Hospital Appointments App

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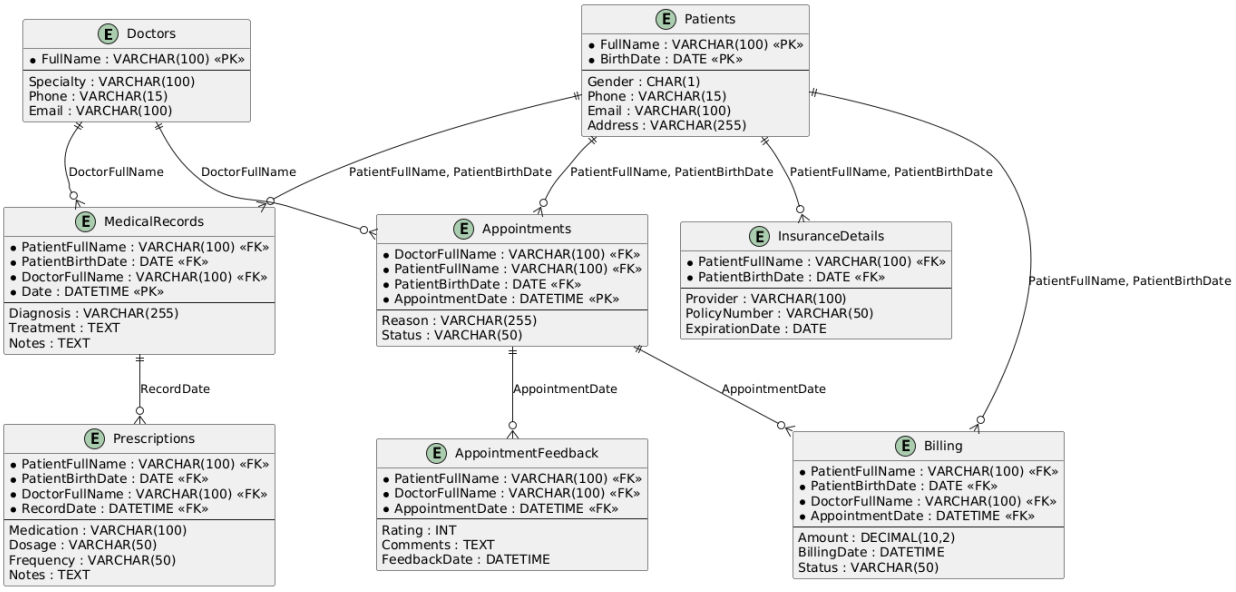
Subject: **Databases Course work**

OLTP

This OLTP solution tracks the day-to-day operations of a healthcare setting—such as doctor assignments, patient appointments, medical records, and billing—so that information remains both accurate and immediately available for transactional updates.

I decided to use composite keys just to simplify ETL and make OLAP more visual and useful. I don't think that is suitable for "normal" business use-cases, but for course work, why not, still usable.

OLTP Schema



OLTP Overview

1. **Tables**
    - **Doctors**: Tracks each doctor’s full name, specialty, phone, and email.
    - **Patients**: Stores patient details (full name, birthdate, gender, contact info).
    - **Appointments**: Links doctors to patients, capturing appointment date, reason, and status.
    - **MedicalRecords**: Logs diagnoses, treatments, and notes per patient visit.
    - **Billing**: Records payment amounts, billing dates, and statuses.
    - **InsuranceDetails**: Holds insurance provider data (policy number, expiration).
2. **Relations**
    - **Doctors** → **Appointments**: One doctor can have many appointments.
    - **Patients** → **Appointments**: One patient can schedule many appointments.
    - **Patients** → **MedicalRecords**: One patient can have multiple records.
    - **Appointments** → **Billing**: Billing references the same date and participants as each appointment.
3. **Insights**
    - **Operational Lookups**: “Which patient is seeing which doctor today?”
    - **Quick Stats**: “How many upcoming appointments this week?” or “How many unpaid bills?”
    - **Immediate Updates**: Staff can check the latest patient contact info, appointment times, and billing status instantly.

4. **Benefits**
    - **Real-Time Access**: Always up-to-date info for scheduling, billing, and patient status.
    - **Accurate Linking**: Minimizes duplication (one record per patient, one record per doctor).
    - **Faster Service**: Quick retrieval of who owes payments, who has which appointment, etc.
    - **Foundation for Analytics**: Structured relationships make it easy to feed data into an OLAP system for deeper analysis.

Data generation using python:

The Python script generates realistic data for an OLTP system involving tables for doctors, patients, appointments, medical records, billing, prescriptions, insurance details, and appointment feedback. It uses the Faker library to generate random but realistic names, dates, addresses, diagnoses, treatments, and other data fields. The script writes this generated data into CSV files for each table, ready to be used in a database.

