FunSQL:
A library for compositional construction of SQL queries

Find all patients born at or after 1950.

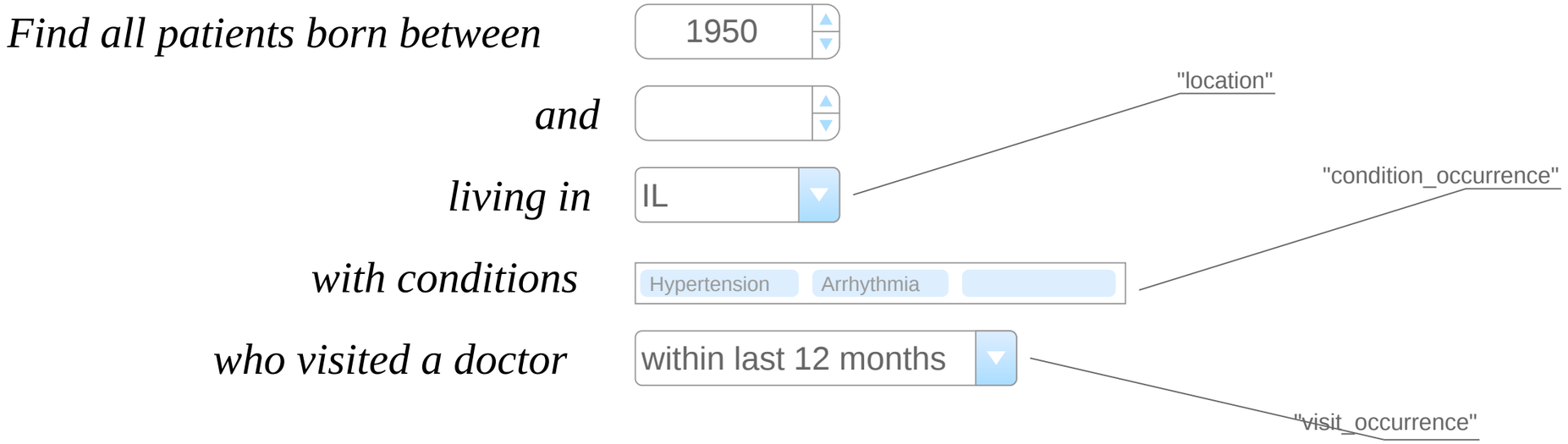
```
function find_patients(conn)
    sql = """
    SELECT person_id
    FROM patient
    WHERE year_of_birth >= 1950
    """
    DBInterface.execute(conn, sql)
end
```

- What is SQL? Data is often stored in relational databases, and to retrieve it, we write queries in SQL.
- Popular databases with SQL interface include MySQL, PostgreSQL, SQLite, Microsoft SQL Server, Redshift, BigQuery, and many others.
- Julia already has a number of libraries that let you interact with SQL databases.
- Why another tool?

