dsOMOP: Integrating OMOP CDM Databases into DataSHIELD

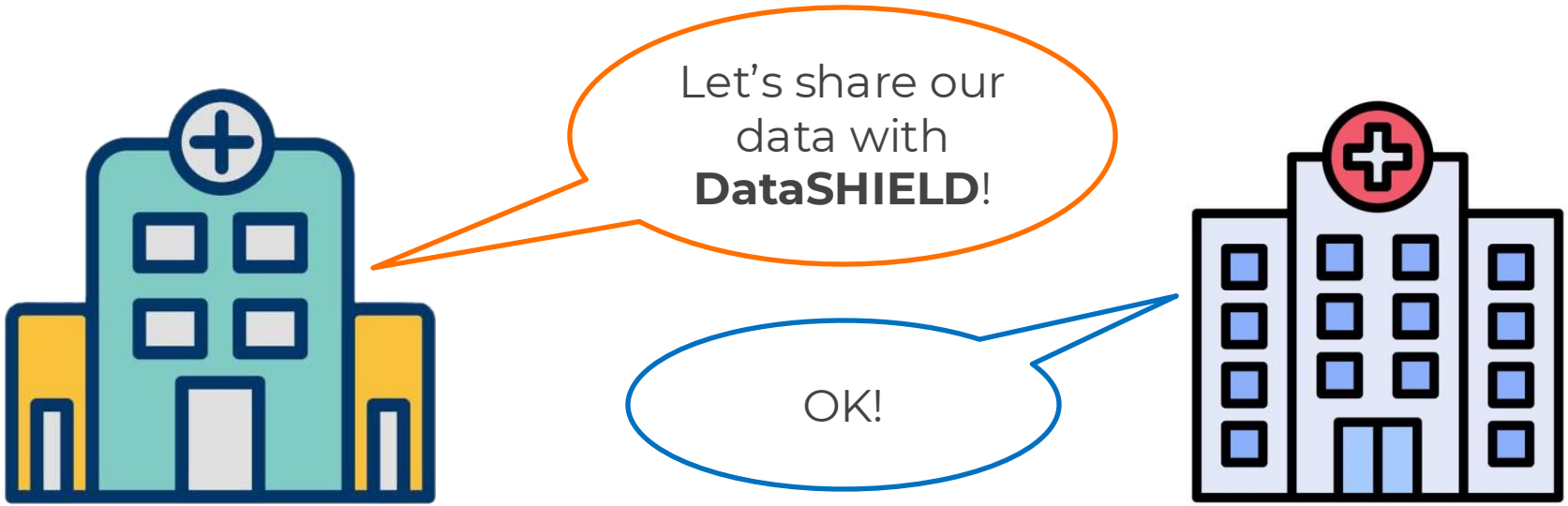
David Sarrat González
Juan R González

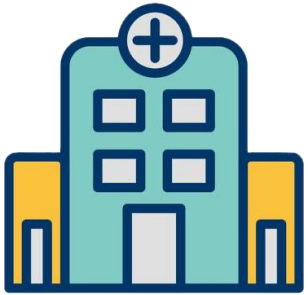
ISGlobal
Barcelona
Institute for
Global Health

BMI brge

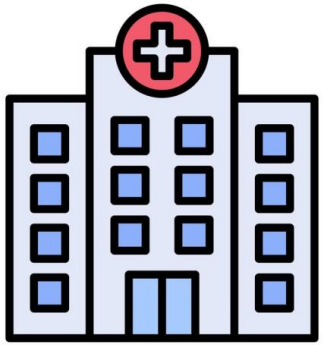
1

Common Data Models (CDM)

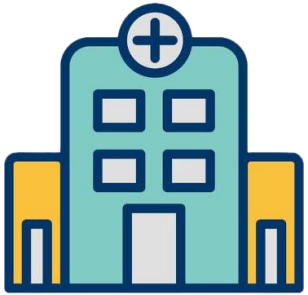

Let’s share our data with **DataSHIELD**!
OK!



ID	Age	Sex	Current_Smoker	Conditions
1A	65	M	Y	Severe COPD
2A	45	F	N	Mild COPD
3A	55	M	Y	Moderate COPD, Diabetes Type 2



PatientCode	DateOfBirth	Gender	Observations	COPD_Level	Diabetes
B001	12/1/1945	Male	Smoker	High	
B002	5/15/1980	Female			Type 2
B003	11/23/1955	Male	Smoker	Medium	



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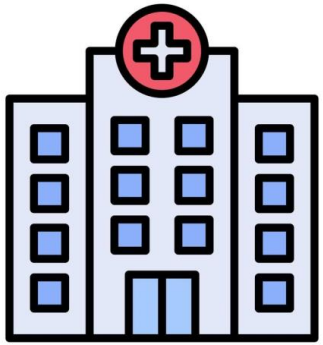

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B003	11/23/1955	Male	Smoker	Medium	

How do we fix this?

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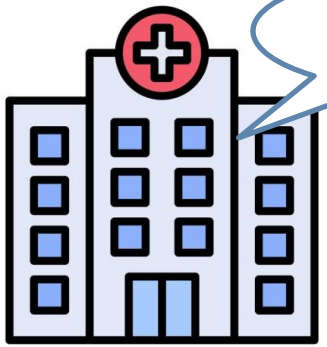
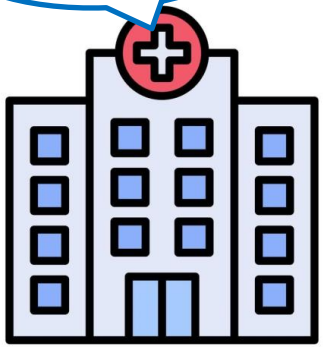


Let's use a **CDM**!

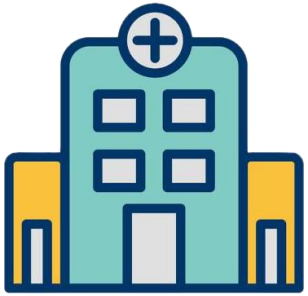
PatientCode	DateOfBirth	Gender	Observations	COPD_Level	Diabetes
B001	12/1/1945	Male	Smoker	High	
B002	5/15/1980	Female			Type 2
B003	11/23/1955	Male	Smoker	Medium	

These will be our CDM rules:

OK!



Attribute	Description
Patient_ID	A unique identifier for each patient; numeric string.
Age	Age of the patient in years; integer.
Gender	Gender of the patient; categorical string ("**Male**" or "**Female**").
Smoking_Status	Smoking status of the patient; categorical string ("**Current**", "**Former**", or "**Never**").
COPD_Severity	Severity level of COPD if present; categorical string ("**Mild**", "**Moderate**", "**Severe**", or blank if not applicable).
Diabetes	Type of diabetes if present; categorical string ("**Type 1**", "**Type 2**", or blank if not applicable).



Patient_ID	Age	Gender	Smoking_Status	COPD_Severity	Diabetes
1	65	Male	Current	Severe	
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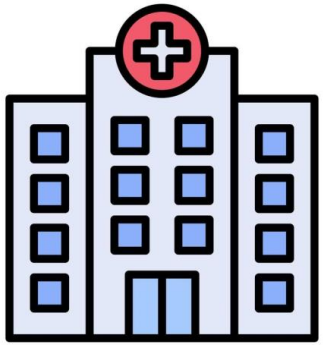
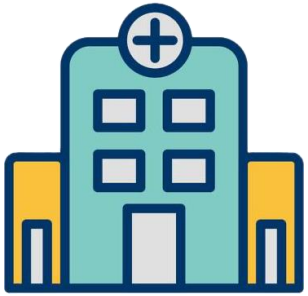
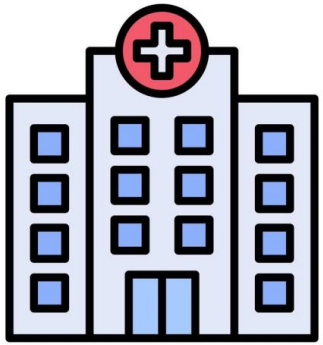


Patient_ID	Age	Gender	Smoking_Status	COPD_Severity	Diabetes
4	77	Male	Current	High	
5	43	Female	Never		Type 2
6	68	Male	Current	Medium	





Patient_ID	Age	Gender	Smoking_Status	COPD_Severity	Diabetes
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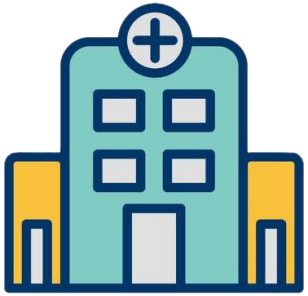

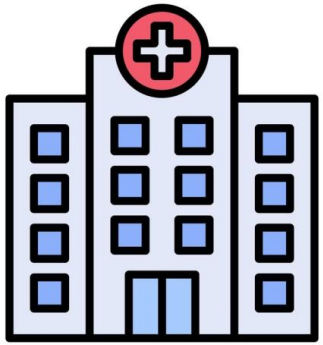

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2	45	Female	Never	Mild	
3	55	Male	Current	Moderate	
4	77	Male	Current	High	
5	43	Female	Never		Type 2
6		Male	Current	Medium	

Common Data Models enable **more robust**, **large-scale** research.

