

Lifespan

Delivering health with care



**LEGORRETA
CANCER CENTER**

BROWN UNIVERSITY

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Panel: Standardized Representations of Systemic Anticancer Therapy Regimens

An Enabler of Real-World Evidence Synthesis

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Professor of Medicine

Brown University



Disclosures



Grant funding: NIH, AACR,
Brown Physicians Incorporated

Consulting: Westat

Ownership: HemOnc.org LLC

Editorial: JCO CCI

Learning Objectives



Understand the complexities of systemic anticancer therapy (SACT) and name several approaches to standardly represent SACT.



Appreciate the challenges of coordinated representation of complex temporal events and discuss several complementary approaches to temporal resolution.



Learn about how patterns of SACT in real-world practice change over time, and how these changes relate to the understanding of the overall landscape of cancer treatment and prognosis.

Targeted therapy [edit | edit source]

- Rituximab (Rituxan)** 375 mg/m² IV once on day 1, **given first**
 - Patients with peripheral blood involvement could have the cycle 1 dose of rituximab delayed or omitted by clinician discretion

Chemotherapy, Part A [edit | edit source]

- Cyclophosphamide (Cytoxan)** as follows:
 - Cycles 1, 3, 5, 7: 300 mg/m² IV over 3 hours every 12 hours on days 2 to 4, **given second** (total dose per cycle: 1800 mg/m²)
- Vincristine (Oncovin)** as follows:
 - Cycles 1, 3, 5, 7: 1.4 mg/m² (maximum dose of 2 mg) IV once per day on days 5 & 12, **given 12 hours after the last dose of cyclophosphamide on day 5**
- Doxorubicin (Adriamycin)** as follows:
 - Cycles 1, 3, 5, 7: 16.6 to 16.7 mg/m²/day IV continuous infusion over 72 hours, started on day 5 (total dose per cycle: 49.8 to 50.1 mg/m²)

Glucocorticoid therapy, Part A [edit | edit source]

- Dexamethasone (Decadron)** as follows:
 - Cycles 1, 3, 5, 7: 40 mg IV or PO once per day on days 2 to 5, 12 to 15

Supportive therapy, Part A [edit | edit source]

- Mesna (Mesnex)** as follows:
 - Cycles 1, 3, 5, 7: 600 mg/m²/day IV continuous infusion over 76 hours, started on day 2, 1 hour prior to cyclophosphamide and completed 12 hours after the last dose of cyclophosphamide
 - "Over 76 hours" is not exactly specified in Romaguera et al. 2005; Wang et al. 2008. It is based on the assumption that "completed 12 hours after the last dose of cyclophosphamide" means that it would finish 12 hours after the last dose of cyclophosphamide completes.

Chemotherapy, Part B [edit | edit source]

- Methotrexate (MTX)** as follows, by the following laboratory-based criteria:
 - Cycles 2, 4, 6, 8, patients with creatinine up to 1.5 mg/dL: 200 mg/m² IV over 2 hours once on day 2, then 800 mg/m² IV over 22 hours (total dose per cycle: 1000 mg/m²)
 - Cycles 2, 4, 6, 8, patients with creatinine greater than 1.5 mg/dL: 100 mg/m² IV over 2 hours once on day 2, then 400 mg/m² IV over 22 hours (total dose per cycle: 500 mg/m²)
 - Urine alkalinized to pH of 6.8 or more prior to the start of methotrexate and kept within that range until methotrexate is cleared
- Cytarabine (Ara-C)** as follows, by the following age- and laboratory-based criteria:
 - Cycles 2, 4, 6, 8, patients up to age 60 and with creatinine up to 1.5 mg/dL: 3000 mg/m² IV over 2 hours every 12 hours on days 3 & 4 (total dose per cycle: 12,000 mg/m²)
 - Cycles 2, 4, 6, 8, patients older than 60 or with creatinine greater than 1.5 mg/dL: 1000 mg/m² IV over 2 hours every 12 hours on days 3 & 4 (total dose per cycle: 4000 mg/m²)

Supportive therapy, Part B [edit | edit source]

- Folinic acid (Leucovorin)** as follows:
 - Cycles 2, 4, 6, 8: 50 mg PO once on day 3, 12 hours after methotrexate is complete, then 15 mg PO every 6 hours for 8 doses. If serum methotrexate level at 24 hours is greater than 1000 nmol/L or at 48 hours is greater than 100 nmol/L, dose is increased to 100 mg IV Q3H.
- Prednisolone** as follows:
 - Cycles 2, 4, 6, 8: 1% ophthalmic solution 2 drops in each eye four times per day on days 3 to 9 was started on the day of the start of cytarabine infusion and was continued for 7 days to prevent chemical conjunctivitis.

Supportive therapy, all cycles [edit | edit source]

All growth factors and antibiotics given for 10 days, starting 24 to 36 hours after doxorubicin infusion is complete in A cycles and not specified in B cycles

- Filgrastim (Neupogen)** 5 mcg/kg SC once per day
- Valacyclovir (Valtrex)** 500 mg PO once per day
- Fluconazole (Diflucan)** 100 mg PO once per day
- ONE of the following fluoroquinolones:
 - Levofloxacin (Levaquin)** 500 mg PO once per day
 - Ciprofloxacin (Cipro)** 500 mg PO twice per day
- Erythropoietin** was permitted throughout therapy

21-day cycle for 8 cycles

Subsequent treatment [edit | edit source]

- Merli et al. 2012, responders: **autologous HSCT (regimen not specified)**

R-HyperCVAD/R-MA

State of the art, 1965-2011

MBC

Use:	Head and neck cancer	Cycle: 21 days		
Regimen:	Methotrexate	40 mg/m ²	IV	Days 1–15
	Bleomycin	10 units/m ²	IM	Days 1, 8, 15
	Cisplatin	50 mg/m ²	IV	Day 4

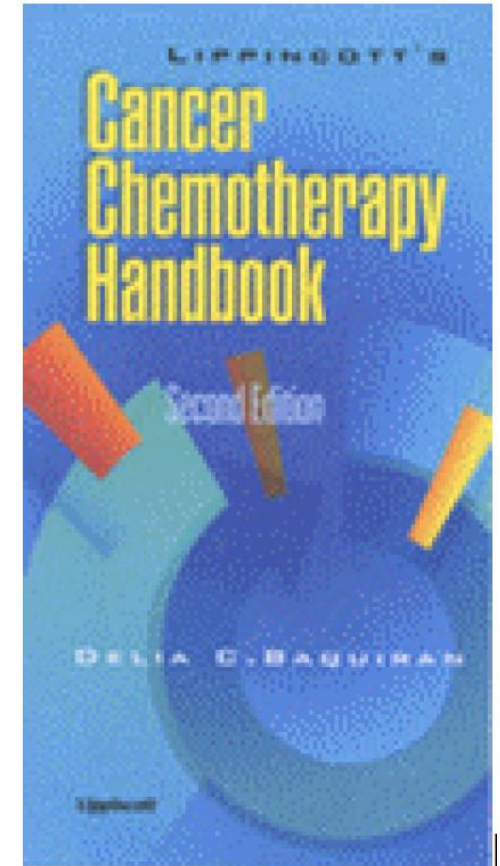
MC

Use:	Acute myelocytic leukemia (AML; adult induction)	Cycle: 28 days		
Regimen:	Mitoxantrone	12 mg/m ²	IV	Days 1–3
	Cytarabine	100–200 mg/m ² /day	CI	Days 1–7

MF

Use:	Breast cancer	Cycle: 28 days		
Regimen:	Methotrexate	100 mg/m ²	IV	Days 1–8
	Fluorouracil	600 mg/m ²	IV	Days 1, 8, given 1 h after MTX
	Leucovorin	10 mg/m ²	IV or PO	Every 6 h for 6 doses, 24 h after MTX

MICE (ICE)





HemOnc.org is a knowledge base aiming to capture all **standard of care** systemic anticancer treatment.