Loading generated data to database using sql script:

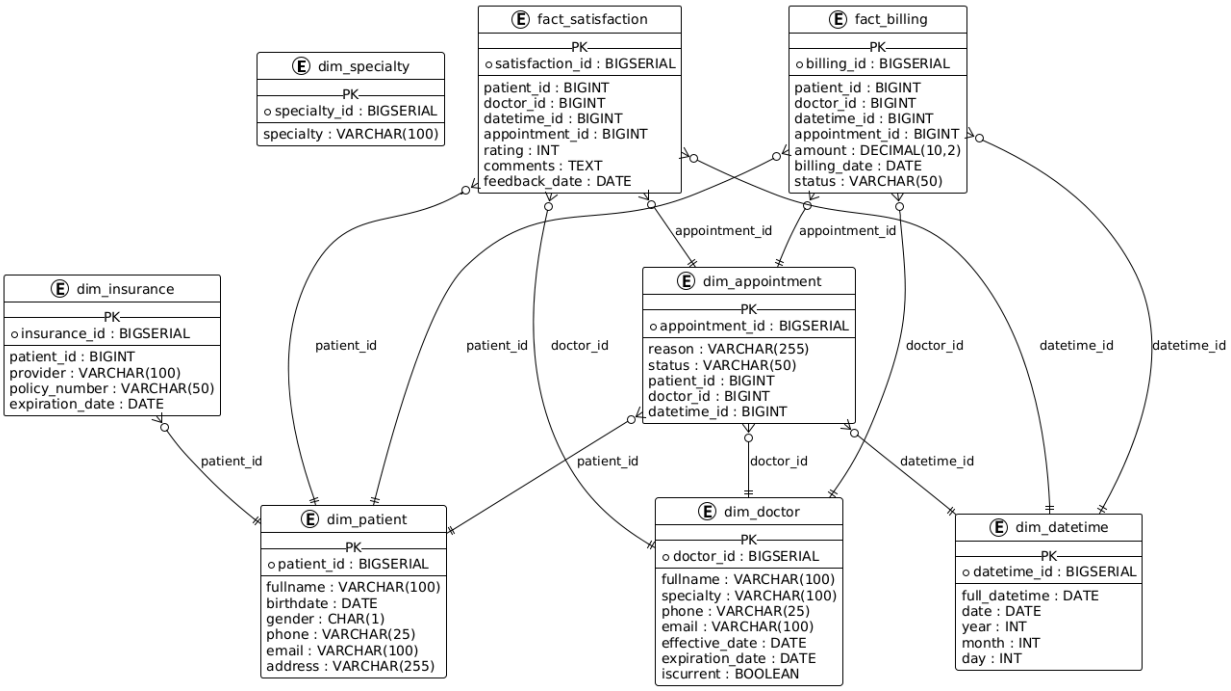
The SQL script is designed to load the data from the generated CSV files into PostgreSQL tables. It first creates the necessary tables (Doctors, Patients, Appointments, Medical Records, etc.) if they don't already exist. Then, it loads the data from the CSV files into temporary tables and inserts the records into the main tables, ensuring that no duplicates are added. This is done by checking if a record already exists before inserting it. Finally, the temporary tables are cleaned up after the data is successfully loaded.

This combination of Python and SQL scripts helps automate the data generation and loading process, ensuring that the database can be populated with realistic data without overwriting any existing records.

OLAP

This OLAP solution is designed to support advanced analytics and reporting in a healthcare setting by consolidating transactional data into structured dimensions and facts. It enables efficient trend analysis, revenue tracking, and patient satisfaction insights while preserving historical data for in-depth evaluation over time.

OLAP Schema



OLAP Overview

1. **Tables**
    - **dim_doctor**: Tracks doctors' historical data (full name, specialty, phone, email), with SCD Type 2 fields like effective/expiration dates.
    - **dim_patient**: Stores patient attributes (name, birthdate, gender, contact) to provide consistent patient lookups.
    - **dim_datetime**: Holds date-only info (year, month, day) to group or filter results by date.
    - **dim_appointment**: Captures appointment reason, status, plus links to patients, doctors, and timestamps.
    - **dim_insurance**: Contains insurance data (policy, provider) linked to each patient.
    - **dim_specialty**: Manages unique specialty names.
    - **fact_billing**: Aggregates financial transactions (amount, billing date) with references to patient, doctor, appointment, and date.
    - **fact_satisfaction**: Records patient feedback (rating, comments) tied to patient, doctor, appointment, and date.
2. **Relations**

    - **Fact Tables → Dimension Tables**: For example, fact_billing links to dim_patient, dim_doctor, dim_datetime, and dim_appointment. This allows slicing revenue by doctor, date, or appointment type.
    - **dim_appointment → dim_patient/dim_doctor/dim_datetime**: Tracks which patient saw which doctor on which date.
    - **dim_insurance → dim_patient**: Ties an insurance entry to the correct patient ID.
3. **How to Get Insights**
    - **Aggregations**: Summarize amounts in fact_billing by year/month, or see how satisfaction ratings vary by specialty.
    - **Trends Over Time**: Use dim_datetime to compare revenue or feedback across quarters or years.
    - **Slicing and Dicing**: Filter metrics by doctor, datetime or any dimension field

ETL

Now the tough part. This ETL process takes raw data from the OLTP system and transforms it into a structured format for the OLAP database, making it ready for analysis. It handles everything from cleaning messy data to linking tables together so we can pull insights like revenue trends or patient feedback ratings.

What It Does

1. **Extract**
    - Grabs data from the OLTP tables (like doctors, patients, and appointments) and puts it into staging tables.
    - This is the raw data dump—it's messy and needs cleaning.
2. **Transform**
    - **Clean-Up**: Filters out invalid or outdated data (e.g., appointments with missing patient names, old billing records).
    - **Linking**: Matches data across tables (e.g., linking billing info to the correct appointment).
    - **Track Changes**: For things like doctor details, it keeps track of updates (SCD Type 2) so we don't lose history when something changes.
    - **Standardize**: Fixes inconsistencies, like making sure all dates are formatted properly.
    - **Add IDs**: Creates useful keys like appointment_id to simplify relationships in the OLAP tables.
3. **Load**

    - **Dimensions**: Fills in the descriptive tables like dim_doctor, dim_patient, and dim_datetime to give context to facts.
    - **Facts**: Populates tables like fact_billing (for revenue) and fact_satisfaction (for feedback). These tables hold the numbers we care about.