What are the **advantages** of adhering to a widely extended common data model?

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Universal
interoperability

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Analytical tools and scripts designed for that CDM

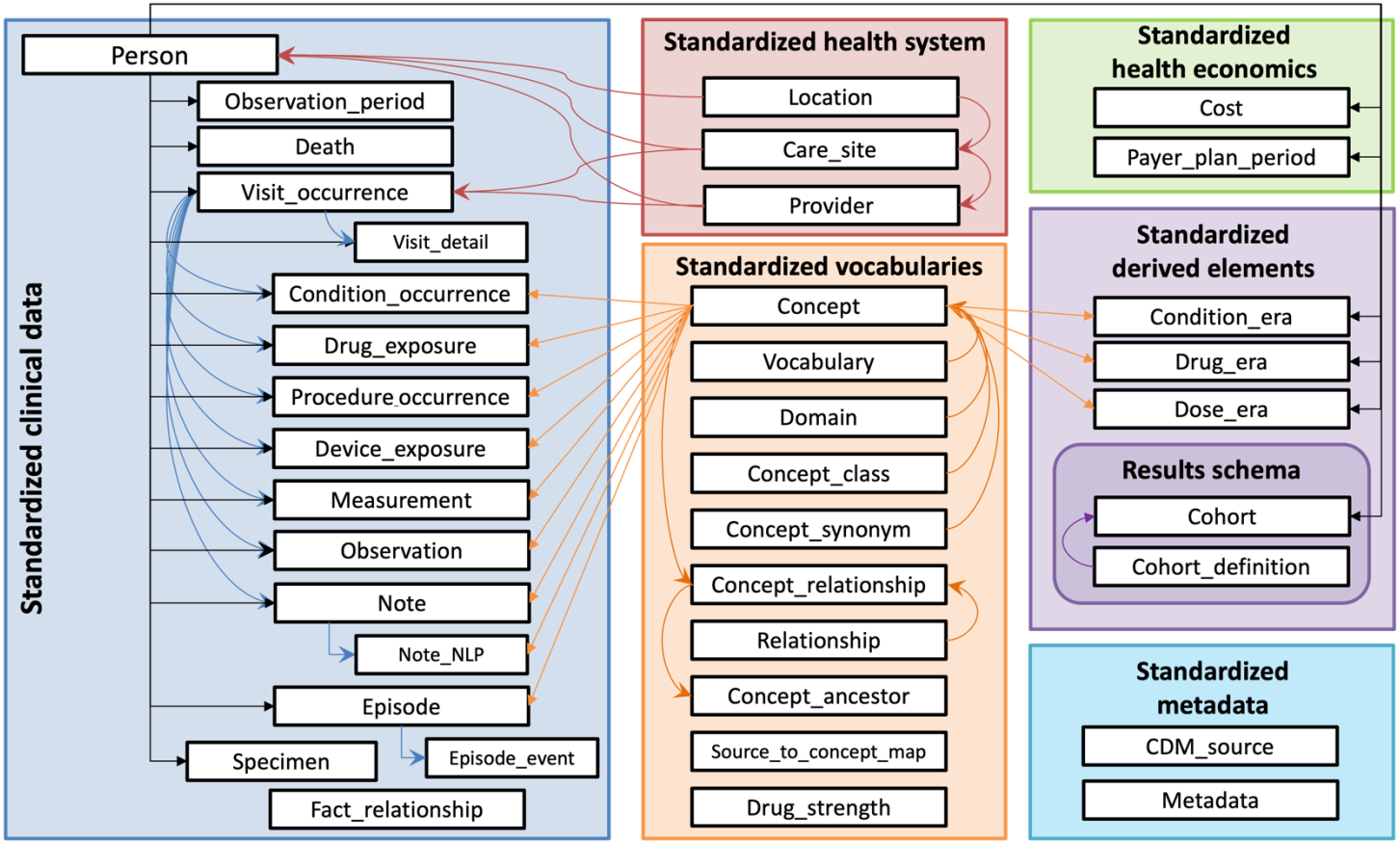
2

What is the OMOP CDM?

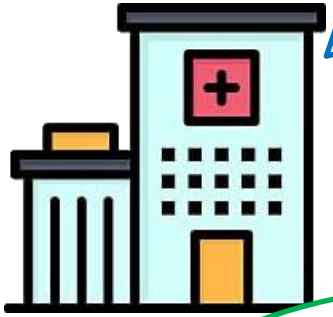
Observational Medical Outcomes Partnership Common Data Model (OMOP CDM)

- ✓ All kinds of clinical research
- ✓ Interdisciplinary collaborative
- ✓ Public, open-source
- ✓ Community developed tools

OMOP CDM structure

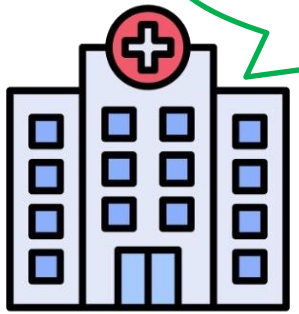


Do you have records of **Varicella** in your database?

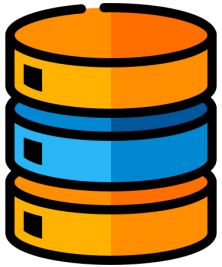


No, we only have ***Chickenpox***

No, we only have 水痘



Original DB



Standardized tables

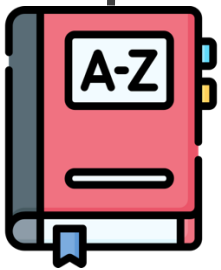
Drug exposure

Atorvastatin

Loratadine

Acetylsalicylic acid

...



