Assembling cohort queries with FunSQL

http://github.com/MechanicalRabbit/FunSQL.jl

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OHDSI DevCon 2023

FunSQL is...

- a library for constructing SQL queries
- released under open-source MIT license
- written in Julia, but can also be used with R

and

- designed for assembling analytical queries from reusable components

Introduction

Cohort definitions and SQL query builders

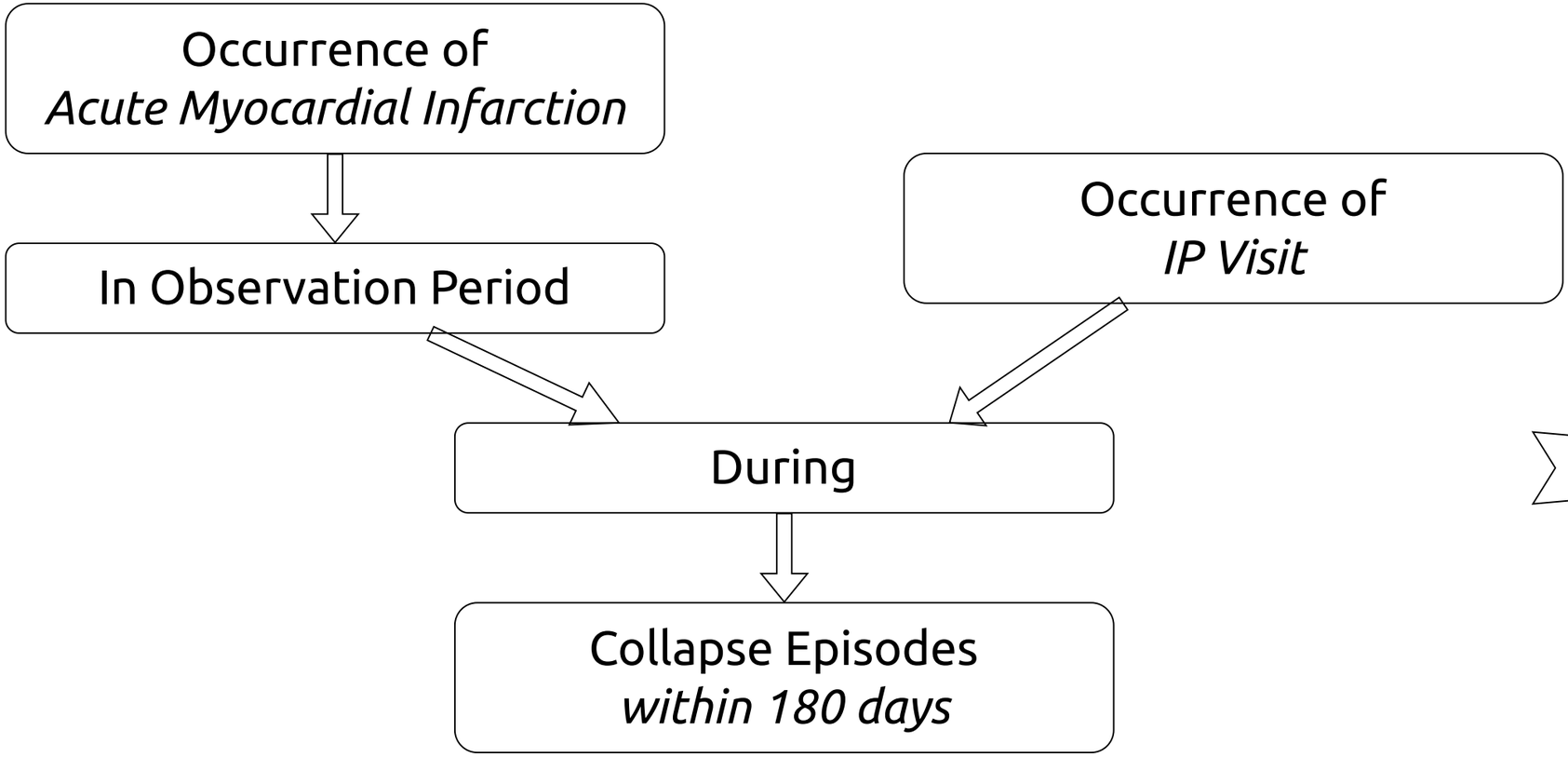
Examples

Reusable query components with joins, recursion, and aggregate and window functions

Conclusion

Build yourself a query language

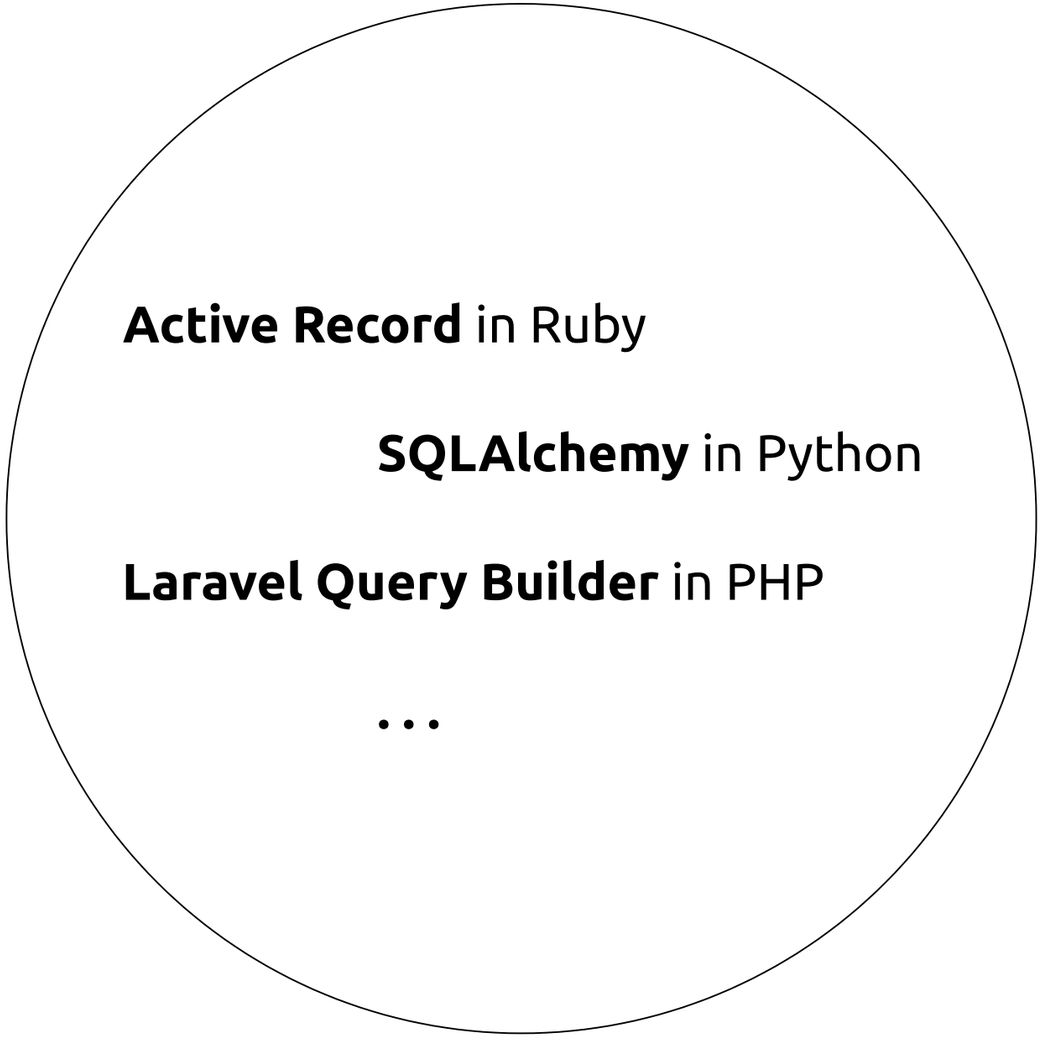
What makes translating **cohort definitions** difficult?



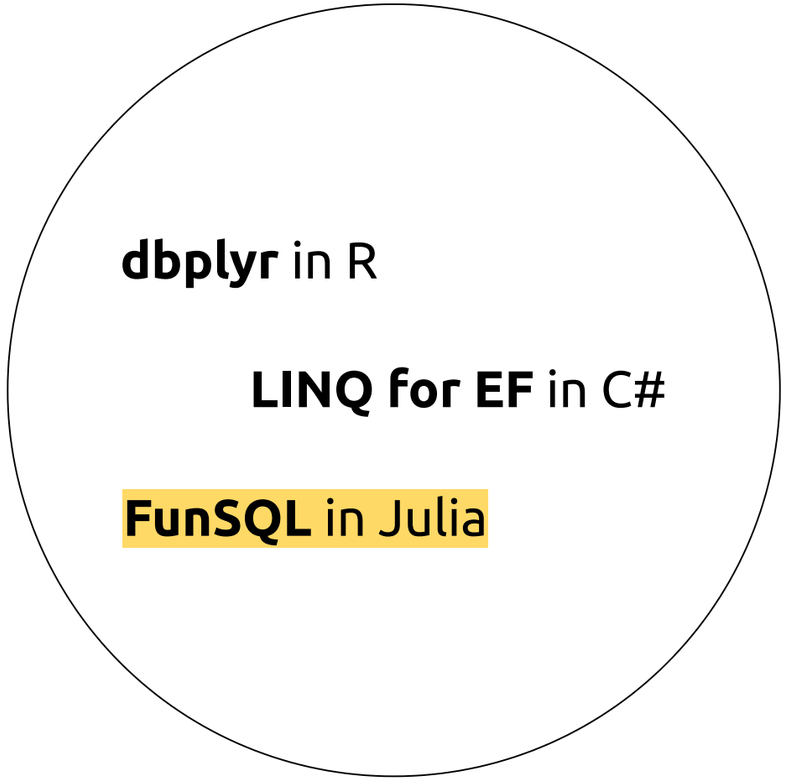

```
SELECT
  person_id,
  cohort_start_date,
  cohort_end_date
FROM
  ...
```

- Expressed in **multi-stage logic**
- Requires **advanced SQL**
- Translated **dynamically**

