CSE 3241 PROJECT

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PART 1

1. Research

a. Process

- Registration:

  Patients can register using the in-person form (directly to the dental office) or create an account online and fill out necessary forms before scheduling appointments. The registration requires patients' information such as name, DOB, phone number, email address, and SSN. Patients can also give out medical histories in advance to help medical professionals prepare before appointments. [1]

- Scheduling:

  Patients can schedule appointments by directly going to the dental office, online, or by calling the office. Usually, it is preferred that the patient has already registered/make an account before scheduling. However, a new patient is also accepted. If the patient is new, the office requires the name of the caller and the time of the appointment. They will then need to schedule there or online. [3]

1. **Split the process into two blocks of time.** Schedule appointments from noon to maintain maximum productivity and ensure most of the day is scheduled for patients.
2. **Prioritize appointments.** Consider factors such as appointments that need more time to be completed. Use phone calls or email to update any changes throughout their appointments.
3. **Send appointment reminders through text and email.** Guarantee on-time arrivals are important because if one appointment is delayed, it will affect the rest of the appointment. Sending emails and texts to remind patients is necessary.
4. **Create a patient wait list.** The waitlist is important to make the best of this lost time. Send a notification if an open slot becomes available and try to get it booked. This will help save the practice time and revenue.

- Billing processes:

  The billing process has two parts. Patient billing and insurance claim processing. If the patient uses insurance to pay some of the bills, the dental office needs to produce a claim and submit it to the insurance providers so that they will be reimbursed. [2]

  Front-End Medical Billing

1. **Registration:** To process an insurance claim starts when patients contact their provider's office to schedule an appointment.

2. **Eligibility Verification:** Verify that the patient's insurance plan covers these services before starting the treatment.

3. **Point of Service Collections:** You can collect the copay, deductible, coinsurance, or total balance due when the patient approaches the front desk.

4. **Record Form:** This form lists services, medical codes, patient demographics, and clinician notes.

5. **Checkout:** Schedule a follow-up appointment as needed and confirm that the doctor completed the record form.

Back-End Medical Billing

1. **Charge Entry:** Use the record form to verify the procedures and why they were performed. Enter any payments made by the patient at that time.

2. **Claim Generation:** Generate the claim after entering the charges and payments. This process may include compiling charges, description of treatment, and more.

3. **Claim Scrubbing:** Ensure that each procedure, diagnosis, and other necessary information is accurate. This confirms that the patient, provider, and visit information is complete.

4. **Claim Forms:** As a medical biller, you will generally use forms to receive payment from insurers.

5. **Claim Submission:** The provider organization can submit claims to payers electronically. Usually, medical billers use software that meets electronic filing requirements established by HIPAA.

6. **Claim Tracking:** Check each claim status daily.

7. **Patient Payments:** The patient statement should be sent. It needs to include all outstanding balances. The statements should also include the date of services rendered, the services performed, the insurance reimbursement received, the payments compiled at the time of service, and the explanation as to why the patient balance is due.

8. **Denial Management:** Address any denial or reimbursement issues as soon as they are received. If a payer denies a claim, the ERA provides medical billers with a denial code(s) and a quick explanation for the claim's denial.

9. **A/R Collections:** Follow up with patients who don't pay within a set amount of time.

b. Information, Entities, and Attributes

- Person
  - Name
  - Address

        - SSN
        - DOB
        - Phone Number
        - Email Address
    - Patient
        - Occupation
        - Gender
        - Username
        - Password
    - Employee
        - ID
        - Job Type
        - Employment History
        - Education
        - Criminal History
    - Licensure
        - Certifications
        - LicenseID
    - Appointment
        - Time
        - Date
        - Description
        - Charge

        - AppointmentID
- Billing
    - Charge
    - Record
        a. Date
        b. Procedures performed
    - Invoice under one main supervising Dentist
- Insurance
    - Policy
    - Company Name
    - Company Address
    - Company Phone Number
    - Member ID
    - Accepted Types
- Procedures
    - Procedure ID
    - Quantity
    - Per unit charges per insurance plan
    - Procedure Type
- Payments
    - Date
    - PaymentID
- Debit Card

