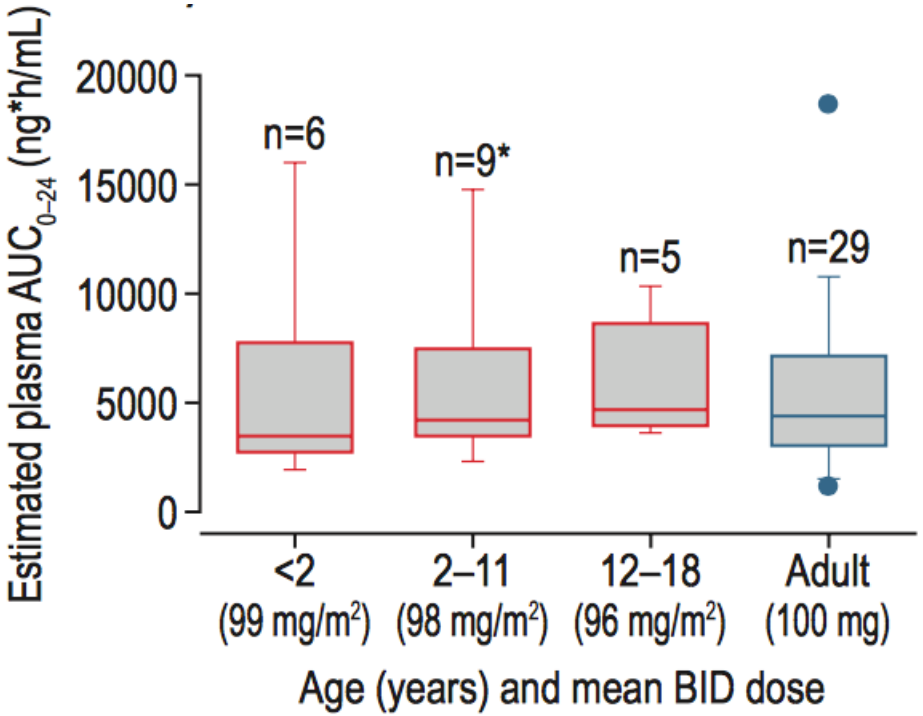
Dosing Considerations Based on Pharmacokinetics

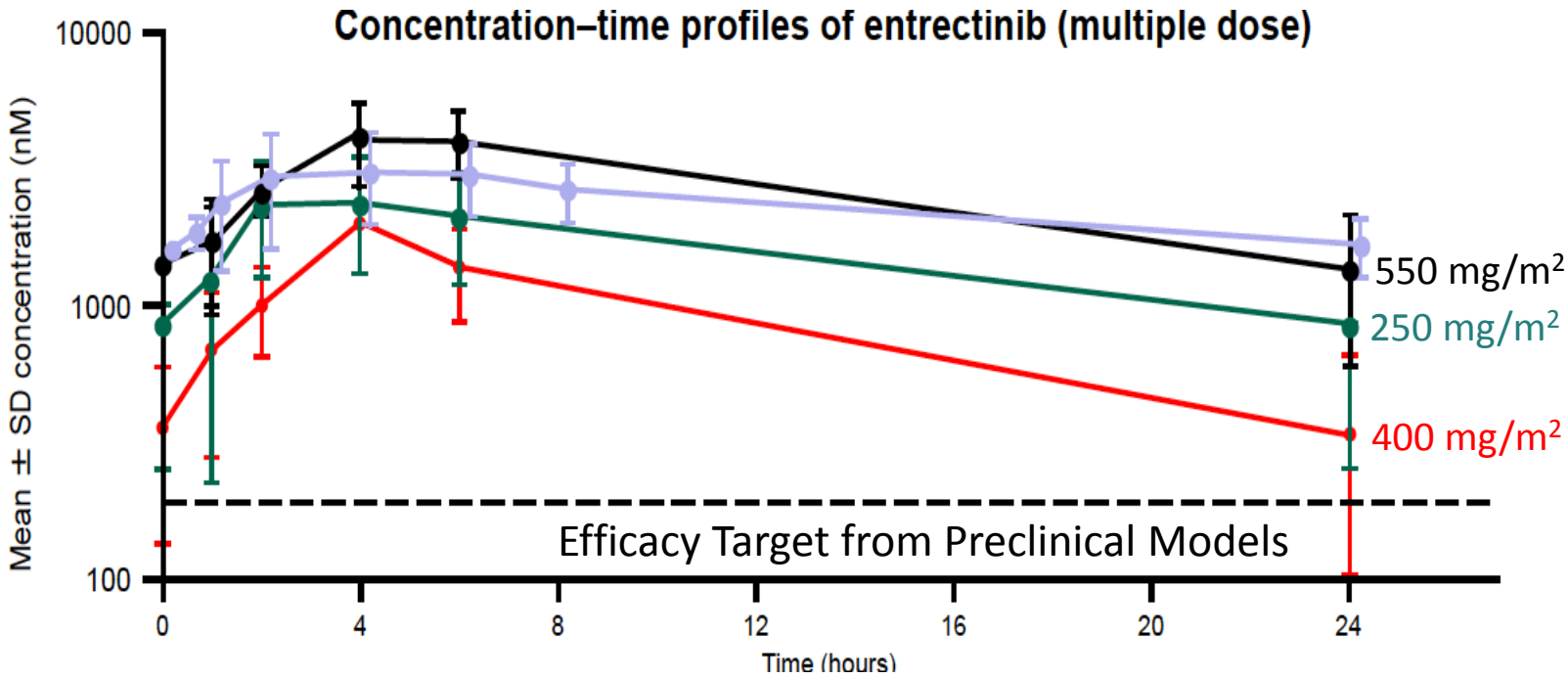
Larotrectinib

Laetsch et.al Lancet Oncol 2018



Entrectinib

Desai et.al ASCO 2018



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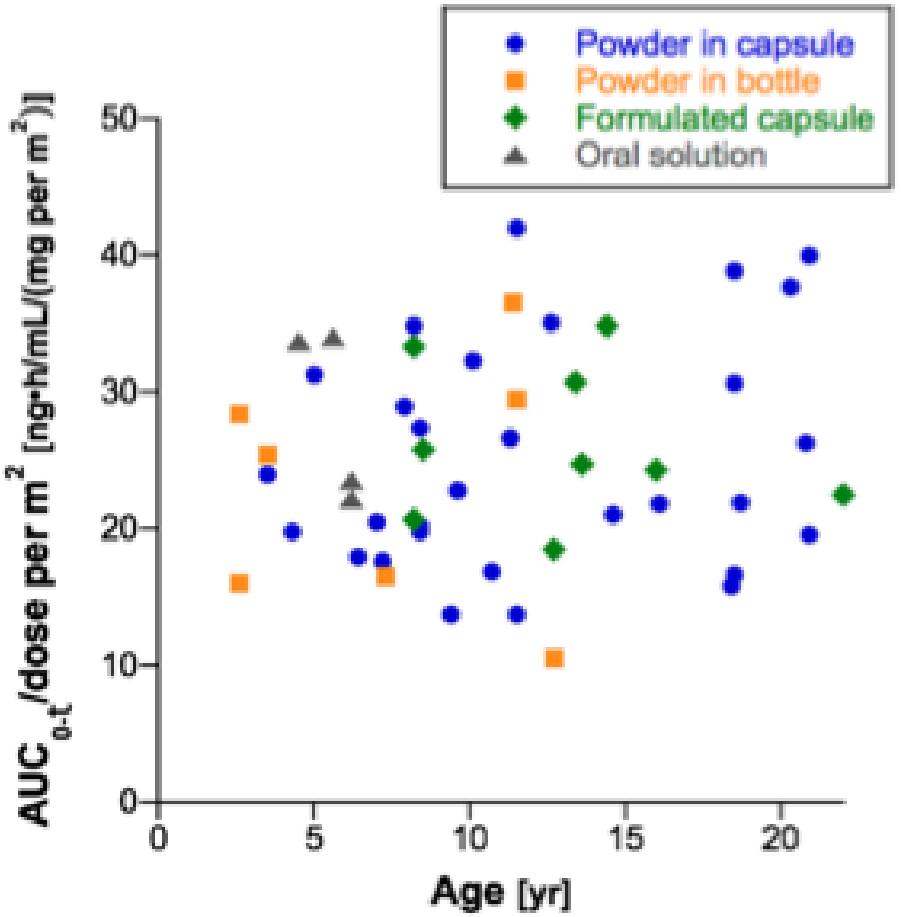
Formulation



- Bioavailability
- Taste
- Palatability
- Concentration
- Stability
- Preparation
- Administration

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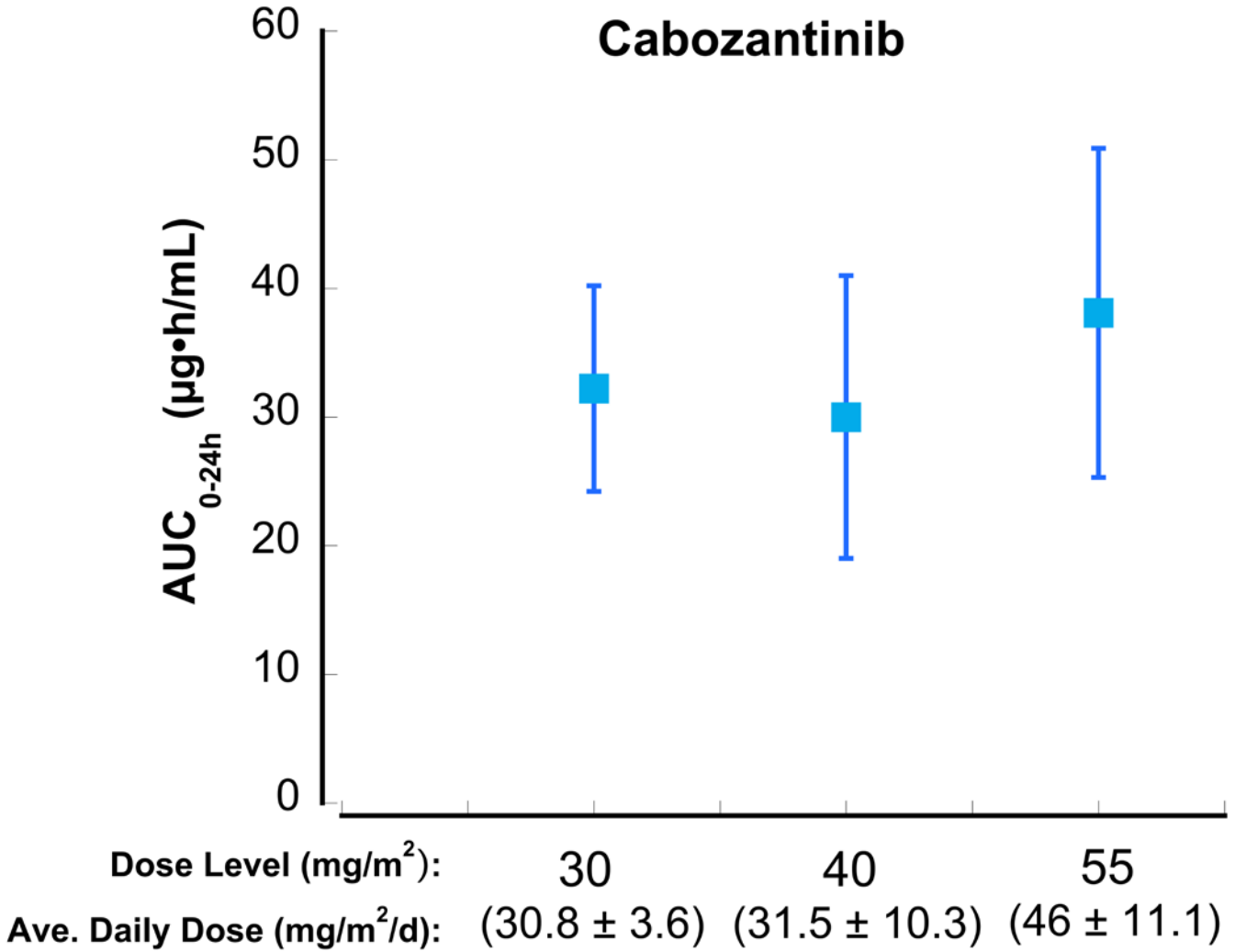
Formulation, Deliverable Dose and PK



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Chuk et al PBC 2018

Toxicity Profile of Targeted Therapy: Small Molecules

Target	Drugs	Toxicity
ALK/ROS1	Ceritinib, Crizotinib, Ensartinib	Arrhythmia, Hyperglycemia, Neuropathy/Neuromuscular, Respiratory, PE, Vision
BCR-ABL1, KIT, PDGFR	Dasatinib, Imatinib, Nilotinib, Ponatinib	Cardiac, Edema, Growth, Pulmonary HTN, Thyroid, Vascular events
BRAF	Dabrafenib, Vemurafenib	Hyperglycemia, SMN, QT prolong, radiation sensitivity
CDK	Palbociclib, Ribociclib	Hepatic, SOS
HDAC	Etinostat, Vorinostat	PE,QTc,
MEK/MAPK	Selumetinib, Trametinib	Cardiac, skin, Vision
mTOR	Everolimus, Sirolimus, Temsirolimus, ABI-009	Dyslipidemia, hyperglycemia
PI3K	CYDC-907, LY3023414	Hyperglycemia
TRK	Entrectinib, Larotrectinib	
MTKI: VEGFR,PDGRF, RET,MET	Axitinib, Bevacizumab, Cabozantinib, Lenvatinib, Vandetanib	Cardiac, Bleeding/Clotting, HTN, Tyroid Dysfunction

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Adapted from Chow et al JCO 2018

Toxicity Profile of Targeted Therapy: Biologics

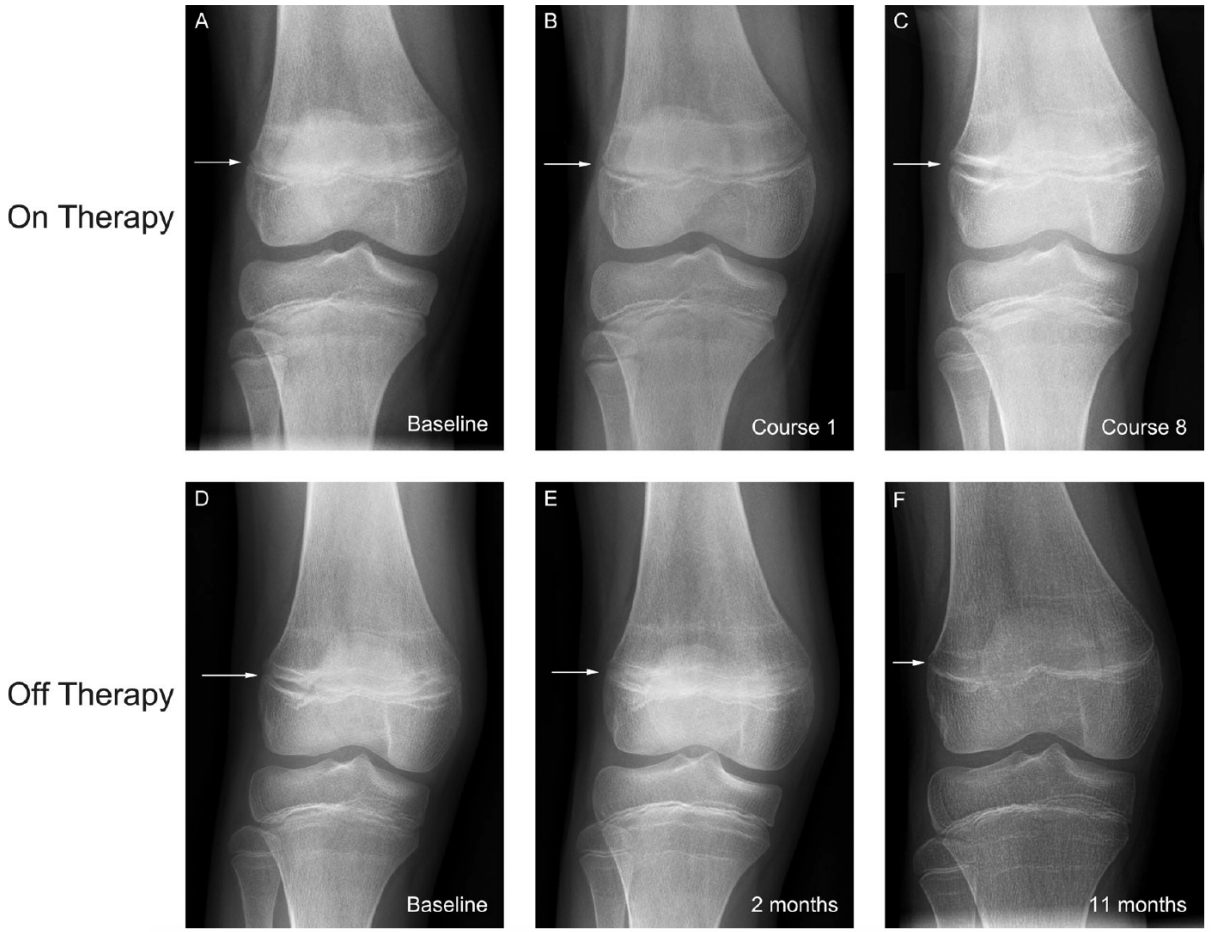
Target	Drugs	Toxicity
CD3	Blinatumomab	Cytokine release syndrome, Neurotoxicity
CD19	Blinatumomab, CAR Tcells	Cytokine release syndrome, Neurotoxicity, B cell aplasia
CD20	Rutuximab	B cell aplasia
CD30	Brentuximab vendotin	Neuropathy, PML
CD33	Gemtuzumab ozogamicin	Hepatic, SOS
GD2	Dinutuximab, 3F8, Hu14.18K322A	Capillary Leak, Neuropathic Pain, RPLE
PD-1, PDL-1, CTLA4	Atezolozumab, Avelumab, Durvalumab, Ipilimumab,Nivolumab, Pembrolizumab, JS001, MEDI4736	AutoImmune/ Inflamatory including: Endocrinopathies, Myopathies, Neurotoxicity, Pneumonitis