SQL query building libraries



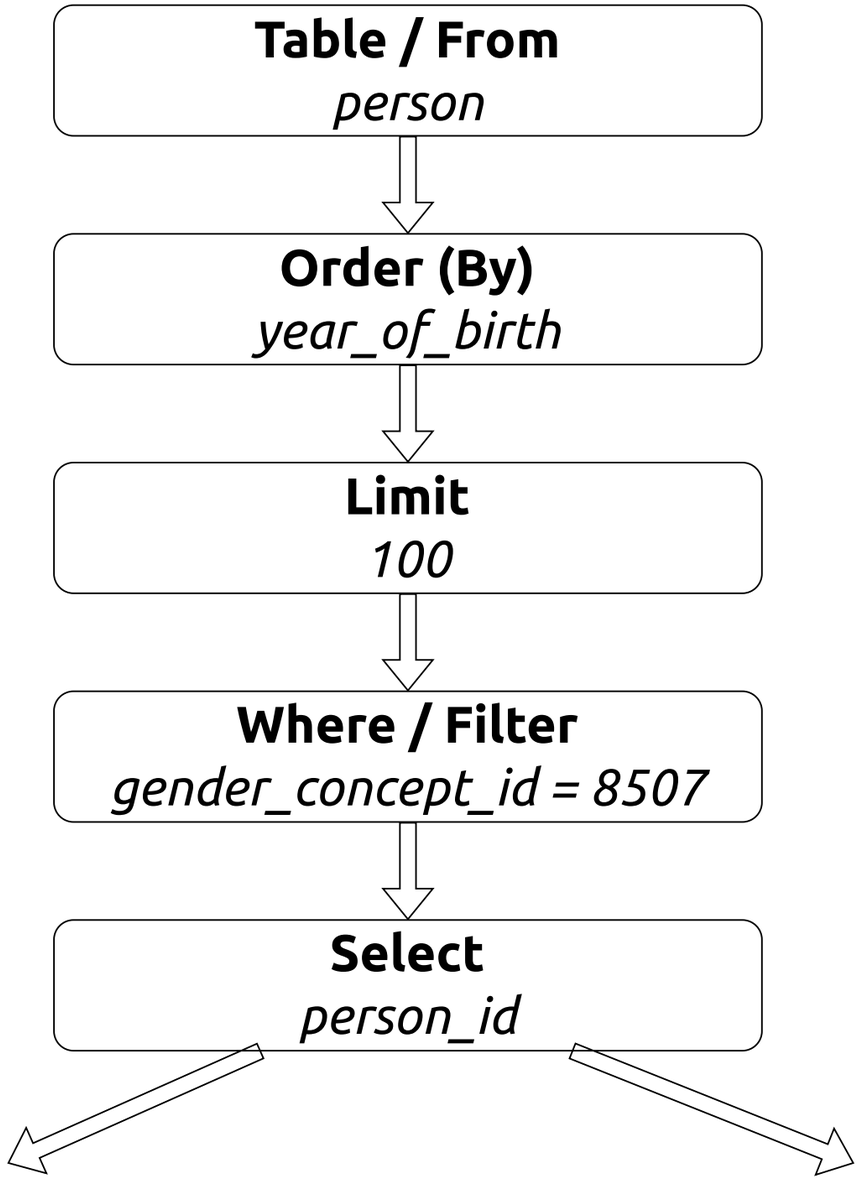
Assemble SQL **syntax** tree



Assemble **data** processing pipeline

Laravel Query Builder in PHP:

```php
DB::table('person')
->orderBy('year_of_birth')
->limit(100)
->where('gender_concept_id',
        '=', 8507)
->select('person_id')
```



FunSQL in Julia:

```julia
from(person)
order(year_of_birth)
limit(100)
filter(gender_concept_id
       == 8507)
select(person_id)
```

Laravel Query Builder in PHP:

```
DB::table('person')
->orderBy('year_of_birth')
->limit(100)
->where('gender_concept_id', '=', 8507)
->select('person_id')
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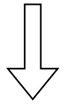
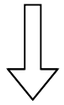
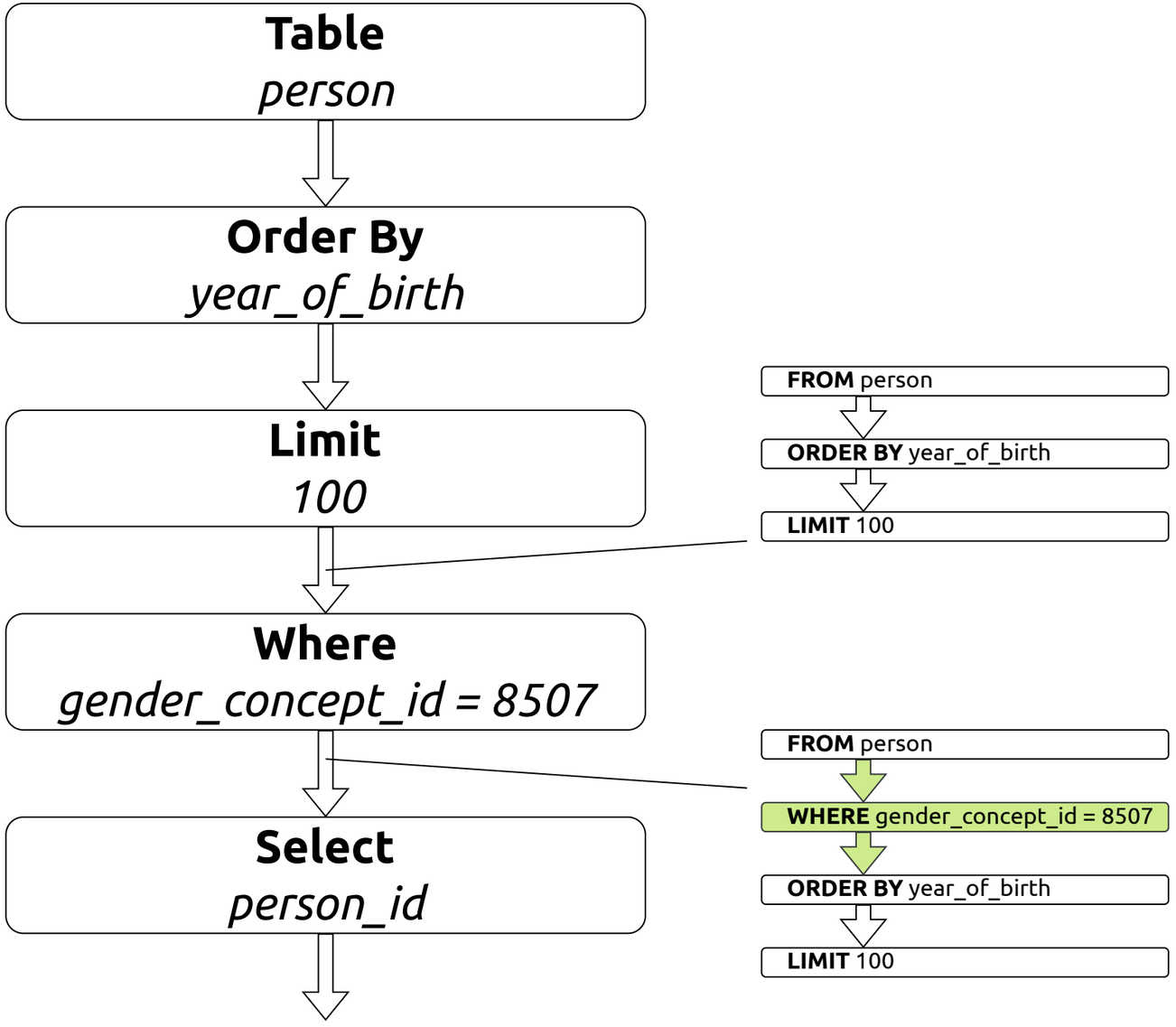


```
SELECT person_id
FROM person
WHERE gender_concept_id = 8507
ORDER BY year_of_birth
LIMIT 100
```

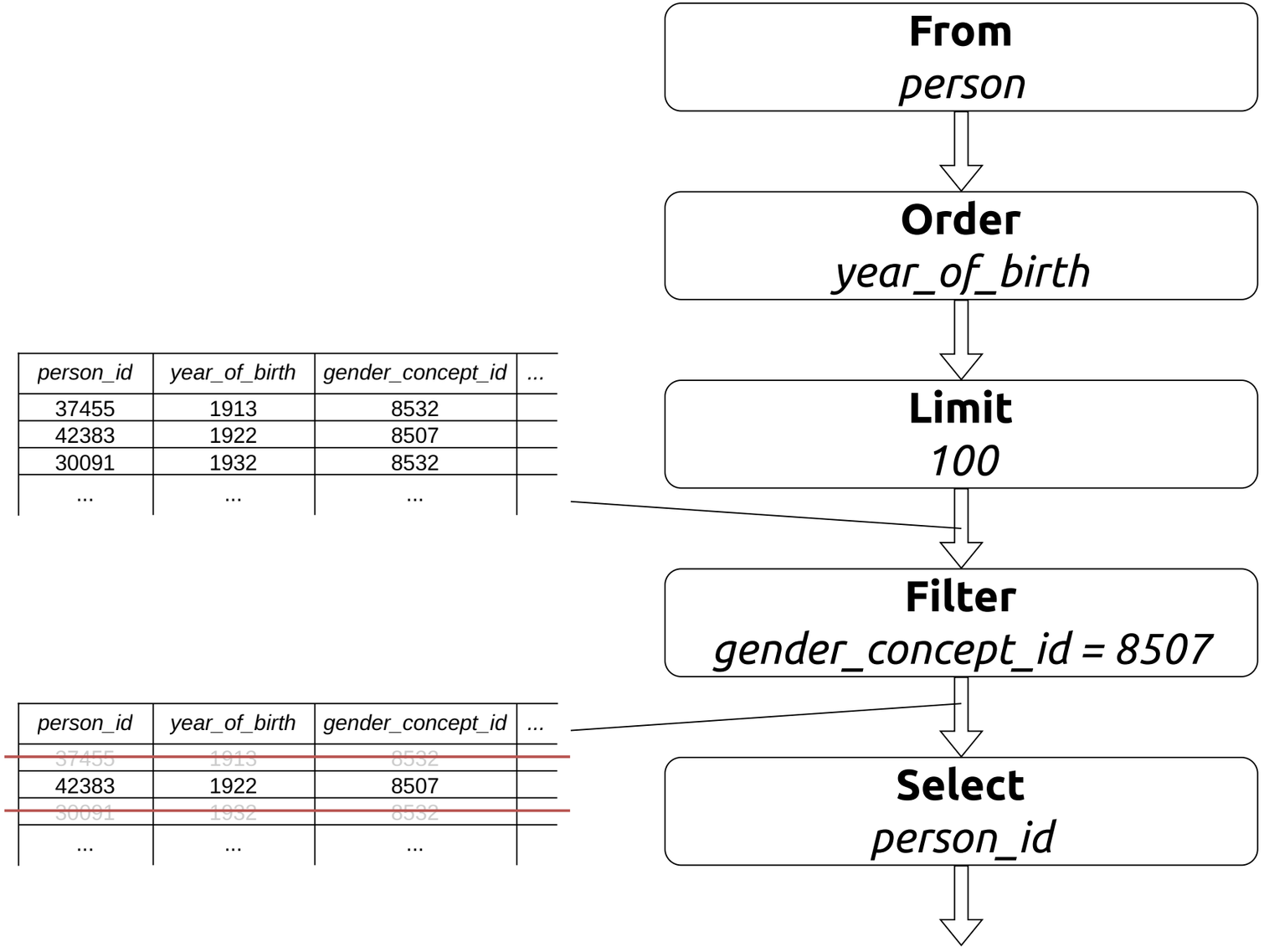


100 oldest male patients

Pipeline that builds SQL **syntax** tree:



Pipeline that processes **data**:



FunSQL in Julia:

```
from(person)
order(year_of_birth)
limit(100)
filter(gender_concept_id == 8507)
select(person_id)
```

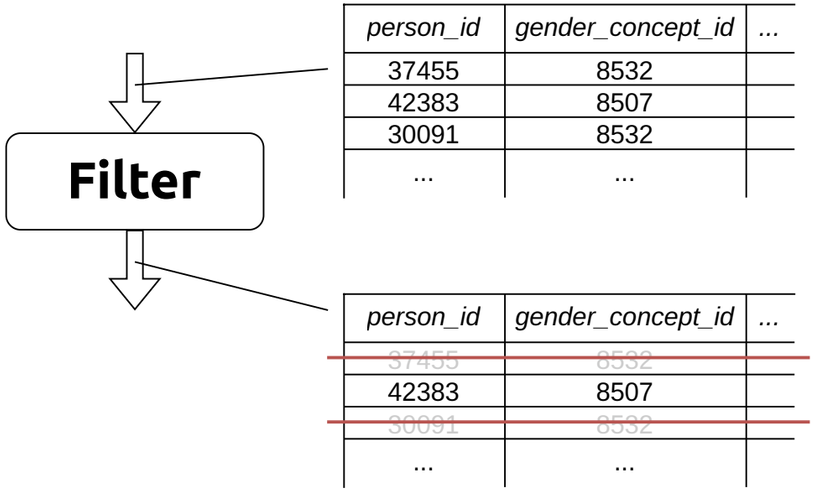
⇩