By the numbers

1037 primary content pages

310 disease-specific pages

>1,000,000 lines of content

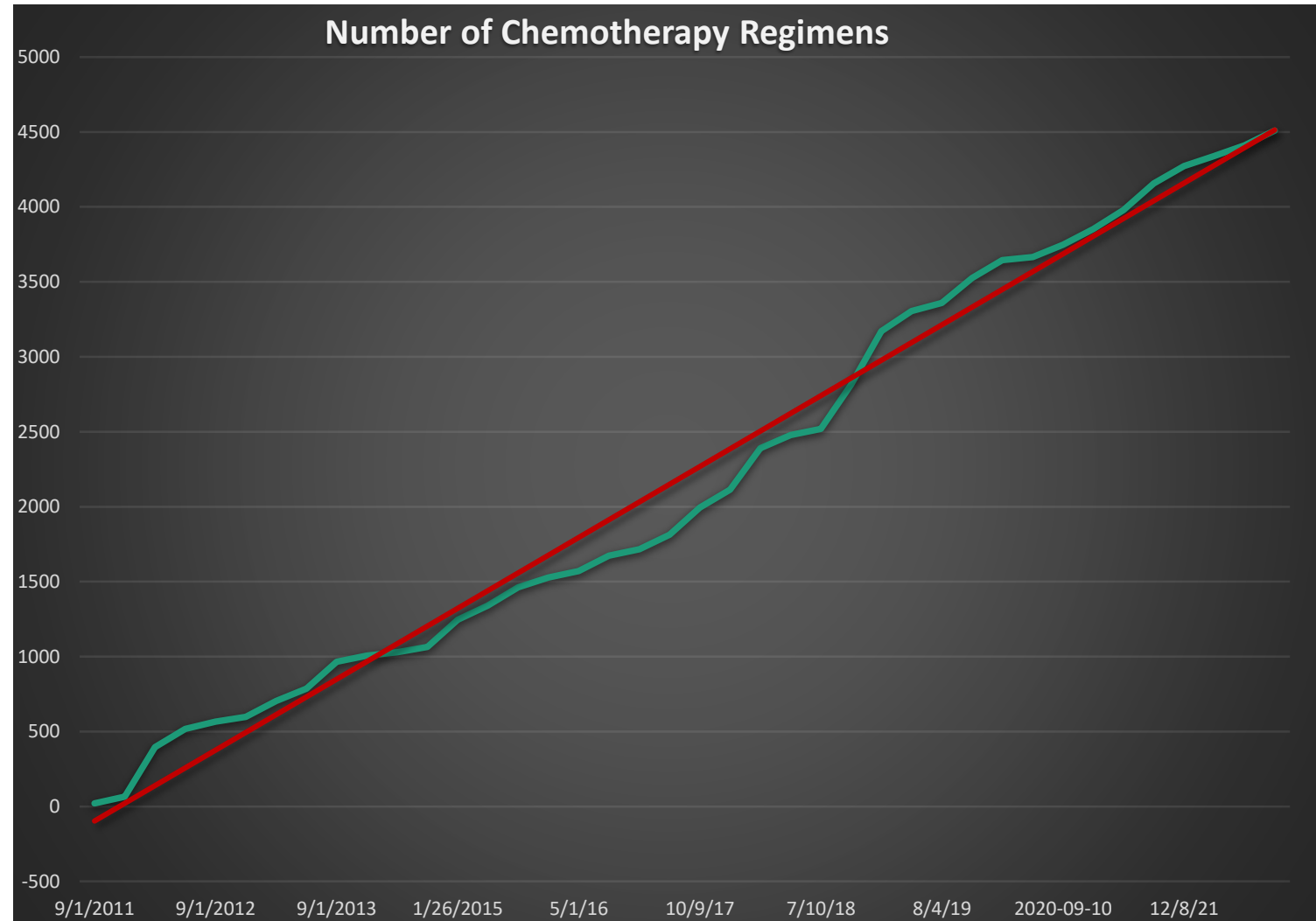
>7000 primary references

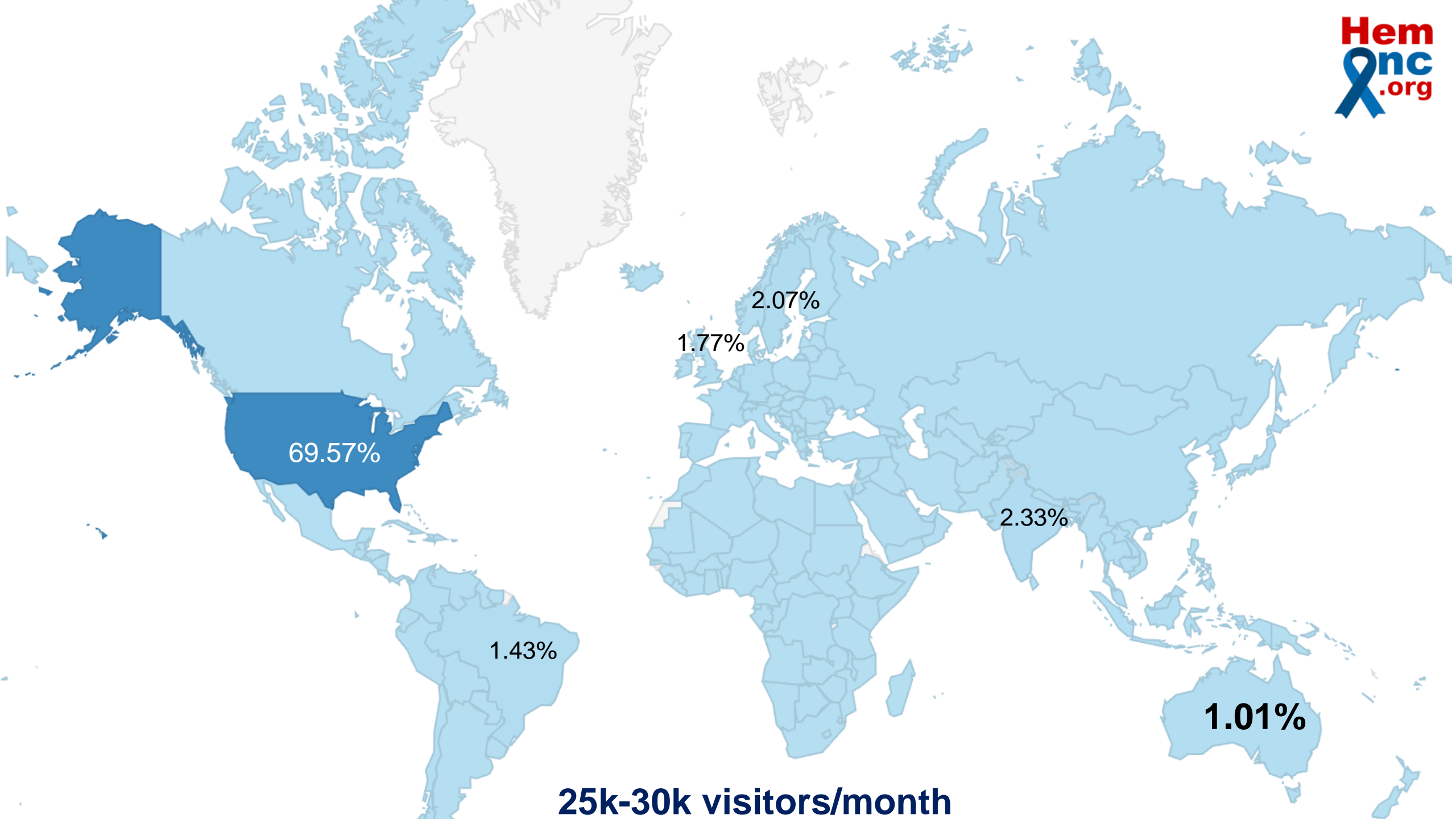
>4000 context-specific regimens

50 members of editorial board

2022 page views

1,428,842





25k-30k visitors/month



Going from Knowledge Base to Ontology





OHDSI

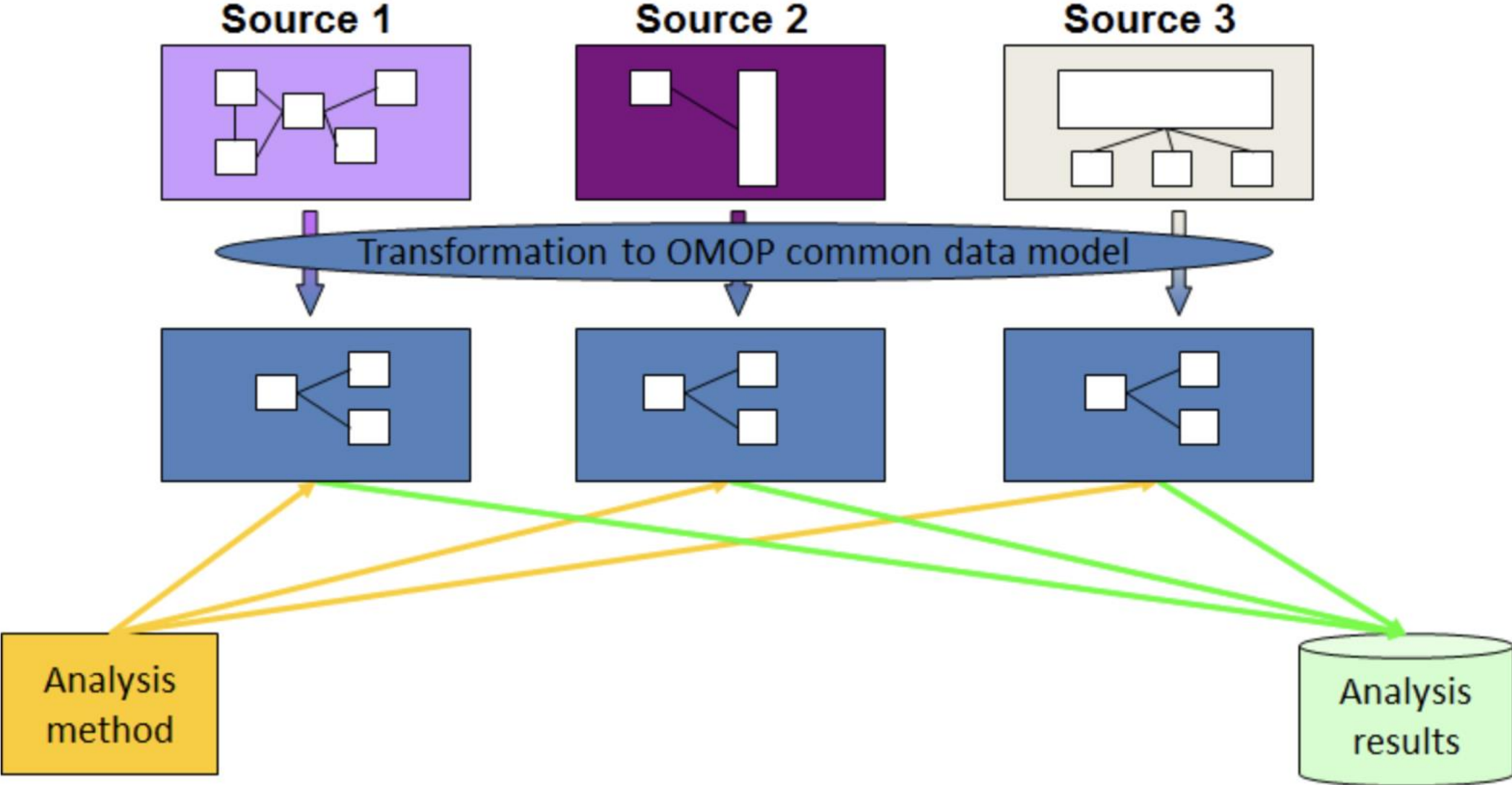