Adapted from Chow et al JCO 2018

Unique Toxicities: Growth Plate Abnormalities

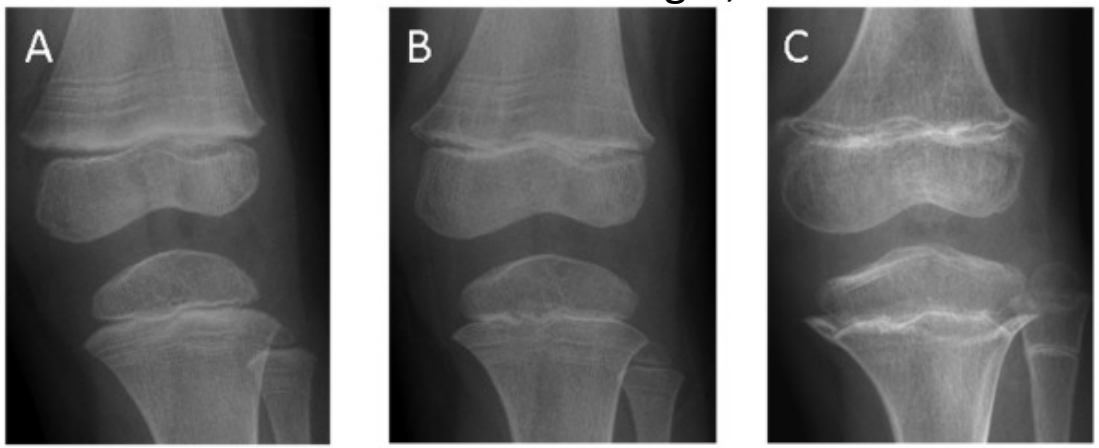
Pazopanib

Voss et al Ped Blood Cancer, 2015



Vismodegib

Robinson et al Oncotarget, 2017



- Serial Evaluations
- Pediatric Specific Grading Criteria
  - Hypertension
  - Neuropathy

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Attributes for Prioritization and Collaboration

Adaptability

- Expected prevalence of biomarker/disease and primary endpoint determine number of sites necessary, additional sites after safety cohort

Agility

- Timely scientific/clinically relevant results require shorter protocol lifecycles with rapid readouts of endpoints and outcome measures

Allegiance

- Goals of cure rather than individual drug or trial
- Mechanism to continue assessment of agents without adult indications

Alignment

- International alignment of goals, risk stratification and strategies: Hepatic Tumors, NBL, GCT

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Future of Cancer Therapy in Children

- Increased preclinical models (*in vivo* and *in silico*)
- Personalized (individualized) therapy based on tumor biology
- Extinction of cytotoxic chemotherapy and increased role for molecularly targeted and immunotherapy
- Challenges of combination therapy
- Age-appropriate Formulations
- Toxicity
  - Chronic oral outpatient therapy with targeted drugs or long half-life
  - Non-myelosuppressive, chronic non-hematological toxicity, impact on growth and development,
  - unknown late effects

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Industry Perspective on Prioritization of Pediatric Relevant Targets and Molecules

June 20nd, 2018 Pediatric Subcommittee of the Oncologic Drug Advisory Committee (pedsODAC) Meeting

Hubert Caron, MD. PhD.
Principle Medical Director
Pediatric Oncology Drug Development Group
Roche
Basel, Switzerland

Disclosure Information

- I am an Employee and Stock Holder of Hoffmann-La Roche AG

- The presentation describes the Roche/Genentech perspective on target & drug prioritization, as part of the approach adapted by the Company towards pediatric drug development

Outline

- Perspective on current pediatric regulatory landscape
- Revisions to PREA – FDARA 2017
  - Impact on the Industry and its challenges
- Roche/Genentech vision for pediatric drug development
- Pediatric target & molecule prioritization
    - MOA-based pediatric potential
    - Pediatric molecule developability
    - Across company prioritization
- Case study on prioritization
- Key Messages

Pediatric Research Equity Act

What it means post-FDARA 2017?

- Implemented on both drugs and biologics
- Pediatric studies are **mandatory**
- **Requires molecularly targeted pediatric cancer investigation** of new molecular entities (drugs and biologics) "intended for the treatment of adult cancers and directed at a **molecular target** substantially relevant to the growth or progression of a pediatric cancer."
- Elimination of **orphan exemption for pediatric studies** for cancer drugs directed at relevant molecular targets
- Once completed, pediatric studies must inform the **product label**

Changing Landscape

Industry-Sponsored Pediatric Oncology Drug Development Needs Innovation

- Sponsors are required to submit 'initial Pediatric Study Plan' (iPSP) for marketing applications for **new molecular entities** submitted after **August 2020** unless the PREA requirement is waived

- Submitting an iPSP outlining the clinical study design to evaluate dose, safety and preliminary efficacy of the drug would require:
  - Pre-clinical data
  - Pediatric formulation and starting dose for pediatric study
  - Adult safety and efficacy data (if available)

Innovative Pediatric Oncology Drug Development

Roche's Vision and Mission

Our Vision

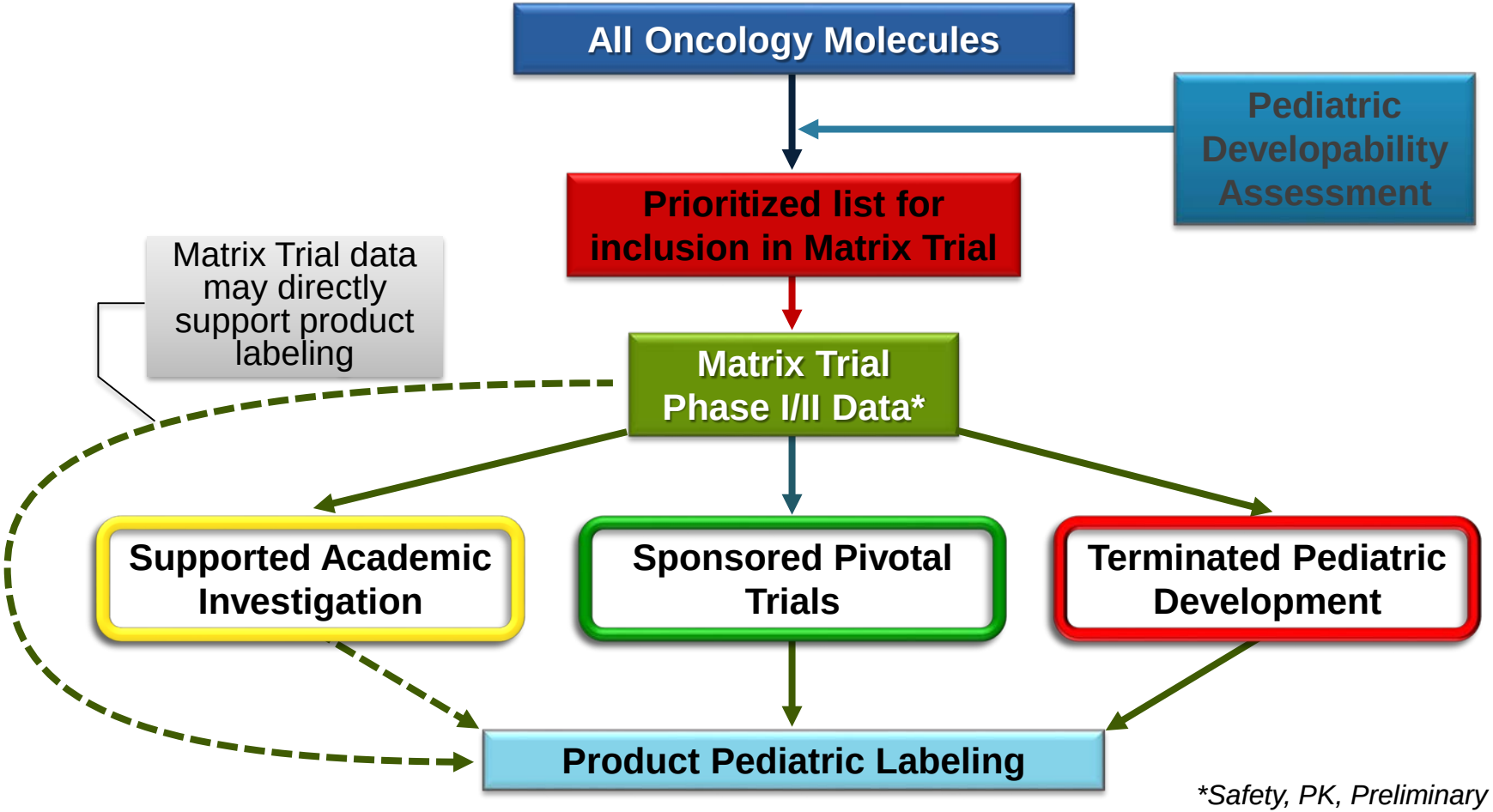
- Provide children with unmet medical needs with innovative, safe, life-saving therapies

Our Missions

- Ensure **early access** to medicines with a strong scientific rationale for children with high unmet medical needs
- Increase **treatment options** through clinical trials aimed at pediatric product labeling for children with cancer
- Fulfill pediatric regulatory obligations to ensure **timely registrations in adults**
- Facilitate **industry innovation and change in policies** in collaboration with regulatory authorities, to increase drug development in pediatric oncology

Developing the Roche Pipeline for Children with Cancer

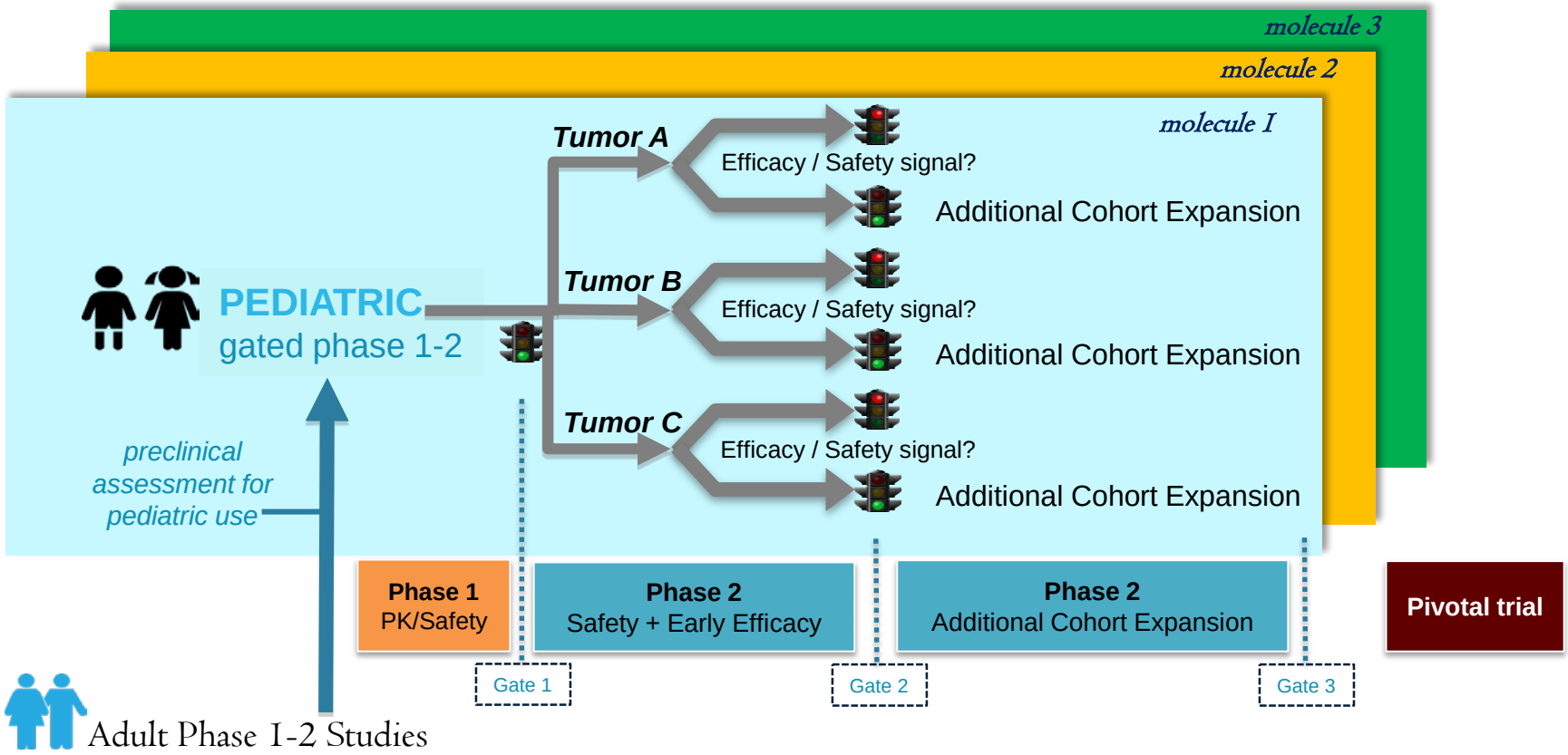
With the intent to inform the product label



*Safety, PK, Preliminary Efficacy

The iMATRIX Trial Concept

MOA-driven, gated for safety + early efficacy, molecule combinations, across multiple diseases



Pediatric Molecule Developability

A multifactorial approach across the portfolio

Regulatory: Do we have an existing or likely future regulatory obligation for this molecule? **1**

De-risk adult filings by addressing EU & US regulatory obligations

Molecule Feasibility:
- MOA match with pediatric biology?
- Is there an unmet medical need?
- Suitable safety (preclinical+adult) profile?
- Is the formulation appropriate for children? **2**

Clinical Feasibility:
- Prevalence of matching patients?
- Perceived improvement over SOC?
- Competing molecules in class? **3**

Deliver high-potential molecules to rare pediatric populations with significant unmet need

Incentives: Can we qualify for regulatory incentives for this molecule? **4**

Leverage opportunities for regulatory incentives (LOE extension, PRV)

Matching MOA with Pediatric Tumor Biology

Strength of the 'MOA match' guides pediatric developability

Roche

Compound → **Mechanism of Action**

Pediatric Tumor Biology → **Pediatric Target Actionability**

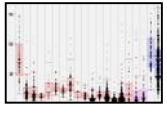
Match

Target classes:
- Tumor dependence
  - ✓ Genomic
  - ✓ Expression (lineage)
- Tumor delivery
- Tumor microenvironment
  - ✓ Immunology
  - ✓ Angiogenesis

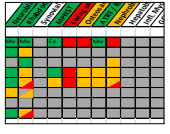
FDA Target Classes:
- *Gene Abnormality Targets*
- *Cell Lineage Targets*
- *Non-cancer cell Targets*
- *Other Targets*