Key Points to Notice

- **Data Validation**: Messy data from the OLTP is cleaned up in staging—bad entries are filtered out so only valid data makes it to the warehouse.
- **History Tracking**: Changes to things like a doctor's specialty or phone number are saved in dim_doctor, so we can see the full timeline.
- **Relationships**: Fact tables are tied to dimension tables (e.g., billing records are linked to patients, doctors, and appointment dates). This makes it easy to slice data in any way.
- **Appointment Linking**: Since OLTP uses composite keys, the process generates a clean appointment_id for the OLAP system, simplifying analysis.
- **Staging Cleanup**: Once data is loaded into the warehouse, the staging tables are cleared to keep things tidy.

Instructions

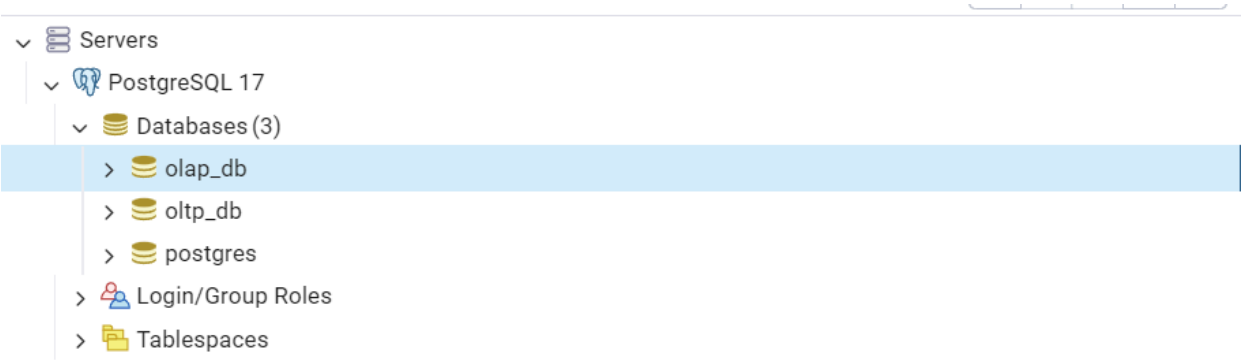
Chapter 1: Which tools I used

Repository link: https://github.com/4llower/hospital-OLTP-OLAP-ETL

Purpose	**Tool**
Database management	pgAdmin4 8.14
Database	PostgreSQL 17
Data generation	Python3, pandas, faker
Analytics visualization	PowerBI 2.138.1452.0 64-bit (November 2024)

Chapter 2: Loading data

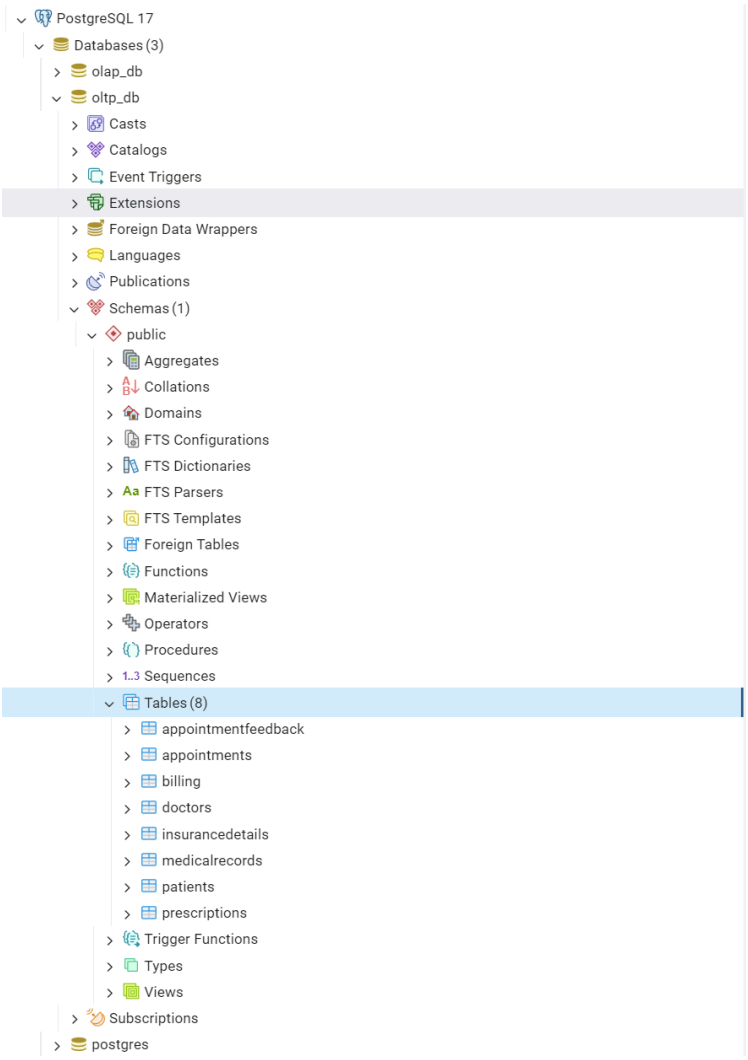
1. I created two empty databases in pgAdmin4:



2. Pull the repository https://github.com/4llower/hospital-OLTP-OLAP-ETL
3. Let's open oltp_db query tool and paste script (load_data_csv) that placed in my repository by path: **./oltp/data/load_data_csv.sql.**

4. And change all paths **D:/EHU/Databases/coursework/oltp/data/generated/** to path where you pull the repository on your computer.