        - DC_number
        - Exp_date
    - Payment Plan
        - Num_of_install
    - Credit Card
        - CC_number
        - Exp_daate
    - Cash
        - Amount
        - Change
    - Check
        - Check_ID
    - Medical history
        - Date of the last X-Ray
        - Surgeries
        - Immunizations
        - Physical test/exam
        - Preferred Pharmacy
        - Date
        - Emergency contact info
        - MH ID
    - HIPAA Form
        - Date Signed

        - Form ID
    - Allergy
        - Severity
        - Allergen
        - Last Date Reaction
        - Reaction
        - Diagnose Date
        - Allergy ID
    - Medication
        - Dosage
        - Medication Name
        - Frequency
        - Provider
        - Route of Administration
        - End Date
        - Start Date
        - Medication ID

B. Additional Features

a. **Schedule (AppID, Order_of_sched):**

This entity would help in keeping track of the schedule for the doctor to meet with a patient. The receptionist will be the one who writes down the daily schedule for the doctor to follow. The order of schedule will allow receptionists to prioritize

appointments based on more important appointments. This also allows receptionists to re-appointment patients in case of emergency.

b. **Equipment (Date_of_purchase, Equipment_type, Cost, Quantity):**
This entity would help in keeping track of the type of equipment purchased, when it was purchased, quantity, and cost. The equipment is purchased by the Employee. It would be beneficial for the employee to know what kind of equipment they require and how much they are spending on it.

C. Additional Requirements and Assumptions

i. Each employee has a license and certifications.
ii. Each employee has an ID, job type, employment history, education certifications, and criminal history.
iii. An employee can be a nurse, doctor, receptionist, or hiring manager.
iv. All patients sign exactly one HIPAA form.
v. The HIPAA form contains the date signed and form ID.
vi. All patients provide medical history.
vii. Medical history contains date of MH ID, last X-ray, surgery, allergy info, date, preferred pharmacy, medication, immunization, illness, physical test/exam, owner, and emergency contact info.
viii. All patients schedule at least one appointment.
ix. The appointment has a charge, time, description, and date.
x. The appointment involves at least one procedure.
xi. The invoice includes the procedures performed.

xii. Each appointment generates only one billing.

xiii. Procedures have a Procedure ID, quantity, type, per unit charges per insurance plan, and are performed by certain medical professionals.

xiv. Each patient can have at most one insurance plan, but may not have any.

xv. Each patient makes at least one payment.

xvi. Each employee follows at least one procedure.

xvii. Each payment is covered by insurance first.

xviii. Canceled appointments are not billed.

xix. The invoice has an ID, record, date, procedures performed, and invoice under one main supervising dentist.

xx. Each payment determines the billing.

xxi. Payment includes the date, payment type, debit card, payment plan, credit card, check, and cash.

xxii. All equipment has a date of purchase and a type.

xxiii. Insurance has accepted types, company names, member ID, company addresses, company phone numbers, and policy.

xxiv. Both employees and patients are special types of people.

xxv. All person have a social security number, name, address, phone, email address, and date of birth.

xxvi. Each patient has an ID, username, occupation, gender, and password.

xxvii. Allergy has allergy ID, severity, allergen, last date reaction, reaction, and diagnosis date.

xxviii. The medication has medication ID, dosage, medication name, frequency, provider, route of administration, end date, and start date.