Pediatric Potential

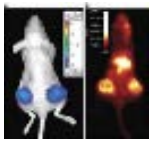
Target Prevalence in Pediatric Clinical Series



Systematic Literature Reviews of Target Actionability



Preclinical Proof-of-Concept Molecule Testing in Pediatric Models



Preclinical Proof of Concept (POC) testing

Data modules for preclinical POC testing

Module 1	Target Activation Status in clinical series
Module 2	Target Dependence: 'in vitro' (molecular validation)
Module 3	Target Dependence: 'in vivo' (molecular validation)
Module 4	Molecule Sensitivity Patterns 'in vitro'
Module 5	Molecule Efficacy 'in vivo'
Module 6	Biomarkers; Predictive and Biological Efficacy (PD)
Module 7	Resistance mechanisms
Module 8	Rational combinations
Clinical data	*Pediatric Clinical trials*

Systematic Target Actionability Reviews

Cochrane-like methodology supported by ITCCP4 R2 data platform

STEP 0: Expert reviewers

- Identify 2 or more reviewers
- Derive specifics for target patterns and target validation from basic target (pathway) biology in cancer

STEP 1: Sensitive literature search for papers on pediatric tumors

- Sensitive PubMed search
- Select relevant papers, based on Title + Abstract

STEP 2: Critical evaluation of papers and scoring of main findings

(independent by each reviewer)

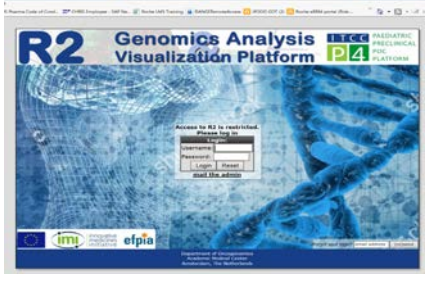
- Extract Main Finding(s) per paper
- Categorize each main finding for disease entitie(s) and for class(es) of POC data
- Appraise + score main findings for Experimental Quality and for Effect Quantity (standardized guidance tables)

STEP 3: Comparison of the scoring from independent reviewers

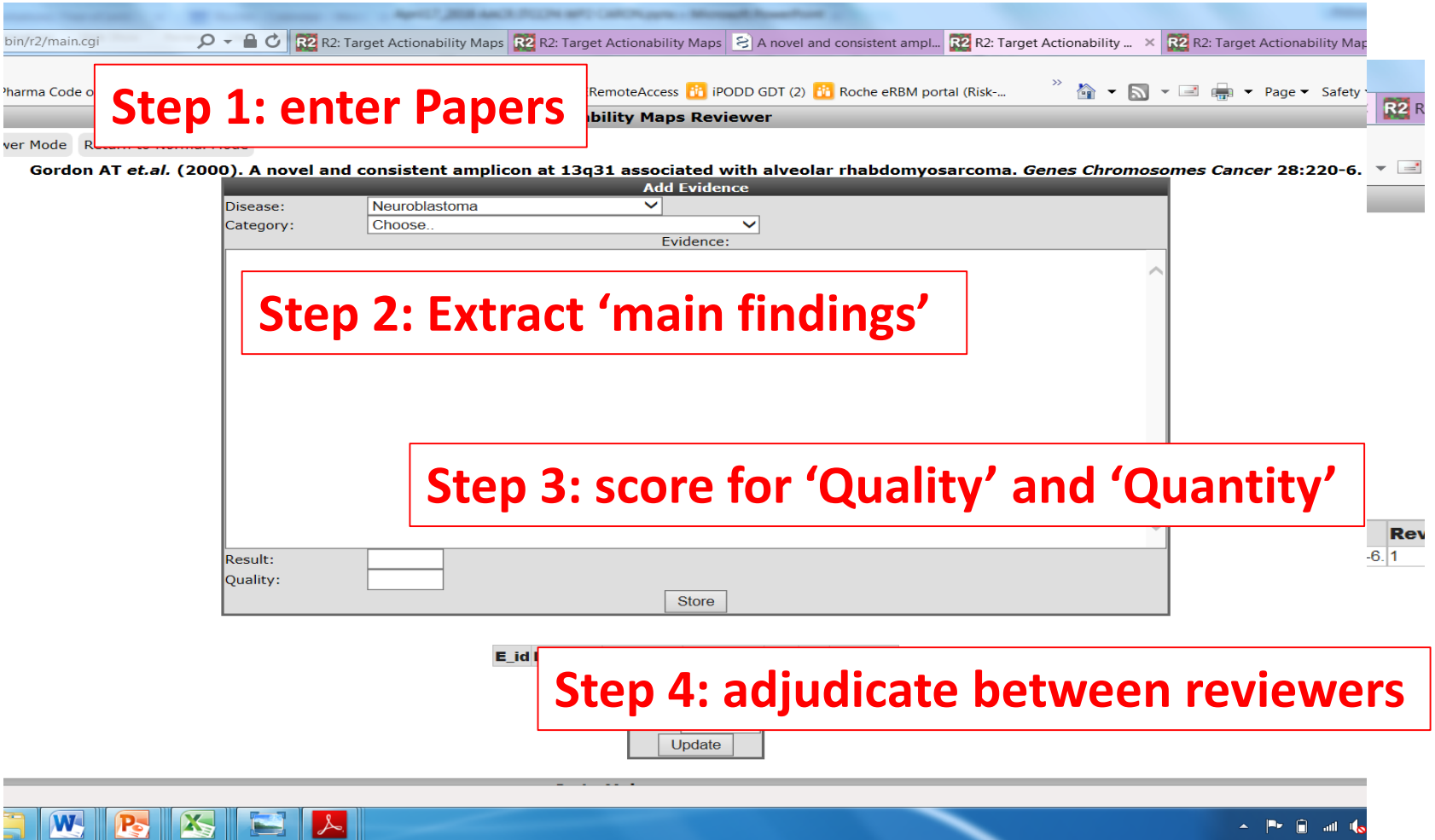
- Reviewer discussion of main findings and evidence scores per tumor entity
- Resolve+adjudicate discrepancies by discussion

STEP 4: visualization in R2 datatool

- Derive POC heatmap from evidence scores



R2-supported review process



ITCC P4 PAEDIATRIC PRECLINICAL PROOF OF CONCEPT PLATFORM

Scoring of Evidence Quality

imi innovative medicines initiative

efpia

Module	Criteria	Scoring	Criteria
1. Target pattern	number of samples/pediatric patients type of analysis	3	n>20 , two or more different methods
		2	n>10<20, at least one reliable method
		1	n<10, one method
2. Target validation in vitro	knockdown/knockout Confirmation and analysis of knockdown	3	Different methods to induce knockdown/knockout of >3 cell lines + phenotypic analysis of knockdown
		2	Single methods to induce knockdown/knockout of < 3 cell lines
		1	questionable knockdown/knockout
3. Target validation in vivo	type of in vivo model used validation in vivo	3	transgenic mouse model and/or at least 2 different xenografts with an appropriate control and/or different methods of genetic modification in vivo (shRNA /CRISPR) + validation
		2	at least 2 different xenografts without appropriate control + validation
		1	no validation of the developed tumors
4. Drug efficacy in vitro	number of cell lines validation including PD biomarkers or phenotypic response	3	5 cell lines or more + at least two appropriate controls + validation
		2	2-5 cell lines + at least one appropriate controls + validation
		1	1 cell line and/or lack of control +/- validation
5. Drug efficacy in vivo	number and type of in vivo models used	3	2 or more xenograft models or one transgenic mouse model with appropriate control + validation
		2	1 xenograft model with appropriate control + validation
		1	1 xenograft model w/o appropriate control or w/o validation
6. Biomarkers	confirmation of correlation patient selection	3	correlation molecularly confirmed in 2 or more models (e.g. silencing, overexpression, etc.)., patient selection
		2	correlation confirmed in one model, patient selection
		1	correlation not confirmed
7. Resistance	development of resistance molecular analysis overcoming resistance	3	reported resistance + comprehensive analysis + reversing/overcoming resistance
		2	reported resistance + analysis of molecular changes underlying or due to resistance
		1	only reporting resistance
8. Combinations	concentrations tested combination index (CI) in vitro / vivo combination	3	>4 concentrations of each compound are tested + CI + in vivo
		2	1-4 concentrations of each compound are tested + CI +/- in vivo
		1	1 concentration of each compound is tested

work in progress

ITCC P4 PAEDIATRIC PRECLINICAL PROOF OF CONCEPT PLATFORM

imi innovative medicines initiative

efpia

Scoring of Evidence Quantity

Module	Criteria	Scoring	
1. Target pattern	Prevalence of abnormal expression/amplification/mutation in cohort (separate scoring)	3	More than 10% in the cohort
		1	Between 2-10%
		-3	No
2. Target validation in vitro	Level of dependency and phenotypic recapitulation	3	Full dependency (>75% cell death OR transformation) after knockdown/knockout
		1	Partial dependency (<75% death OR growth arrest)
		-3	No dependency
3. Target validation in vivo	Level of dependency and phenotypic recapitulation	3	Full dependency (CR / complete tumor regression) after knockdown/knockout or transformation in GEMM
		1	Partial dependency
		-3	No dependency
4. Drug efficacy in vitro	IC50 observed after 72hr exposure	3	< 500 nM
		1	500-1500nM
		-1	>1500 nM
		-3	No activity (> 10uM)
5. Drug efficacy in vivo	In vivo tumor response extrapolation (preferably using clinically relevant dose)	3	Response comparable to PR/CR
		1	Response comparable to SD
		-1	Very minor response (between SD and PD)
		-3	No activity or clear PD, comparable to control
6. Predicitive biomarker	Confirmation of correlation	3	Strong correlation
		1	Moderate correlation
		-3	No correlation
7. Resistance	Reported resistance	3	Resistance reported with drug exposure (at clinically relevant dose) with identification of mechanism of resistance
		1	Resistance reported with no identification of mechanism of resistance
8.Combination	Synergy - CI	3	Strong synergy reported - CI <0.5
		1	Moderate synergy/additive effect - Ci 0.5-0.9
		-1	Very minor synergy/additive effect observed - CI 0.9-1.1
		-3	No synergy

work in progress

ITCC P4 PAEDIATRIC PRECLINICAL PROOF OF CONCEPT PLATFORM

R2 heatmap of POC results

Merging of disease-specific data per POC data module

innovative medicines initiative

efpia

		Neuroblastoma	Rhabdomyosarcoma	STS non-RMS: Synovial Sarcoma	STS non-RMS: MPNST	Ewing sarcoma	Osteasarcoma	ATRT / Rhabdoid	Wilms tumor (Nephroblastoma)	Hepatoblastoma	GCT extracranial	Retinoblastoma	HGG (incl GBM)	LGG	Ependymoma	Medulloblastoma
Target/pathway:	**MDM2-TP53**															
Version Date:	*13 April 2018*															
Author:	*Nil Schubert* *Guillaume Bergthold* *Caitlin Lowery* *Ana Rodriguez* *Jan Molenaar* *Hubert Caron*															
Preclinical																
1.Target activiation in pediatric clinical series	p53 functionality															
	MDM2 amplified															
	MDM2 expressed															
2.Tumortarget dependence (*in vitro* models)																
3.Tumortarget dependence (*in vivo* models)																
4. Compound sensitivity (*in vitro* models)																
5. Compound POC Efficacy (*in vivo* models)																
6. Biomarker (Predictive and PD)																
7. Resistance Mechanisms																
8. Combinations																

work in progress

ITCC P4 PAEDIATRIC PRECLINICAL PROOF OF CONCEPT PLATFORM

R2 heatmap of POC results

Merging of disease-specific data per POC data module

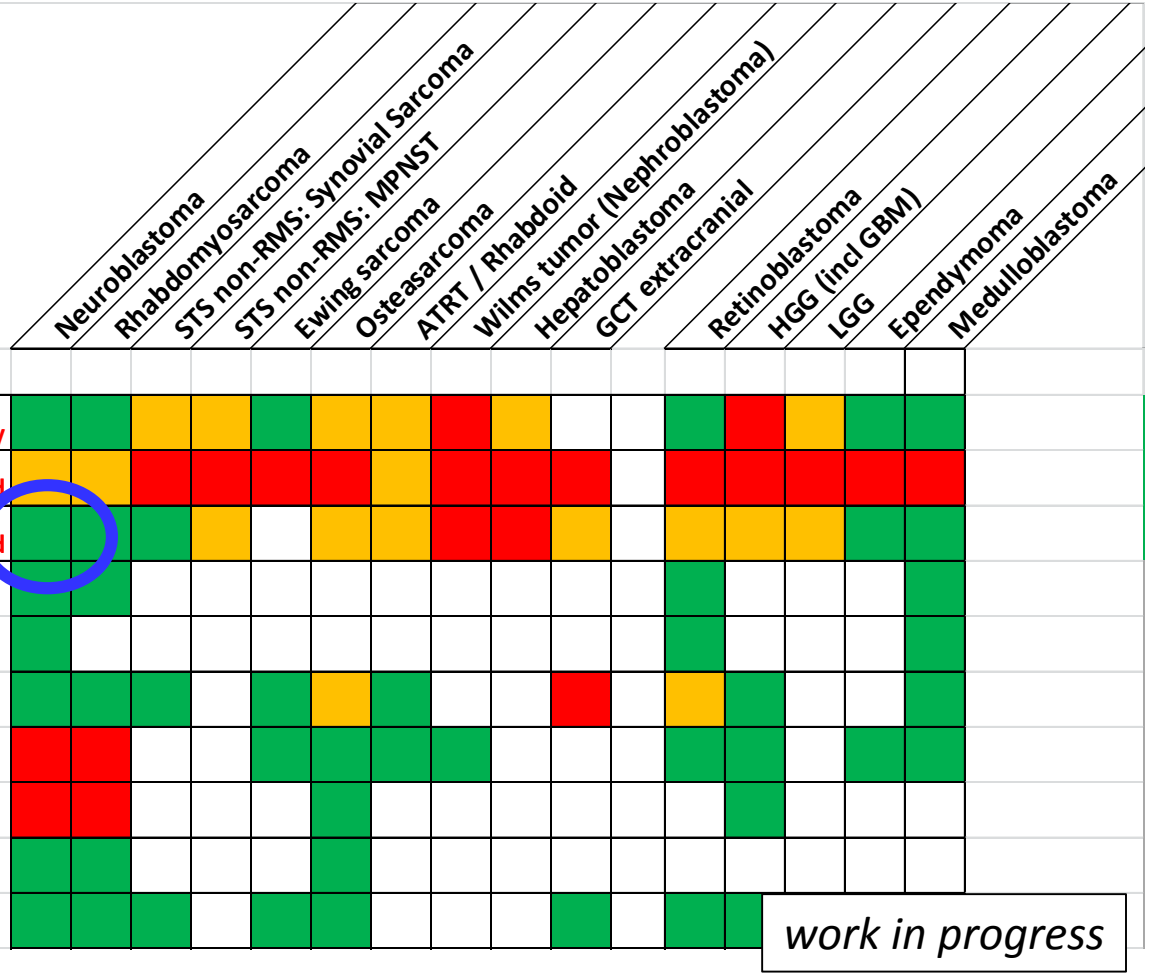
innovative medicines initiative

efpia

Target/pathway: **MDM2-TP53**

Version Date: *13 April 2018*

Author: *Nil Schubert*, *Guillaume Bergthold*, *Caitlin Lowery*, *Ana Rodriguez*, *Jan Molenaar*, *Hubert Caron*



Q:2 | R:3 | S:+6

Remarks:
Amplification or gain of 12q13-15 (includes MDM2) was found in 32% of the 44 primary ARMS samples (CGH analysis).
Publication: Gordon AT *et.al.* (2000). A novel and consistent amplicon at 13q31 associated with alveolar rhabdomyosarcoma. *Genes Chromosomes Cancer* **28**:220-6. Pubmed
Curator: Nil Schubert

Q:3 | R:3 | S:+9

Remarks:
1/26 ERMS and 1/17 ARMS had an MDM2 amplification and very high RNA expression (WGS, FISH, IHC). (9/26 ERMS and 3/17 ARMS had copy number gains for MDM2 between 0.5 and 10 copies).
Publication: Chen X *et.al.* (2013). Targeting oxidative stress in embryonal rhabdomyosarcoma. *Cancer Cell* **24**:710-24. Pubmed
Curator: Nil Schubert