```
SELECT person_id
FROM (
  SELECT person_id,
         gender_concept_id
  FROM person
  ORDER BY year_of_birth
  LIMIT 100) AS person
WHERE gender_concept_id = 8507
```

⇩

Males among 100 oldest patients

In FunSQL, pipeline **components** are...



- *Coherent*

  Every component is interpreted as a data transformation

- *Composable*

  Any compatible components can be connected

- *Comprehensive*

  Components can represent aggregate and window functions, correlated subqueries, lateral joins, CTEs, recursive queries, and more

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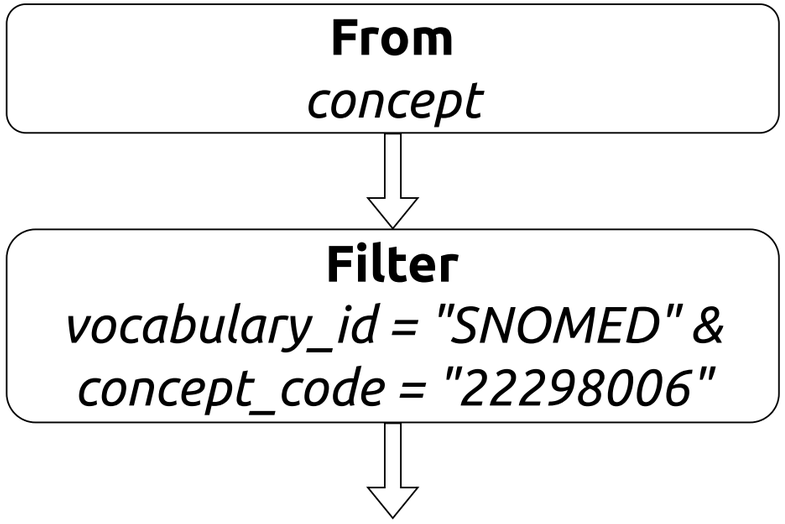
SNOMED 22298006 "Myocardial infarction"

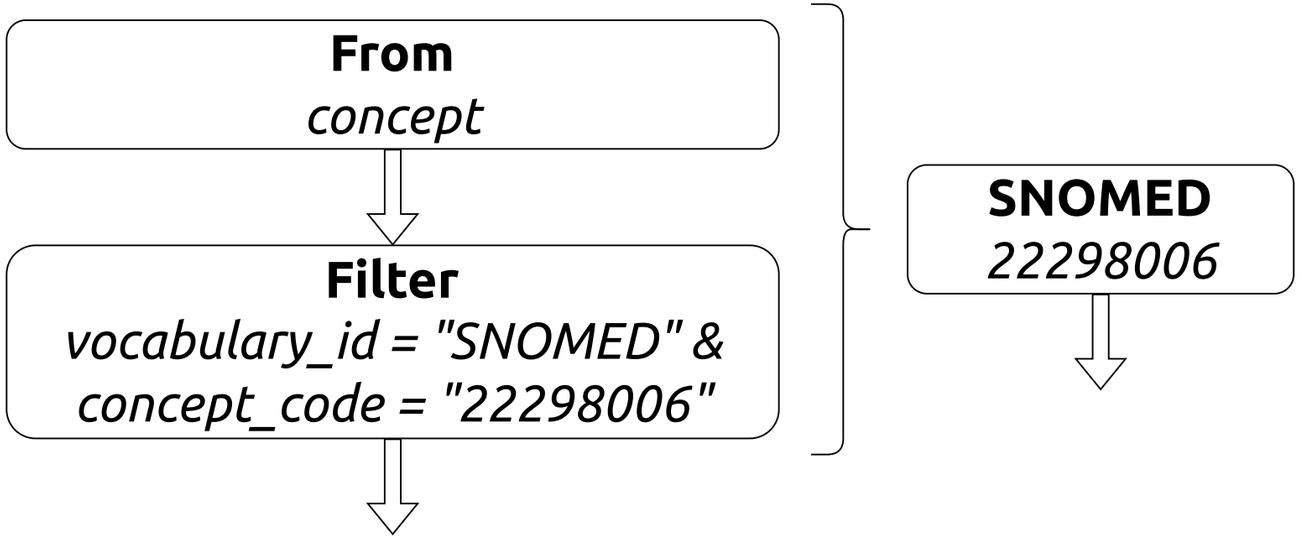
```
begin
  from(concept)
  filter(
    vocabulary_id == "SNOMED" &&
    concept_code == "22298006")
end
```

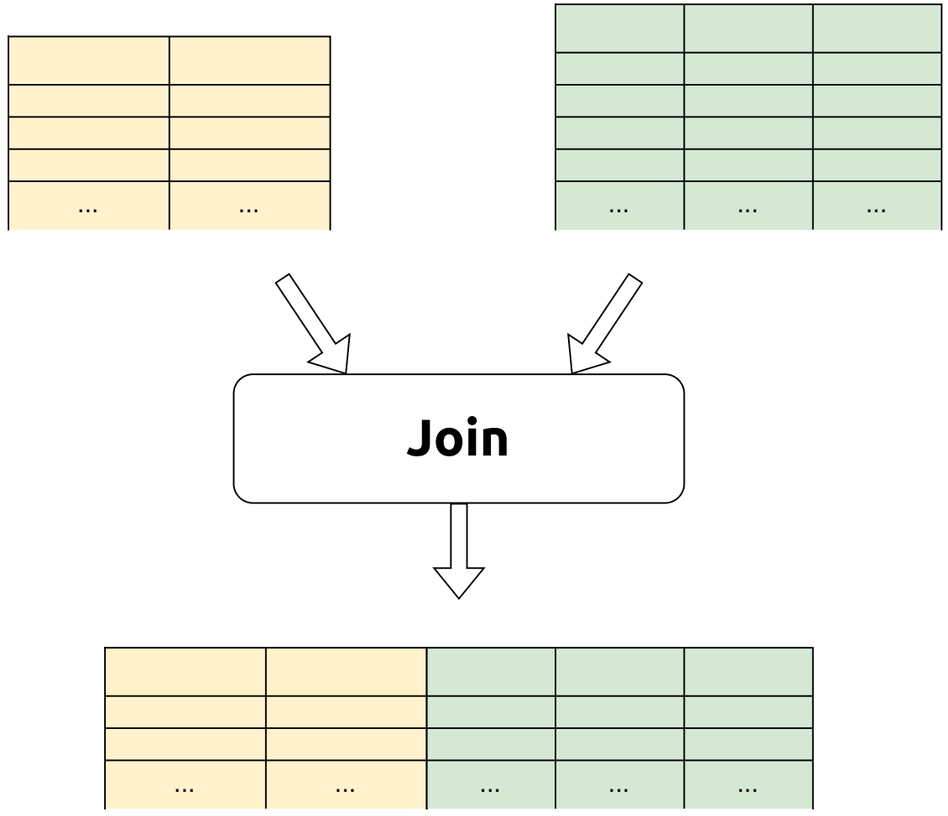


SNOMED 22298006 "Myocardial infarction"

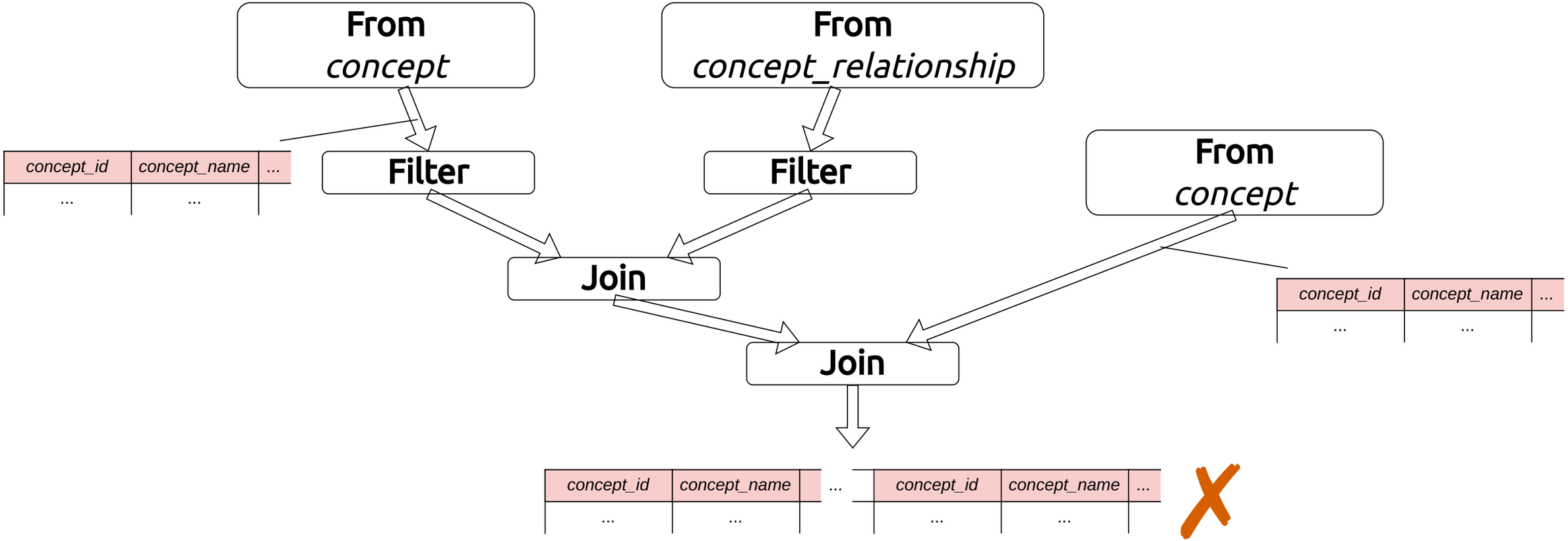
```
snomed("22298006")
```