D. Entities and associated attributes

a. Equipment
    i. Date of purchase
    ii. Equipment type
    iii. Cost
    iv. Quantity
b. Allergy
    i. Severity
    ii. Allergen
    iii. Last Date Reaction
    iv. Reaction
    v. Diagnose Date
    vi. Allergy ID
c. Medication
    i. Dosage
    ii. Medication Name
    iii. Frequency
    iv. Provider
    v. Route of Administration
    vi. End Date

vii. Start Date

viii. Medication ID

d. Medical history

i. Date of last X-ray

ii. Surgery

iii. Date

iv. Preferred pharmacy

v. Immunization

vi. Physical test/exam

vii. Emergency contact info

viii. MH ID

e. Person

i. Email address

ii. Phone number

iii. Social security number

iv. Date of birth

v. Address

vi. Name

f. Patient

i. Username

ii. ID

iii. Occupation

iv. Gender

v. Password

g. HIPAA form

i. Date signed

ii. Form ID

h. Employee

i. Criminal history

ii. Job type

iii. Employment history

iv. Education

i. Nurse

j. Doctor

k. Receptionist

l. Hiring manager

m. Licensure

i. Certifications

ii. LicenseID

n. Invoice

i. Charge

ii. ID

iii. Record

1. Date

2. Procedures performed

iv. Invoice under one main supervising dentist

o. Procedures
    i. Procedure ID
    ii. Quantity
    iii. Procedure Type
    iv. Per unit charges per insurance plan
p. Insurance
    i. Accepted types
    ii. Company name
    iii. Member ID
    iv. Company address
    v. Company phone number
    vi. Policy
q. Appointment
    i. Charge
    ii. Time
    iii. Description
    iv. Date
r. Payment
    i. Date
    ii. PaymentID
s. Debit Card
    i. DC_number
    ii. Exp_date

t. Payment Plan
    i. Num_of_install
u. Credit Card
    i. CC_number
    ii. Exp_daate
v. Cash
    i. Amount
    ii. Change
w. Check
    i. Check_ID
x. Schedule
    i. AppID
    ii. Order_of_sched

E. Relationship between entities

a. A person can be an employee or patient
b. Employees have different positions, which are doctor, nurse, receptionist, and hiring manager.
c. A patient schedules an appointment
d. A patient provides medical history
e. The doctor records the medical history of a patient
f. A patient signs the HIPAA form.
g. An employee has a license.

h. Employee purchase necessary equipment.

i. The patient receives billing and makes a payment.

j. The Receptionist produces billing.

k. Each appointment generates billing.

l. Employee follow procedures during treatment.

m. The patient has insurance to reduce the amount of payment a patient needs to pay.

n. Payments are reduced and covered by insurance.

o. Appointments involve correct procedures.

p. Receptionist writes the schedule for the doctor to follow throughout the day.

q. The schedule includes appointments made by the patient.

r. Licensure can perform more than one procedure.

s. At each appointment, the patient may receive medication.

t. Each allergy may receive medication.

u. Each medication requires an allergy.

v. Each medication may be appointed to an appointment.

F. Informal queries/reports:

a. A patient wants to see past appointment scheduling history. This will be useful for the patient if they need to know when they last got a procedure done, or how much it cost.