Q:2 | R:-3 | S:-6

Remarks:
No MDM2 amplification was found in 22 pediatric RMS tumor samples (differential PCR).
Publication: Ognjanovic S *et.al.* (2012). Low Prevalence of TP53 Mutations and MDM2 Amplifications in Pediatric Rhabdomyosarcoma. *Sarcoma* **2012**:492086. Pubmed
Curator: Nil Schubert

Q:3 | R:3 | S:+9

Remarks:
MDM2 amplification (qPCR) was found in 2/22 RMS tumors and over-representation of MDM2 was found in 3/22 tumors. The amplification-positive tumors were only of the ARMS and anaplastic ERM type and not of the classic ERM type. High MDM2 mRNA expression correlated with protein expression (IHC).
Publication: Ragazzini P *et.al.* (2004). Amplification of CDK4, MDM2, SAS and GLI genes in leiomyosarcoma, alveolar and embryonal rhabdomyosarcoma. *Histol Histopathol* **19**:401-11. Pubmed
Curator: Nil Schubert

Q:3 | R:3 | S:+9

Remarks:
MDM2 was overexpressed (IHC) in 9/72 cases and amplified (PCR) in 3/18 cases, but there was no correlation between amplification and overexpression. MDM2 status was not associated with prognosis or other clinicopathologic parameters.
Publication: Takahashi Y *et.al.* (2004). Altered expression and molecular abnormalities of cell-cycle-regulatory proteins in rhabdomyosarcoma. *Mod Pathol* **17**:660-9. Pubmed
Curator: Nil Schubert

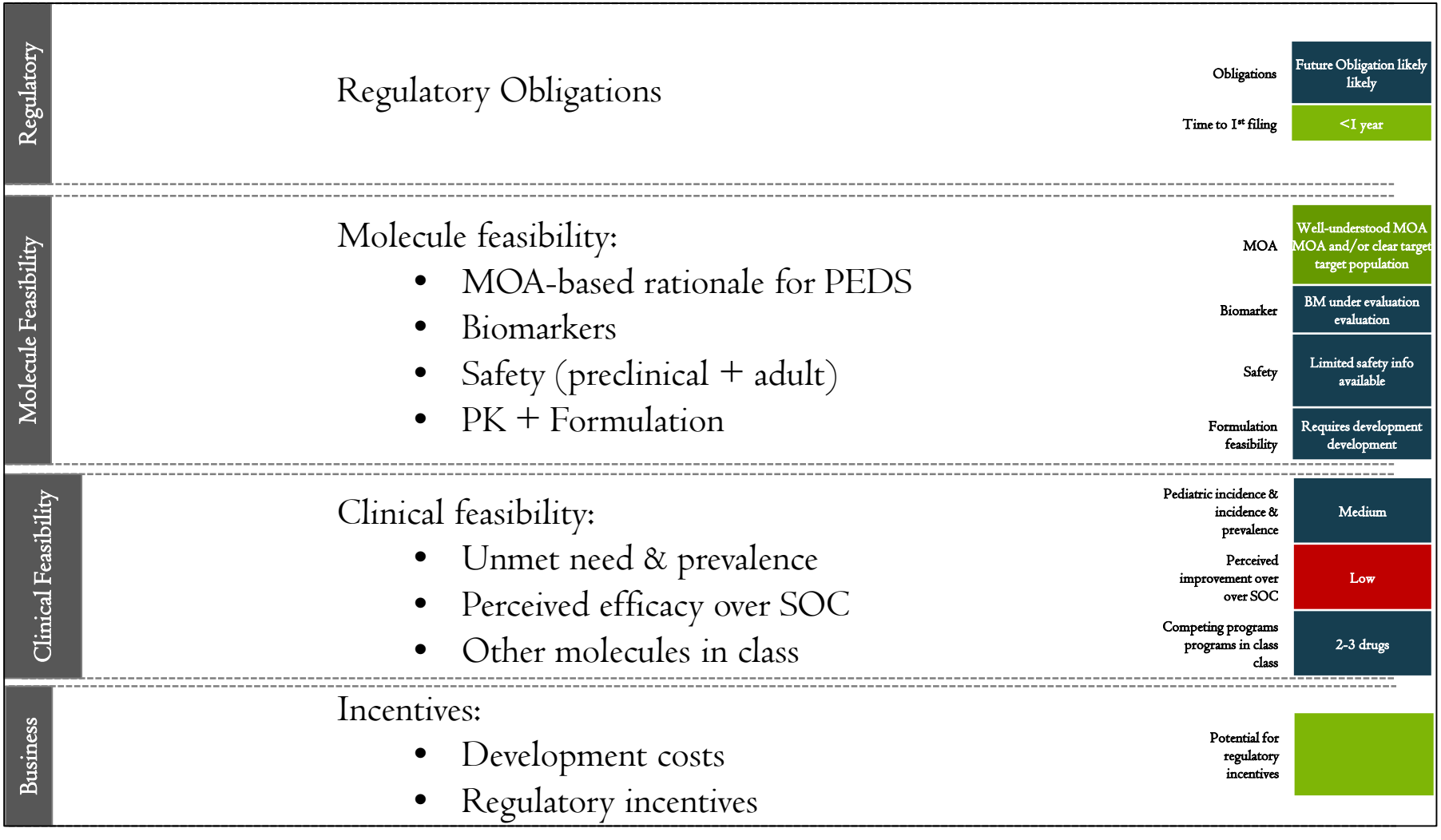
Q:2 | R:-3 | S:-6

Remarks:
No MDM2 amplifications were detected in a cohort with 67 high-grade round cell sarcomas, including ES/PNET (23), SS (5) and RMS (11) samples (FISH).
Publication: Tanas MR *et.al.* (2010). Utilization of fluorescence in situ hybridization in the diagnosis of 230 mesenchymal neoplasms: an institutional experience. *Arch Pathol Lab Med* **134**:1797-803. Pubmed
Curator: Nil Schubert

Q:2 | R:3 | S:+6

Remarks:

iPODD Pediatric Developability Assessment



Prioritization across Molecules & Companies

Accelerate multi-stakeholder strategy forums

- Setup:
  - Molecules in same class OR disease-specific
  - Multi-stakeholder (academia, patient advocates, pharma, health authorities)
  - Formatted data sharing across molecules:
    - MOA
    - Safety (juvenile toxicity / adult safety profile)
    - Pharmacokinetics (biodistribution, CNS penetration, dosing schedules)
    - Adult efficacy data
    - Stage of adult development
    - Formulation (pediatric?)
    - Available pediatric data
  - Hosted by European Medicines Agency (EMA) in London

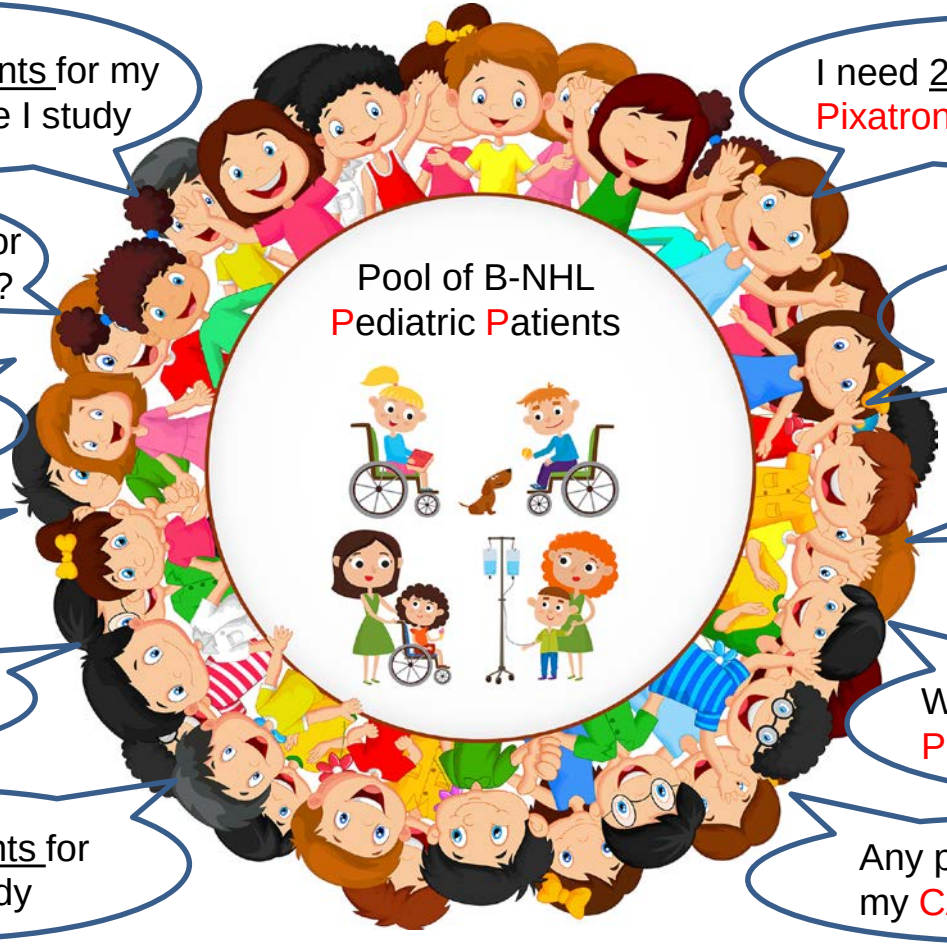
- Experience: ALK Strategy forum (Jan. 2017: 7 ALK-inh from 6 companies)
  BNHL Strategy forum (Nov. 2017: 20 molecules from 15 companies)
  Immuno-checkpoint inh. (Sept. 2018: in preparation)

A Case Study
Prioritization of Molecules for pediatric B-cell Non Hodgkin Lymphoma (B-NHL)




Do we need a Pediatric B-NHL Strategy?

Molecule prioritization



I need 36 patients for my Idelalisib Phase I study

I need 280 patients for my Pixatrone studies

Where are patients for my CD20 CD3 study?

I need patients for my Pembrolizumab studies

Don't forget Venetoclax!

…and some for the Pralatrexate!

What about the Nivolumab study?

I need patients for my Acalabrutinib

We may need patients for Polatuzumab studies!

I need 72 patients for my Ibrutinib study

Any patients left for my CAR-T studies?

What are the Issues Faced in Pediatric B-NHL?

	B-NHL patients numbers (EU)		
	(0-19 yr)	(0-19 yr)	(≥ 20 yr)
	1L	r/r	1L
Total B-NHL	2000		180,000
Burkitt Lymphoma	800	40	9000
DLBCL (Diffuse large B-cell Lymphoma)	250	12	54,000
FL (Follicular Lymphoma)	10-20	2	72,800

Source: Adapted from Dr. Thomas Gross's presentation at the Accelerate Strategy Forum, November 2017

- Few pediatric patients in both 1L and r/r B-NHL
- '*MabThera + LMB-96*' 1L treatment has 94% EFS => high bar for new molecules and less r/r patients expected in the future

- Too many drugs to test and <u>not enough pediatric patients</u>
- Current pediatric studies facing recruitment challenges due to competition => 9 ongoing PIPs and 4 future PIPs
  - High risk of early study closure without sufficient data to support a label update
- High resource burden on companies to maintain pediatric studies with low chance of obtaining incentives
- Difficulty to obtain Product Specific Waiver (PSW) vs. PIP based on non-feasibility of conducting pediatric trial

Internal Prioritization of Roche B-NHL Molecules

Rationale and Strategy moving forward

- 3 Molecule are pursuing same/similar adult indications for pivotal studies in DLBCL and FL
- Timing of adult programs overlap, which translates into overlapping PIP obligations in pediatric DLBCL/BL/mature BLL
- iPODD Team solicited feedback from the 3 EU Forums on which B-NHL molecule they would prioritize and how:
    - EMA PedOnc Portfolio meeting 22 Sept 2017
    - Advisory Board 11 Oct 2017
    - Pediatric Strategy B-NHL Forum 13-14 November 2017
- Key feedback received
    1. The preferred drugs to be investigated in pediatric B-NHL are CAR-T, T-cell bispecific antibodies and some ADCs (depending on target and on toxicity profile of drug-conjugate)
    2. Feasibility is not grounds for waiver but, if justified with supportive evidence, could be considered

Outcome

- iPODD team was successfully able to conduct the prioritization of the molecules across its portfolio in B-NHL space receiving EMA-PDCO agreement on its proposal based on:
  - Strong scientific rationale to move ahead with the molecule(s) whose MOA and overall profile would most likely to be effective
  - Feasibility challenges to successfully enroll pediatric patients in all programs for a meaningful outcome
  - Feedback received from academic experts to support the above

- The team is currently working on a multi-arm early phase clinical design to study prioritized molecule

Key Messages

- Revision of PREA to direct MOA-based pediatric drug development is the right approach and is much needed for the timely development and access of cancer drugs to the pediatric patients
- It will enforce the proactive and early consideration of integrating pediatric development as part of overall clinical development plan for the molecule
- Strong collaboration among Regulators, Sponsors and, Academic Partners, detailed preclinical POC testing, global harmonization of study designs, and molecule prioritization will be critical for it successful implementation
- Innovative trial designs, establishing clinical development matching pediatric potential and molecule developability and shifting mindsets to take a MOA-based portfolio approach will be the new norm

Thank You

Pediatric Oncology Subcommittee of ODAC:

Mechanisms to assure efficiency and to enhance global coordination through international collaboration

Recommendations for International Collaborations and Coordination

Gilles Vassal

Gustave Roussy, France

June 20, 2018

The oncology paradoxe in 2018

Many drugs in adults
Adult disease – based pediatric developments

- Waived or delayed pediatric developments
- Poor access to pediatric patients

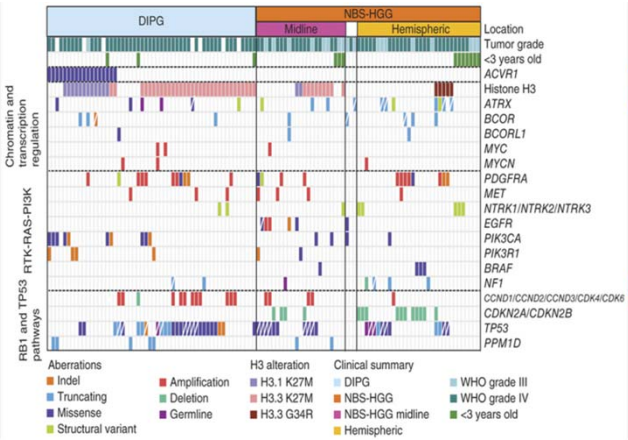
Rare patients

- Poor access to innovation

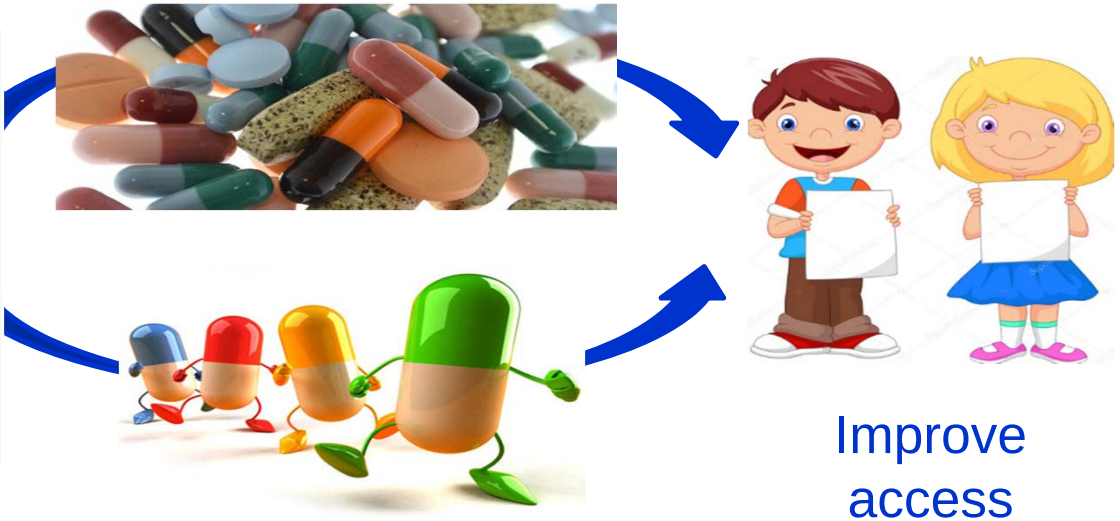
New oncology drug development for children : the goal

Many drugs in adults

SCIENCE MOA* – based development and prioritisation **NEEDS**



Nat Genet. 2014 May;46(5):444-450.