OBSERVATIONAL HEALTH DATA SCIENCES AND INFORMATICS

The Observational Health Data Sciences and Informatics (or OHDSI, pronounced "Odyssey") program is a multi-stakeholder, interdisciplinary collaborative to bring out the value of health data through large-scale analytics. All our solutions are open-source.

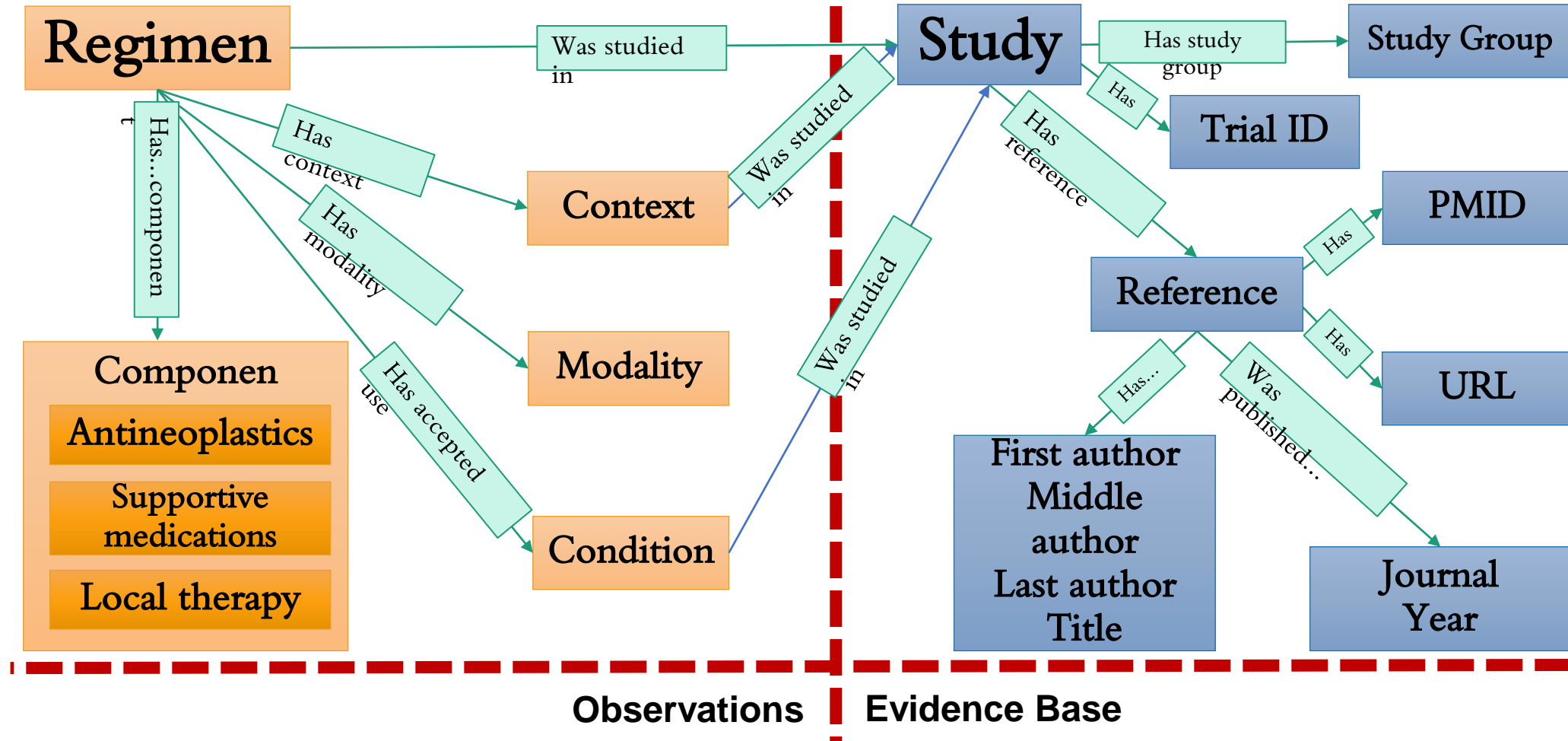


IMAGE: FINE ART IMAGES/HERITAGE IMAGES/GETTY IMAGE

OMOP Common Data Model



HemOnc Regimen Model (simplified)