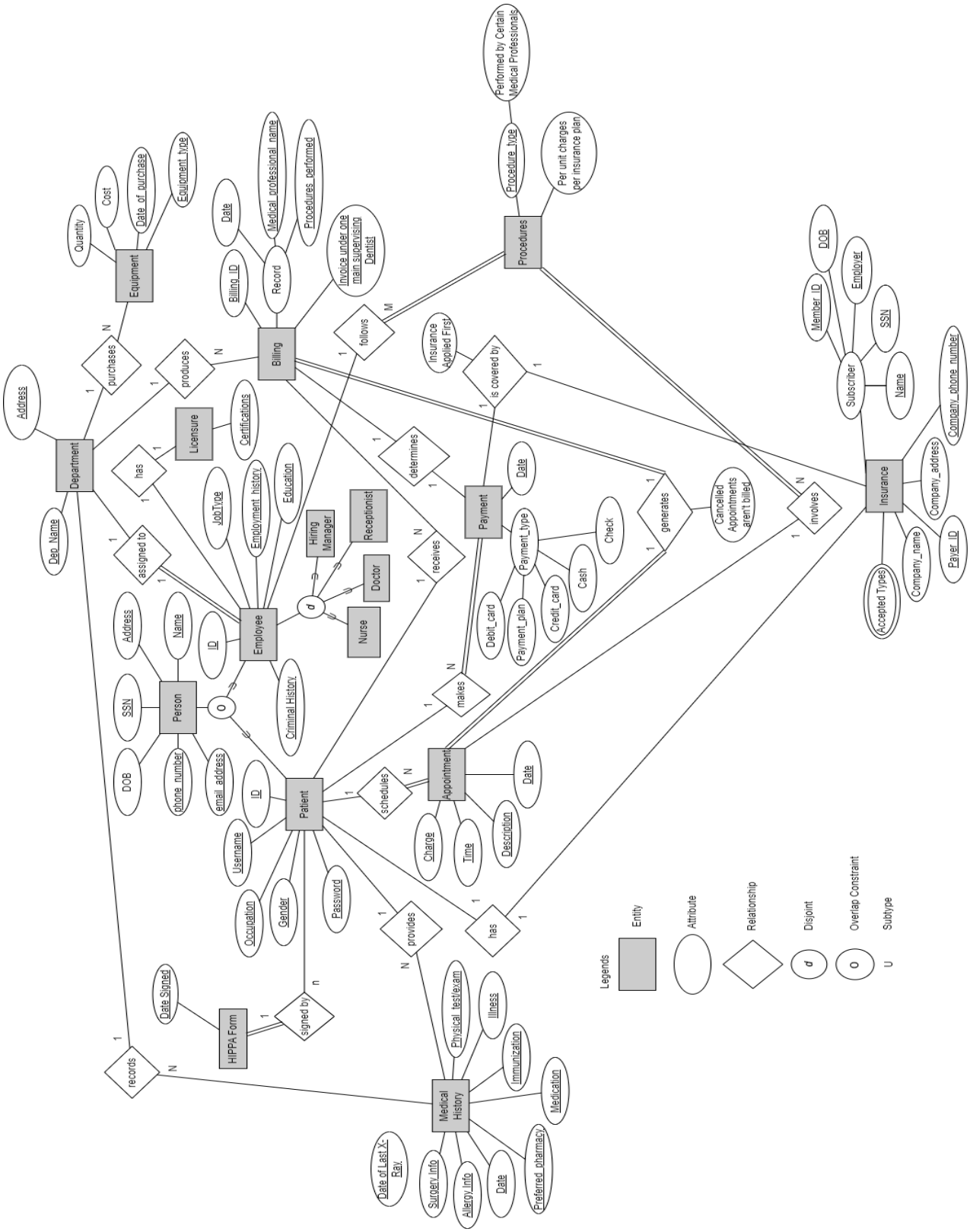
b. An Employee wants to know how much equipment was purchased. This will be useful for the employee if they need to do an inventory check and know what kind

of equipment they need, how much they are spending on equipment, and when they need to be replaced.

c. A Receptionist wants to know how many billings it has produced. This will be useful for the receptionist when they need to check their finances and provide records.

d. An employee wants to know many many procedures they have conducted. This will be useful if the employee needs to keep a record of which patients they have interacted with and which procedures they might conduct in the future.

G. ERD


Department
Address
Dep_Name
Equipment
Quantity
Cost
Date_of_purchase
Equipment_type
purchases
produces
Billing
Billing_ID
Date
Record
Medical_professional_name
Procedures_performed
Invoice under one main supervising Dentist
follows
Procedures
Performed by Certain Medical Professionals
Procedure_type
Per unit charges per insurance plan
Insurance Applied First
is covered by
Subscriber
Member_ID
DOB
Employer
SSN
Name
insurance
Company_phone_number
Company_address
Company_name
Payer_ID
Accepted Types
has
Licensure
Certifications
determines
Payment
Date
Payment_type
Check
Cash
Credit_card
Debit_card
Payment_plan
generates
Cancelled Appointments aren't billed
involves
assigned to
Employee
ID
Address
Name
JobType
Employment history
Education
Hiring Manager
Receptionist
Doctor
Nurse
receives
Person
SSN
DOB
phone_number
email_address
Criminal History
Patient
Username
Occupation
Gender
Password
makes
schedules
Appointment
Charge
Time
Description
Date
HIPPA Form
Date Signed
Signed by
records
provides
has
Medical History
Physical_test/exam
Illness
Immunization
Medication
Date of Last X-Ray
Surgery_info
Allergy_info
Date
Preferred_pharmacy
Legends
Entity
Attribute
Relationship
Disjoint
Overlap Constraint
Subtype