Specific pediatric drugs

Improve access

*Mechanism of action

A favorable regulatory environment, now!

FDA REAUTHORIZATION OF 2017

SEC. 504. DEVELOPMENT OF DRUGS AND BIOLOGICAL PRODUCTS FOR PEDIATRIC CANCERS: molecular targets regarding cancer drugs and biological products…….. if the drug or biological product is ……..

"(i) **intended for the treatment of an adult cancer**;

and

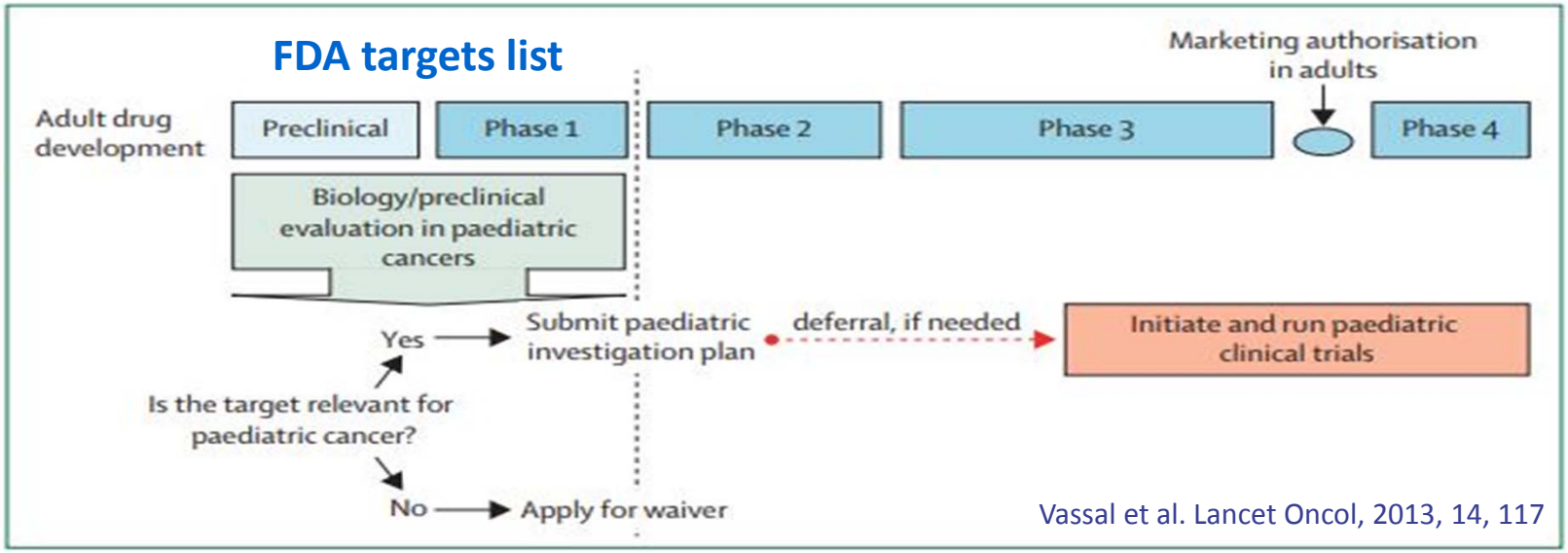
"(ii) **directed at a molecular target that the Secretary determines to be substantially relevant to the growth or progression of a pediatric cancer**."

EUROPEAN MEDICINES AGENCY
SCIENCE MEDICINES HEALTH

EMA decision (CW/0001/2015) of 23 July 2015 on class waivers, in accordance with Regulation (EC) No 1901/2006 of the European Parliament and of the Council.

Revised Class Waiver List
Enters into force July 28, 2018

Early evaluation of MOA relevance

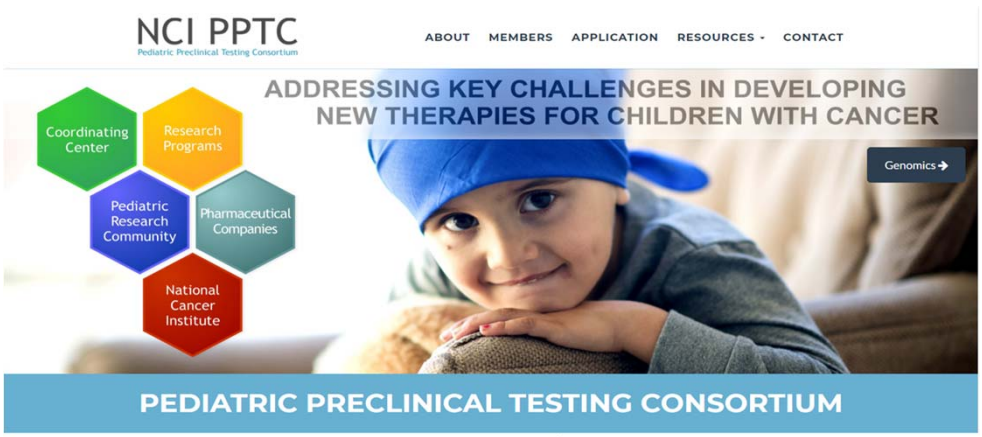


Vassal et al. Lancet Oncol, 2013, 14, 117

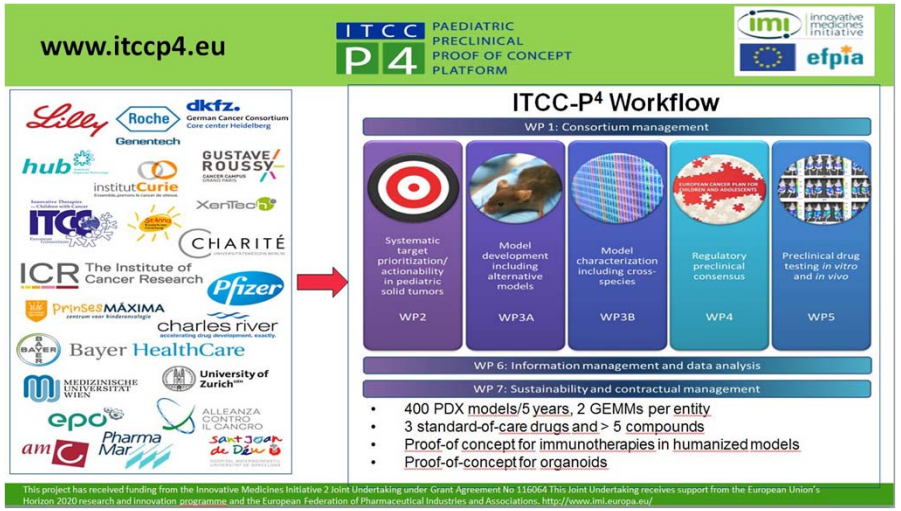
NEED for :

- **Early pipeline discussions between scientists, ped oncologists and Pharma**
- **Easy access to data and high quality preclinical platforms**
- **International consensus on required biological and preclinical data**

Easy access to preclinical platforms



http://www.ncipptc.org/



First joint PPTC ITCC-P4 meeting
at the 2018 American Association for Cancer Research annual meeting

ITCC P4 – GA No. 116064

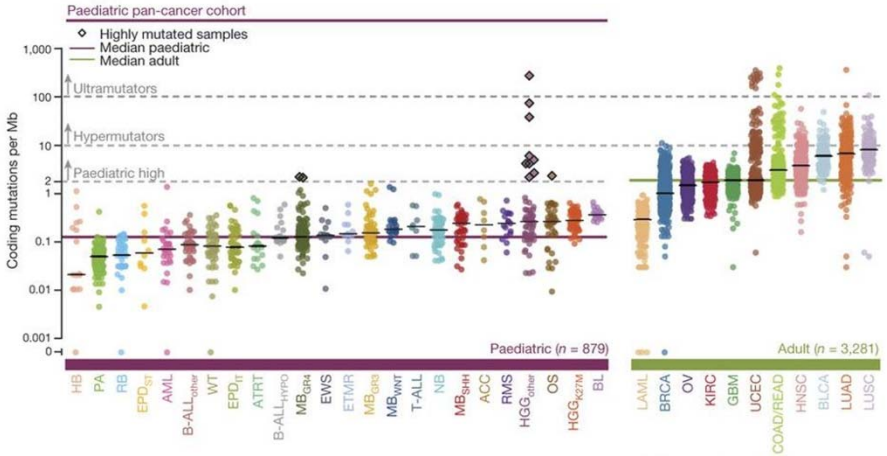
ITCC-P4 International Workshop

IMPROVING PEDIATRIC ONCOLOGY DRUG DEVELOPMENT THROUGH PRECLINICAL RESEARCH

September 27th and 28th, 2018 // Amsterdam, NL

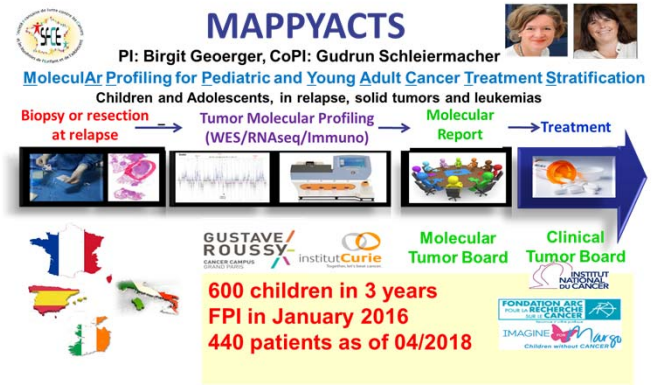
an **international scientific consensus on preclinical evaluation** that will be published in a peer-reviewed journal and will serve as a basis for a guidance to be submitted to regulatory authorities for qualification.

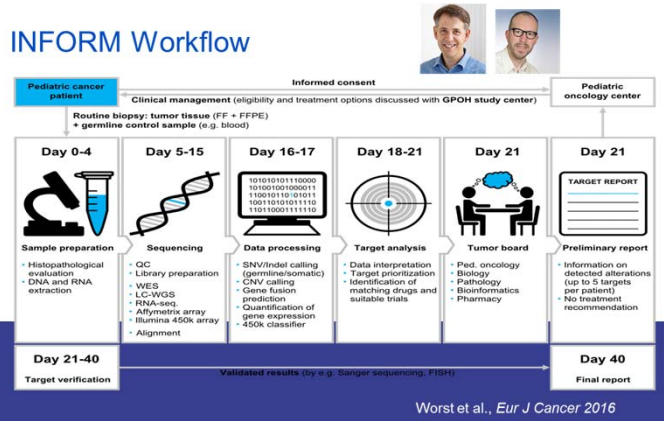
Access to molecular data at diagnosis and at relapse (examples)



Grobner et al. Nature, 2018, 555, 321

https://www.pedpancan.com





Worst et al., *Eur J Cancer 2016*

International cooperation to run trials

- Track record of successful phase III academic trials
  - Burkitt lymphoma, Hepatoblastoma, Osteosarcoma, Ewing, ……..
- But major regulatory and administrative hurdles for academic trials
- Most industry trials are international

- Pediatric oncology drug development is global
- This is NECESSARILY a multistakeholder endeavor

International Multistakeholder Paediatric Oncology Platform

To improve new oncology drug development for children

Creating a unique, multi-stakeholder Paediatric Oncology Platform to improve drug development for children and adolescents with cancer

Eur J Cancer 2015;51:218.

Gilles Vassal [a,*], Raphaël Rousseau [b], Patricia Blanc [c], Lucas Moreno [d], Gerlind Bode [e], Stefan Schwoch [f], Martin Schrappe [g], Jeffrey Skolnik [h], Lothar Bergman [i], Mary Brigid Bradley-Garelik [j], Vaskar Saha [k], Andy Pearson [l], Heinz Zwierzina [m]

Academia,
Industry,
Parents,
Regulatory Bodies

ACCELERATE
INNOVATION FOR CHILDREN AND ADOLESCENTS WITH CANCER

Created in December 2015

www.accelerate-platform.eu

ACCELERATE

INNOVATION FOR CHILDREN AND ADOLESCENTS WITH CANCER

The value of working together

No blame! No shame!

Generate data and find solutions

European Journal of Cancer 62 (2016) 1–8

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.ejcancer.com

Current Perspective

Implementation of mechanism of action biology-driven early drug development for children with cancer

Andrew D.J. Pearson [a,*,1], Ralf Herold [b], Raphaël Rousseau [c], Chris Copland [d], Brigid Bradley-Garelik [e], Debbie Binner [f], Renaud Capdeville [g], Hubert Caron [h,i], Jacqueline Carleer [j], Louis Chesler [k], Birgit Geoerger [l], Pamela Kearns [m], Lynley Marshall [n], Stefan M. Pfister [o], Gudrun Schleiermacher [p], Jeffrey Skolnik [q], Cesare Spadoni [r], Jaroslav Sterba [s,t], Hendrick van den Berg [b], Martina Uttenreuther-Fischer [u], Olaf Witt [v], Koen Norga [w], Gilles Vassal [x] on behalf of Members of Working Group 1 of the Paediatric Platform of ACCELERATE[2]

Mechanism of action – driven development plans in pediatric oncology

along with

Prioritisation of compounds among those developed in adults

Paediatric Strategy Forum

Paediatric Strategy Forum - scientific meeting to **share information and advance learning on a topic** which will inform a paediatric drug development strategy and subsequent decisions :
Define the needs and facilitate prioritization

Principle: dialogue and constructive interactions between **ALL relevant international stakeholders** :
clinicians, academics, patients advocates, pharmaceutical companies and regulators

Output: Summary on websites and Article in a peer-reviewed journal

Paediatric Strategy Forums

Forum n° 1 - January 2017
Alk inhibition

- Very substantially relevant target for 3 paediatric malignancies (NB, ALCL, IMT)
- 6 drugs (4 approved) and no PIPs
- Clear activity in ALCL and IMT through academic trials

Forum n° 2 - November 2017
Mature B-cells malignancies

- Rare diseases with 94% cure rate with new standard treatment
- Many drugs in development in adults (20 were discussed)

Paediatric Strategy Forums

Forum n° 3 - September 2018

Checkpoint inhibitors in combination

- Several PD1 and PDL1 inhibitors approved
- Many in development with a vast majority likely to be approved in adults
- Very limited activity in paediatric malignancies, qualified as “cold” tumors

Forum n° 4 - April 2019

Pediatric acute myeloid leukemias

- Rare conditions
- Many drugs in adults
- Several PIPs in competition for access to patients in phase III trials

Proposal for International Paediatric Strategy forums

- Co-organised by ACCELERATE, EMA and FDA (permanent preparatory team)
- A dedicated Programm Committee for each forum with experts from EU and US Cooperative Groups
  = a single international forum for each topic
- Invitation of academia, pharma and patients advocates following expression of interest
- Venue : alternatively in Europe and the US
- Up to 4 Forums in paediatric oncology per year

ACCELERATE

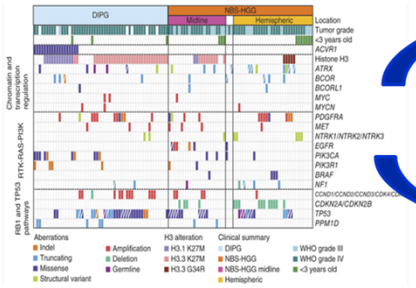
INNOVATION FOR CHILDREN AND ADOLESCENTS WITH CANCER

- Re-organised with an International Steering Committee
- Working and interactive meetings
- An International platform for multistakeholder discussions to facilitate and accelerate a coordinated global agenda in the new regulatory environment in the US and Europe
- Need to engage more pediatric oncologists and scientists.

Next meeting – February 2019, Brussels

New oncology drug development for children : an international collaboration

SCIENCE

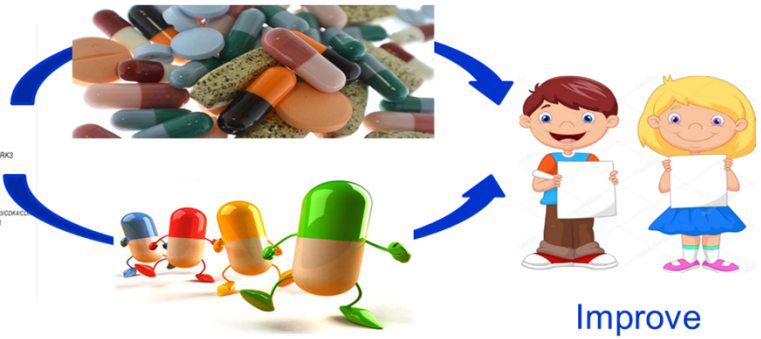


Nat Genet. 2014 May;46(5):444-450.