After executing the script data should be loaded from csv and you can see tables in oltp_db public schema:



Check some tables if they consist the data, if some tables doesn't contain a data please

verify the path from step 3:

Query Query History

```
1 SELECT * FROM public.doctors
2 ORDER BY doctorid ASC
```

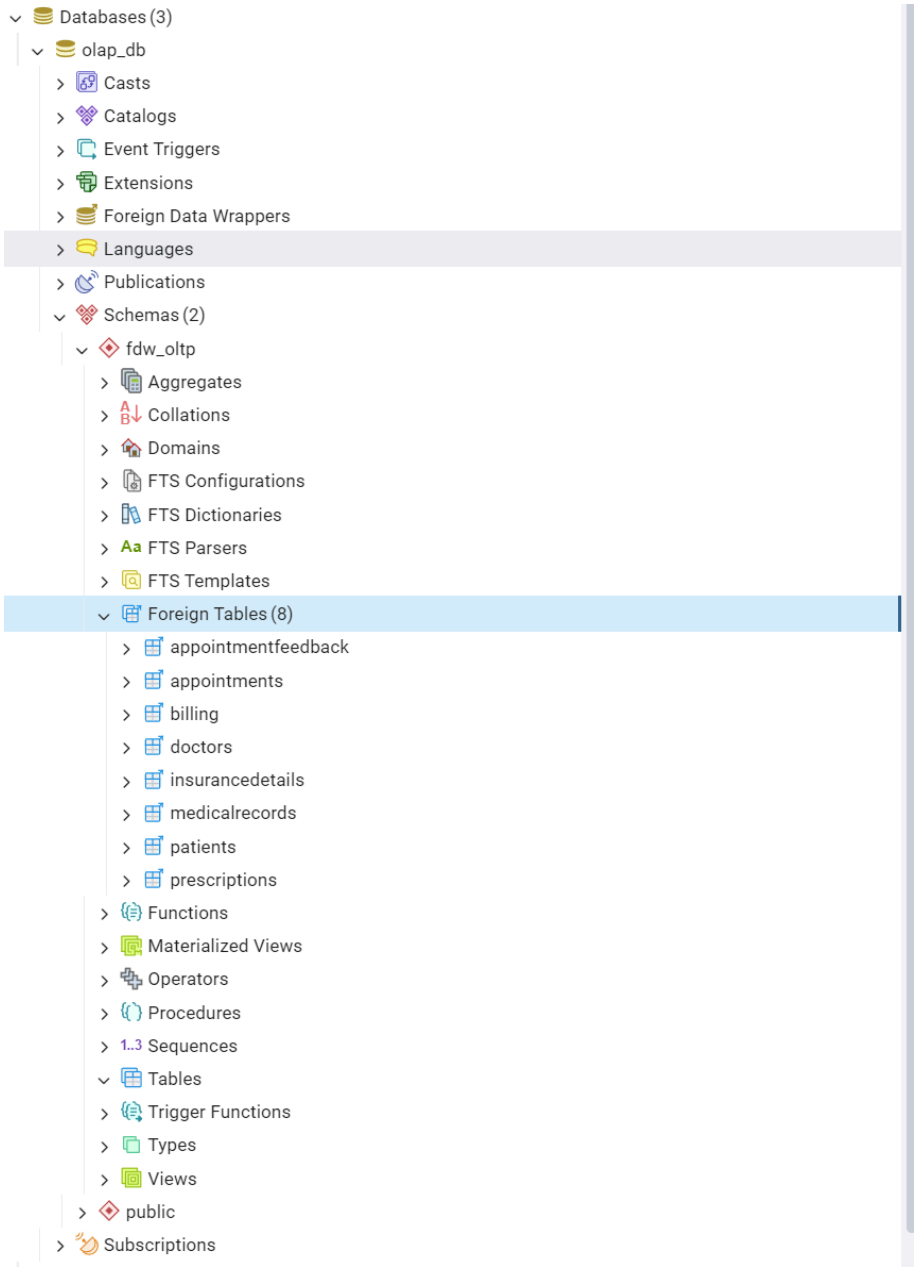
Data Output Messages Notifications

	doctorid [PK] integer	fullname character varying (100)	specialty character varying (100)	phone character varying (25)	email character varying (100)
1	1	Robert Smith	Dermatology	6859604662	grayjennifer@example.net
2	2	Jasmine Henry	Neurology	585-731-0641	lauragilmore@example.net
3	3	Lisa Garcia	Neurology	+1-864-895-5831x3428	icox@example.net
4	4	Barbara Bailey	Pediatrics	735.426.5565	ryan88@example.org
5	5	Jonathan Foster	Cardiology	511-509-8788	sototrevor@example.org
6	6	Jonathan Thomas	Neurology	(268)508-7232	savannah30@example.org
7	7	Samantha Molina	Neurology	+1-572-766-7806x94580	morgan54@example.net
8	8	Cody Neal	Dermatology	348-481-6701x9145	cjohnson@example.org
9	9	John Paul	Cardiology	884.997.0700x76935	ilee@example.org
10	10	Jonathan Ross	Orthopedics	(223)748-8260x1225	pdavenport@example.net
11	11	Lori Brown	Dermatology	+1-511-793-4911	johnsonrachel@example.net
12	12	Bradley Martin	Neurology	+1-813-738-6607	morgansandy@example.com
13	13	Teresa Ingram	Pediatrics	792-906-7967x250	aharrington@example.com
14	14	Mary Nunez	Cardiology	+1-361-975-5523x7029	villanuevaelizabeth@example.net