Concepts: 95,242

2023-06-07

Relationships: 290,527

HemOnc has more **content** than other existing publicly available terminologies/ontologies.

Terminology	Maps to Drugs	Disease Context	Treatment Context	Modality	Link to Evidence	Number of regimens
SNOMED-CT	Yes ¹	No	No	No	No	6
SEER*Rx	Yes ¹	No	No	Yes	No	516
NCI Thesaurus	Yes ¹	Yes	No	No ²	No	1021
HemOnc	Yes	Yes	Yes	Yes	Yes	3737*

¹Antineoplastics; HemOnc also maps to supportive medications

²In some cases, modality can be inferred

*As of 2023-06-07; includes 1494 regimen “stubs” which are not yet completely defined

HemOnc is available to **you!**



Retrospective research (any user)

The screenshot shows the Athena Vocabulary List interface. The search term 'aspirin' is entered in the search bar. The results table lists various measurement concepts related to aspirin, including 'Complement c1r2+c1s2 measurement', 'Complement c1r2-c1s2 measurement', 'Complement IC3 measurement', 'Complement protein measurement', 'Complement and immunoglobulin measurement', 'Complement C3 fragment measurement', 'Complement C3a measurement', 'Complement C3d measurement', 'Complement C4d measurement', 'Complement C5a measurement', 'Complement factor BA measurement', 'Complement factor BB measurement', and 'Complement factor H measurement'. The table columns include ID, CODE, NAME, CLASS, CONCEPT, VALIDITY, DOMAIN, and VOCAB. A 'CLEAR' button is visible at the bottom left of the table.

ID	CODE	NAME	CLASS	CONCEPT	VALIDITY	DOMAIN	VOCAB
4015460	104341007	Complement c1r2+c1s2 measurement	Procedure	Standard	Valid	MeasurementSNOMED	
4015461	104342000	Complement c1r2-c1s2 measurement	Procedure	Standard	Valid	MeasurementSNOMED	
4015462	104343005	Complement IC3 measurement	Procedure	Standard	Valid	MeasurementSNOMED	
4015463	104345003	Complement protein measurement	Procedure	Standard	Valid	MeasurementSNOMED	
4015464	104346002	Complement and immunoglobulin measurement	Procedure	Standard	Valid	MeasurementSNOMED	
4015465	104348001	Complement C3 fragment measurement	Procedure	Standard	Valid	MeasurementSNOMED	
4015466	104349009	Complement C3a measurement	Procedure	Standard	Valid	MeasurementSNOMED	
4015467	104352001	Complement C3d measurement	Procedure	Standard	Valid	MeasurementSNOMED	
4015468	104358002	Complement C4d measurement	Procedure	Standard	Valid	MeasurementSNOMED	
4015469	104359005	Complement C5a measurement	Procedure	Standard	Valid	MeasurementSNOMED	
4015470	104362008	Complement factor BA measurement	Procedure	Standard	Valid	MeasurementSNOMED	
4015471	104363003	Complement factor BB measurement	Procedure	Standard	Valid	MeasurementSNOMED	
4015472	104364009	Complement factor H measurement	Procedure	Standard	Valid	MeasurementSNOMED	

<http://athena.ohdsi.org/vocabulary/list>

Non-commercial user (any use)

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<https://dataverse.harvard.edu/dataverse/HemOnc/>

Any user (subset focused on drugs & diseases)

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<https://dataverse.harvard.edu/dataverse/HemOnc/>

Commercial user (full ontology)

Contact us for further details: licensing@hemonc.org



Lifespan

Delivering health with care®



You can reach me at:

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Panelist Introductions

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Global Head of Data Science at Odysseus Data Services, Inc.

Professor of the Practice & Director of Clinical Research at the OHDSI Center, Northeastern University

Travis Zack, MD, PhD

Hematology/Oncology Fellow

University of California, San Francisco

Georgina Kennedy, PhD

Maridulu Budyari Gumal (SPHERE) Cancer Clinical Academic Group

Ingham Institute for Applied Medical Research

Timothy Churches, MBBS, MPhil

University of New South Wales

Ingham Institute for Applied Medical Research



Detecting Systemic Anticancer Therapy Regimens from temporal drug exposures – the OHDSI experience



OHDSI community

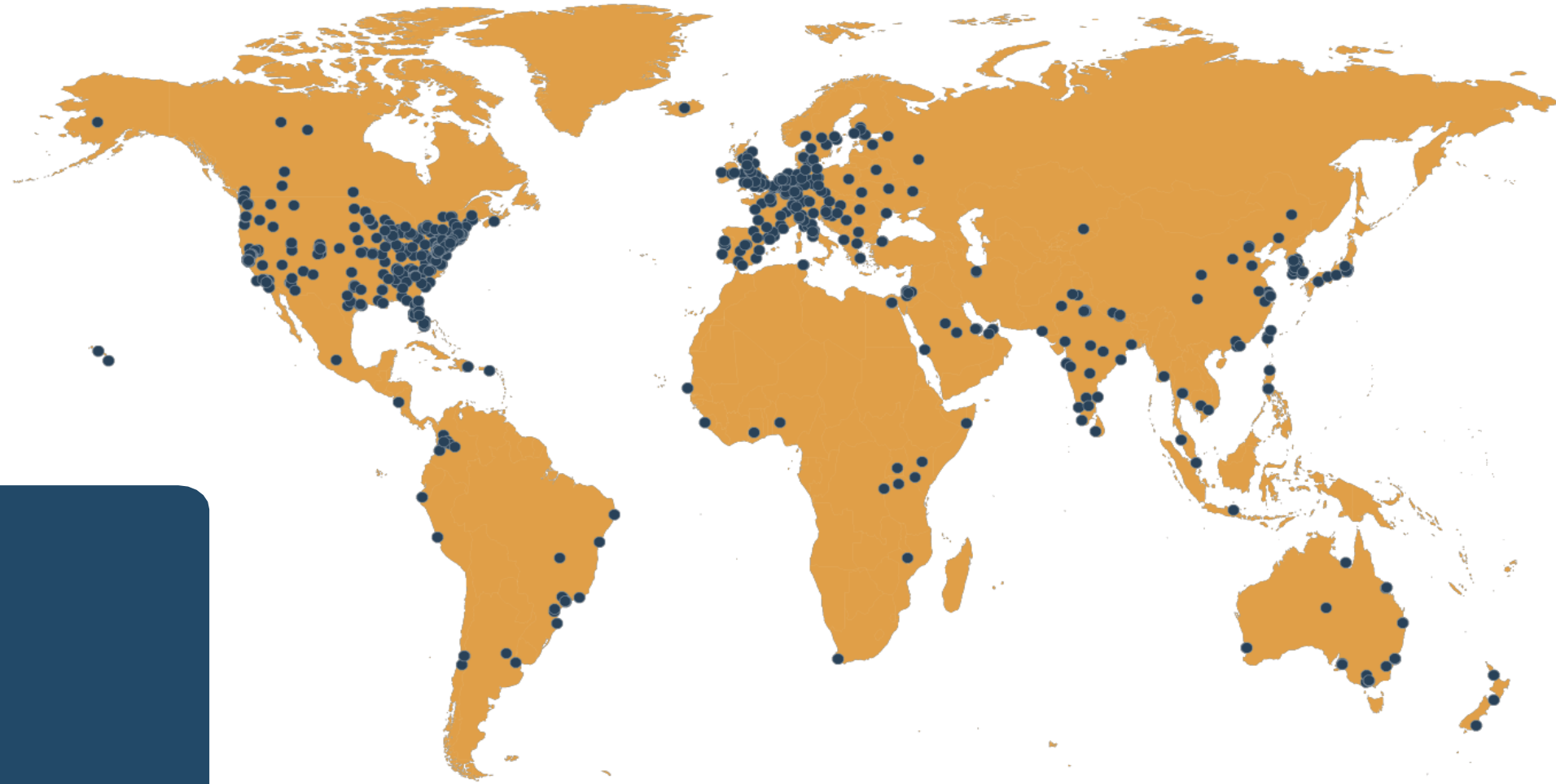
We're all in this journey together...