Clinical vocabularies

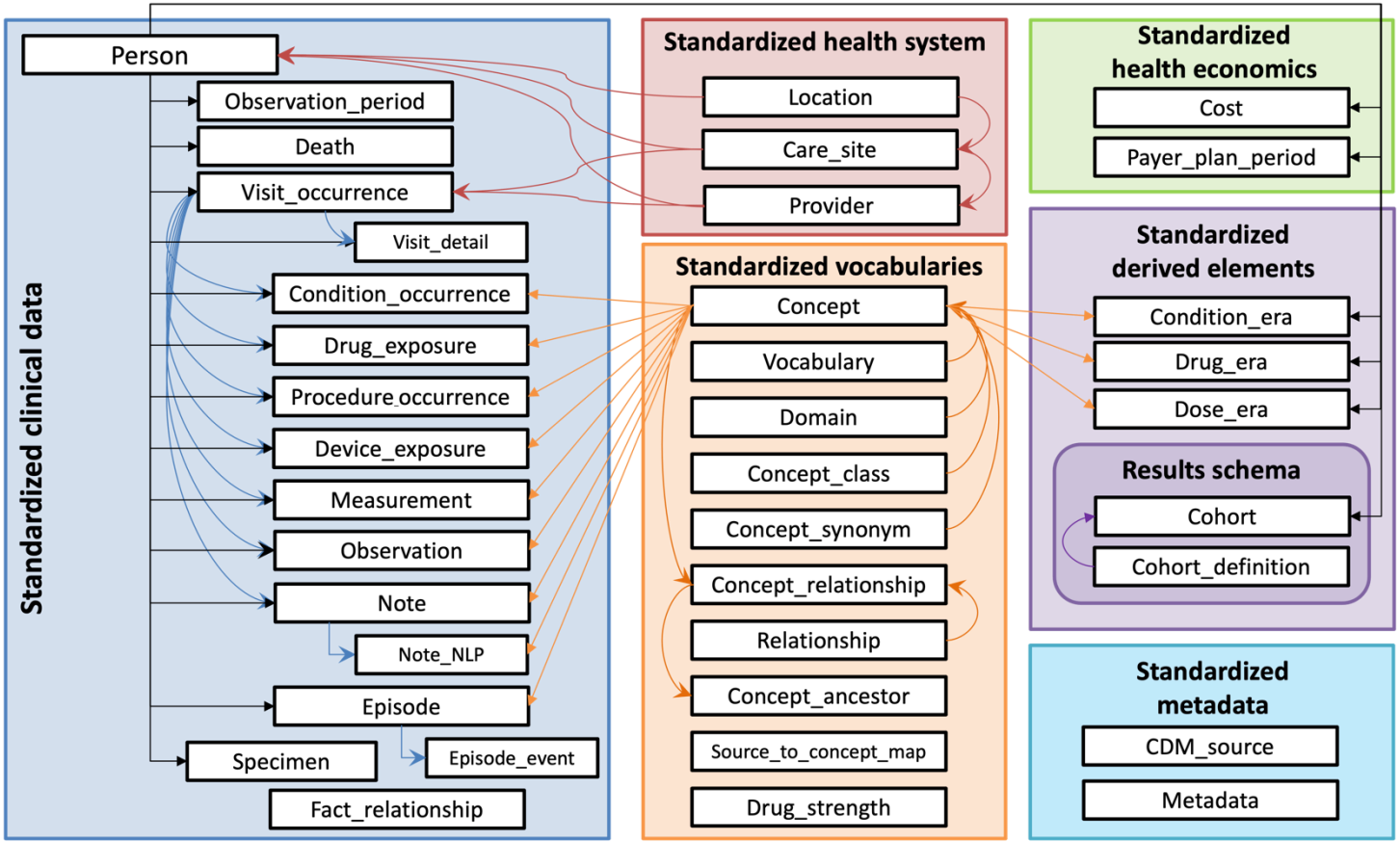
21601860

21603514

21600041

...

OMOP CDM structure



Person table:

person_id	gender_concept_id	year_of_birth
11312	8507 *(male)*	1985

Person ID: 11312

Person table:

person_id	gender_concept_id
11312	8507 *(male)*

Person ID: 11312

Measurement table:

measurement_id	person_id	measurement_concept_id	value_as_number
64534	11312	4152194 *(SBP)*	120

Person table:

person_id	gender_concept_id
11312	8507 *(male)*

Person ID: 11312

Measurement table:

measurement_id	person_id	measurement_concept_id	value_as_number
64534	11312	4152194 *(SBP)*	120
76857	11312	4245997 *(BMI)*	25

Person table:

person_id	gender_concept_id
11312	8507 *(male)*

Person ID: 11312

Measurement table:

measurement_id	person_id	measurement_concept_id	value_as_number
64534	11312	4152194 *(SBP)*	120
76857	11312	4245997 *(BMI)*	25

Observation table:

observation_id	person_id	observation_concept_id	value_as_concept_id
63453453	11312	4005823 (Smoking status)	8515 *(Current)*

Person table:

person_id	gender_concept_id
11312	8507 *(male)*

Person ID: 11312

Measurement table:

measurement_id	person_id	measurement_concept_id	value_as_number
64534	11312	4152194 *(SBP)*	120
76857	11312	4245997 *(BMI)*	25

Observation table:

observation_id	person_id	observation_concept_id	value_as_concept_id
63453453	11312	4005823 (Smoking status)	8515 *(Current)*

Condition occurrence table:

condition_occurrence_id	person_id	condition_concept_id
423483	11312	317009 *(Asthma)*

Person table:

person_id	gender_concept_id	year_of_birth
11312	8507 *(male)*	1985

Person ID: 11312

Person table:

person_id	gender_concept_id
11312	8507 *(male)*

Person ID: 11312

Measurement table:

measurement_id	person_id	measurement_concept_id	value_as_number	measurement_date
64534	11312	4152194 *(SBP)*	120	2022-01-01

Person table:

person_id	gender_concept_id
11312	8507 *(male)*

Person ID: 11312

Measurement table:

measurement_id	person_id	measurement_concept_id	value_as_number	measurement_date
64534	11312	4152194 *(SBP)*	120	2022-01-01
89851	11312	4152194 *(SBP)*	125	2022-04-14

Person table:

person_id	gender_concept_id
11312	8507 *(male)*

Person ID: 11312

Measurement table:

measurement_id	person_id	measurement_concept_id	value_as_number	measurement_date
64534	11312	4152194 *(SBP)*	120	2022-01-01
89851	11312	4152194 *(SBP)*	125	2022-04-14
124352	11312	4152194 *(SBP)*	130	2022-07-22

Person table:

person_id	gender_concept_id
11312	8507 *(male)*

Person ID: 11312

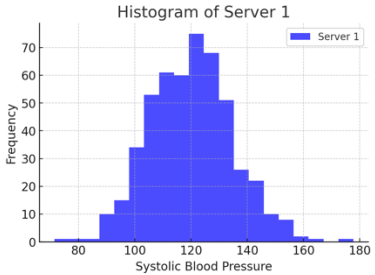
Measurement table:

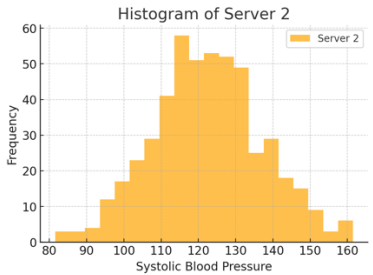
measurement_id	person_id	measurement_concept_id	value_as_number	measurement_date
64534	11312	4152194 *(SBP)*	120	2022-01-01
89851	11312	4152194 *(SBP)*	125	2022-04-14
124352	11312	4152194 *(SBP)*	130	2022-07-22
138176	11312	4152194 *(SBP)*	128	2022-11-15

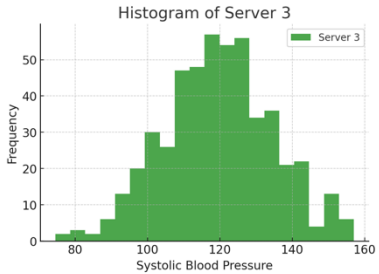
3

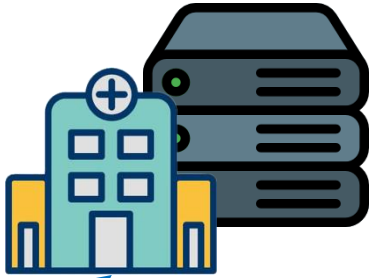
The goal: Combining DataSHIELD and OMOP CDM