Chapter 3: OLAP and ETL

1. I used foreign data wrapper to have links for tables from OLTP. That's why firstly in olap_db we need to initialize the foreign data wrapper to make everything work.
Script for fdw placed in **./olap/init_foreign_data_wrapper.sql**
Paste the script in **olab_db** query editor. If you have other credentianls than just postgres/postgres use them :)
After executing the script you should see new schema in oltp_db that will contain a lot of foreign

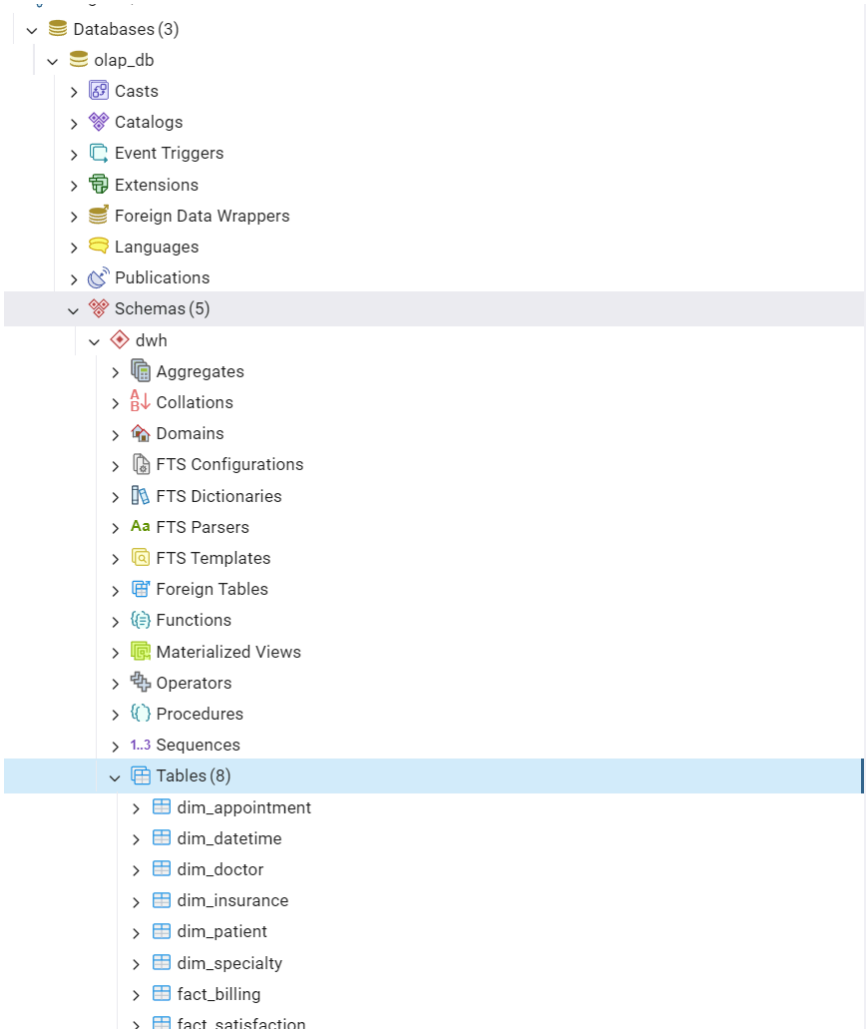
table:

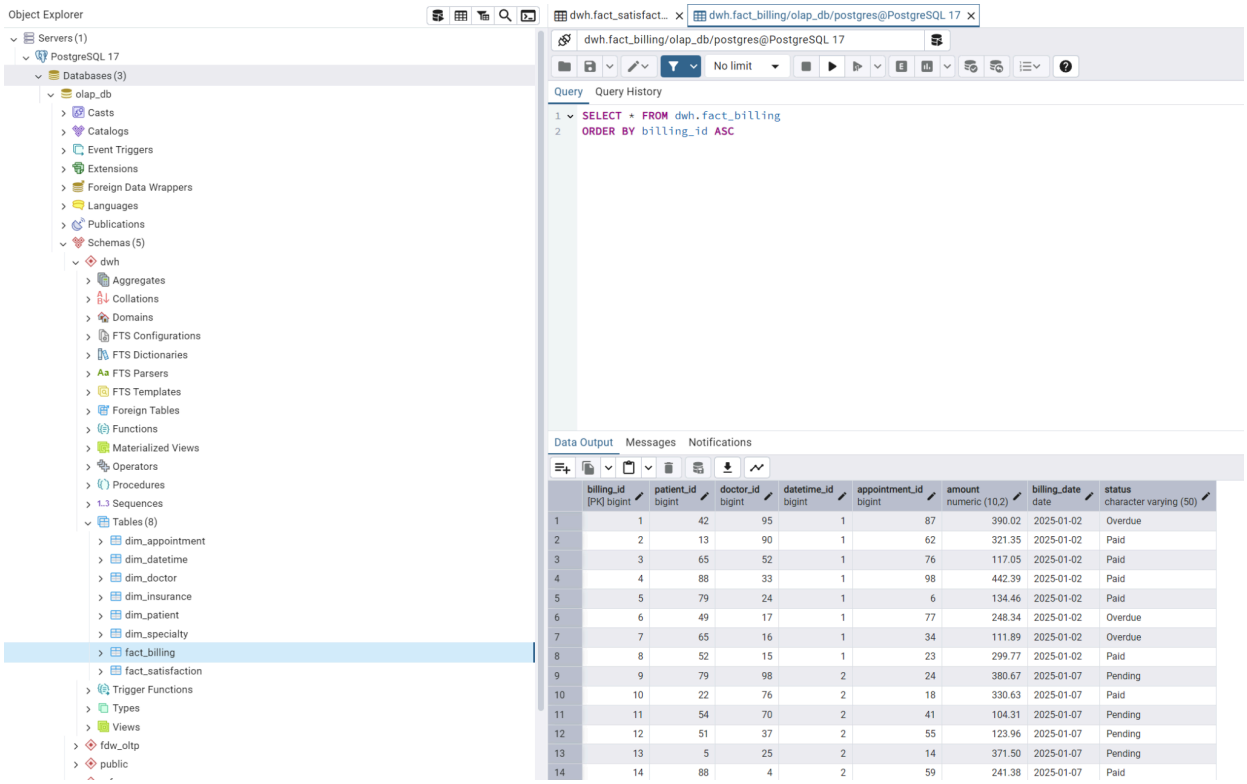


2. LET'S FINALLY EXECUTE THE ETL MONSTER SCRIPT THAT WILL DO ALL THE JOB, I really proud of myself that it works, it took a lot of time. Maybe it's not perfect -> but it's my child :)
It's placed **./olap/etl.sql**

Paste this script to olap_db query editor. After executing the script you should see a lot of new dimension/facts table in dwh schema. Also in etl script I created a reference schema with table that contain medical speciality that allowed for dwh, it's just formal point to prove that we CAN FILTER if we want :)

You should see something like this:





Chapter 4. Insight queries

You need to paste queries to oltp_db in olap_db depending on the name of query.

1. ./insights/oltp_1.sql (oltp_db)

Query | Query History

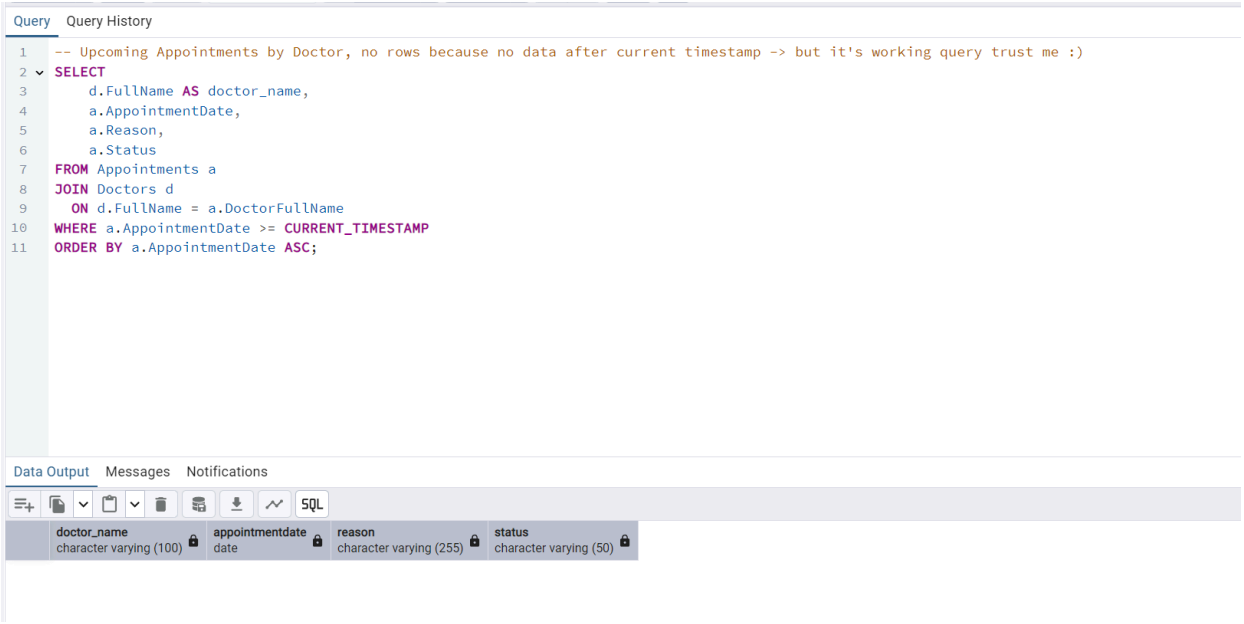
```sql
-- Patients with the Most Appointments in the Last 3 Months
SELECT
    a.PatientFullName AS patient_name,
    COUNT(*) AS total_appointments
FROM Appointments a
WHERE a.AppointmentDate >= (CURRENT_DATE - INTERVAL '3 months')
GROUP BY a.PatientFullName
ORDER BY COUNT(*) DESC
LIMIT 5;
```