NEEDS

Many drugs in adults

MOA* – based development and prioritisation



Specific pediatric drugs

Improve access

Work together (all stakeholders)

In a favorable regulatory environment

*Mechanism of action

Pediatric Health Policy, Regulatory Affairs, Global Drug Development

Addressing Challenges to Global Coordination

Christina Bucci-Rechtweg MD, Global Head Pediatric Health Policy
FDA, CDER, *PedsODAC Meeting*
20 June 2018

NOVARTIS

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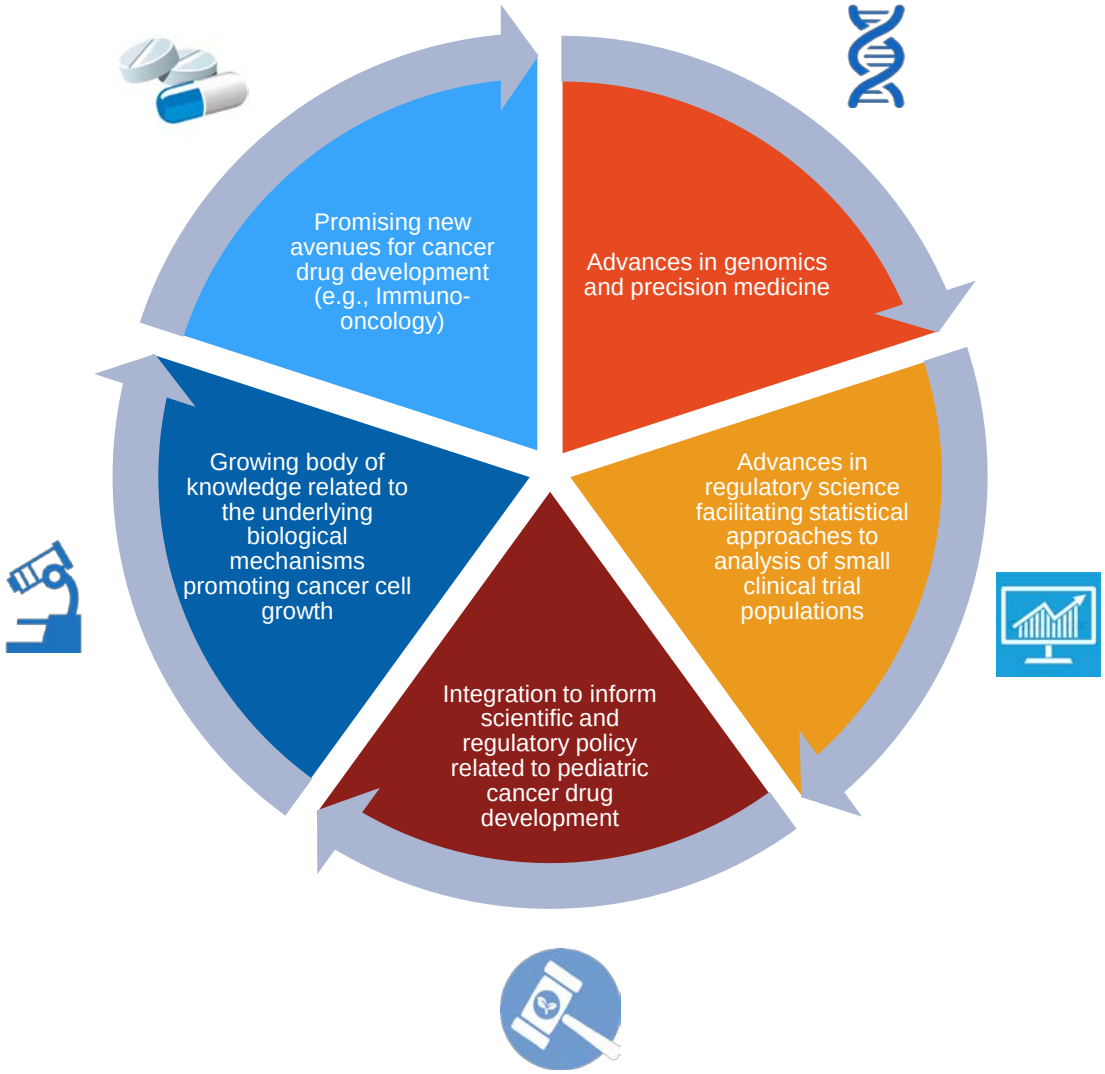
Agenda

1. Setting the scene
2. Global solutions focused approaches
   - Population specific
   - Identification of unmet need
   - Regulatory pathway to agreeing a pediatric plan
3. Parting Thoughts

Setting the scene

NOVARTIS

Setting the scene



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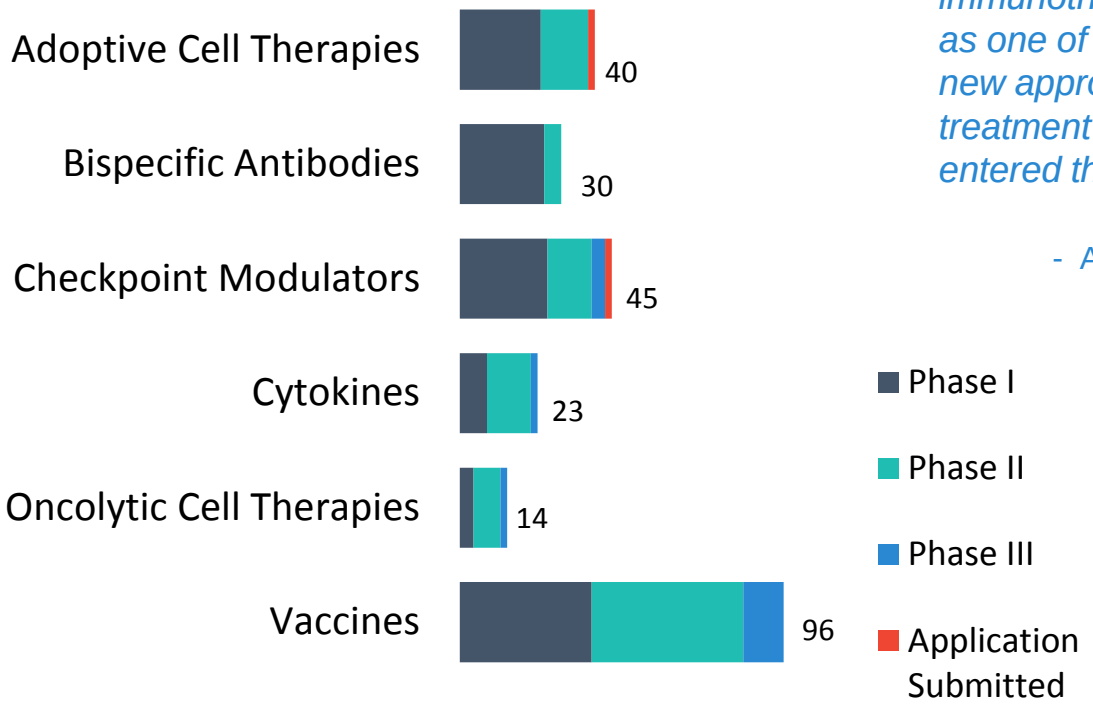
Promise in the Pipeline: More than 200 Immuno-oncology Medicines in Development

Number of Medicines in Development in the United States, May 2017, Selected Classes of Immunotherapy

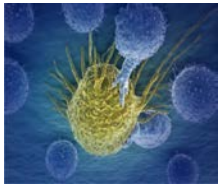


"In the past 5 years, immunotherapy has emerged as one of the most exciting new approaches to cancer treatment that has ever entered the clinic."

- American Association for Cancer Research

Sources: PhRMA, "Medicines in Development for Cancer," September 2015, http://phrma.org/sites/default/files/pdf/oncology-report-2015.pdf; American Association for Cancer Research. "Jose Baselga, MD, PhD" http://cancerprogressreport.org/2015/Pages/baselga.aspx .

Slide courtesy PhRMA - Used with permission



CAR-T therapy is an individualized adaptive immunotherapy

Pediatric acute lymphocytic leukemia (pALL) is the **leading cause of childhood cancer** with ~3,100 new cases annually in the US

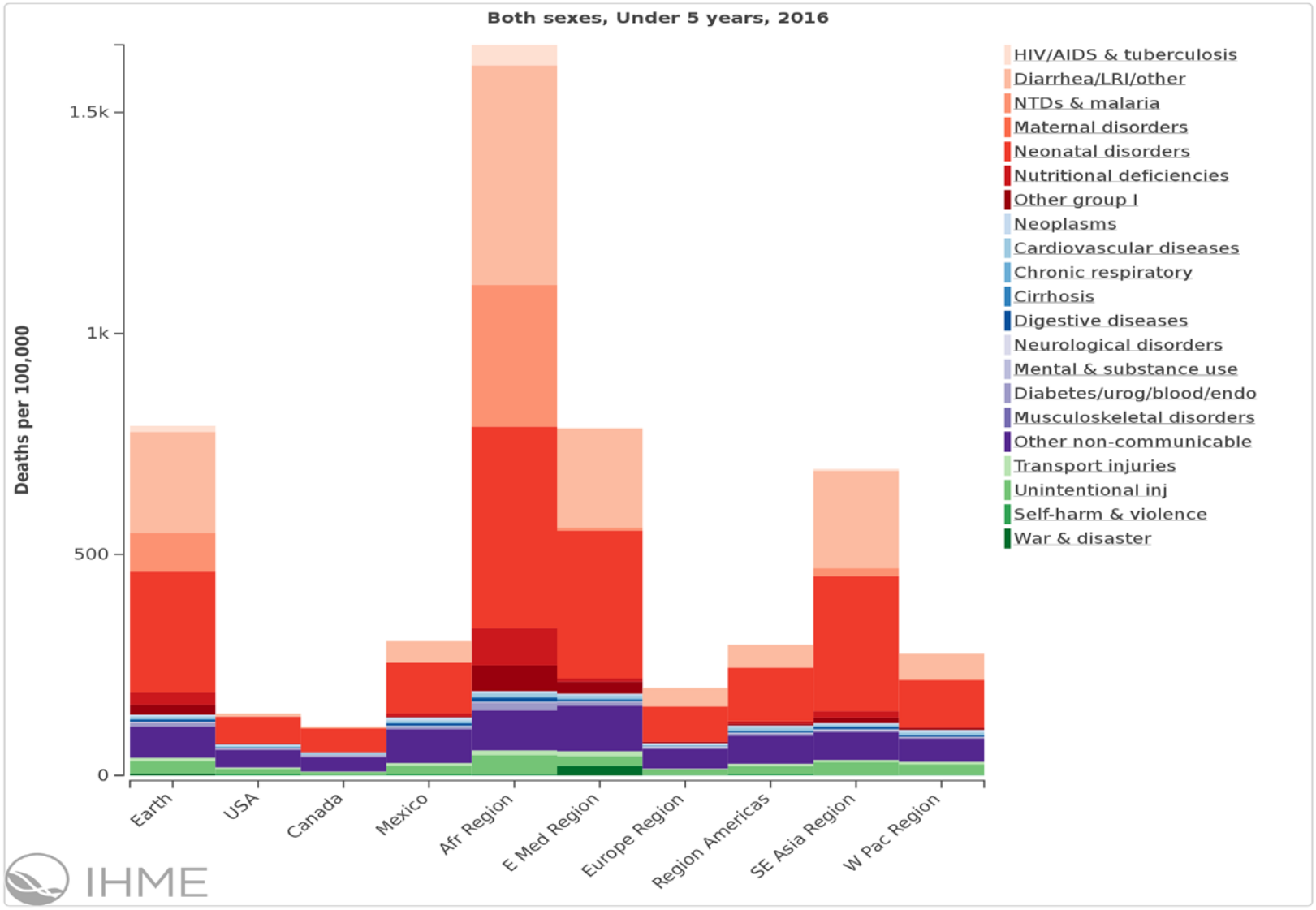
Treatment options for r/r pALL are limited & outcomes are suboptimal

- Allo-HSCT is the only potential curative option, but is limited by eligibility requirements and presents less than optimum outcomes:
  - A matched donor must be identified and patients need to achieve remission
  - 5-yr OS in children receiving HSCT during the 2nd and ≥ 3rd remission is approximately 40% and 30% respectively
  - HSCT is associated with 10-20% treatment-related mortality and serious adverse effects (e.g. GVHD and infections)
- Other treatment options are mainly considered “bridges” to HSCT

Response rate of 83% ORR[1] in pediatric patients with r/r ALL when treated with tisagenlecleucel suspension

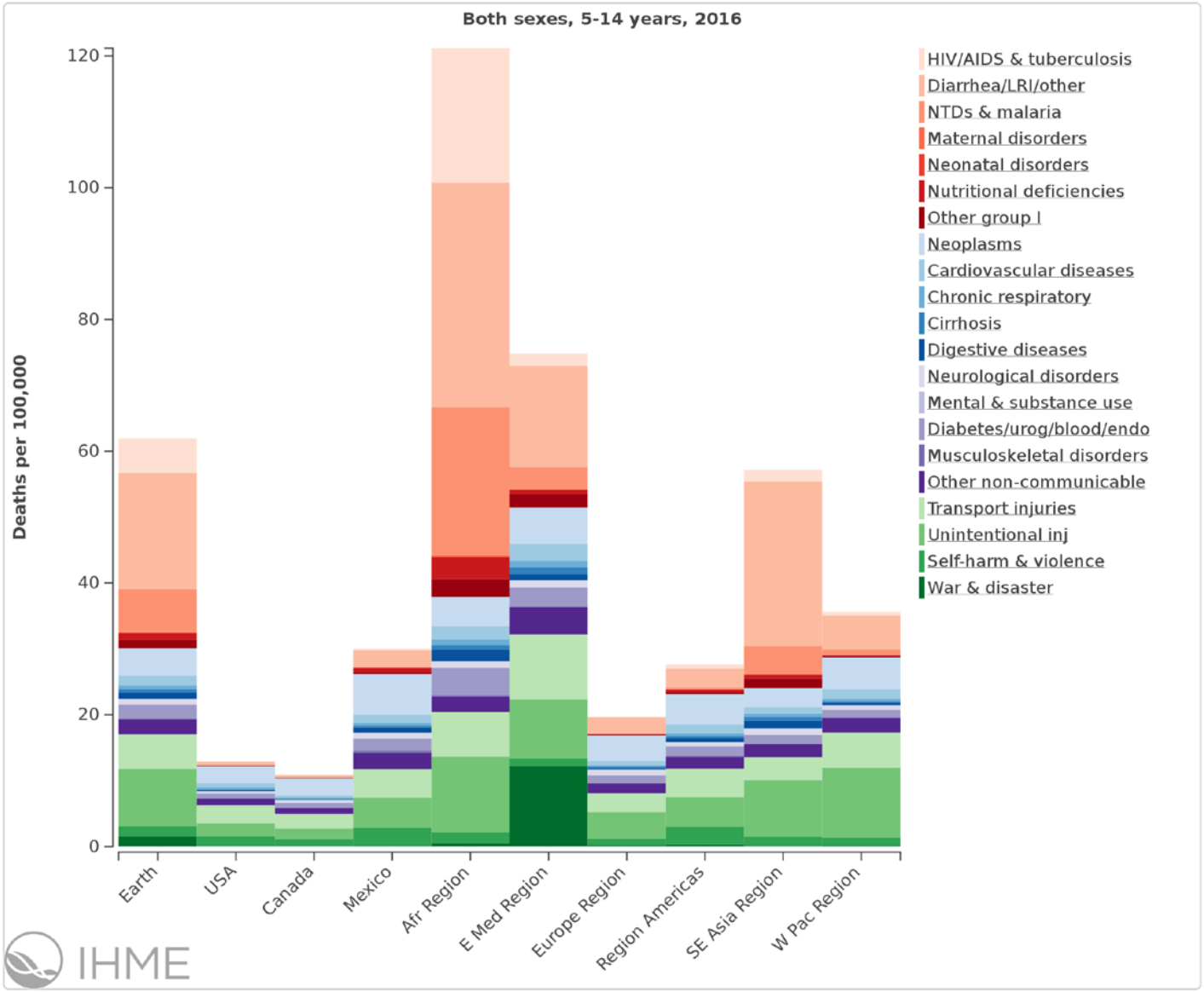
[1] ORR = Overall Remission Rate; Source: KYMRIAH™ (tisagenlecleucel) suspension USPI

Global Burden of Disease:
Causes of Death in Children < 5 years



Institute for Health Metrics and Evaluation (IHME). GBD Compare Data Visualization. Seattle, WA: IHME, University of Washington, 2016. Available from http://vizhub.healthdata.org/gbd-compare. Accessed 29 May 2018.