Distributed analysis



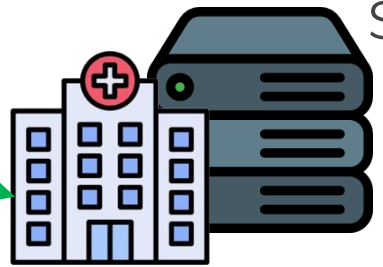






Server 1

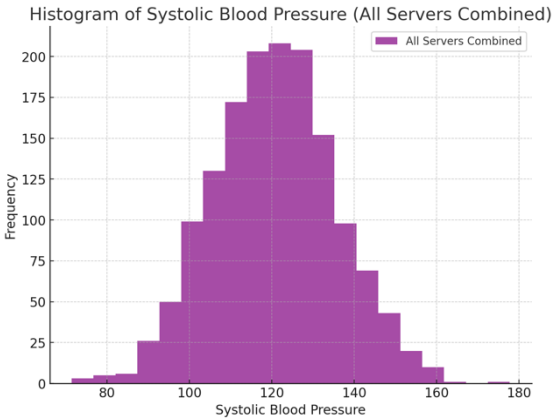
Server 2

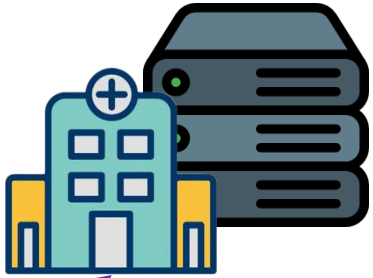


Server 3

DataSHIELD client

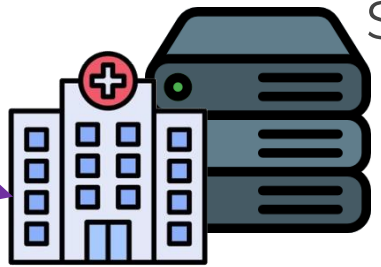
Researcher





Server 1

Server 2

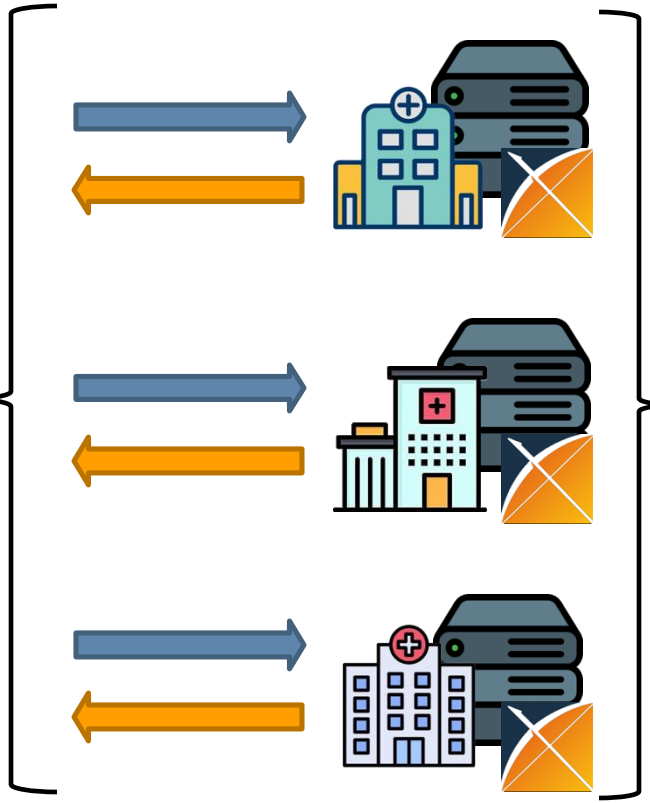


Server 3

DataSHIELD client

Researcher

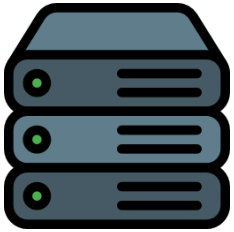
DataSHIELD
Secure Bioscience Collaboration



Same data format
=
1 script 4 all!

4

Pushing the boundaries of DataSHIELD

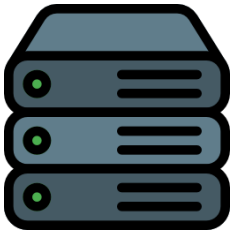


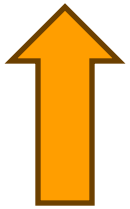
DataSHIELD server

Let’s say we want to incorporate a new functionality to DataSHIELD

Researcher

DataSHIELD server

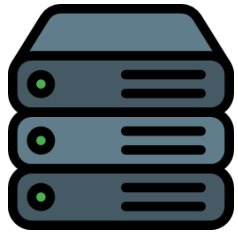




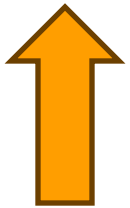
Server package with new functionalities

Researcher

DataSHIELD server



The server can now execute new methods



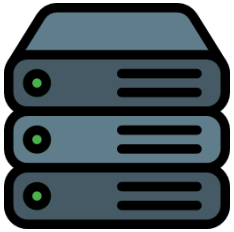
Server package with new functionalities

Researcher

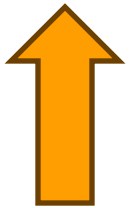
Client package that can call the server package functions