Data Output | Messages | Notifications

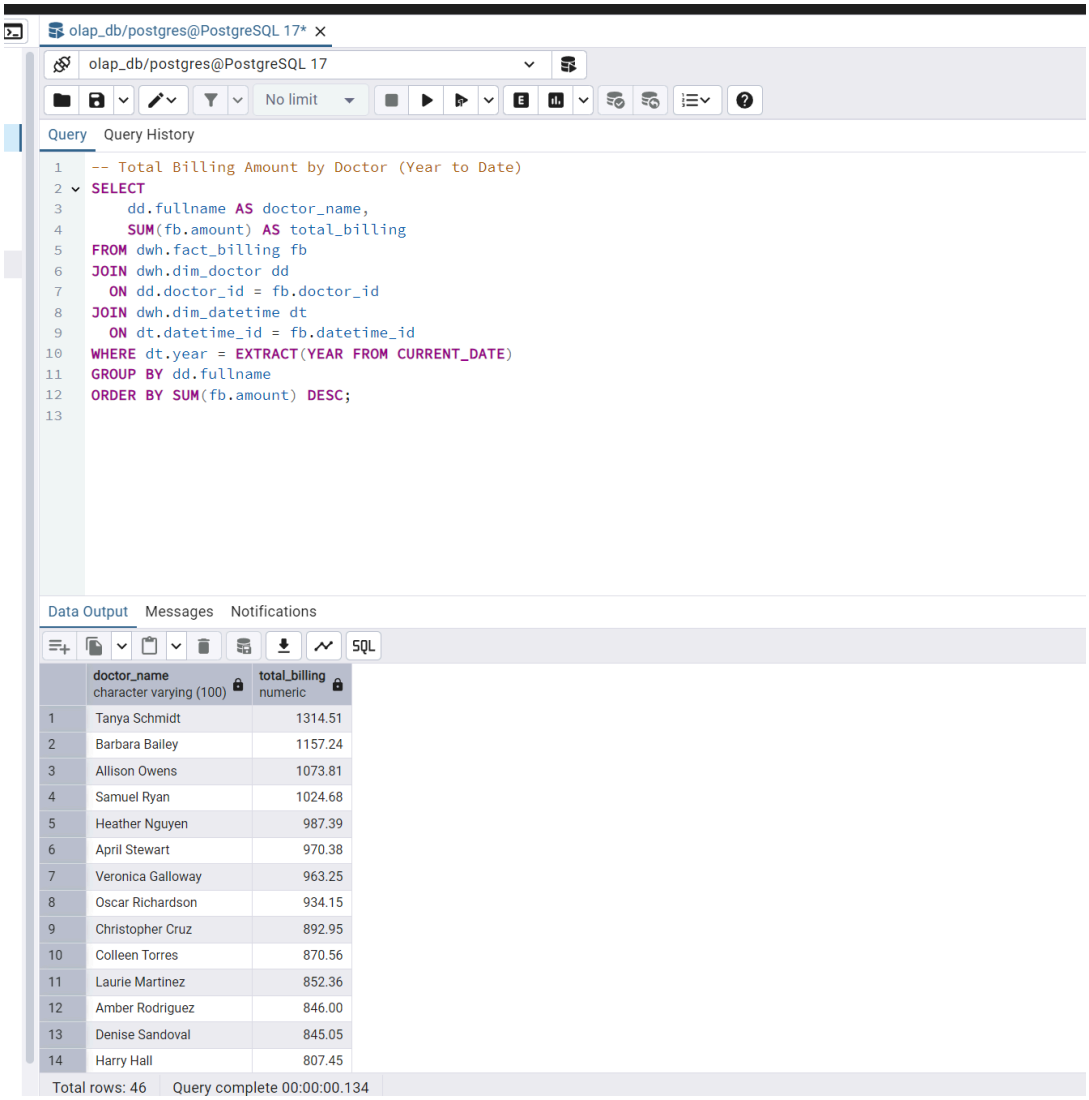
	patient_name character varying (100)	total_appointments bigint
1	Margaret Trevino	5
2	Leslie Franklin	5
3	Kimberly Rodriguez	4
4	Margaret Wood	3
5	Eric Chan Jr.	3

2. ./insights/oltp_2.sql (oltp_db query)
Trust me if it will be more data with data more that current_timestamp there will be data

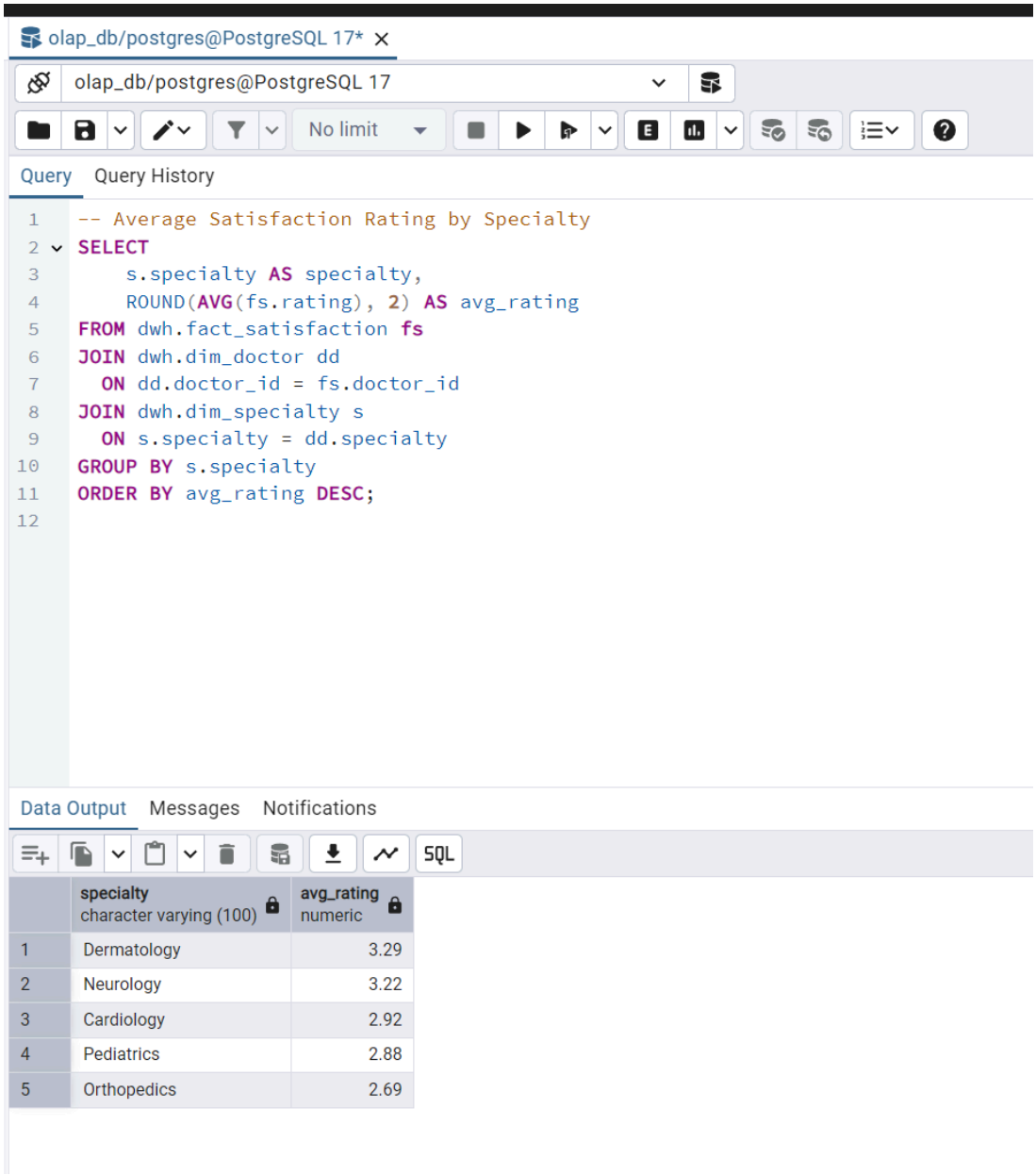
;)