```
snomed(code) = begin
  from(concept)
  filter(
    vocabulary_id == "SNOMED" &&
    concept_code == code)
end
```




...
...
...
...
...
Join
...
...
...
...
...

Find immediate children of the concept
SNOMED 22298006 "Myocardial infarction"

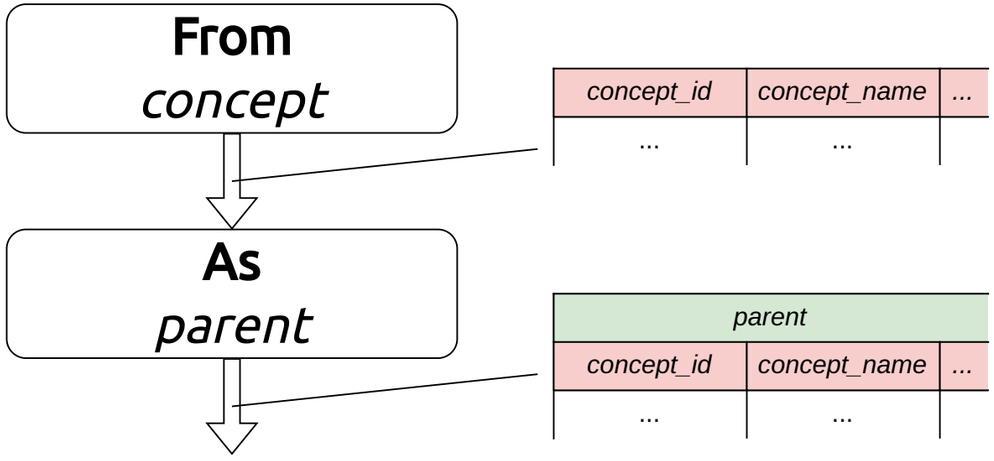


How to deal with **duplicate** column names?

SQL:
table **aliases**

dplyr:
mangled column names

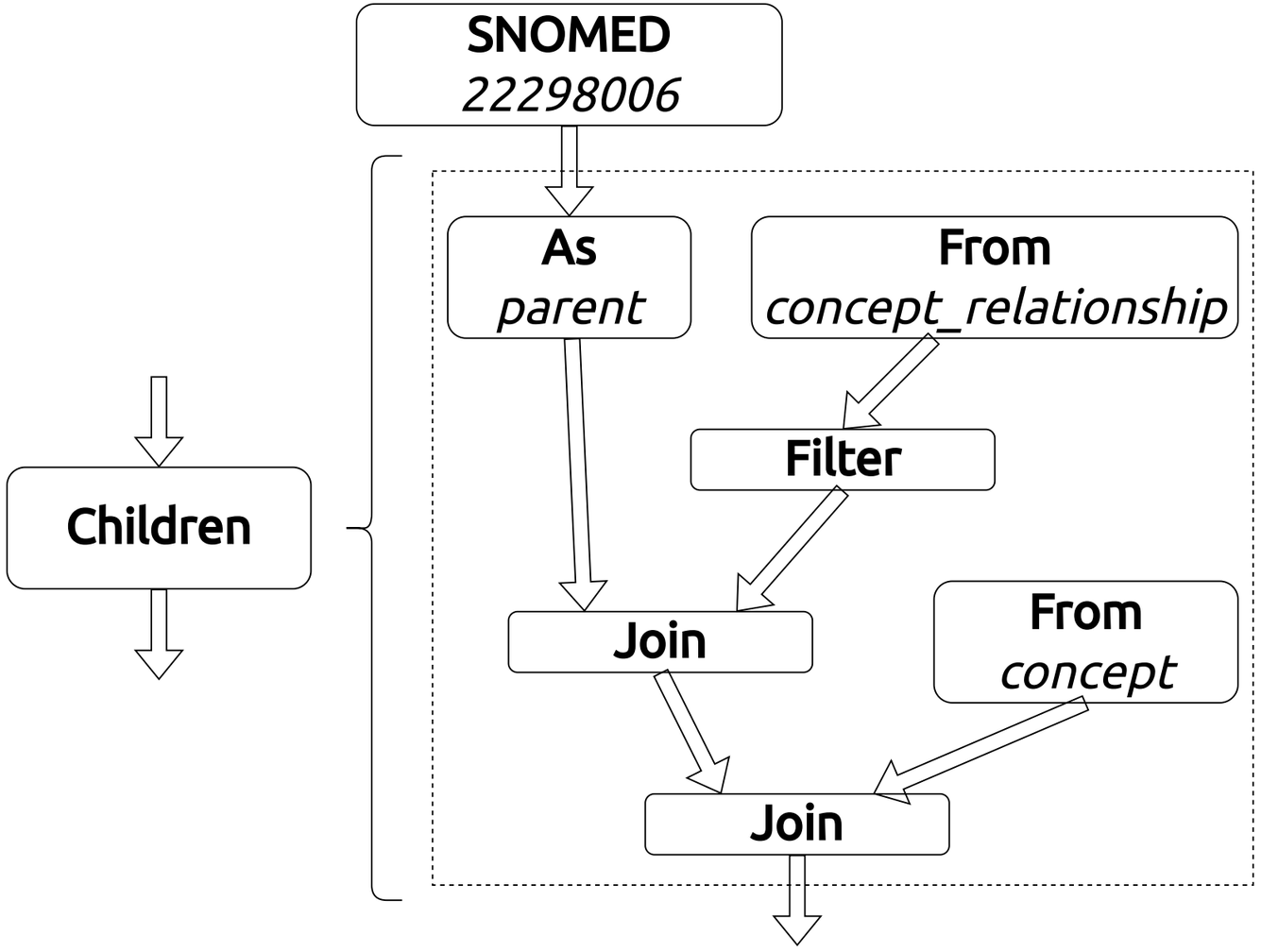
FunSQL:
nested records



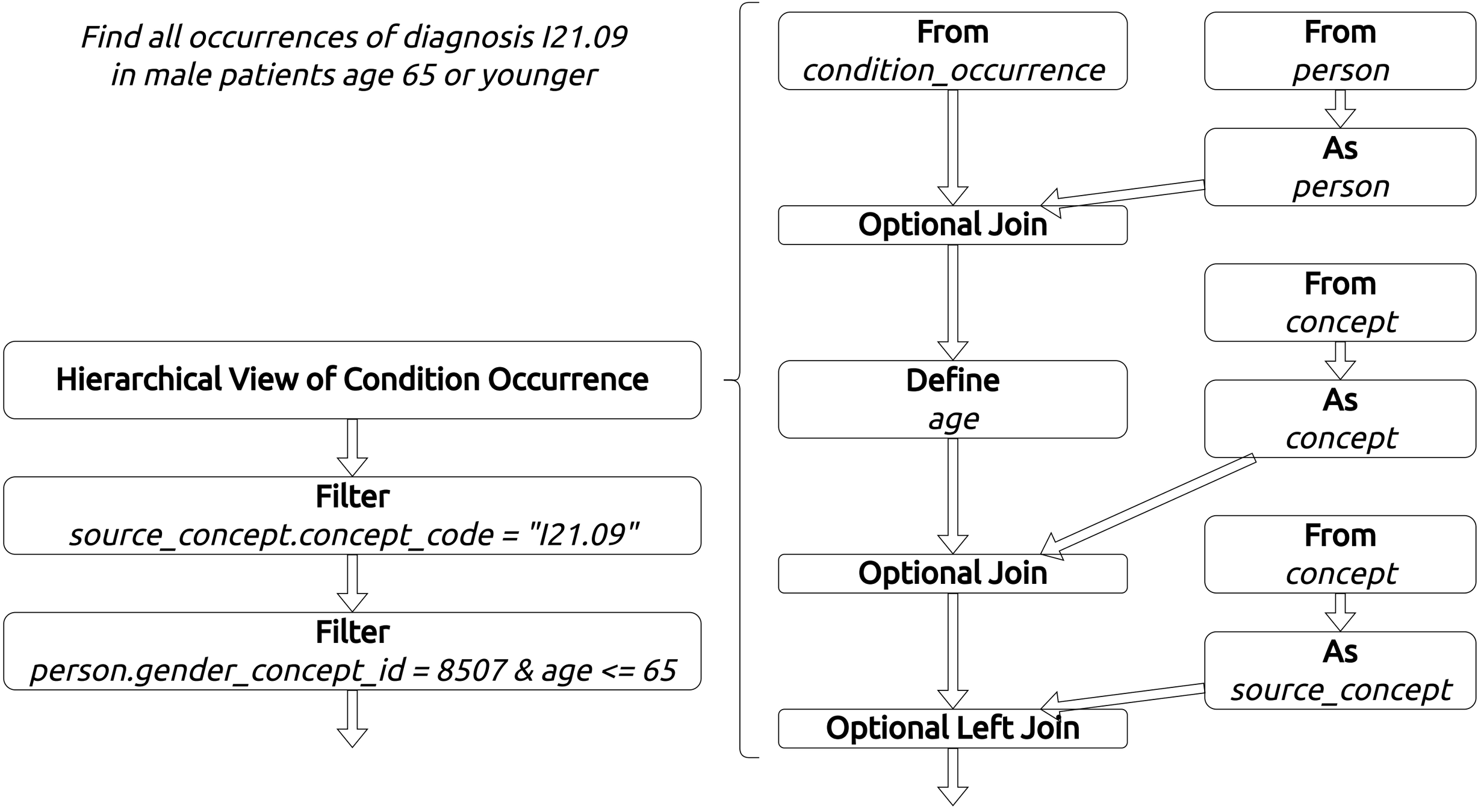
Find immediate children of the concept
SNOMED 22298006 "Myocardial infarction"

```
snomed("22298006")
children()
```

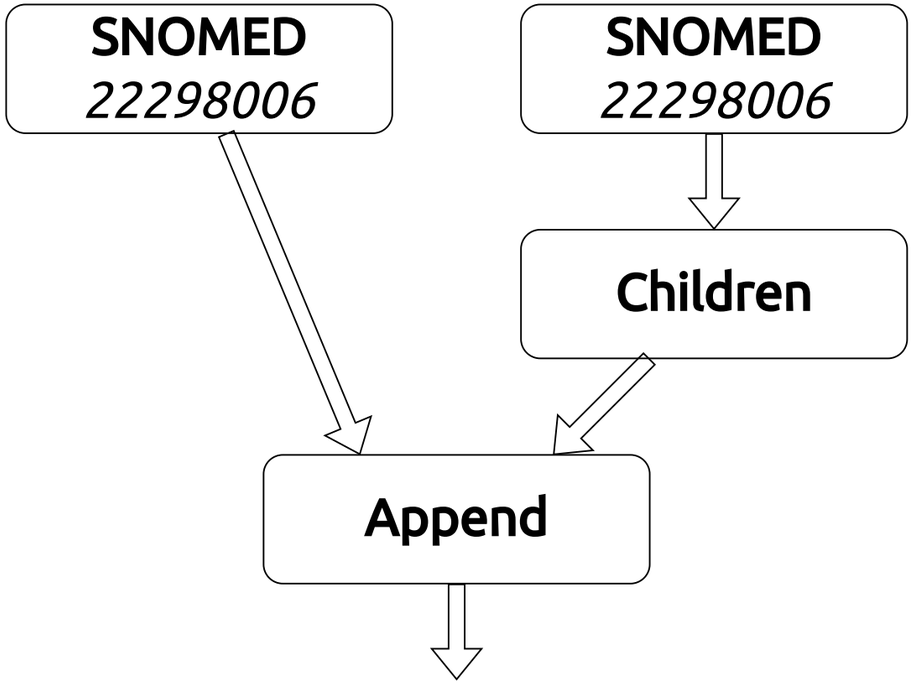
```
children() = begin
  as(parent)
  join(
    from(concept_relationship).
    filter(
      relationship_id == "Subsumes"),
    parent.concept_id == concept_id_1)
  join(
    from(concept),
    concept_id_2 == concept_id)
end
```

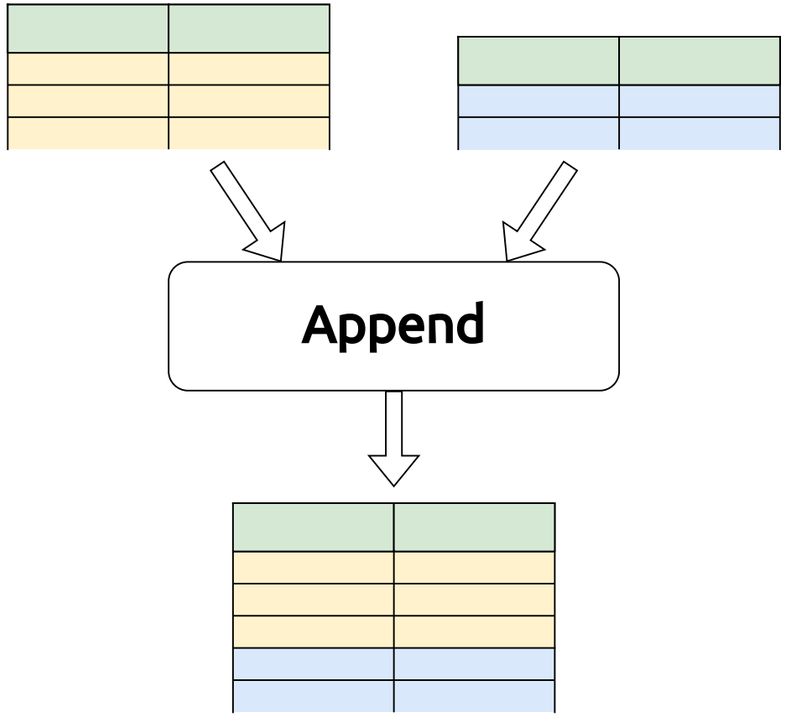


Find all occurrences of diagnosis I21.09
in male patients age 65 or younger



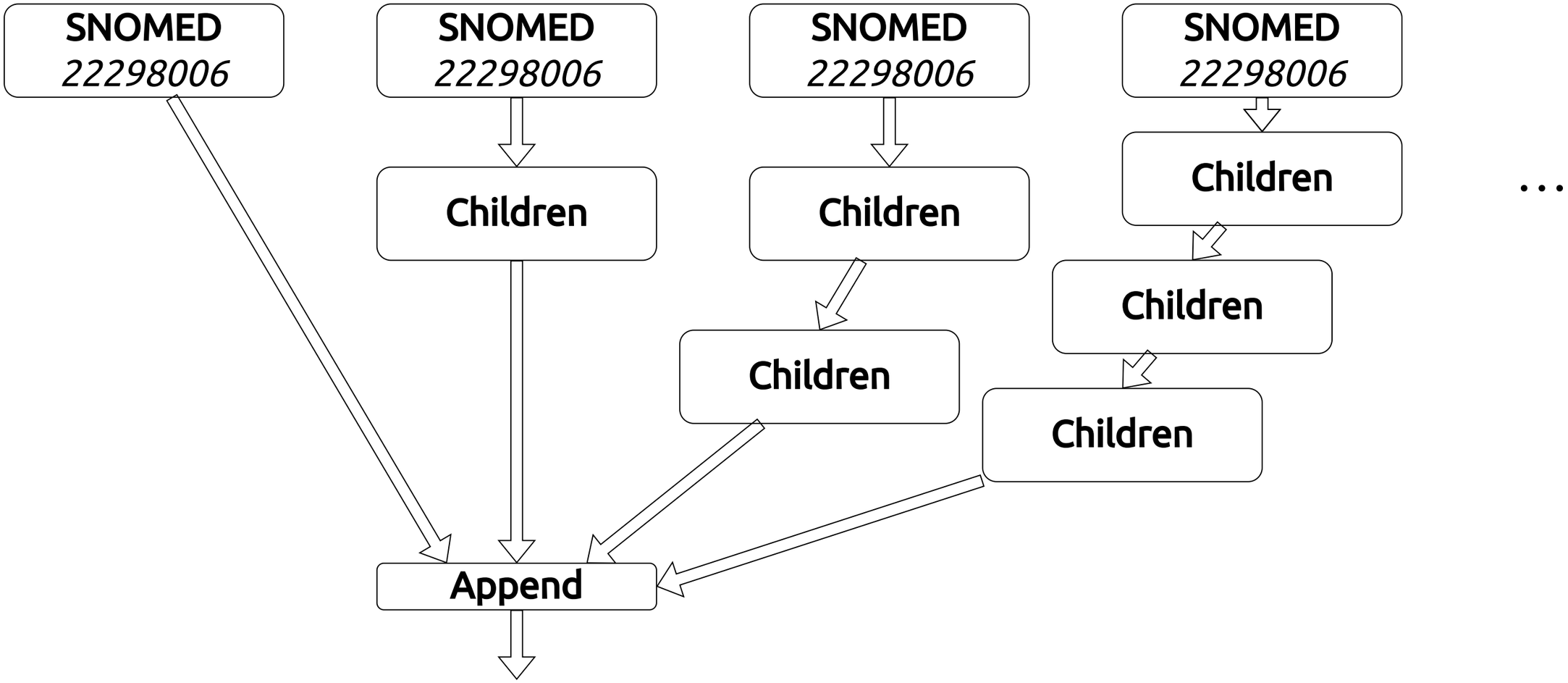
Concept SNOMED 22298006 "Myocardial infarction"
***and** its immediate children*