Researcher

DataSHIELD server



The server can now execute new methods

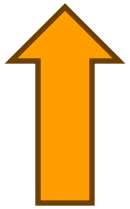


Server package with new functionalities

Client package that can call the server package functions

DataSHIELD server

The server can now execute new methods

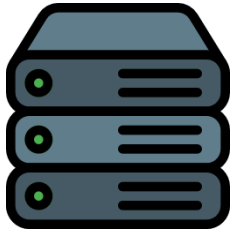


The user can now call the new server methods

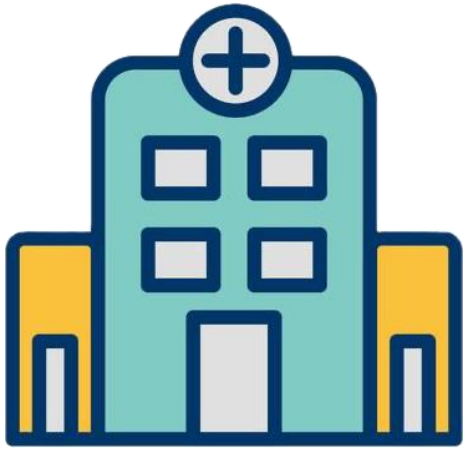
Researcher

Server package with new functionalities

DataSHIELD
Secure Bioscience Collaboration



DataSHIELD server

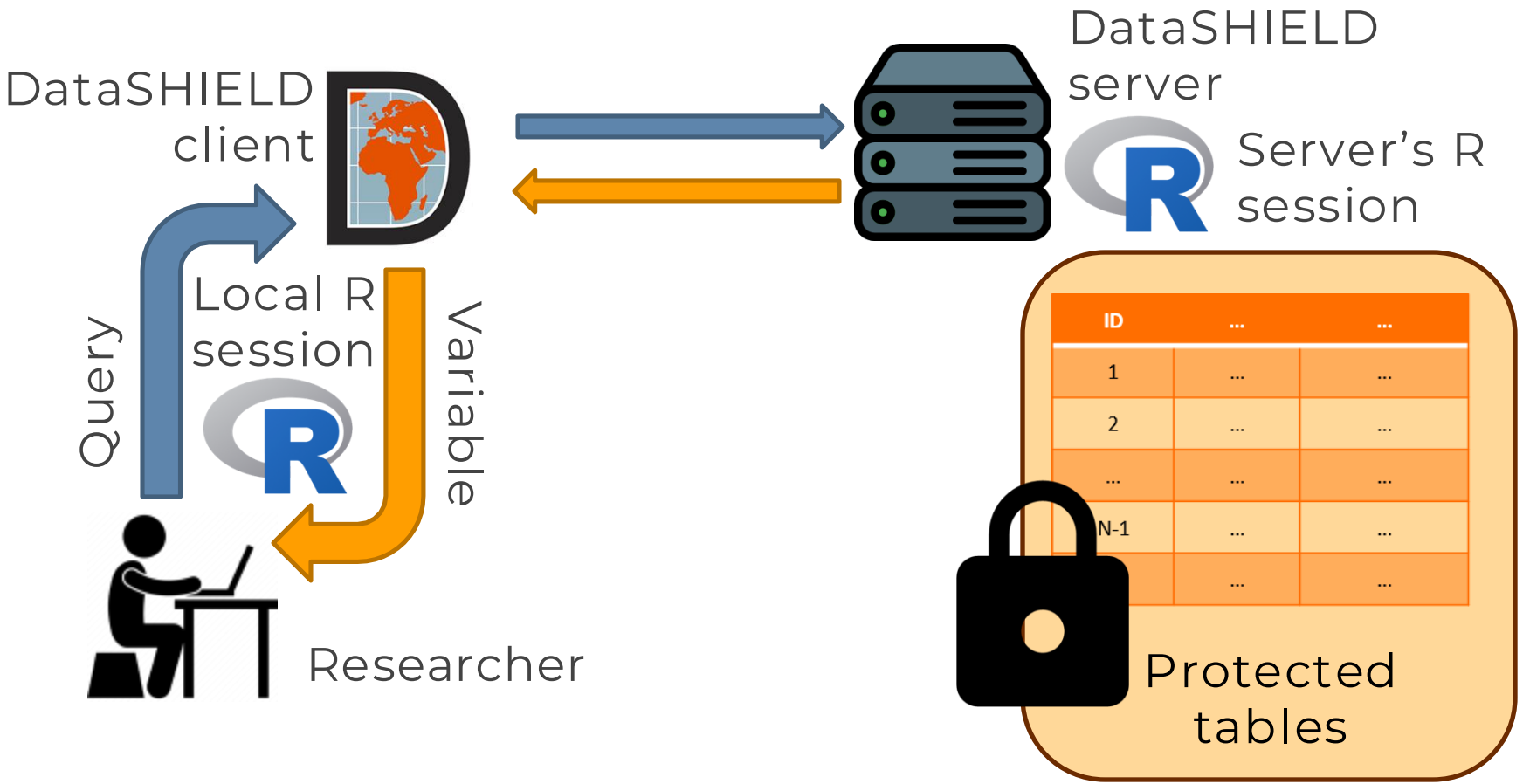


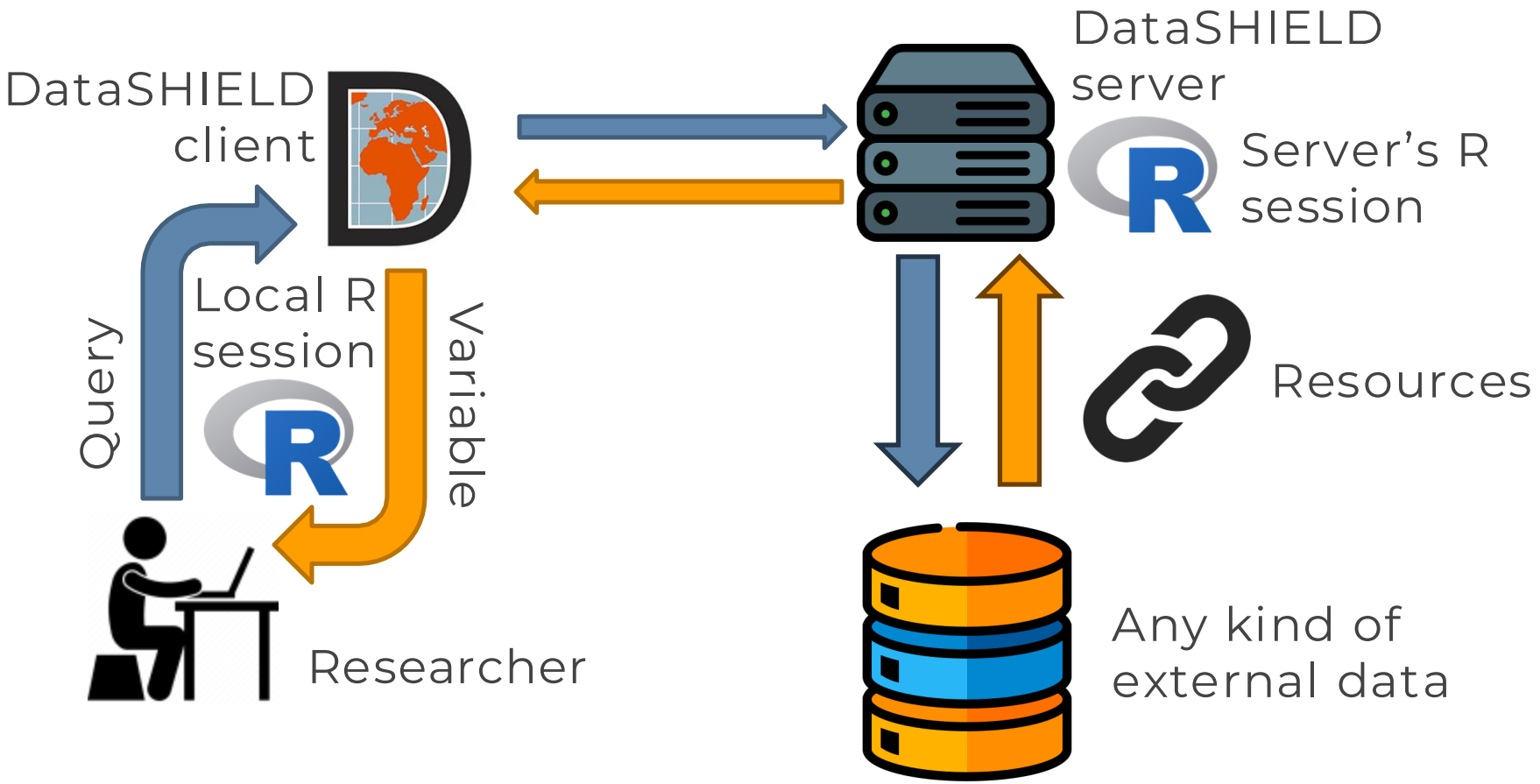
Medical data owner

Data uploading

ID	...	...
1	...	...
2	...	...
...	...	...
N-1	...	...
N	...	...

Data tables


DataSHIELD client
DataSHIELD server
Server's R session
Local R session
Query
Variable
Researcher
ID
...
...
1
2
N-1
Protected tables

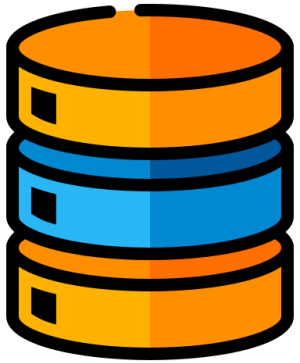

DataSHIELD client
DataSHIELD server
Server's R session
Local R session
Query
Variable
Resources
Researcher
Any kind of external data

Server-side session

DataSHIELD's base server-side functions

Client-side session

DataSHIELD's base client-side functions



OMOP CDM Database

There was no native implementation to connect to and map OMOP CDM databases!

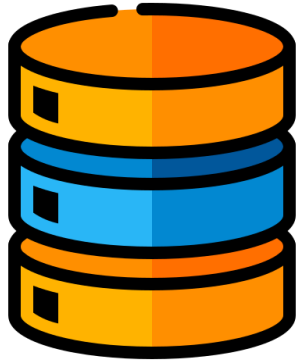
Server-side session

dsOMOP

Client-side session

dsOMOP Client

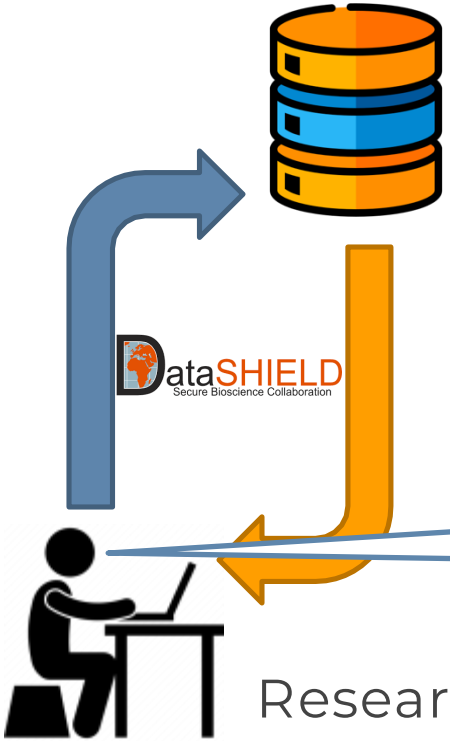
OMOP CDM Resource



OMOP CDM Database

We fixed it with dsOMOP!