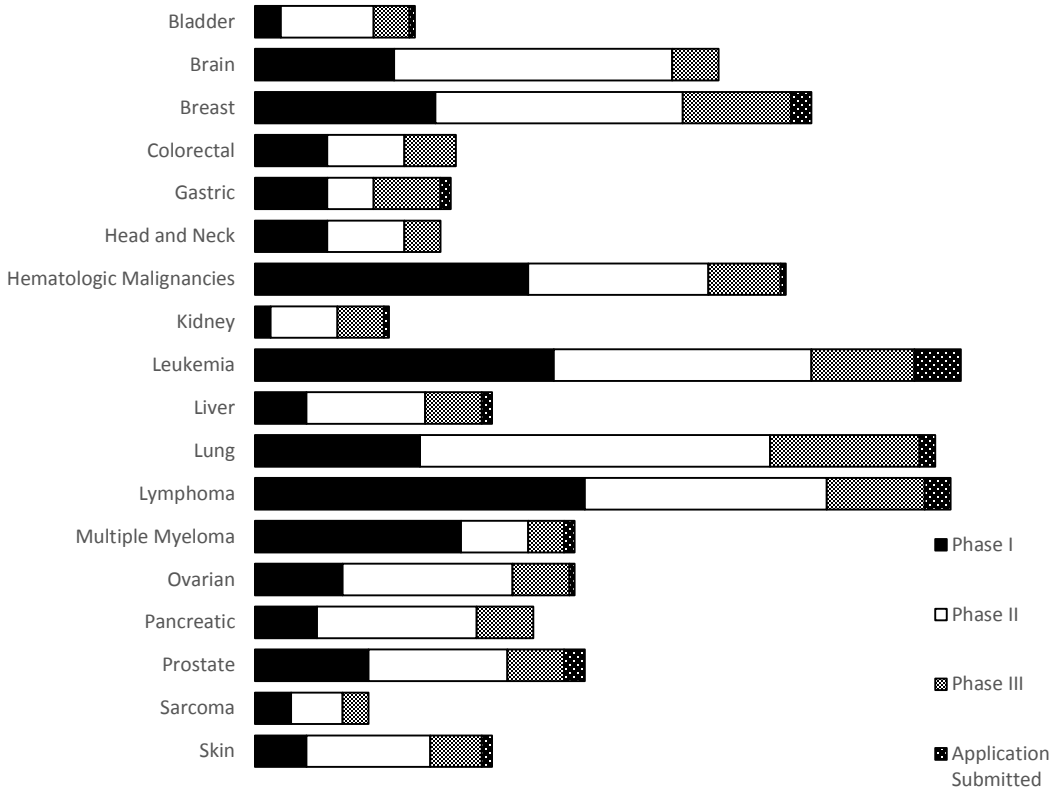
Global Burden of Disease:
Causes of Death in Children 5-14 years



Institute for Health Metrics and Evaluation (IHME). GBD Compare Data Visualization. Seattle, WA: IHME, University of Washington, 2016. Available from http://vizhub.healthdata.org/gbd-compare. Accessed 29 May 2018.

Promise in the Pipeline: More than 1,100 Medicines in Development for Various Cancers

Medicines and Vaccines in Development for Cancer by Tissue of Origin (Selected) – May 2018



*Some medicines may be in more than one therapeutic category.

Sources: PhRMA, Medicines in Development for Cancer, May 2018; American Association for Cancer Research. "Jose Baselga, MD, PhD" http://cancerprogressreport.org/2015/Pages/baselga.aspx .

"These are exciting times… the pace of discovery and application of new knowledge to patient care is rapidly accelerating."

— Dr. Jose Baselga, Physician-in-Chief, Memorial Sloan Kettering Cancer Center

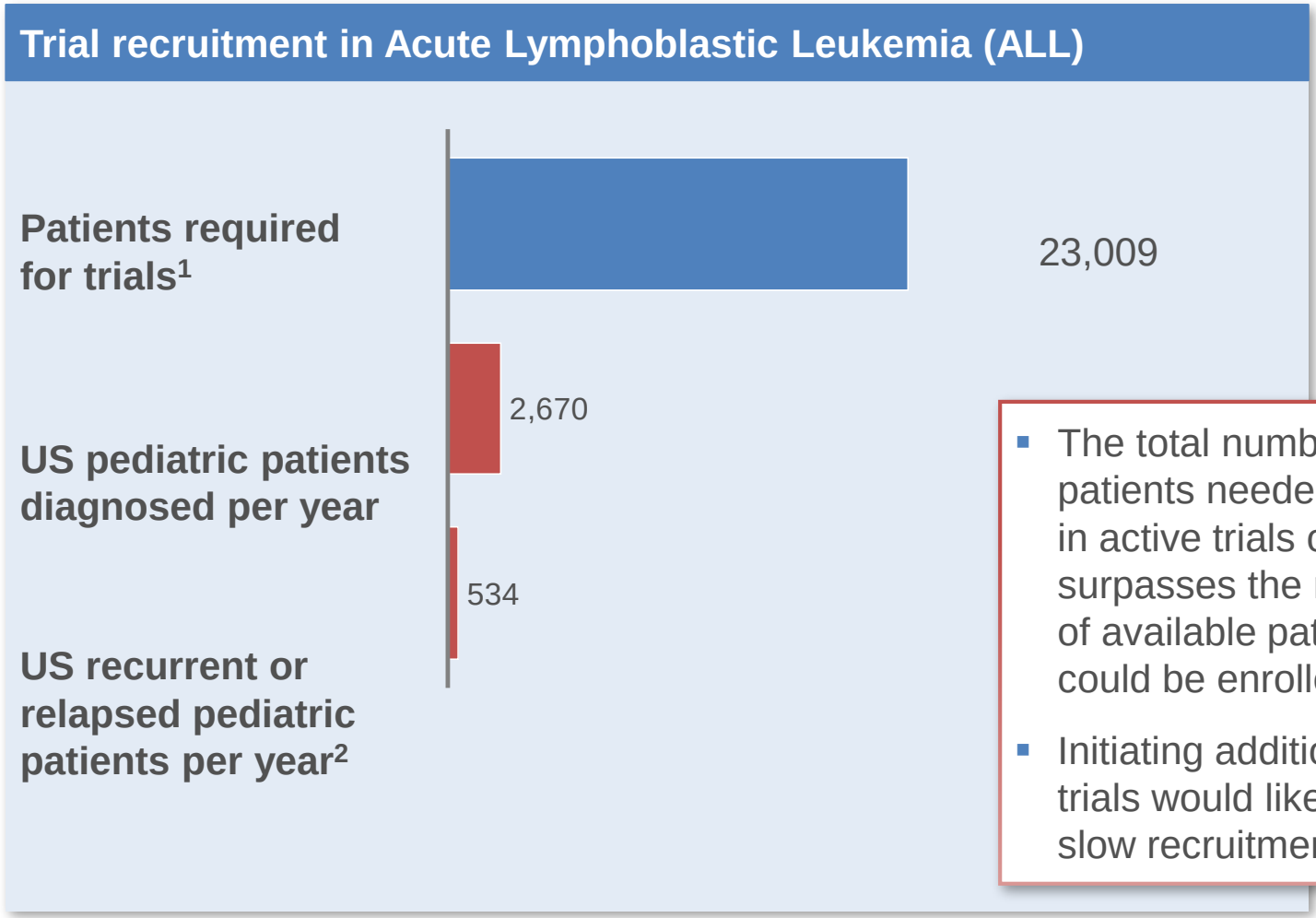
Slide courtesy PhRMA - Used with permission

Industry pipelines are expanding

- 5212 active drugs in development pipelines for Anticancer therapies
- Cancer pipeline candidates posted a 7.6% increase in this year
  - ✓Close to three times that of the overall industry pipeline

Source: Pharmaprojects: track pharma R&D
https://pharmaintelligence.informa.com/resources/product-content/undefined

In today's environment, pediatric oncology trials face significant recruitment challenges



1 Total interventional trials in the US with active recruitment status compiled from Clinicaltrials.gov online database
2 Pediatric ALL relapse rate is ~20%

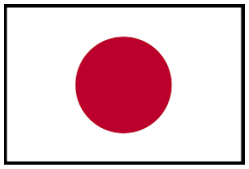
Slide courtesy PhRMA - Used with permission

SOURCE: Cancer.gov; ClinicalTrials.gov; team analysis

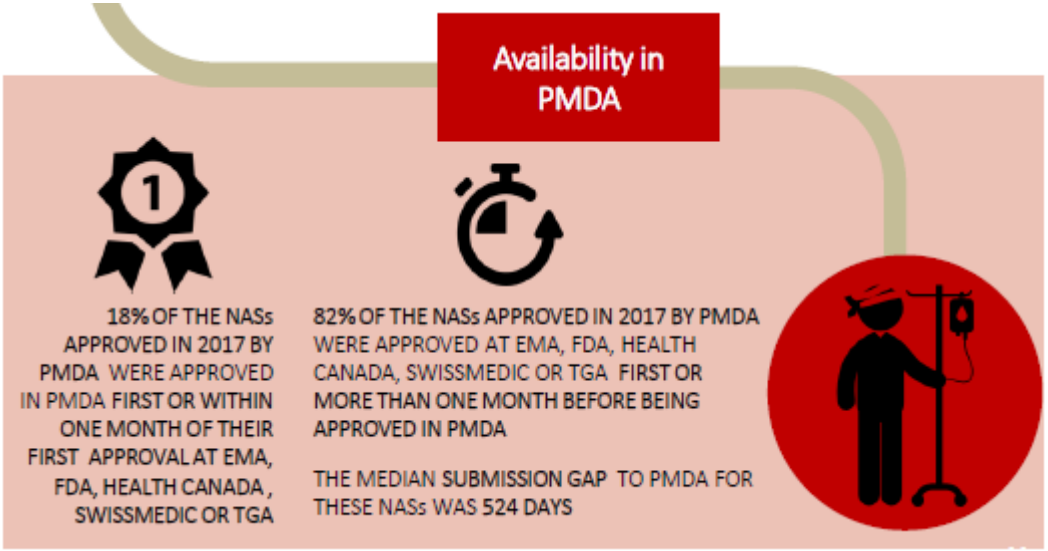
"New generation of cell therapies helps Chinese emerge as industry leaders"

"There are already more clinical trials in the country than in the US, and executives and scientists say it has several strategic advantages that could allow China to challenge US dominance, including an accommodating regulatory regime, low labour costs and expertise in precision manufacturing."

An improved regulatory environment & changes in strategic focus are enhancing access to new therapies globally



Japan



Source: 2018 CIRS – Centre for Innovation in Regulatory Science *R&D Briefing*. P 17.

Solutions focused

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Population specific approaches

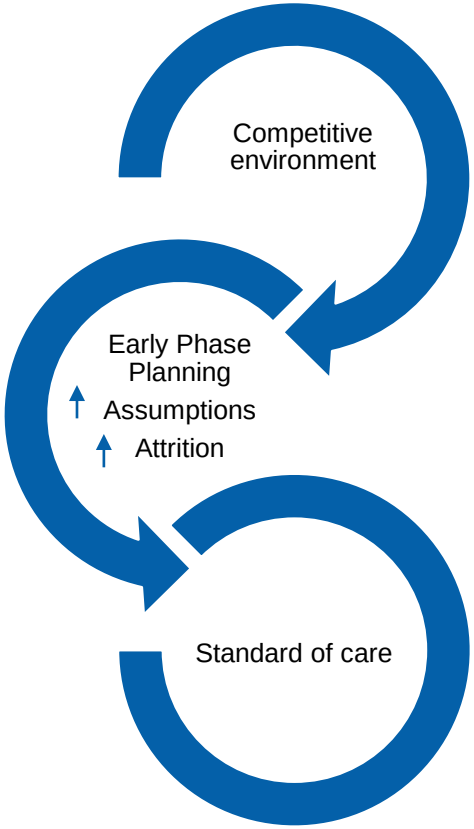
- ✓ Pediatric only cancers
- ✓ Ultra rare cancers
- ✓ Cancers with high mortality despite research investment
- ✓ Cancers occurring in both adults and children

Multi-pronged approach to addressing population specific challenges

	Pediatric cancer	Proposed solutions
Pediatric only cancers	▪ Retinoblastoma	▪ Few novel therapies in development ✓ Drive innovation → Investment in foundational science and **discovery** ✓ **Market drivers** → Meaningful incentives, funding models, manufacturing models, pricing models
Ultra rare cancers	▪ Infantile fibrosarcoma	▪ Extremely limited populations for trial participation ✓ Drive regulatory science → Role for **non-traditional quantitative approaches** to data analytics (Bayesian, etc) ✓ **Dedicated Global pediatric regulatory advice** pathway to facilitate convergence
Cancers with persistently high mortality	▪ Diffuse Intrinsic Pontine Gliomas (DIPG)	▪ Clinical advancement remains limited despite research ✓ Define and target critical **unmet needs** → Coalesce research community in identifying scientific basis of disease ✓ Investment in **foundational science** and discovery
Cancers occurring in both adults and children	▪ Certain bone sarcomas	▪ Translational research of novel therapies generally excludes adolescent eligibility in adult oncology studies ✓ Regulatory guidance to facilitate **earlier inclusion** of adolescents (where appropriate) ✓ Regulatory agreement to key program design elements (not details) on **high-level pediatric plans** prior to availability of adult data

Global cooperative groups

Global coordination on identification of unmet need



Neutral arbiter

Global multi-stakeholder forum to discuss, align on critical pediatric cancer needs

To converge

(1) mapping of therapies to therapeutic target

and

(2) enhance efficiencies in development of scientifically and commercially viable pediatric therapies