```
snomed("22298006")
append(snomed("22298006").children())
```

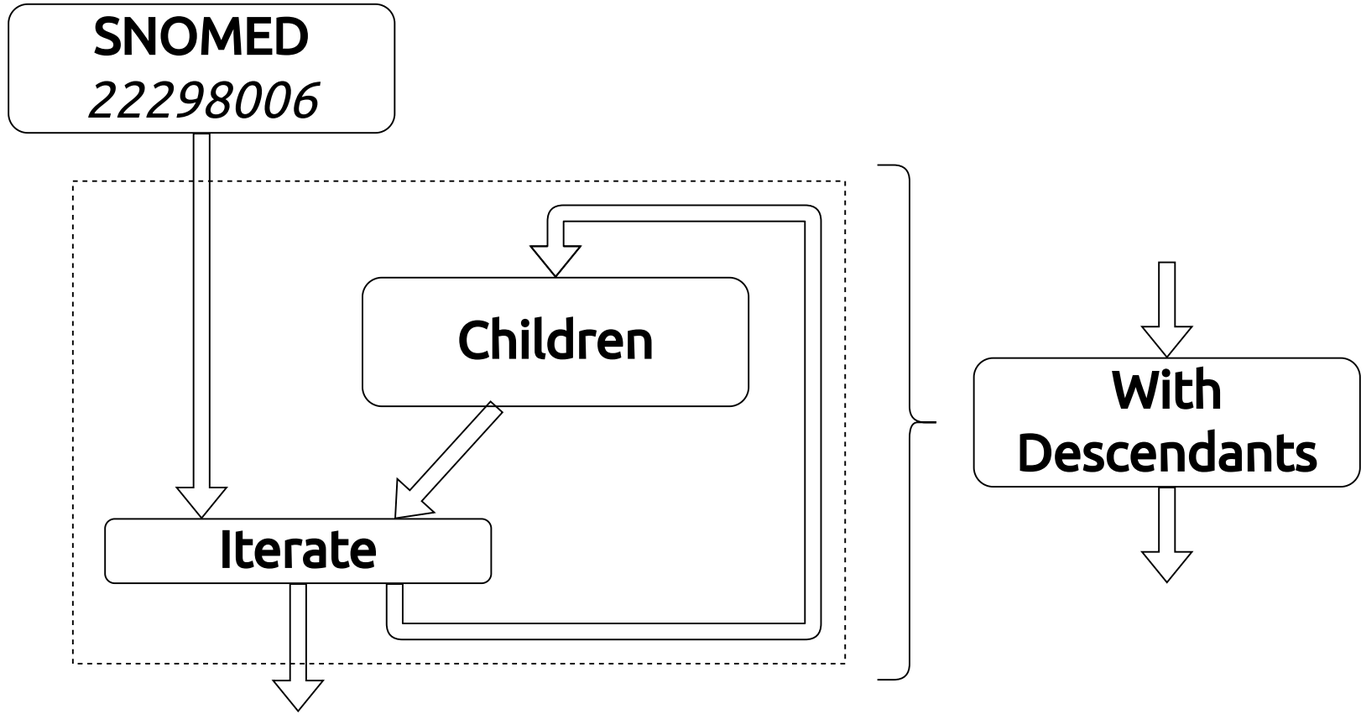
Concept SNOMED 22298006 "Myocardial infarction"
*and all its **descendants***



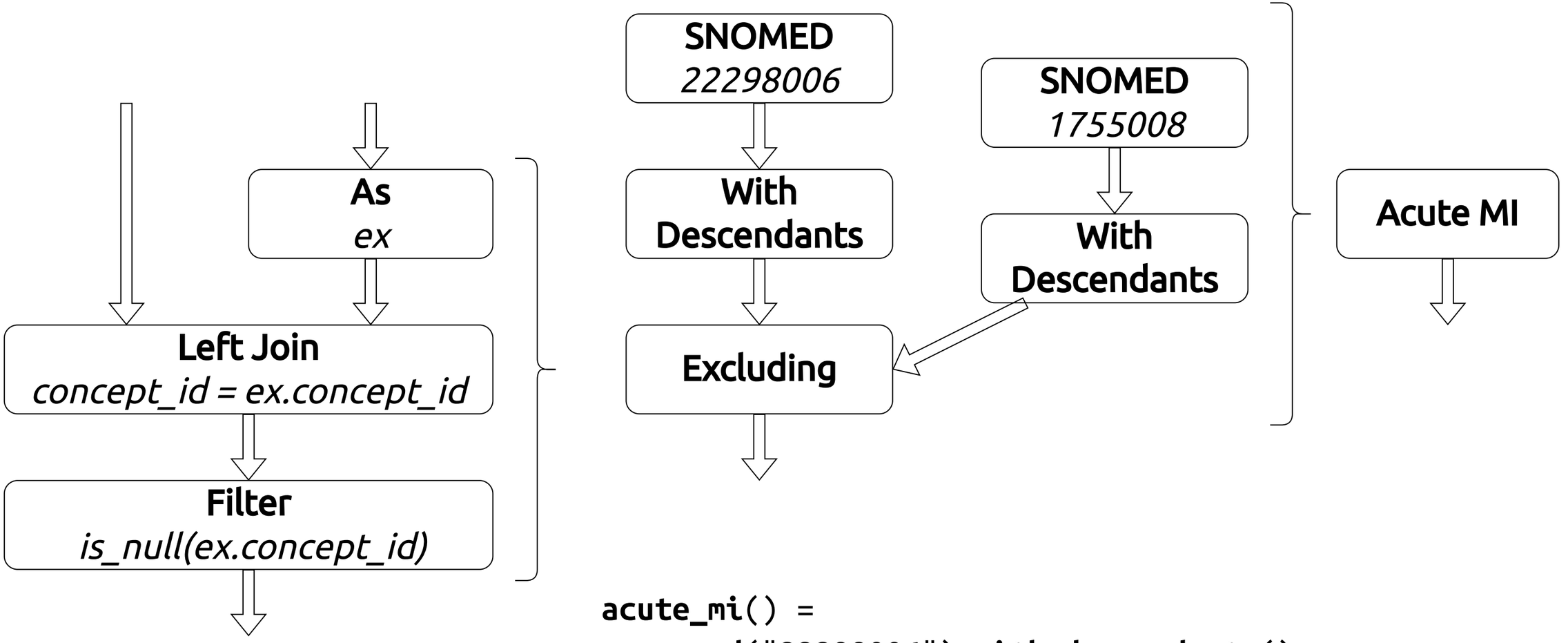
Concept SNOMED 22298006 "Myocardial infarction"
*and all its **descendants***