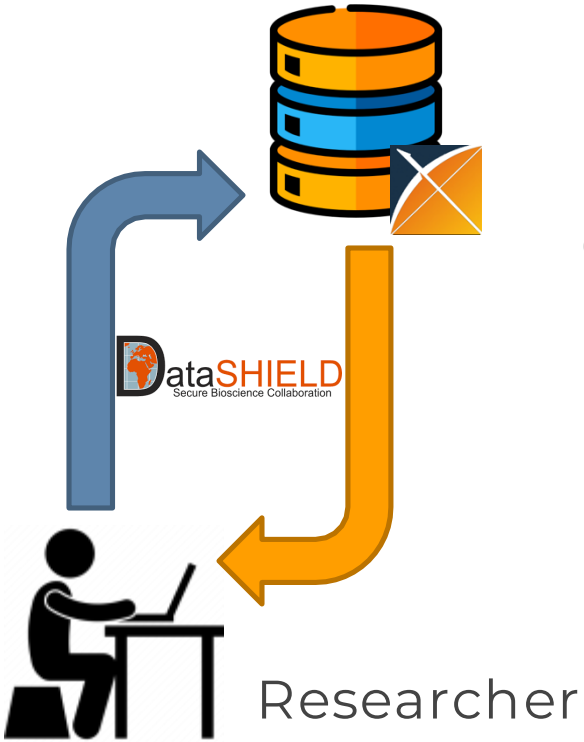
Complexity



Patient_ID	Age	Gender	Smoking	FEV1	FVC
P1000	80	Male	Current	1.04	5.89
P1001	47	Female	Former	3.85	3.51
P1002	41	Male	Never	1.68	4.21
P1003	57	Male	Former	0.82	5.32
P1004	55	Male	Current	0.84	4.47

```
ds.glm: COPD_Severity ~ Age + Smoking_Status
```

Complexity



Person table:

person_id	year_of_birth	gender_concept_id
1	1940	8507
2	1973	8532
...	...	...

gender_concept_id: 8507 for Male, 8532 for Female

Observation table:

person_id	observation_concept_id	value_as_concept_id
1	4005823	8515
2	4005823	8516
...	...	...

observation_concept_id: 4005823 for Smoking Status
value_as_concept_id: 8515 = Current, 8516 = Former, 8517 = Never…

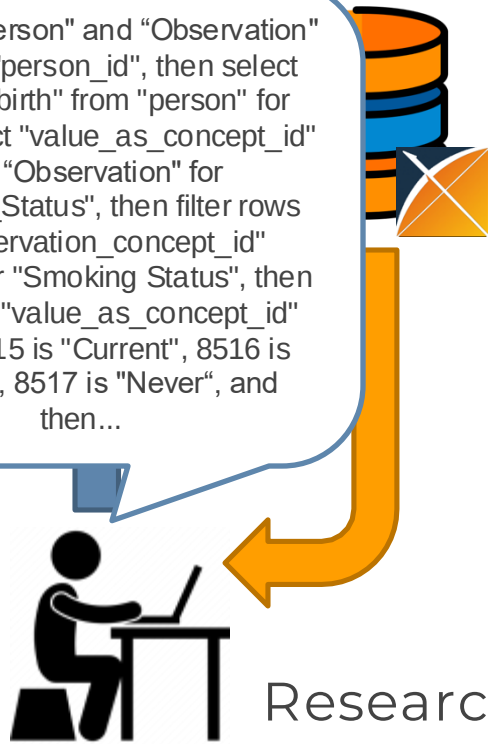
Measurement table:

person_id	measurement_concept_id	value_as_number
1	3023540	1.04
1	3025315	5.89
...	...	...

measurement_concept_id: 3023540 for FEV1, 3025315 for FVC…

Complexity

I will join “Person" and “Observation" tables on "person_id", then select "year_of_birth" from "person" for "Age", select "value_as_concept_id" from “Observation" for "Smoking_Status", then filter rows by "observation_concept_id" 4005823 for "Smoking Status", then I will get a "value_as_concept_id" where 8515 is "Current", 8516 is "Former", 8517 is "Never“, and then...



Researcher

Person table:

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2	1973	8532
...	...	...

gender_concept_id: 8507 for Male, 8532 for Female

Observation table:

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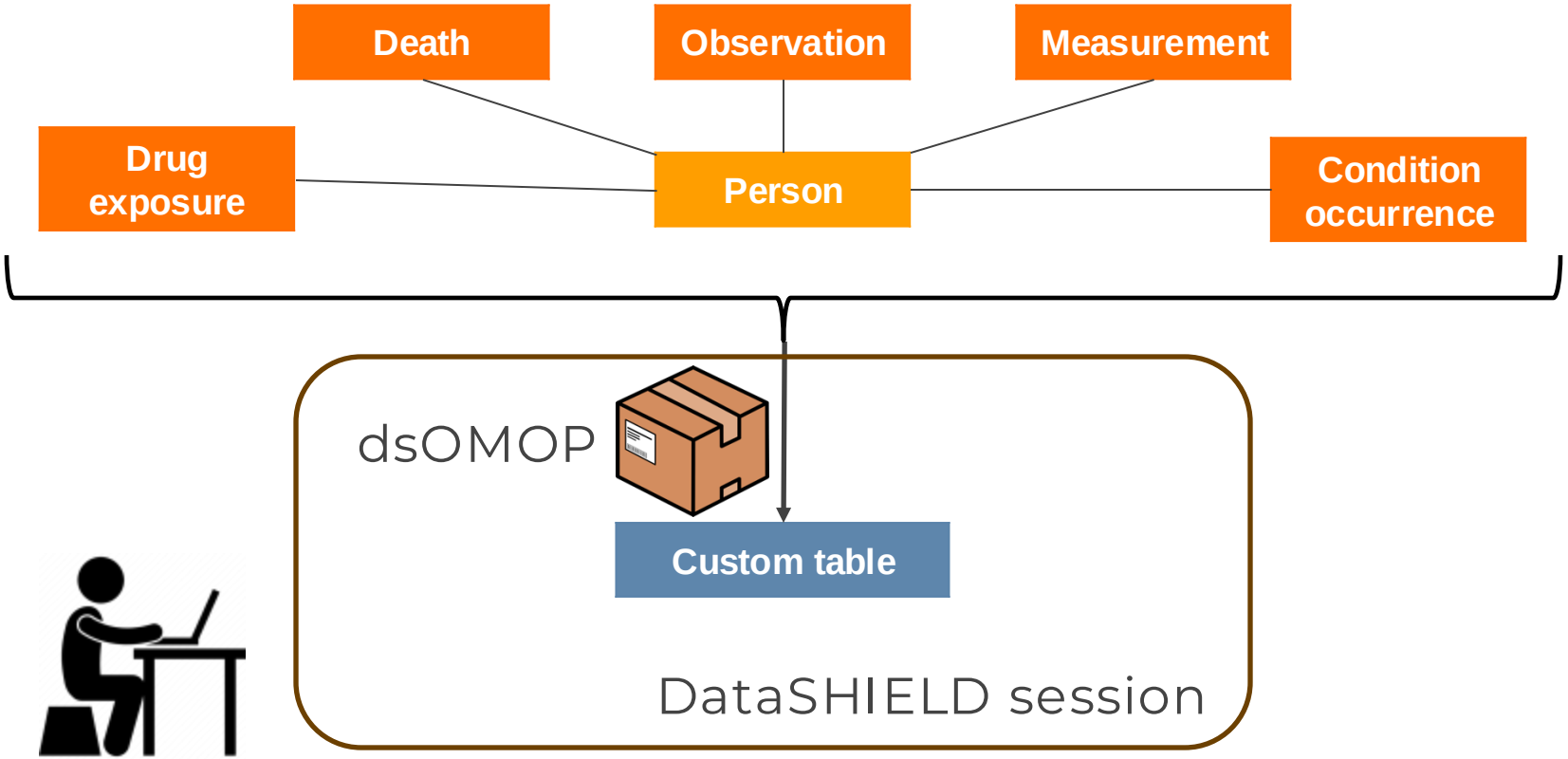


On-demand custom dataset creation!