OHDSI Collaborators

- 3,266 collaborators
- 80 countries
- 21 time zones
- 6 continents

OHDSI Data Network

- 435 data sources
 - 347 EHRs
 - 34 registries
 - 30 administrative claims
- 41 countries
- 928 million unique patient records (12% of the world's population)



Open community
data standards
(OMOP CDM)

Methodological
research

Open-source
development
(OHDSI tools)

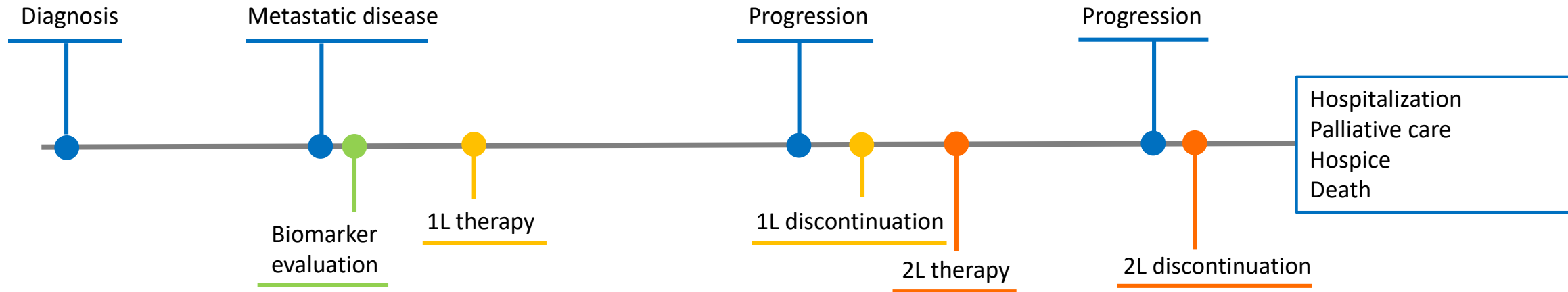
Clinical evidence
generation



Why is oncology any different than
the rest of medicine?



Schematic Cancer Patient Journey



Clinical Trial Endpoints for the Approval of Cancer Drugs and Biologics Guidance for Industry

- Overall Survival
- Symptom Endpoints
- Disease-Free Survival/Event-Free Survival
- Objective Response Rate
- Complete Response
- Progression Free Survival/Time to Progression

Cancer is Complicated

HIGHLIGHTS OF PRESCRIBING INFORMATION

These highlights do not include all the information needed to use TABRECTA safely and effectively. See full prescribing information for TABRECTA.

TABRECTA™ (capmatinib) tablets, for oral use
Initial U.S. Approval: 2020

INDICATIONS AND USAGE

TABRECTA is a kinase inhibitor indicated for the treatment of adult patients with metastatic non-small cell lung cancer (NSCLC) whose tumors have a mutation that leads to mesenchymal-epithelial transition (MET) exon 14 skipping as detected by an FDA-approved test.

This indication is approved under accelerated approval based on overall response rate and duration of response. Continued approval for this indication may be contingent upon verification and description of clinical benefit in confirmatory trial(s). (1)

DOSAGE AND ADMINISTRATION

- Select patients for treatment with TABRECTA based on presence of a mutation that leads to MET exon 14 skipping. (2.1)
- Recommended dosage: 400 mg orally twice daily with or without food. (2.2)

DOSAGE FORMS AND STRENGTHS

Tablets: 150 mg and 200 mg (3)

CONTRAINDICATIONS

None. (4)

WARNINGS AND PRECAUTIONS

- **Interstitial Lung Disease (ILD)/Pneumonitis:** Monitor for new or worsening pulmonary symptoms indicative of ILD/pneumonitis. Permanently discontinue TABRECTA in patients with ILD/pneumonitis. (2.3, 5.1)
- **Hepatotoxicity:** Monitor liver function tests. Withhold, dose reduce, or permanently discontinue TABRECTA based on severity. (2.3, 5.2)
- **Risk of Photosensitivity:** May cause photosensitivity reactions. Advise patients to limit direct ultraviolet exposure. (5.3)
- **Embryo-Fetal Toxicity:** Can cause fetal harm. Advise patients of the potential risk to a fetus and to use effective contraception. (5.4, 8.1, 8.3)

ADVERSE REACTIONS

The most common adverse reactions (≥ 20%) are peripheral edema, nausea, fatigue, vomiting, dyspnea, and decreased appetite. (6)

To report SUSPECTED ADVERSE REACTIONS, contact Novartis Pharmaceuticals Corporation at 1-888-669-6682 or FDA at 1-800-FDA-1088 or www.fda.gov/medwatch.

DRUG INTERACTIONS

Strong and Moderate CYP3A Inducers: Avoid

USE IN SPECIFIC POPULATIONS

Lactation: Advise not to breastfeed. (8.2)

See 17 for PATIENT COUNSELING INFORMATION and approved patient labeling.

1. Cancer is rare
2. Cancer is complicated
3. No Terminologies

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The OHDSI Oncology Working Group Has Worked on the **Solution**

- Oncology Network
- OMOP Oncology Module



OMOP CDM: Oncology Module

Solves all problems of oncology research

1 Cancer Disease Model

Cancer Diagnosis: Base Diagnosis + Diagnostic Modifiers
(One-to-many connection between them)

2 Cancer Treatment Model

Composite Level (Treatment Episodes) or Individual Level (standard OMOP)

3 Cancer Episode Model

Continuous periods of disease or treatment with distinct clinical meaning
Composed of multiple events
Essential for conducting cancer research



Cancer Disease Model: Terminologies

Solves all problems of oncology research

1 Cancer Disease Model

Cancer Diagnosis: **Base Diagnosis** + **Diagnostic Modifiers**

ICD-O

Cancer Modifiers + OMOP Genomics

2 Cancer Treatment Model

Composite Level (**Treatment Episodes**) or Individual Level (standard OMOP)

HemOnc

3 Cancer Episode Model

Overarching disease episode
Disease dynamic (remission, stable, progression)
Disease extent (confined, invasive, metastatic)