```
snomed("22298006")
with_descendants()
```

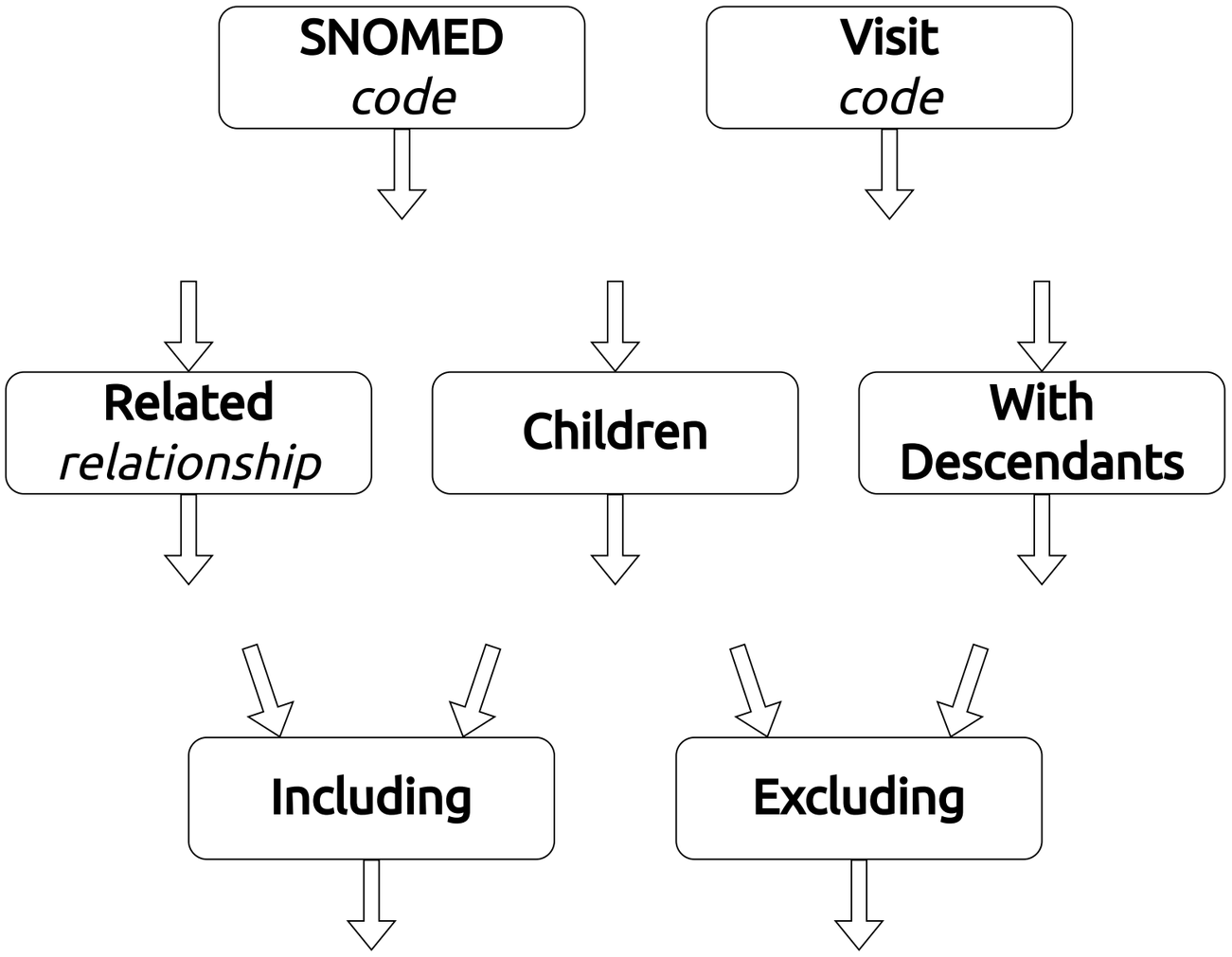
```
with_descendants() =
  iterate(children())
```



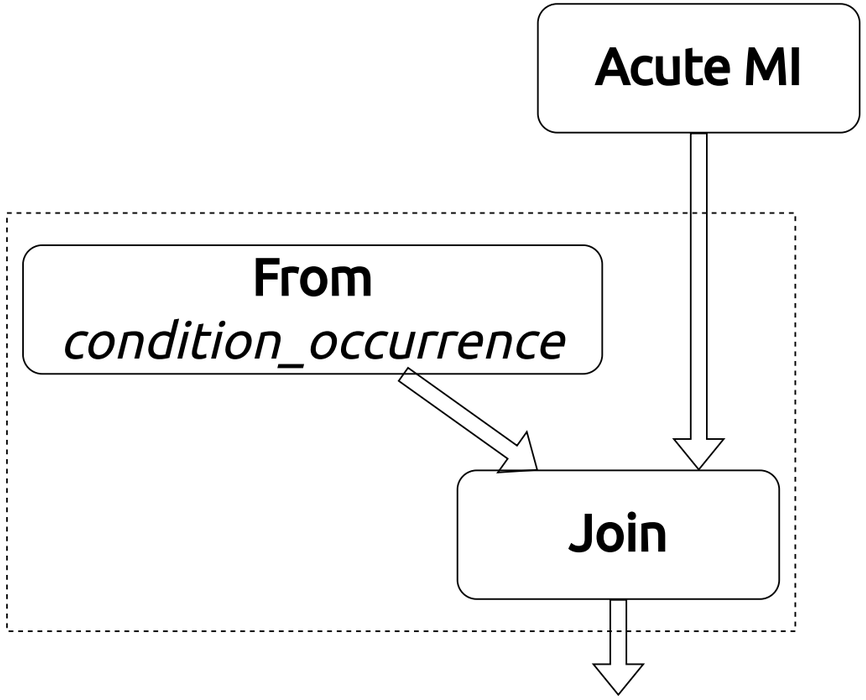
Acute MI is SNOMED 22298006 "Myocardial infarction" and all its descendants excluding SNOMED 1755008 "Old myocardial infarction" and all its descendants



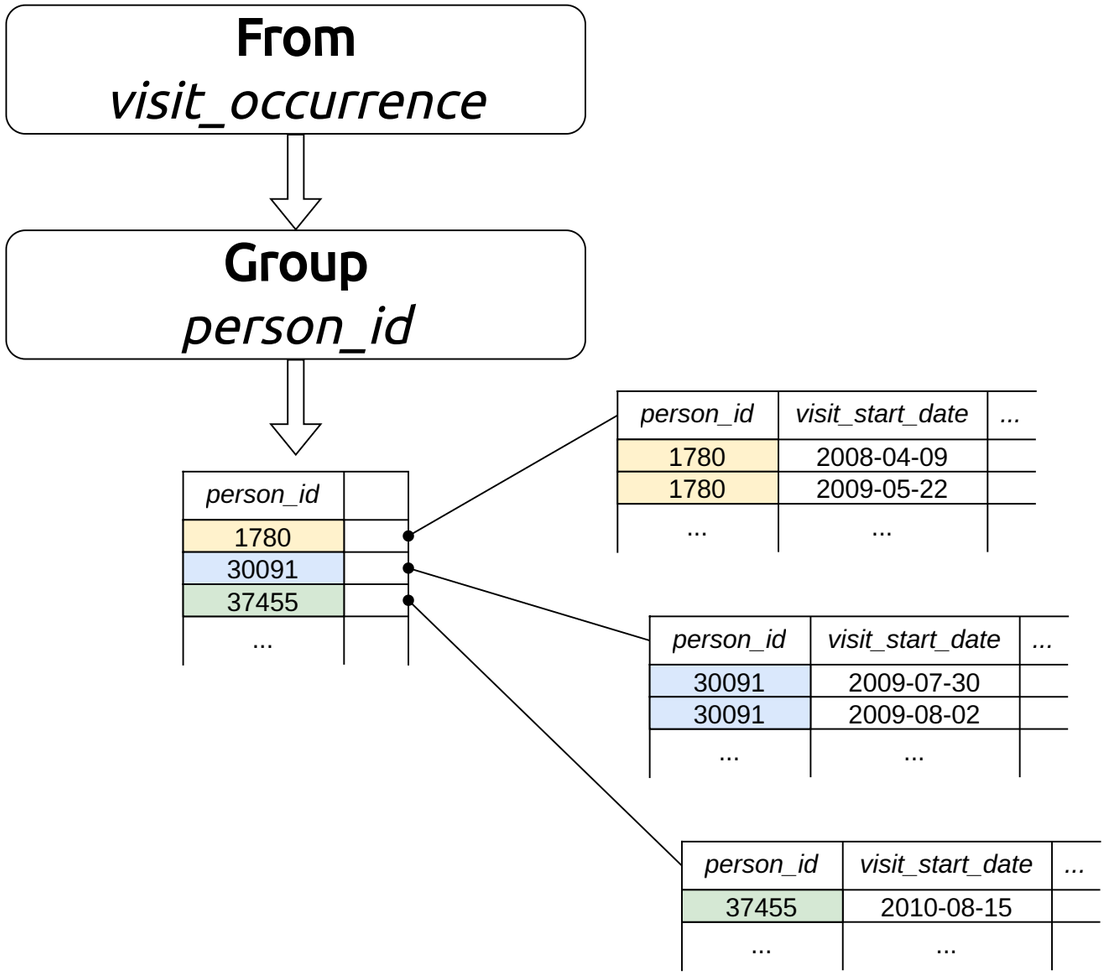

```
acute_mi() =
  snomed("22298006").with_descendants().
  excluding(snomed("1755008").with_descendants())
```

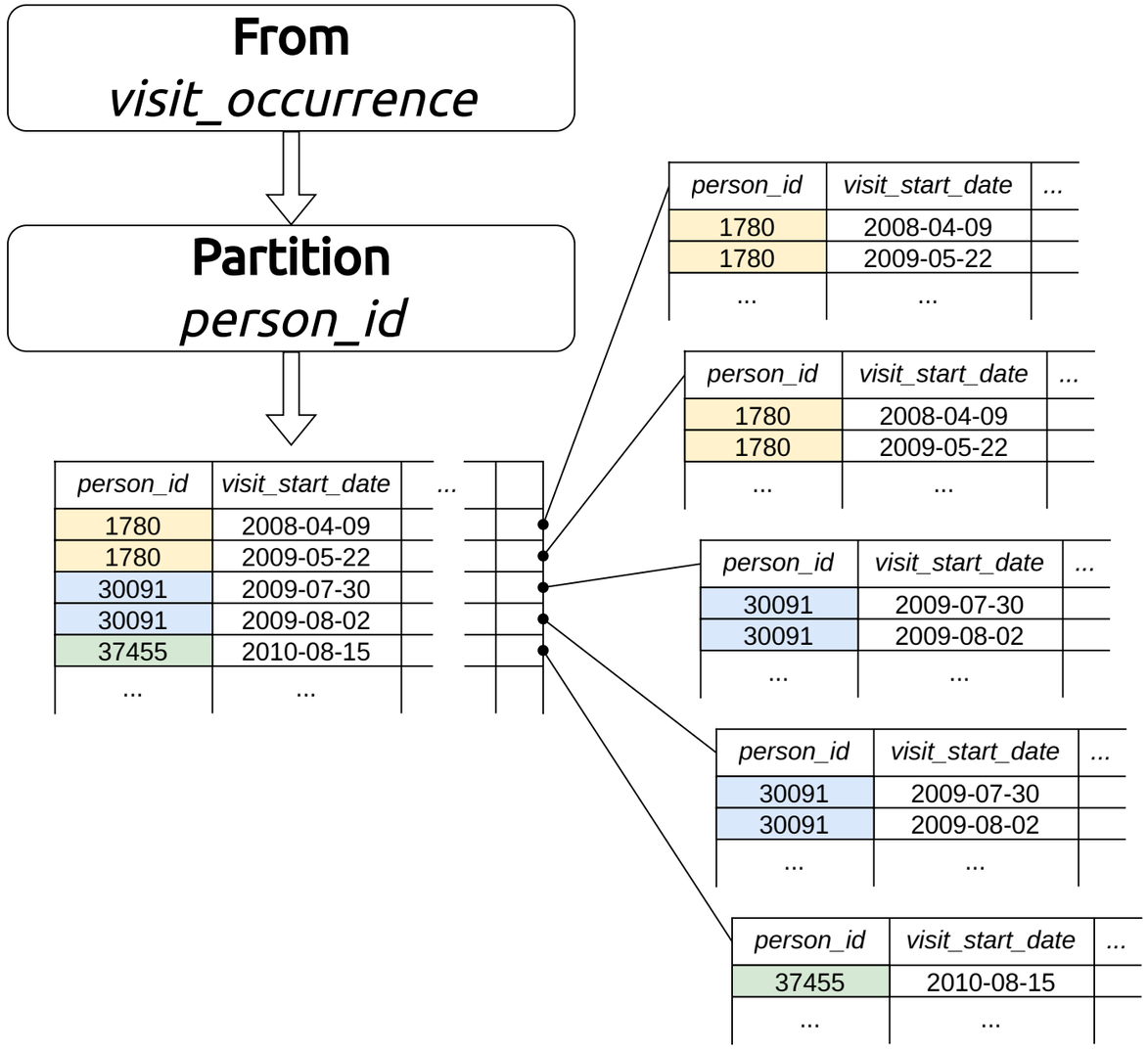


All occurrences of Acute MI