Concept table

concept_id

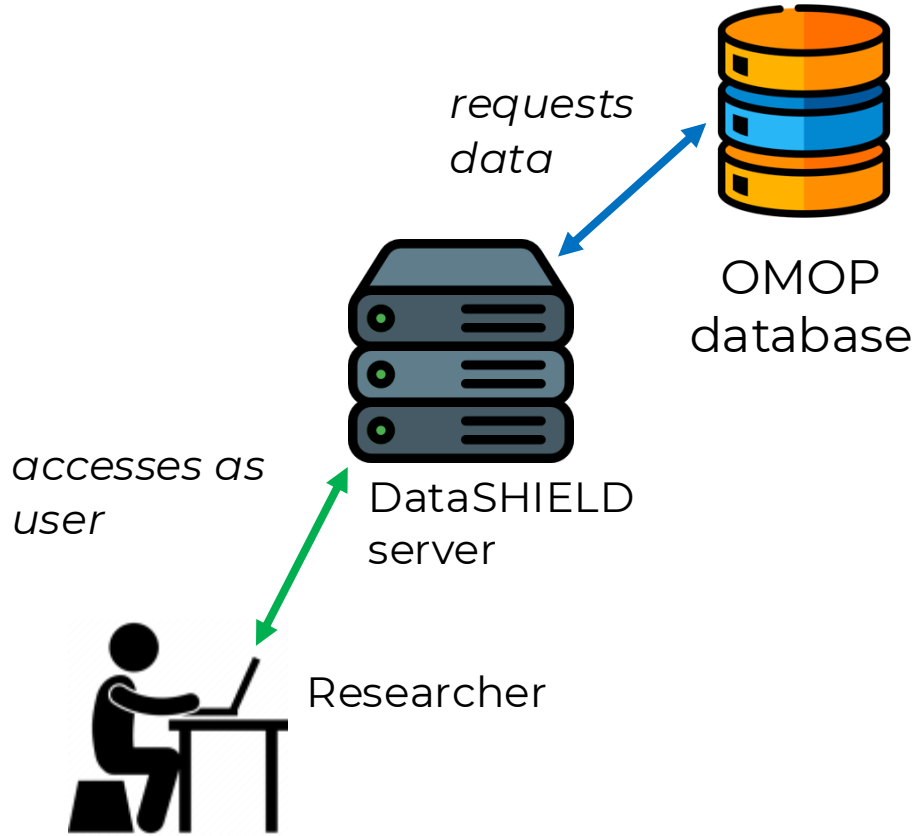
concept_name

person_id	gender	4221442	4214963
1	8507	45877984	8517008
2	8532	4221688	4214964
3	8507	4221334	4214965
4	8532	45877984	4214964
5	8507	4221688	8517008

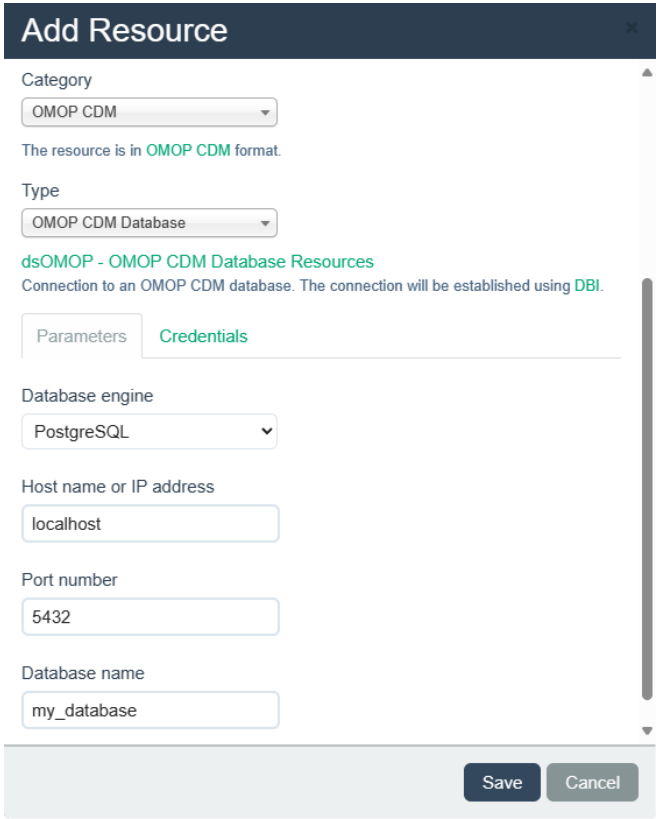
Patient_ID	Gender	COPD_Severity	Smoker
1	Male	Mild	Current
2	Female	Moderate	Never
3	Male	Severe	Former
4	Female	Mild	Never
5	Male	Moderate	Current

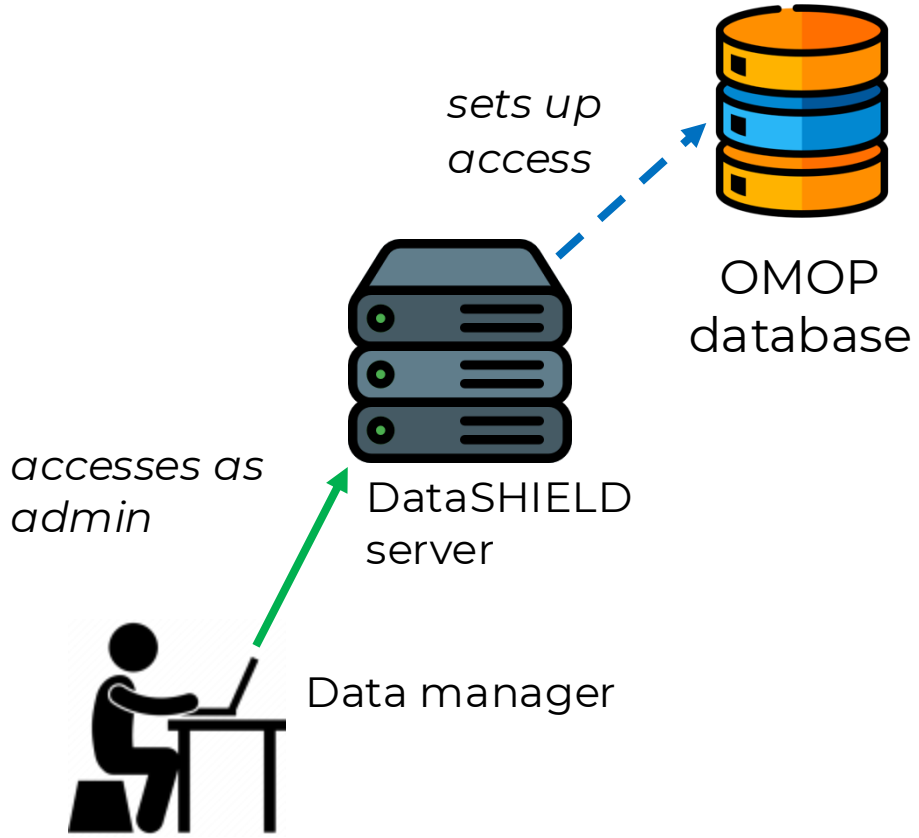
Available data catalog:

Code	Concept
4237017	Genetic test
4245261	Prothrombin time
4246053	**Blood test**
4261836	Thyroid panel
4326419	HIV-1 ELISA assay