De novo vocabularies



2

OMOP Oncology: Cancer Treatment Model

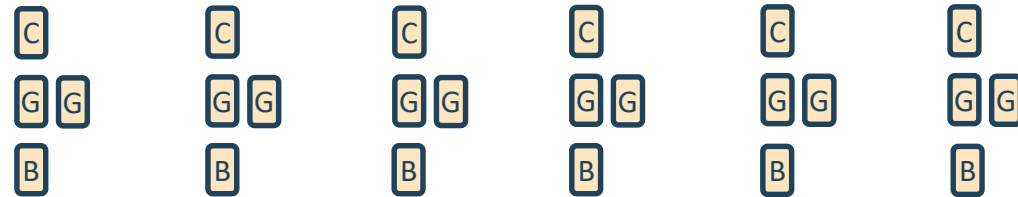
Abstracted **chemotherapy** regimens rarely available

Metastatic non-squamous NSCLC

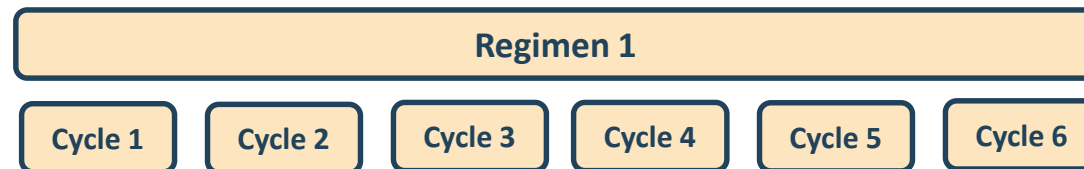
Cisplatin+Gemcitabine (GC)
21-day cycle for up to 6 cycles



Available in the data



Needed for research but mostly not available





A patient's medical record can be treated as a temporal sequence of events

- Apply sequence alignment methodologies to infer regimens from discrete events
 - Sequence alignment:
 - Standard for assessing biological sequence homology.
 - Established approach in bioinformatics and has been applied to other domains, including sequences of temporal events.
 - A combination of recursive dynamic programming and a scoring matrix guarantees optimal alignment
 - Two classic algorithms for sequence alignments:
 1. Needleman-Wunsch (NW)
 2. Smith-Waterman (SW)
- Traditional NW and SW **do not incorporate missing events, treatment delays, protocol deviation and relative time between events**
 - Extensions of both NW and SW incorporates relative timing information have been used to extract chemotherapy regimens with high accuracy



ARTEMIS: A Modified Smith-Waterman algorithm

accounts for missing events, treatment delays, protocol deviation and relative time between events

User input:

Alignment parameters: $\left\{ \begin{array}{l} \text{gap penalty (g)} \\ \text{maximum temporal penalty} \\ \text{loss function} \end{array} \right.$

Substitution matrix $S(x_i + y_j) = \begin{cases} +1, & x_i = y_j \\ -1, & x_i \neq y_j \end{cases}$

$$TR_{i,j} = \begin{cases} 0, & \text{if } D(i,j) = 0 \\ TR_{i,j-1}, & \text{if } D(i,j) = 1 \\ TR_{i-1,j} + t_{xi}, & \text{if } D(i,j) = -1 \end{cases}$$

$$TC_{i,j} = \begin{cases} 0, & \text{if } D(i,j) = 0 \\ TR_{i,j-1} + t_{yi}, & \text{if } D(i,j) = 1 \\ TR_{i-1,j}, & \text{if } D(i,j) = -1 \end{cases}$$

$$D_{i,j} = \begin{cases} 0, & \text{if } H(i,j) = 0 \\ -1, & \text{if } H(i,j) = H(i-1,j) - g \\ 1, & \text{if } H(i,j) = H(i,j-1) - g \end{cases}$$

$$H_{i,j} = \max \left\{ \begin{array}{l} 0 \\ H_{i-1,j-1} + S(x_i + y_j) - f(t_{xi} + TR_{i-1,j-1} + TC_{i-1,j-1}) \\ H_{i-1,j} - g \\ H_{i,j-1} - g \end{array} \right.$$

$\forall i \in [1, m], j \in [1, n]$

H		7.A	0.B	0.C	7.A	7.D					
	0	0	0								
0.C	0				H	7.A	0.B	0.C	7.A	7.D	
7.D	0				0	0	0	0	0	0	
15.C	0				0.C	0	0	0.125	0	0	
7.A	0				7.D	0	0	0	0	1	
0.B	0				15.C	0	0	0	0.0625	0	0.6
0.C	0				7.A	0	1	0.6	0.2	1.0625	0
7.A	0				0.B	0	0.6	2	1.6	1.2	0
7.D	0				0.C	0	0.2	1.6	3	2.6	2.2
7.E	0				7.A	0	1	1.2	2.6	4	3.6
7.E	0				7.D	0	0.6	0.8	2.2	3.6	5
					7.E	0	0.2	0.4	1.8	3.2	4.6
					7.E	0	0	0	1.4	2.8	4.2

Alignment Result:

0.C-7.C-15.C-7.A-0.B-0.C-7.A-7.D-7.E-7.E
 --_-_-_-_-_-7.A-0.B-0.C-7.A-7.D



Modified Temporal Smith-Waterman

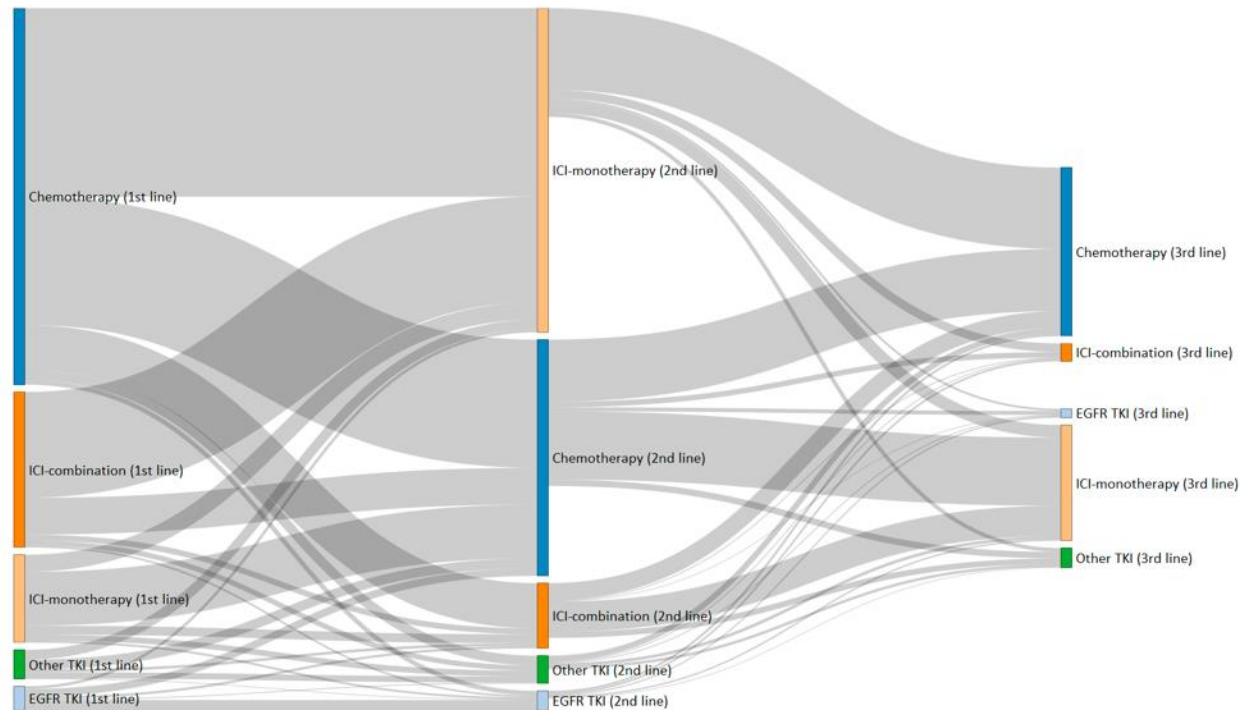
1 Patient 57
Drug Record



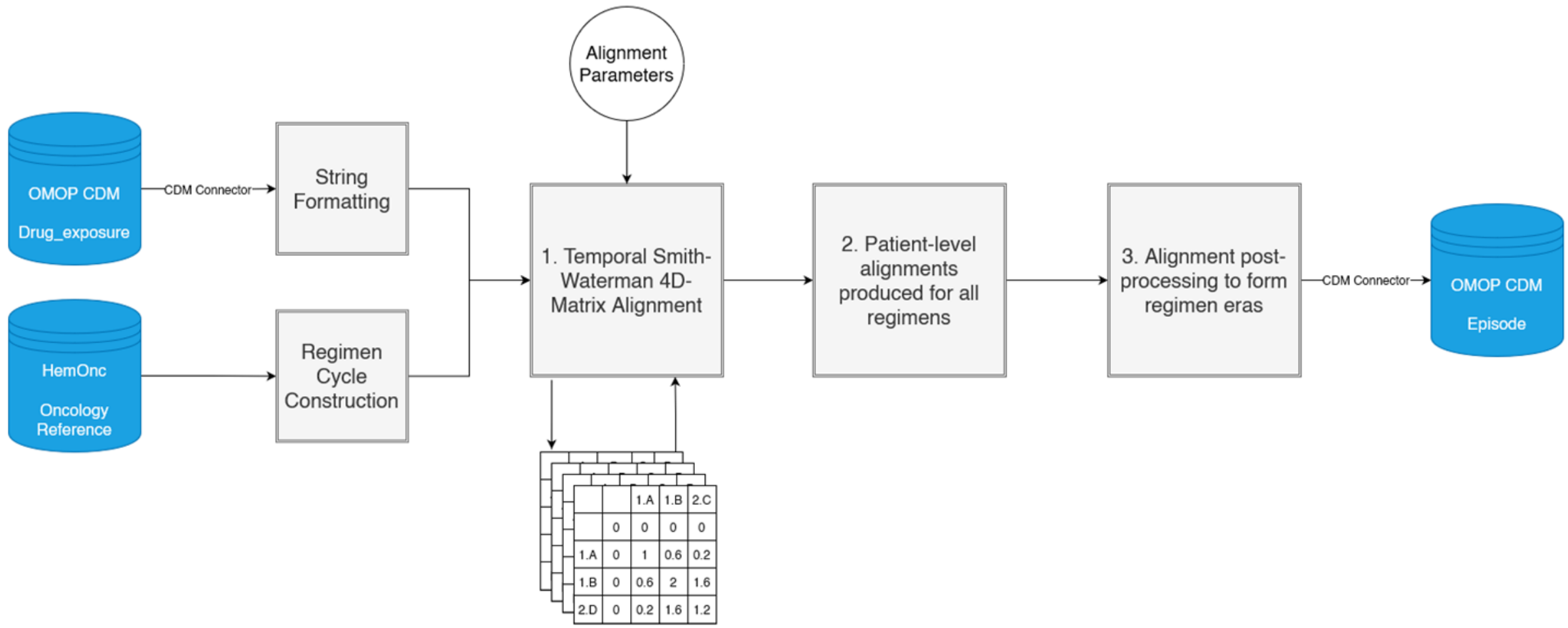
2 Cycle identification



3 Regimen identification



ARTEMIS - Method Flow Chart



Placeholder for Travis Zack slides

Mapping and semantic harmonization of Australian and US SACT protocol definitions

MEG STEVENS, TIMOTHY CHURCHES, LEO COLEMAN, SHELLEY RUSHTON,
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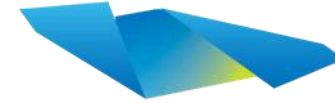


MEDINFO23

8 - 12 JULY 2023 | SYDNEY, AUSTRALIA



UNSW
SYDNEY



Ingham Institute
Applied Medical Research



Health
South Western Sydney
Local Health District



Cancer Institute NSW



**Maridulu
Budyari
Gumal**

Cancer
Clinical Academic Group

Australian context: eviQ



Free, online resource of cancer treatment protocols and treatment information developed for the Australian context

National program

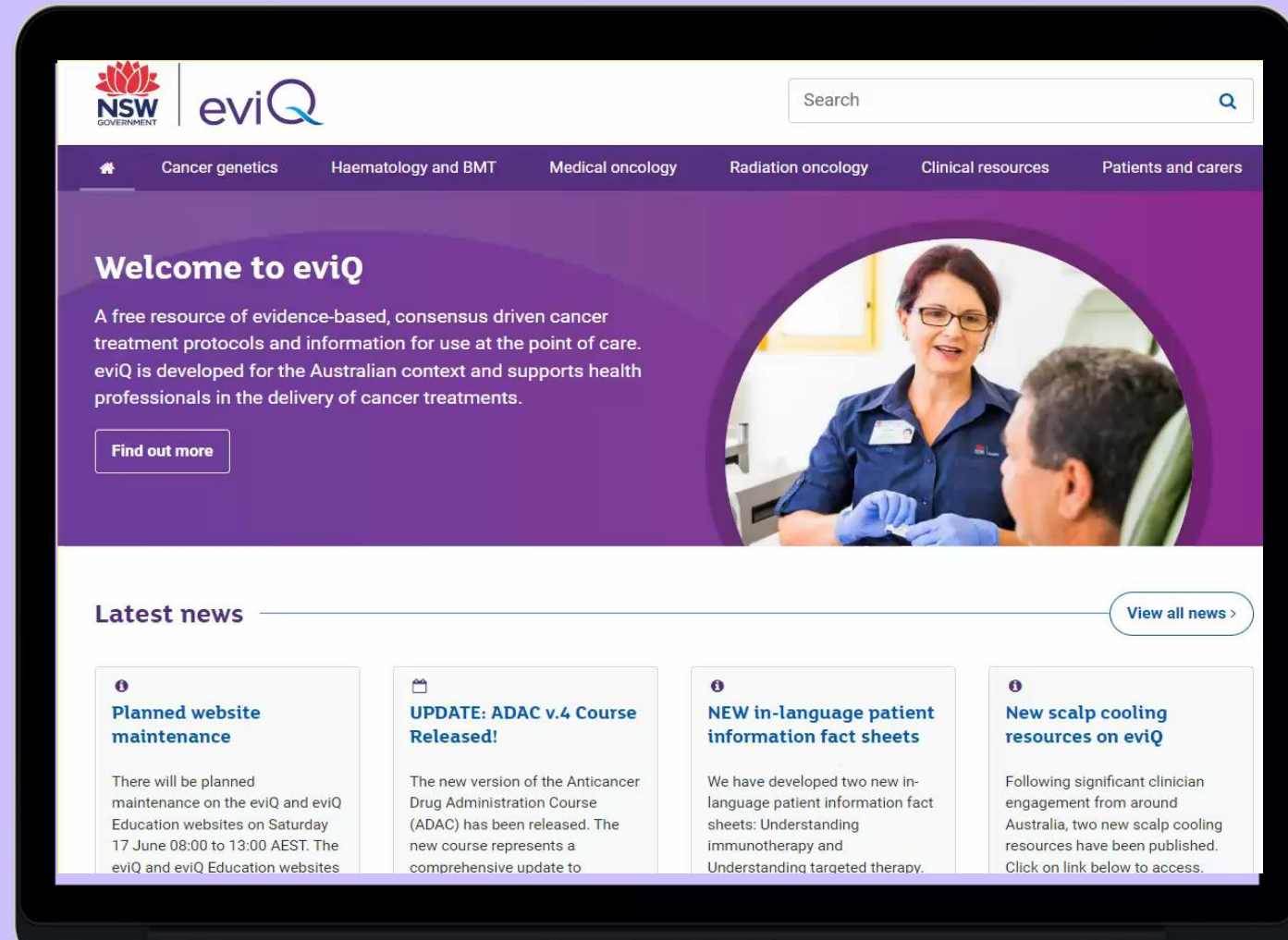
Embedded into clinical practice and used in every cancer centre across Australia