```
condition_occurrence(concept_set) = begin
  from(condition_occurrence)
  join(
    concept_set,
    condition_concept_id == concept_id)
end
```





`max[visit_start_date]`

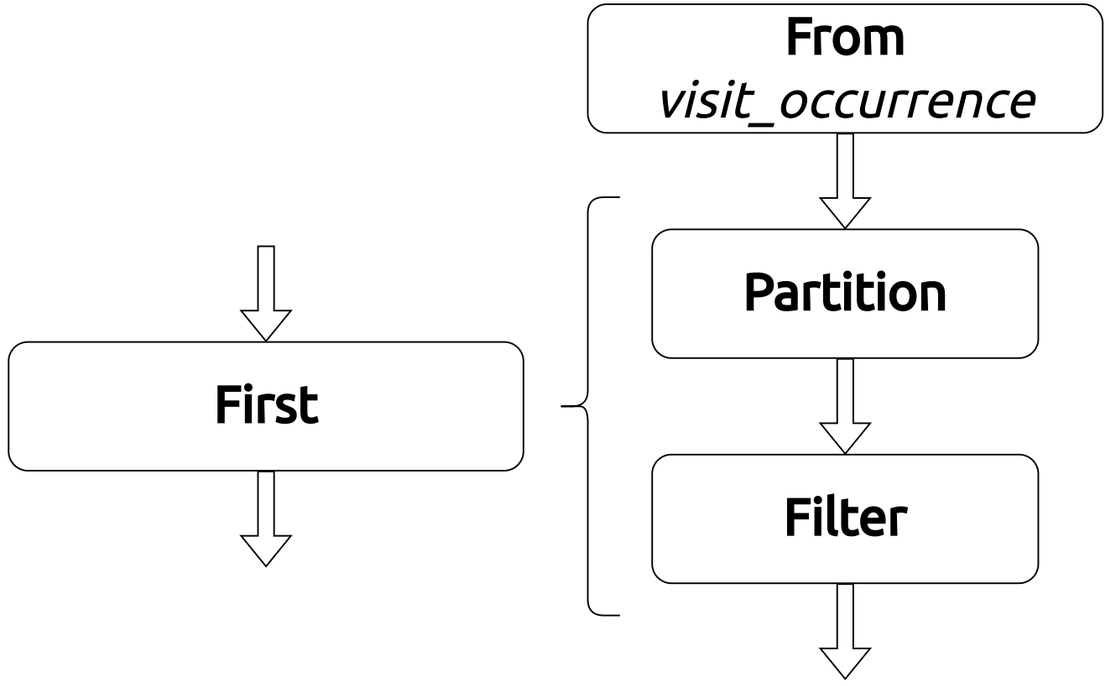
An aggregate function when applied to the output of the *universal aggregate function*

A window function when applied to the output of the *universal window function*

For each patient, find their latest visit

```
from(visit_occurrence)
first(visit_start_date.desc())
```

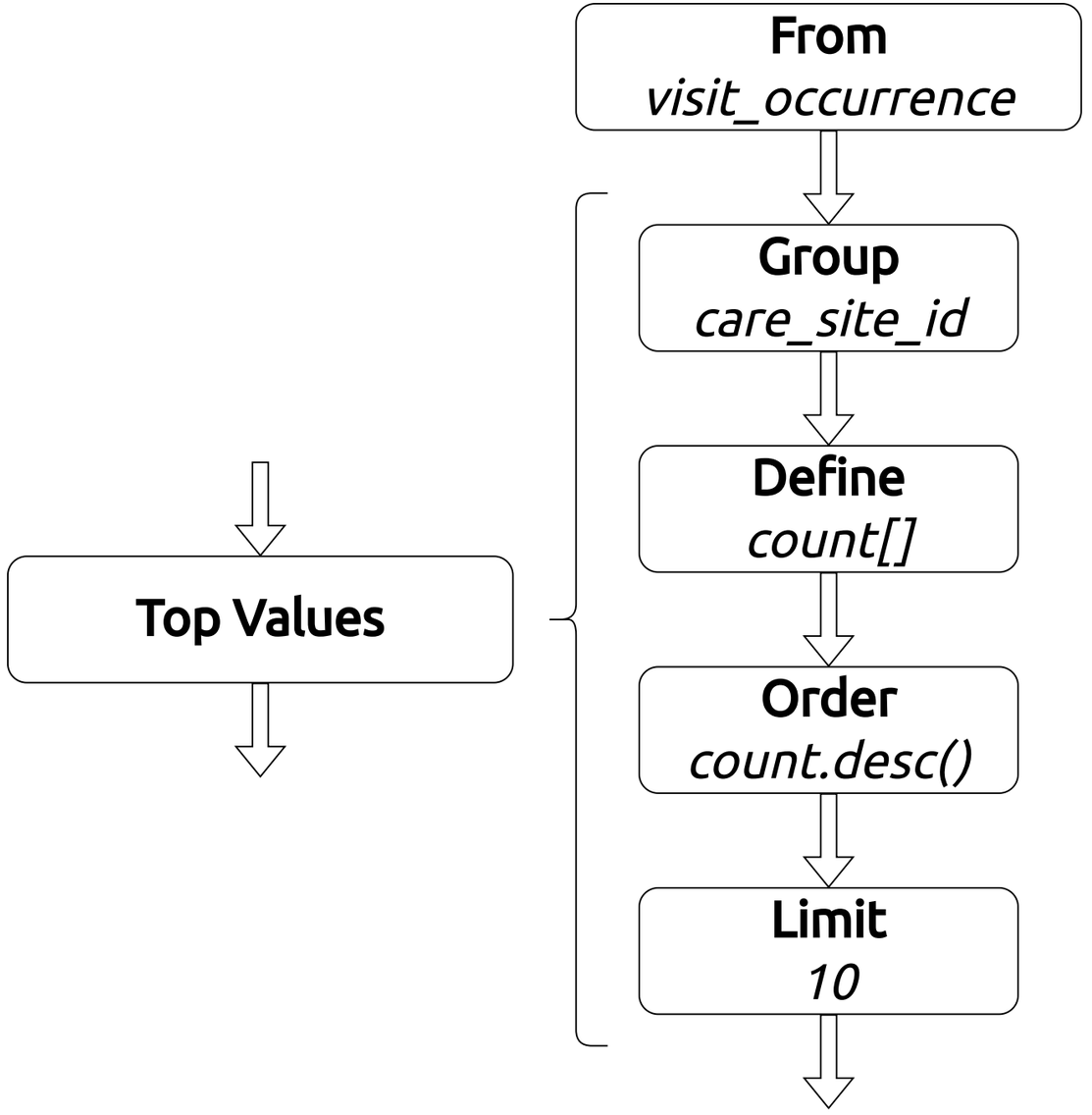
```
first(order_by...) = begin
  partition(
    person_id,
    order_by = [order_by...])
  filter(row_number[] == 1)
end
```



Find 10 most common care sites and the number of associated visits

```
from(visit_occurrence)
top_values(care_site_id)
```

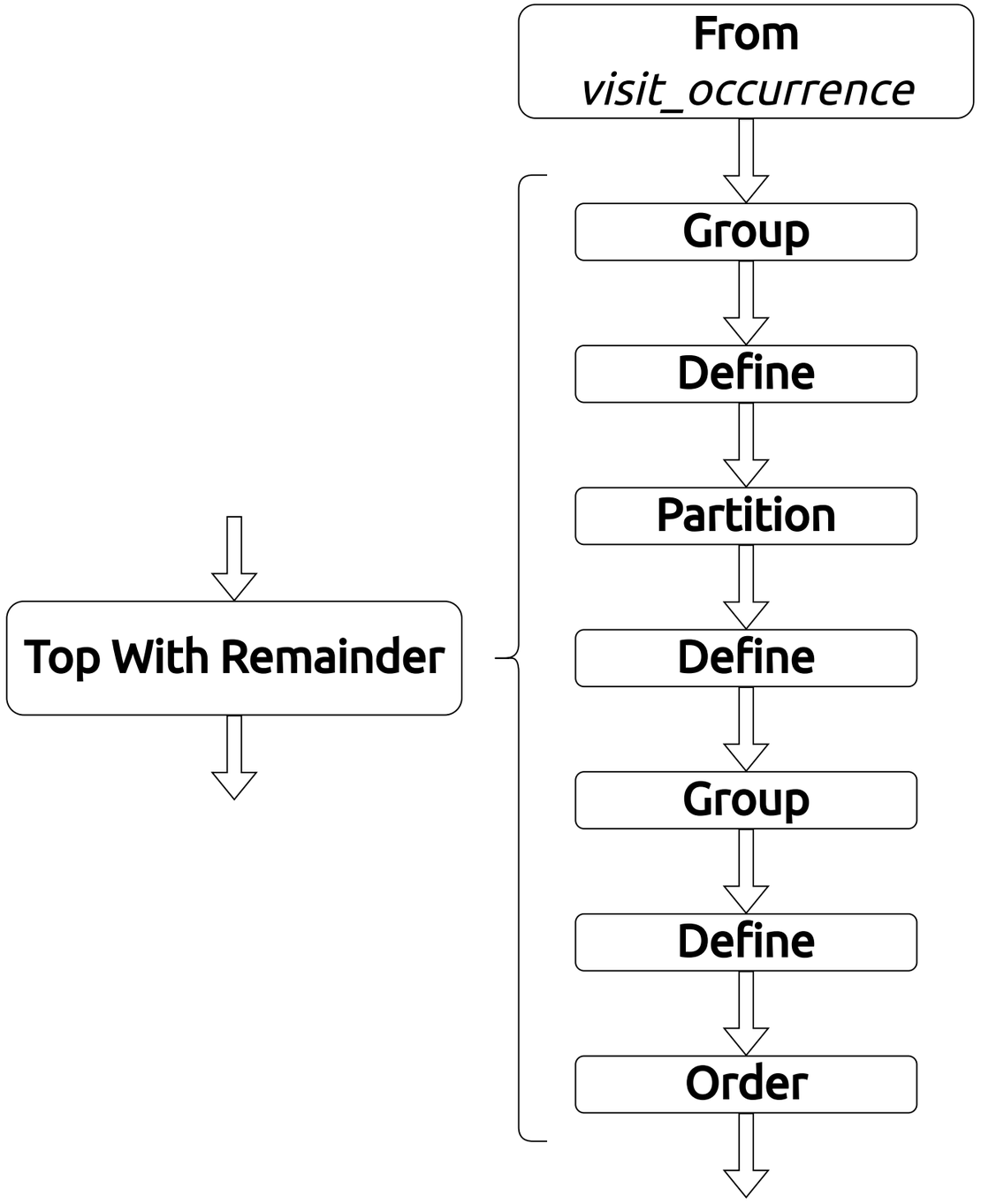
```
top_values(column, n = 10) = begin
  group(column)
  define(count => count[])
  order(count.desc())
  limit(n)
end
```



Find 10 most common care sites with their visit counts and the remainder

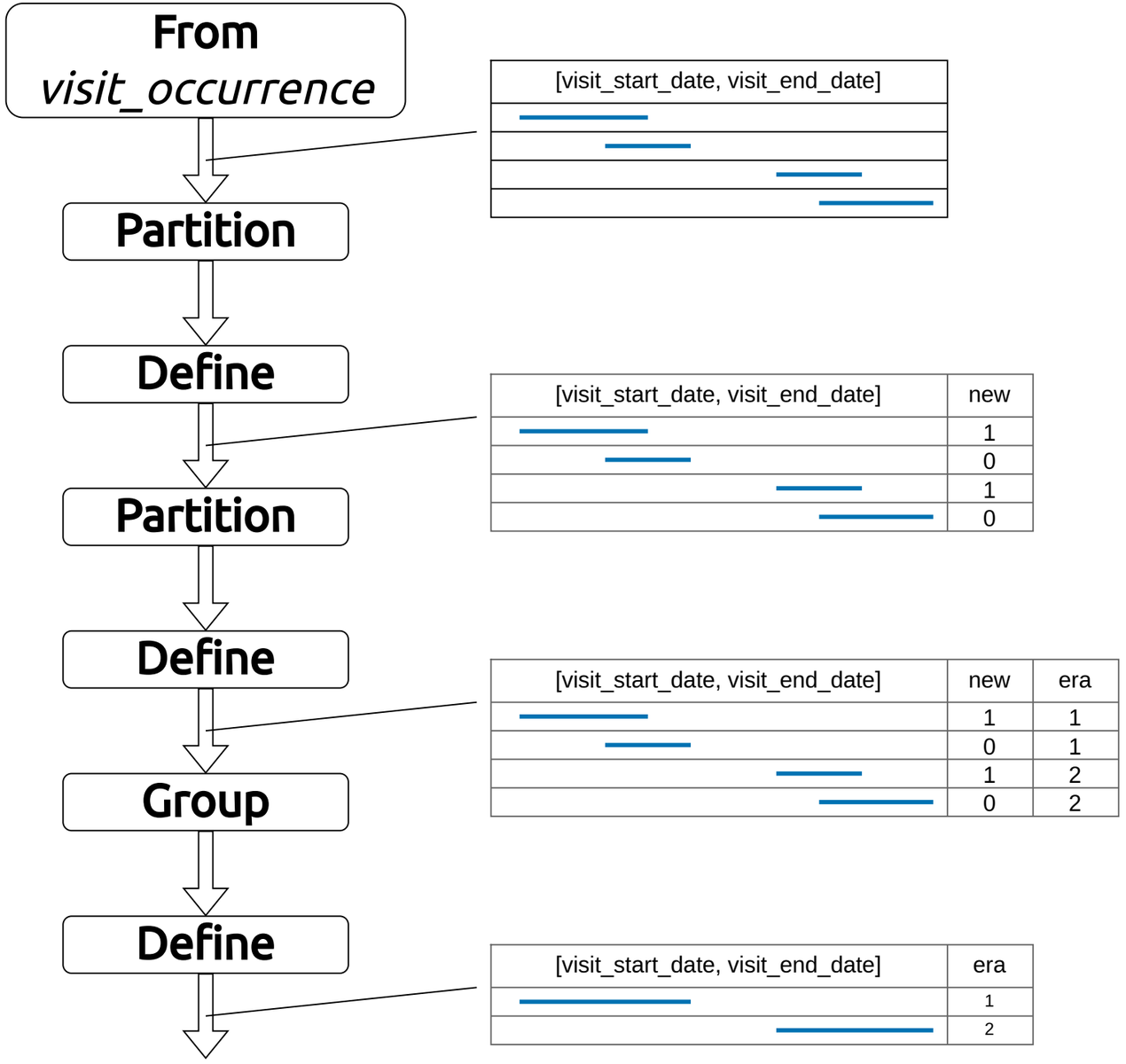
```
from(visit_occurrence)
top_with_remainder(care_site_id)
```