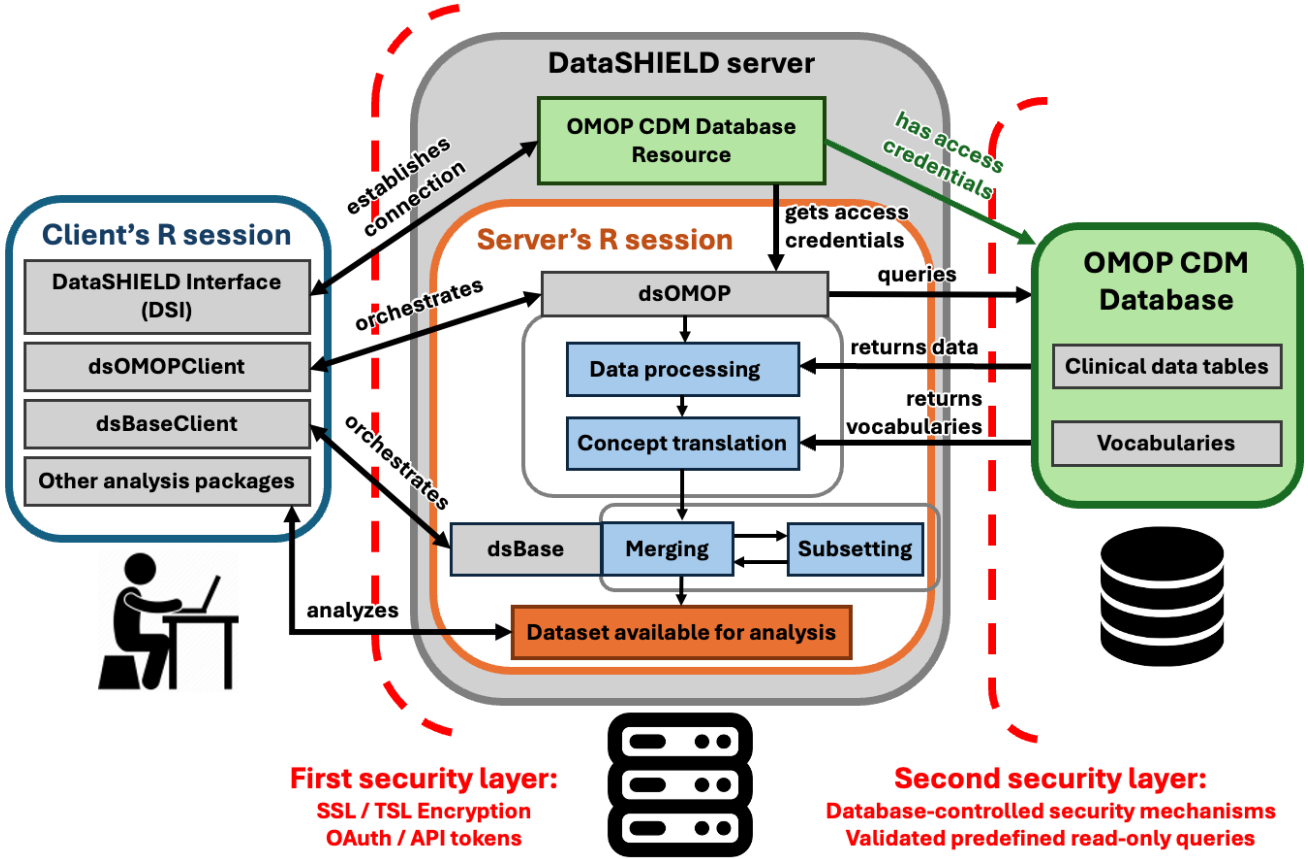


Setting up a connection to a DB:





dsOMOP's internal structure



5

Introducing the dsOMOP framework


David Sarrat González


Xavier Escribà Montagut


Juan R González

- ✅ Enables integration with OMOP CDM databases
- ✅ Open source
- ✅ OMOP CDM-specific security checks
- ✅ User-friendly design
- ✅ Supports development of extensions

🔗 https://isglobal-brge.github.io/dsOMOP

dsOMOP extensions

dsOMOP

Server-Side DataSHIELD Integration for OMOP CDM Databases

This package facilitates interaction with remote databases in the OMOP CDM format from a DataSHIELD environment. It is responsible for fetching and transforming data from databases into a user-intelligible table format, integrated into the DataSHIELD workflow to ensure compliance with the DataSHIELD security model.

GitHub

dsOMOPClient

Client-Side DataSHIELD Integration for OMOP CDM Databases

This package facilitates interaction with remote databases in the OMOP CDM format from a DataSHIELD environment. It enables users to invoke server-side functions that perform fetching and transforming of data from OMOP CDM databases, integrating these operations into the DataSHIELD workflow to maintain adherence to the DataSHIELD security model.

GitHub | User guide

dsOMOPHelper

dsOMOP Helper Functions

This package provides a set of functions to help the user to work with the dsOMOPClient package in DataSHIELD. It provides plug-and-play functionalities for data selection and fetching, streamlining interactions with most simple use cases.

GitHub | User guide

dsOMOP.oracle

dsOMOP Oracle Extension

Extends the functionality of the dsOMOP package to support OMOP CDM databases in Oracle. Requires the oracle.resourcer package.

GitHub

ORACLE DATABASE

ICO Institut Català d'Oncologia

resourcer

dsOMOP

oracle.resourcer

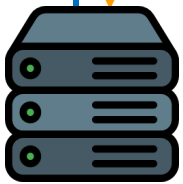
dsOMOP.oracle

Everything comes pre-installed in a Docker image for easy setup!

Oracle OMOP database

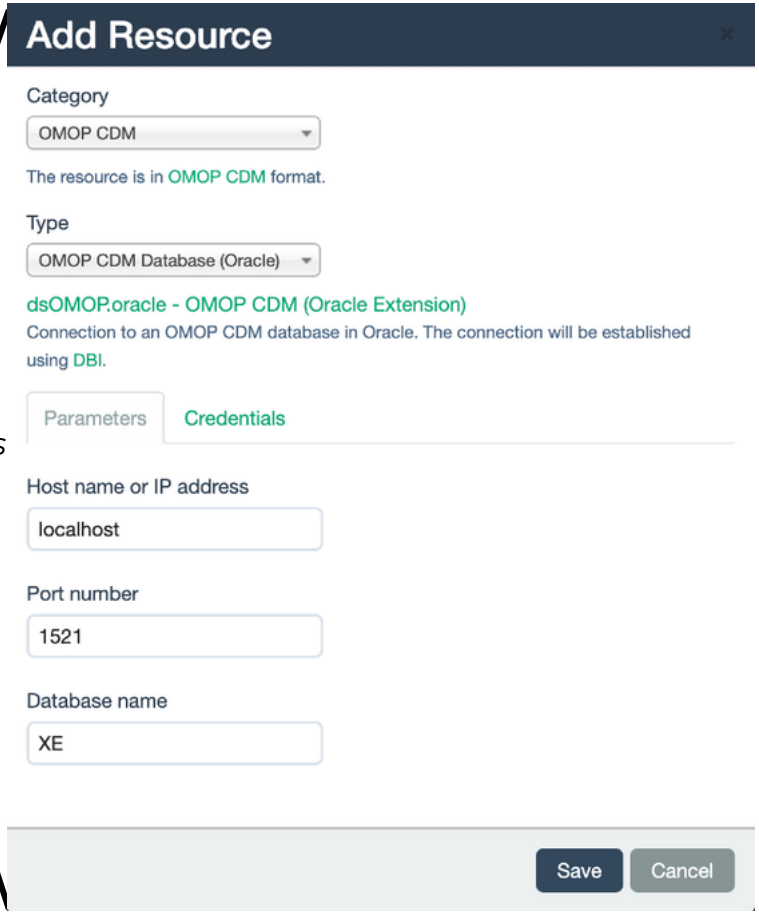
Analysis server with:

- All Oracle dependencies
- resourcer
- oracle.resourcer
- dsOMOP
- dsOMOP.Oracle
- DataSHIELD packages



DataSHIELD server

enables

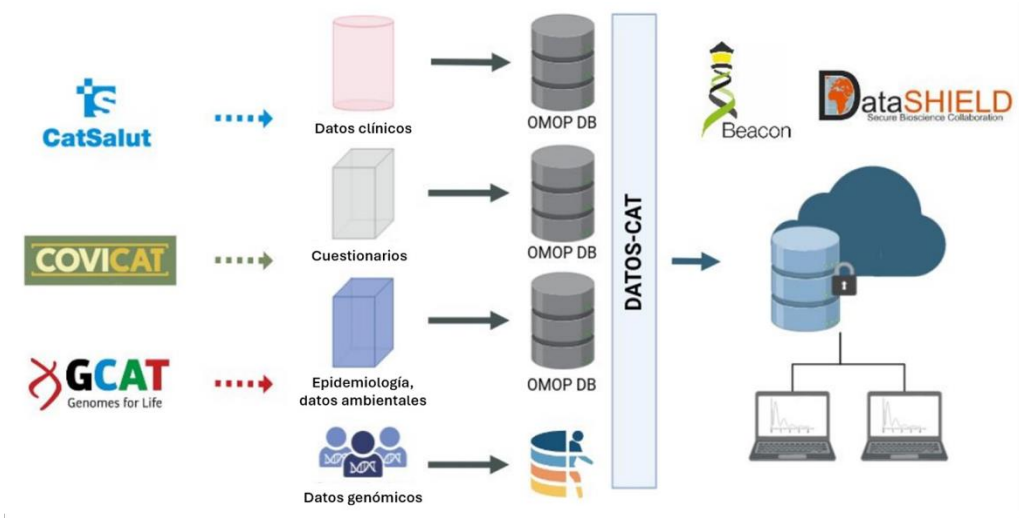


6

dsOMOP’s adoption state

Projects using dsOMOP

DATOS-CAT structure



P4COPD

CADSET

Let’s proceed with a practical example!