To identify and align on the

RIGHT

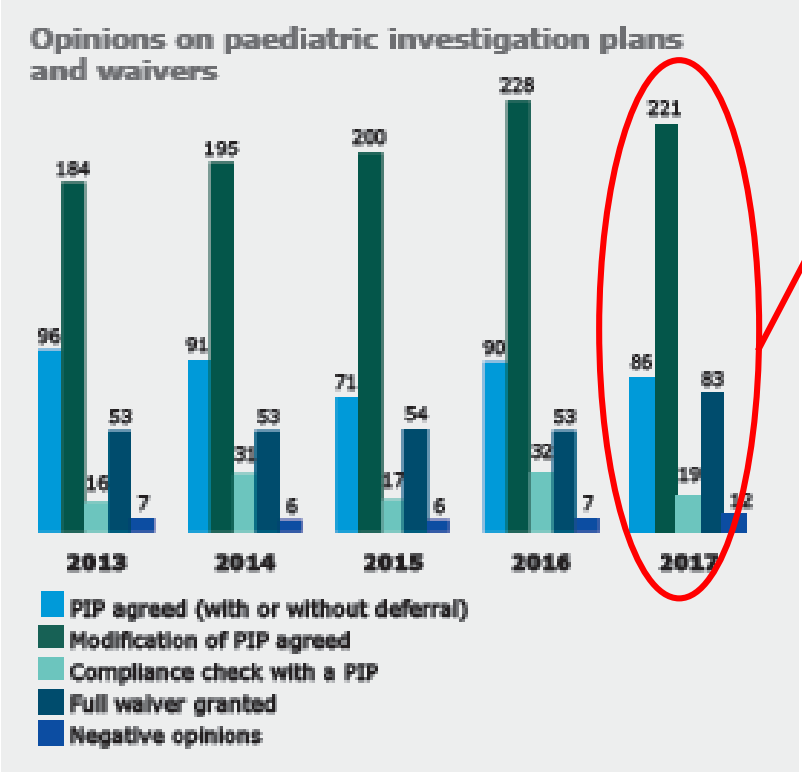
- Indication
- Population
- End-points

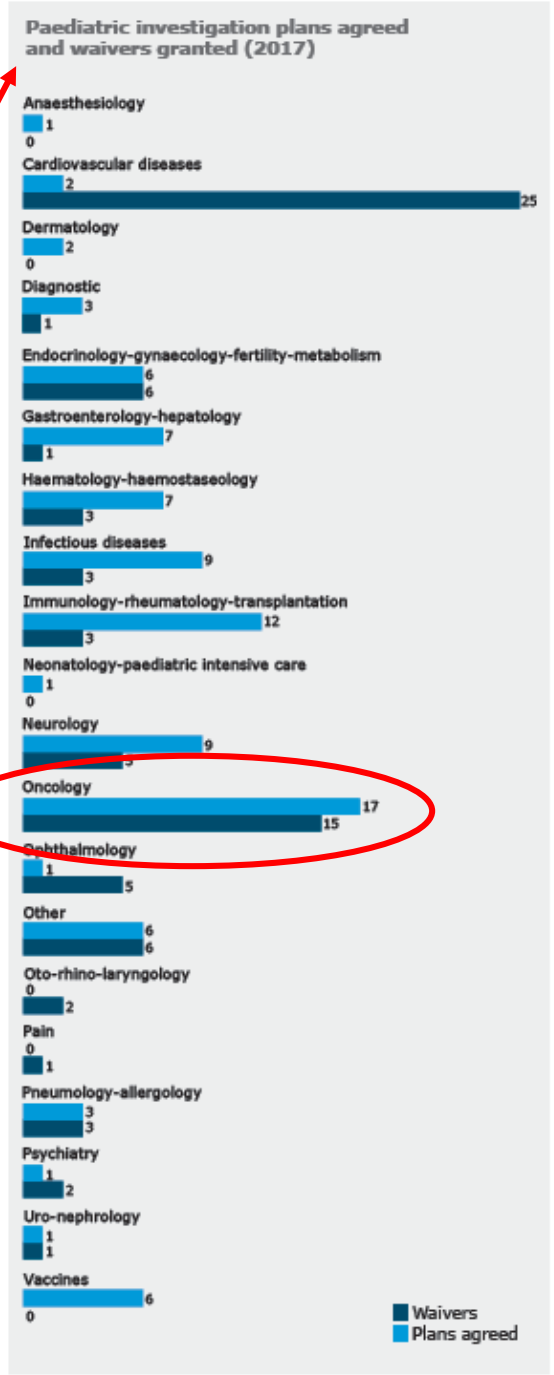
To enhance program and development viability

And

To reduce waste of resource-consuming activities to agree unfeasible programs

EU: 2017 paediatric planning





Source: EMA Annual Report 2017
http://www.ema.europa.eu/docs/en_GB/document_library/Annual_report/2018/04/WC500248201.pdf

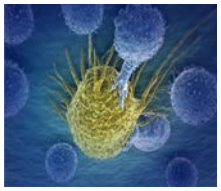
Agreeing a “pediatric plan”

THE PAEDIATRIC REGULATION

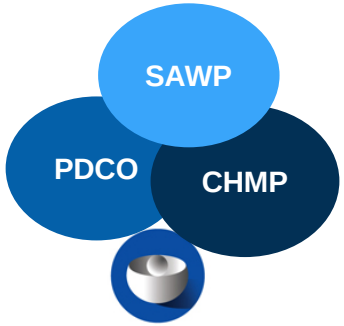
PREA

BPCA

GENERATE DATA



VARIOUS HAs INTERACTIONS



Division

FDA

Applicant

EUROPEAN MEDICINES AGENCY
SCIENCE MEDICINES HEALTH

THE ACTORS

Break-through Designation

Pre-IND / IND Meeting

Type B / C Meeting

Parallel Advice

SA

PRIME

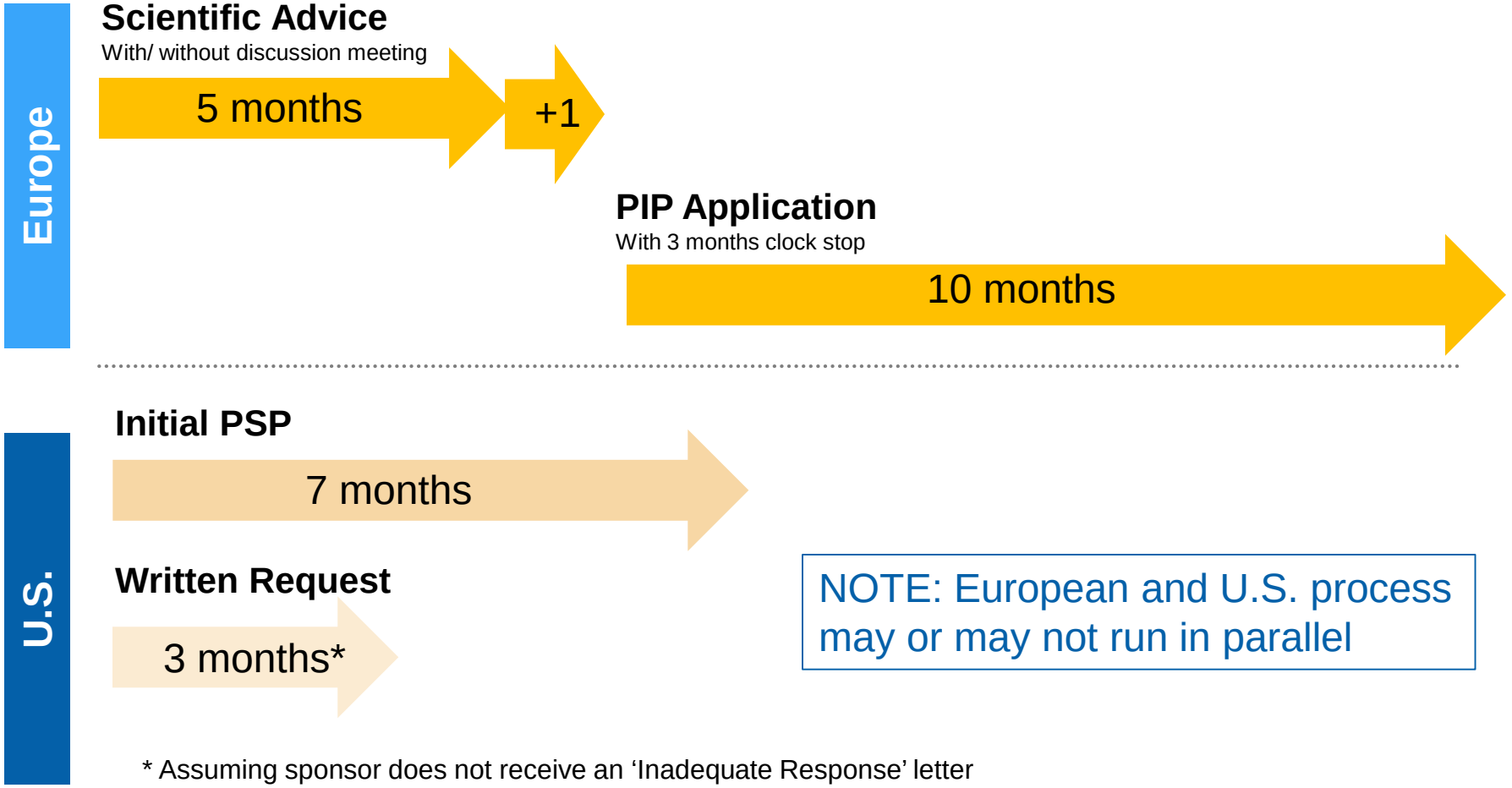
WHEN TO DO WHAT?

RfM

APPLICATION

PAEDIATRIC STRATEGY

Timelines to agree a EU and U.S. "pediatric plan": Overview

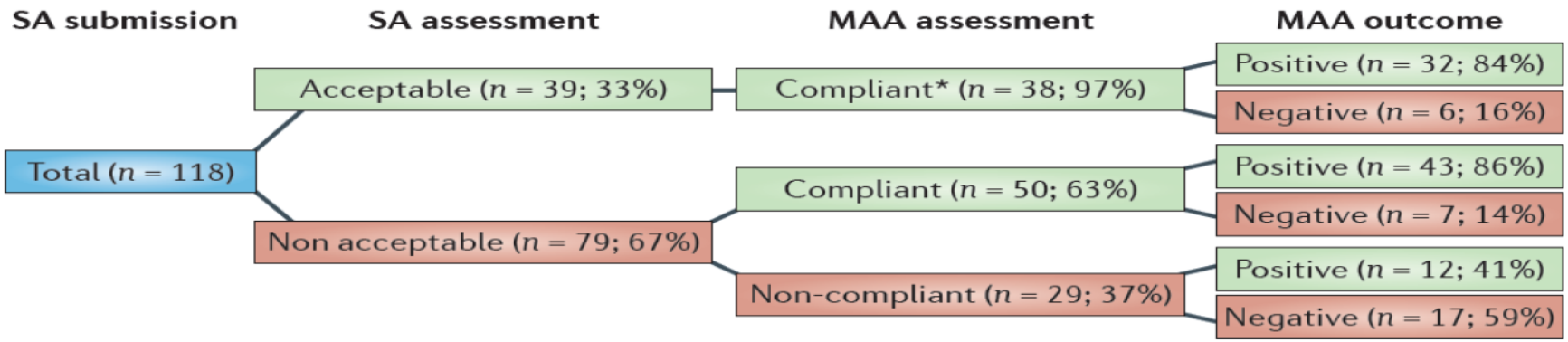


* Assuming sponsor does not receive an 'Inadequate Response' letter

Why do sponsor's seek regulatory advice?

EUROPEAN MEDICINES AGENCY

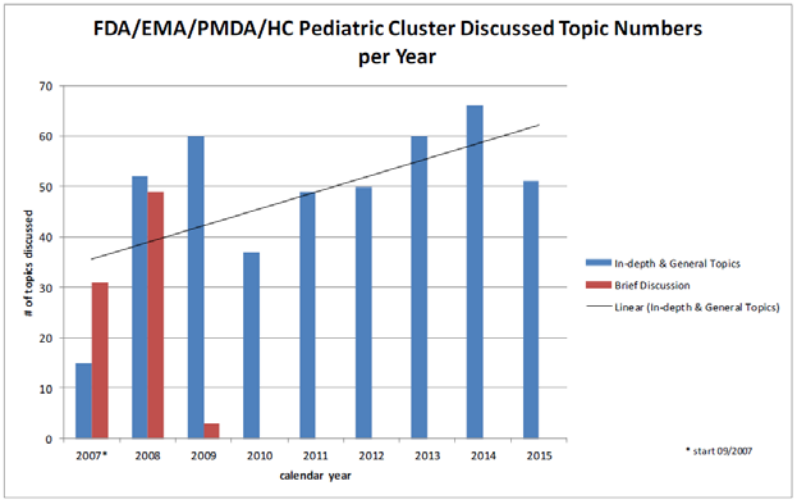
SA can help to guide changes in the pivotal clinical development towards improved regulatory acceptability



- Obtaining and complying SA is strongly associated with a positive outcome of a MAA: almost 90% of those who obtain and follow SA receive a positive opinion compared to 40% for those who do not follow SA; *Hofer et al. 2015*

Jan Regnstrom. Scientific Advice Office (EMA). Presented for SME Info Day.

Regulatory cooperation: Pediatric Cluster & 'Common Commentary



Source: FDA web-site. https://www.fda.gov/downloads/ScienceResearch/SpecialTopics/PediatricTherapeuticsResearch/UCM451789.pdf

- ✓ Pediatric Cluster facilitates conversation **between regulatory bodies** to **enhance the science** of pediatric trials and to **avoid exposing children to unnecessary trials**
  - FDA, EMA, Health Canada, PMDA, TGA
  - Aug 2007 - Oct 2017: Discussions on 456 products and 153 general topics
- ✓ Common Commentary is used to inform sponsors of products discussed at the Pediatric Cluster
  - **Informal**, non-binding comments on **pediatric development plans** that have been **submitted to** both **FDA and EMA**

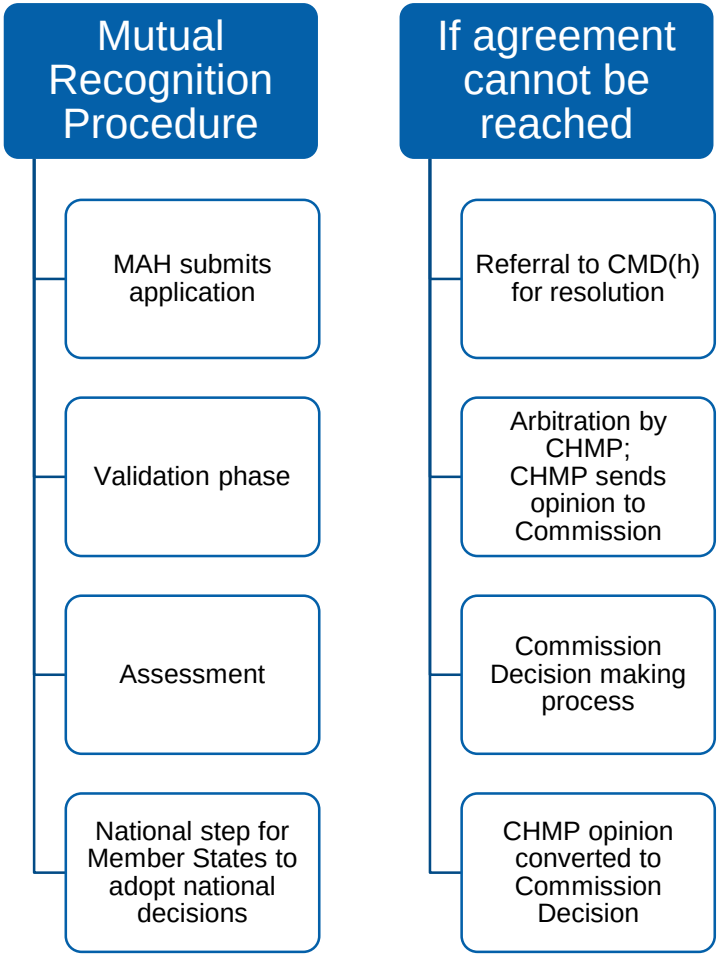
Parallel Scientific Advice

- Mechanism for **EMA**, **FDA and sponsors** to exchange views on scientific issues during program development
  - Increased dialogue between the agencies and sponsors
  - Optimizes development and avoids unnecessary trial replication and divergence of testing methodologies (where applicable)
- Intended for breakthrough drugs or to address important safety issues for:
  - **Oncology**, Vaccines, Orphan Drugs, drugs in the **Pediatric Population**, Nanotechnologies, Advanced Therapies, Pharmacogenomics and Blood products
- Especially useful in early phase development where there is limited precedence
- Focused on sharing information and perspectives, rather than specific harmonization of study or regulatory requirements*
- Resource intensive for all parties

*Advice of each agency may still differ after joint discussion

European Mutual Recognition Procedure*

- A European authorization route resulting in a mutually recognized product
- Can be used when a product is already authorized in at least one Member State (MS) on a national basis and the Marketing Authorization Holder (MAH) wishes to obtain a Marketing Authorization (MA) for the same product in at least one other Member State
  - The MS that has already authorized the product is known as the Reference Member State (RMS)
  - The RMS submits their evaluation of the product to other MSs, or the Concerned Member States (CMS)
  - The CMS is asked to mutually recognize the MA of the RMS
- If the applicant is successful, the CMS will then issue a MA for that product permitting the marketing of that product in their country



* Legal basis: Directive 2001/83/EC

Role for global regulatory cooperative pathway to agree a pediatric plan (Expand, refine, or create)

- ✓ Life-threatening nature of pediatric cancers
- ✓ Small populations
- ✓ Complexity of existing treatment paradigms
- ✓ Molecularly targeted development approaches
- ✓ Assay development

- ➢ Could consideration be given to a pediatric-cancer specific parallel advice pathway, that includes observer agencies?
- ➢ Could consideration be given to establishment of a “mutual recognition” pathway (between EMA-FDA) for agreed pediatric plans?
  - ➢ If joint guidance was developed (by molecular target/pediatric cancer)?
  - ➢ Other?

Parting thoughts

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Parting thoughts

We have an opportunity to facilitate meaningful change in how we develop medicines for children with cancer

Small pediatric oncology patient numbers creates an opportunity for **global collaboration** and avenues for **innovative** approaches

Successful transformational change requires **trust**

The **children** are depending on us

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Thank you

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