```
top_with_remainder(column, n = 10) = begin
  group(column)
  define(count => count[])
  partition(order_by = [count.desc()])
  define(remainder => row_number[] > n ? 1 : 0)
  group(
    column => remainder == 0 ? column : missing,
    remainder)
  define(count => sum[count])
  order(remainder, count.desc())
end
```

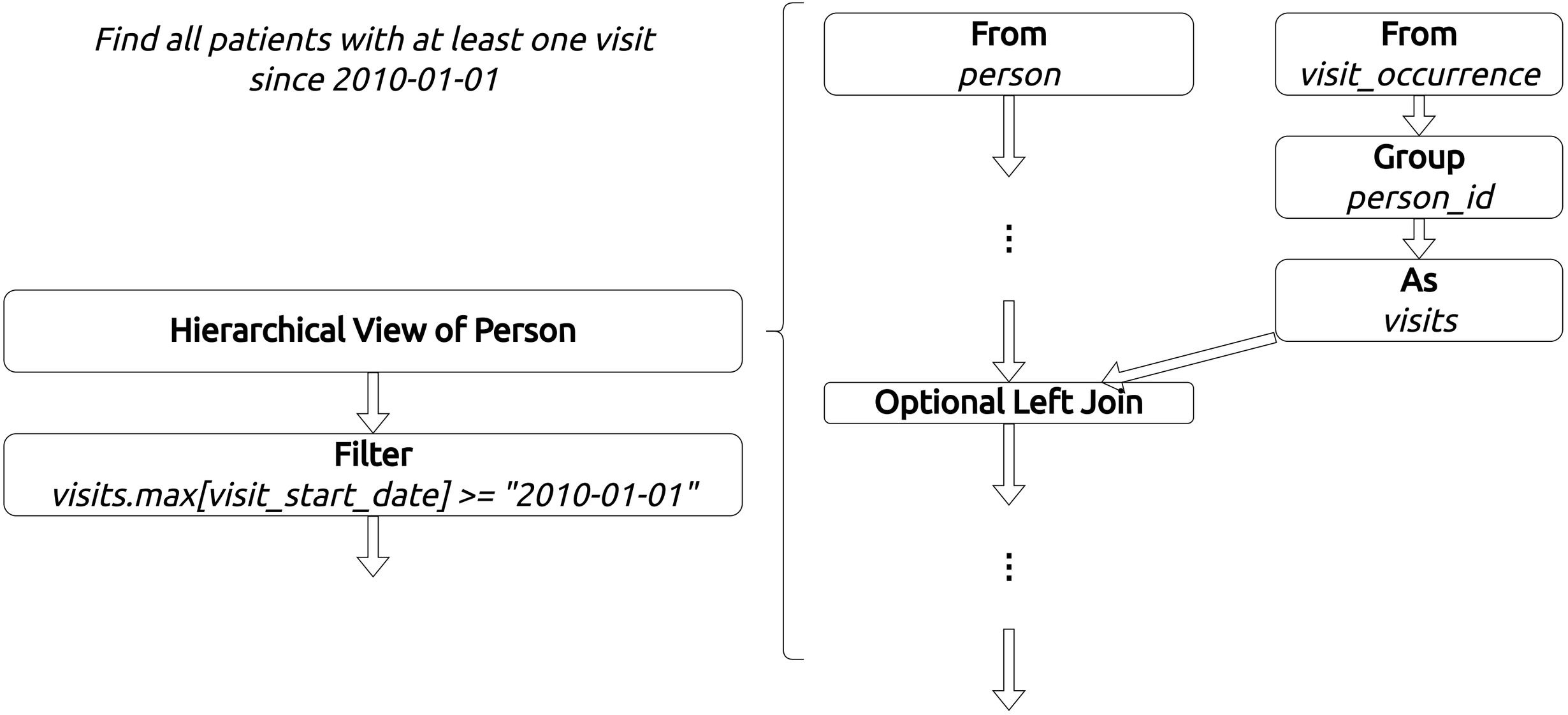


Merge overlapping visits

```
from(visit_occurrence)
partition(
  person_id,
  order_by = [visit_start_date],
  frame = (mode = rows,
           start = -Inf, finish = -1))
define(
  new =>
    visit_start_date <=
      max[visit_end_date] ? 0 : 1)
partition(
  person_id,
  order_by = [visit_start_date, -new],
  frame = (mode = rows))
define(era => sum[new])
group(person_id, era)
define(
  visit_start_date => min[visit_start_date],
  visit_end_date => max[visit_end_date])
```



Find all patients with at least one visit since 2010-01-01



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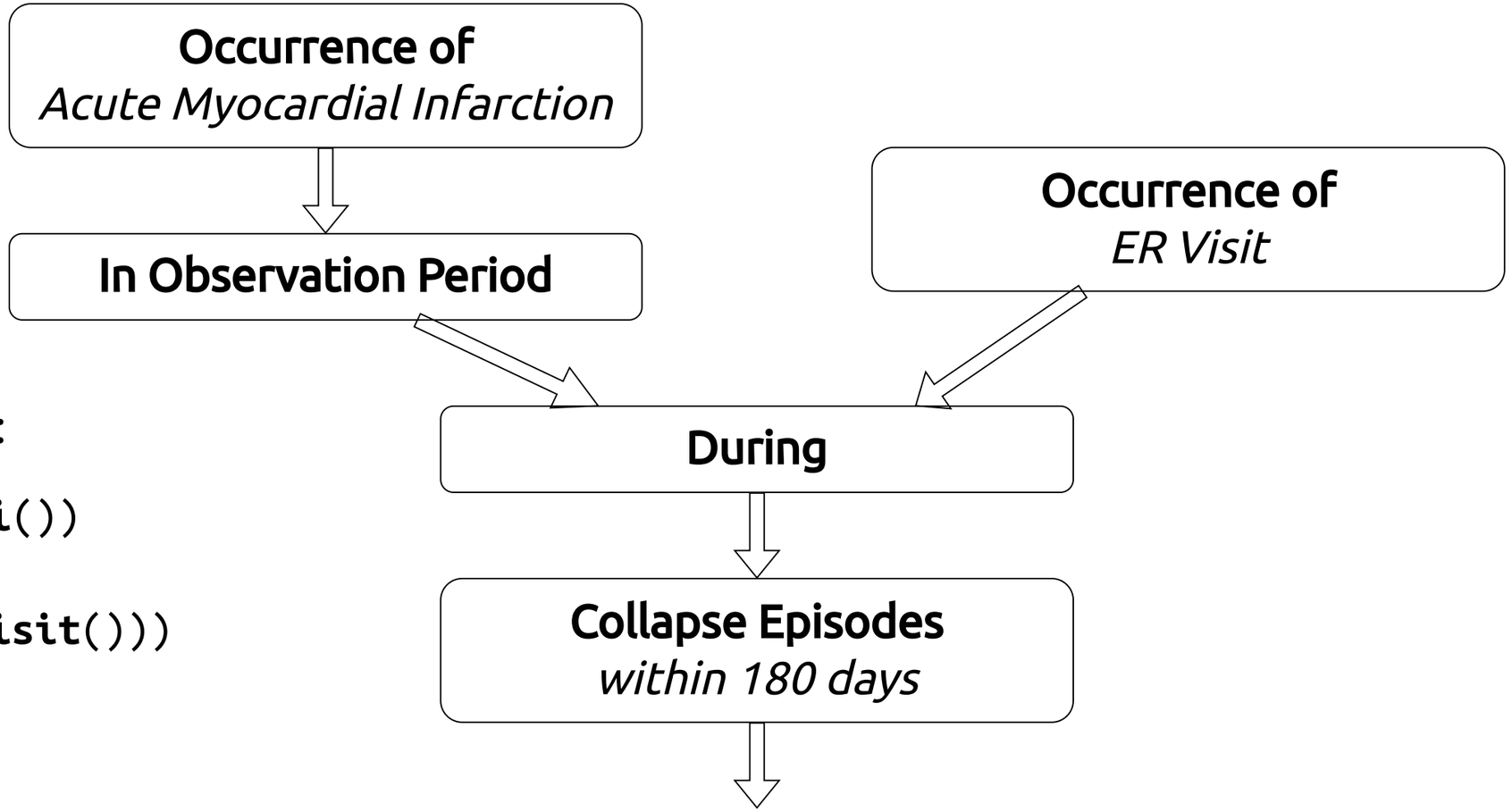

Build yourself a query **language**:

```
condition_occurrence(acute_mi())
in_observation_period()
during(visit_occurrence(ip_visit()))
collapse_episodes(180)
```