Find all patients born between 1950

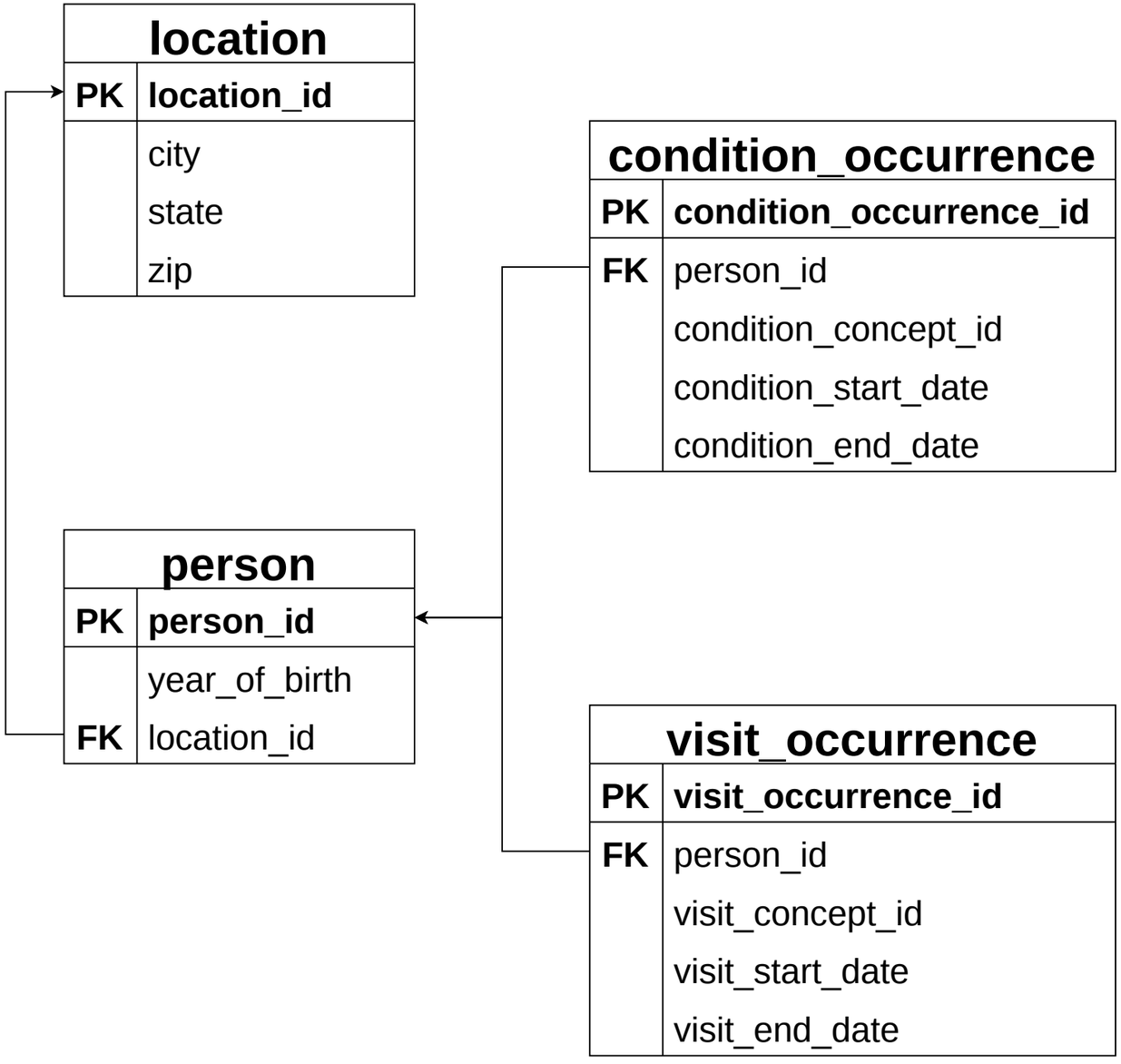
and

```
function find_patients(conn; start_year = nothing,
                             end_year = nothing)
    sql = """
    SELECT person_id
    FROM patient
    """
    conditions = String[]
    if start_year !== nothing
        push!(conditions, "year_of_birth >= $start_year")
    end
    if end_year !== nothing
        push!(conditions, "year_of_birth <= $end_year")
    end
    if !isempty(conditions)
        sql *= "\nWHERE " * join(conditions, " AND ")
    end
    DBInterface.execute(conn, sql)
end
```




```
function find_patients(conn; start_year = nothing,
                             end_year = nothing,
                             state = nothing,
                             conditions = []
                             last_visit = nothing)
    sql = """
    SELECT person_id
    FROM patient
    """
    ???
    DBInterface.execute(conn, sql)
end
```

- Clearly, a more systematic approach is necessary.



- A small diversion to introduce the database schema which we will use in subsequent examples.
- OMOP Common Data Model is a popular open-source used in healthcare of observational research.
- As typical in healthcare, the schema is patient-centric. The *person* table stores information about patients including basic demographic information. Their address is stored in a separate table called *location*.
- Most of the patient data consists of clinical events: encounters with healthcare providers, recorded observations, diagnosed conditions, performed procedures, etc.

```
using FunSQL: SQLTable

const person =
    SQLTable(name = :person,
             columns = [:person_id, :year_of_birth, :location_id])

const location =
    SQLTable(name = :location,
             columns = [:location_id, :city, :state, :zip])

const condition_occurrence =
    SQLTable(name = :condition_occurrence,
             columns = [:condition_occurrence_id, :person_id,
                        :condition_concept_id,
                        :condition_start_date, :condition_end_date])

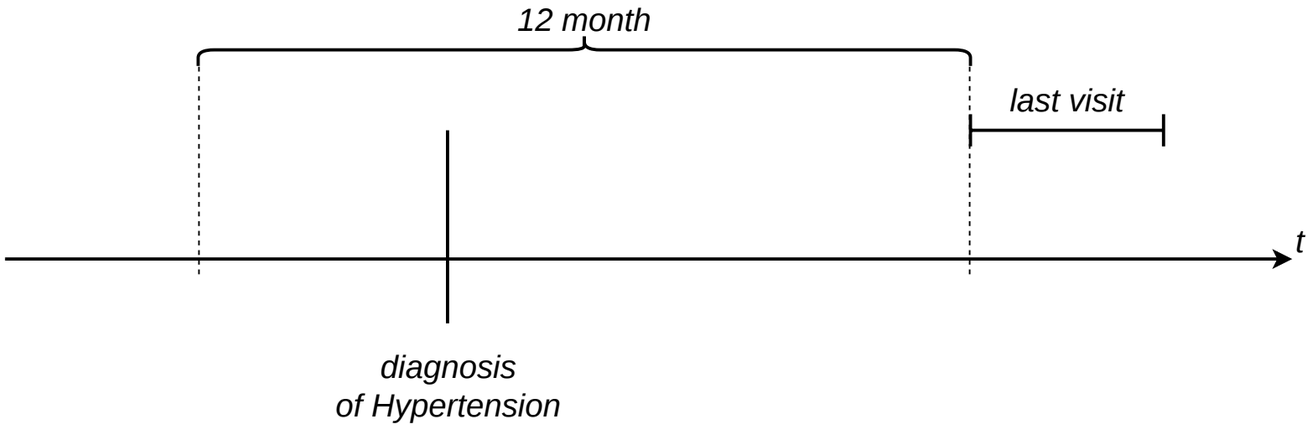
const visit_occurrence =
    SQLTable(name = :visit_occurrence,
             columns = [:visit_occurrence_id, :person_id,
                        :visit_concept_id,
                        :visit_start_date, :visit_end_date])
```