Primary audience: health professionals



Secondary audience: patients and carers



eviQ Program History




*Cancer Institute's Standard Cancer Treatments Program (CI-SCaT)

eviQ usage and reach 2022




- Guidance not a guideline
- Not mandated
- Editorially independent
- Complies with Australia's regulatory and reimbursement process i.e., TGA/PBS
- Variation may be appropriate

448,084 Australian users




166% increase in total monthly users since 2018

331,437 International users



2018 = 22%

2022 = 44%



202 countries



1.  Australia
2.  United States
3.  New Zealand
4.  Brazil
5.  United Kingdom



- Oncology
- Haematology
- BMT
- Radiation oncology
- Cancer genetics


1064 Treatment protocols




162 Clinical resources



123 Patient information sheet



6 calculators

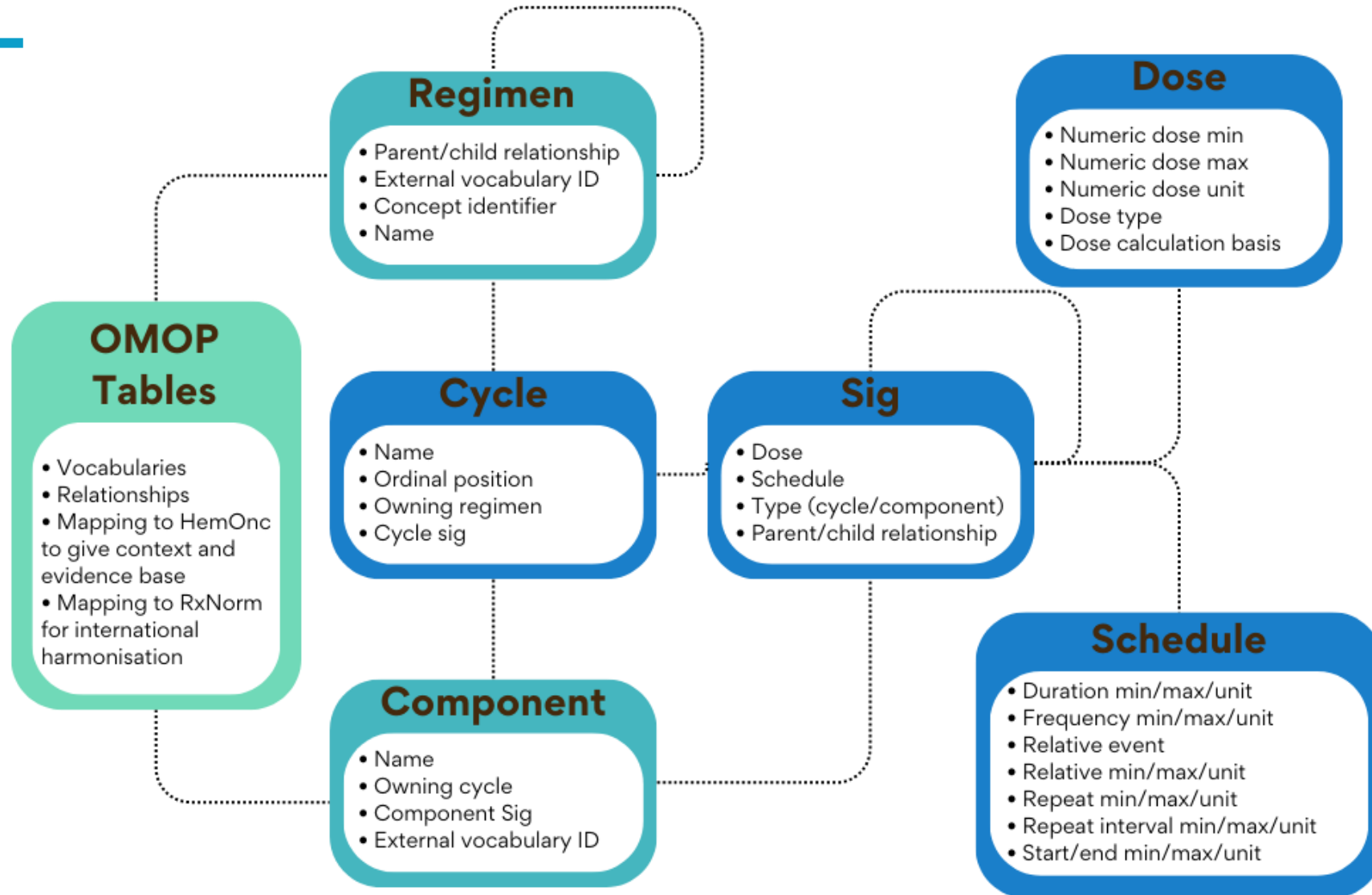


Why is it important to identify lines of therapy?

- Assess real-world treatment effectiveness
- Quality indicators to assess appropriateness of treatment patterns
- Determine future treatments

Why is it hard to identify SACT regimens in RWD?

CaVa Regimen Model: Computable Baselines



CaVa Regimen Model: Computable Baselines

Regimen	
ID:	123
Name:	Breast adjuvant Paclitaxel dose dense
Status:	approved
Create date:	2005-01-12
Status date:	2019-10-01
Regimen code:	160

Cycle	
ID:	999
Regimen ID:	123
Sequence:	1
SigID:	1

Dose					
DoseID	NumMin	NumMax	NumUnits	DoseBasis	Route
1	20	20	mg		PO
2	10	10	mg		PO
3	20	20	mg		PO
4	175	175	mg/m2	BSA	IV
5	6	6	mg		SC

Cycle Component			
CompID	CycID	Type	Component
1	999	Supportive therapy	Dexamethasone
2	999	Supportive therapy	Loratadine
3	999	Cytotoxic chemotherapy	PAcLitaxel
4	999	Growth factor support	Pegfilgrastim

Sig				
Sig ID	Source Type	Source ID	Dose ID	Schedule ID
1	Cycle	999	None	1
2	Component	1	1	2
3	Component	2	2	3
4	Component	1	3	4
5	Component	3	4	5
6	Component	4	5	6

Schedule							
SchedID	FreqMin	FreqMax	FreqUnit	RepeatMin	RepeatMax	StartOffset	StartUnit
1	14	14	Days	4	4	0	Days
2				1	1	-1	Days
3				1	1	-60	Minutes
4				1	1	-60	Minutes
5				1	1	0	Days
6				1	1	1	Days

Computable Baselines: Detect & Measure Variation



Cancer Institute NSW



Health
South Western Sydney
Local Health District



Ingham Institute
Applied Medical Research



UNSW
SYDNEY



Maridulu
Budyari
Gural

Cancer
Clinical Academic Group

Harmonisation



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SWSLHD

Nasreen Kaadan

Mei Mei Xiong

Angela Berthelsen

Mahbuba Sharmin

Ingham Institute & UNSW

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Funding

UNSW Research Infrastructure

Maridulu Budyari Gumal (SPHERE) Cancer Clinical Academic Group

Narellan Rotary Club

ARDC Platforms Grant (Australian Cancer Data Network)

MRFF Research Data Infrastructure (NextCR)