1. ./insights/olap_1.sql (olap_db query tool)



2. ./insights/olap_2.sql (olap_db query tool)

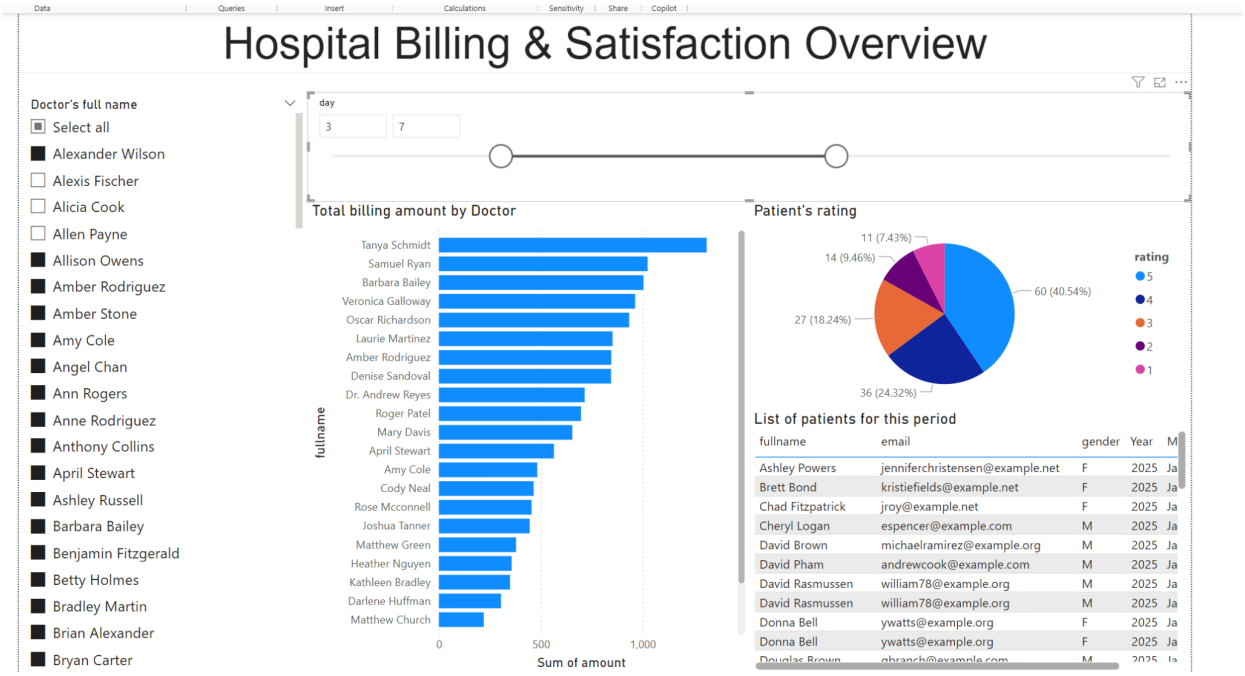


Chapter 5. Power BI

It was suprising for me that PostgreSQL integration with powerBI works so well. But at moment when I started to do PowerBI I had a lot of connections to my db, and it wasn't work. But I just removed connections to olap_db and it was fixed. I just imported everything and started to work with visualizations practically immediately.

Open the report that placed: "./powerbi.pbix"

You will see something like this:



You can use slicers to check analytical data for doctors:
1. Which doctors earned more money
2. Compare doctors (amount of money billed and also satisfaction of patients)
3. You can see patients for this period (if you add email or other information you can contact them for example and ask more information for the doctor)

Date slicer is shitty because when I was generating the data I didn't check that it generated only for 13 days. But anyway it can be configured easy and changed. I just showed how it can be in mvp :)

Thank you! That's it