Find all patients born in 1970 or later and living in Illinois
who have been diagnosed with Hypertension
no more than 12 months before their last visit to
a healthcare provider.

- To demonstrate FunSQL, we will use it to construct one SQL query.
- We will state the full query in English, then construct it using FunSQL step by step.
- This will also give us an opportunity to discuss different capabilities of FunSQL.

Find patients

- *born in 1970 or later,*
- *living in Illinois,*
- *such that their last visit to the healthcare provider satisfies:*

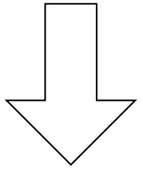


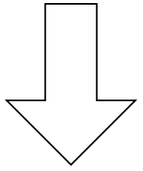
Find all patients born in 1970 or later.

- A SQL query starts with a FROM clause, where you can choose the starting table.
- What follows it is a sequence of operations which let you shape the output.
- The final clause is always SELECT, which is written at the top, but is always performed last.
- In FunSQL, we replicate the structure of the query using appropriate constructors and the chain operator for composing them.

```
FROM person p
```

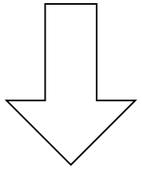
```
From(person)
```

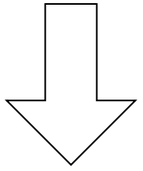




```
FROM person p
WHERE p.year_of_birth >= 1950
```

```
From(person) |>
Where(Get.year_of_birth .>= 1950)
```





```
SELECT p.person_id
FROM person p
WHERE p.year_of_birth >= 1950
```

```
From(person) |>
Where(Get.year_of_birth .>= 1950) |>
Select(Get.person_id)
```

Bound References

```
q.year_of_birth        q.person_id

q = From(person)
q = q |> Where(q.year_of_birth .>= 1950)
q = q |> Select(q.person_id)
```

- Both bound and unbound references are supported.
- Unbound references make decomposition easier.

Unbound References

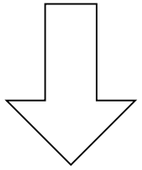
```
Get.year_of_birth      Get.person_id

q = From(person) |>
    Where(Get.year_of_birth .>= 1950) |>
    Select(Get.person_id)
```

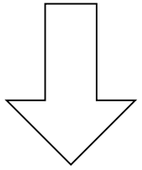
```
BornInOrLater(y) =
    Get.year_of_birth .>= y

q = From(person) |>
    Where(BornInOrLater(1950)) |>
    Select(Get.person_id)
```

```
FROM person p
```

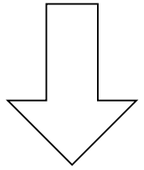


```
FROM person p
JOIN location l
  ON (p.location_id = l.location_id)
```

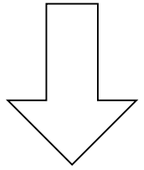


```
SELECT p.person_id, l.state
FROM person p
JOIN location l
  ON (p.location_id = l.location_id)
```

```
From(person)
```

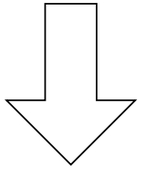


```
From(person) |>
Join(:location => location,
     Get.location_id .==
         Get.location.location_id)
```

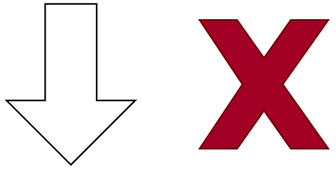


```
From(person) |>
Join(:location => location,
     Get.location_id .==
         Get.location.location_id) |>
Select(Get.person_id)
```

```
FROM person p
```



```
FROM person p
WHERE p.year_of_birth >= 1950
```



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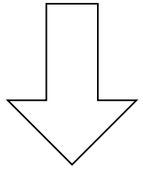
WHERE p.year_of_birth >= 1950
JOIN location l
  ON (p.location_id = l.location_id)
```

```
From(person)
```



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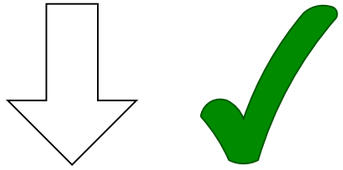
From(person) |>
Where(Get.year_of_birth .>= 1950)
```



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Where(Get.year_of_birth .>= 1950) |>
Join(:location => location,
     Get.location_id .==
         Get.location.location_id)
```