H. MS Excel Spreadsheet

Person					
Name	Address	DOB	SSN	Phone Number	Email Address
Edward Stevens	2792 Adams Avenue, Columbia, MD, 21044	07/23/96	231-23-1844	614-348-9724	edward.s@gmail.com
Paula McGuffin	2490 Philli Lane, Tulsa, OK, 74136	09/12/87	938-34-1056	614-684-7954	paula.m@gmail.com
Dave Philbert	3034 Saint John Ct, Columbus, OH, 43202	01/31/67	659-94-5947	320-927-2947	dave.p@gmail.com
John Smith	4324 Cedar Street, Jonesboro, AR, 72401	02/20/79	392-75-7604	614-737-0183	john.s@gmail.com
Abe Thomson	391 Huntz Lane, Boston, MA, 02210	06/19/90	106-33-9386	241-474-2125	abe.t@gmail.com
Phoebe Dillon	2605 Oakdale Avenue, Avon Park, FL, 33825	11/10/09	029-49-7432	614-927-0384	phoebe.d@gmail.com
Nina Fuller	251 Ralph Drive, Mentor On The Lake, OH, 44060	06/28/95	191-57-4552	614-127-7526	nina.f@gmail.com
Skyla Chavez	4944 Still Pastures Drive, Columbia, SC, 29210	05/07/69	783-02-4729	614-179-9032	skyla.c@gmail.com
Maisy Sims	868 Dola Mine Road, Durham, NC, 27707	08/03/04	772-16-8273	614-562-5543	maisy.s@gmail.com
Roy Kelley	1897 Grim Avenue, San Diego, CA, 92103	12/10/85	546-83-9886	614-693-6237	roy.k@gmail.com

Patient				
ID	Username	Password	Occupation	Gender
12345	Phoebe.D	Apricots321	Student	Female
12344	Maisy.S	J8dv9J94NDj	Student	Female
12343	Roy.K	Buck4Eyes0	Banker	Male
12342	Abe.T	H4m1lt0n	Actor	Male
12341	John.S	Password1234	Photographer	Male

Employee				
ID	Job Type	Employ. History	Education	Crim. History
91234	Doctor	Charity Clinic	Doctorate	n/a
91432	Hiring Manager	Franklin Clinic	Masters	n/a
91342	Receptionist	n/a	Bachelors	n/a
91232	Doctor	2:30 Dentistry	Doctorate	Shoplifting
91254	Nurse	Dentist Den	Bachelors	n/a

Schedule	
Schedule	Order_of_sched
32132	1
45354	2
34342	3
45345	4
34534	5

Appointment			
Time	Description	Date	AppointmentID
9:50	Cleaning	01/23/20	32132
13:45	Cleaning, Cavity Removal	02/12/19	45354
14:05	Root Canal	12/30/22	34342
16:55	Tooth Removal	03/06/21	45345

17:45	Cleaning, Veneer	08/14/22	34534

Procedures

Type	Per Unit Charge	Quantity	Procedure_ID
Cavity Removal	$98	1	1234
Root Canal	$359	2	1233
Tooth Removal	$283	1	1232
Cleaning	$76	3	1231
Veneer	$123	4	1230

Invoice

Billing ID	Date	Procedures Performed	Main Sup. Dentist	Charge
193484	01/23/20	Cleaning	Skyla Chavez	$76
138382	02/12/19	Cleaning, Cavity Removal	Skyla Chavez	$104
238482	12/30/22	Root Canal	Dave Philbert	$359
234848	03/06/21	Tooth Removal	Skyla Chavez	$283
945487	08/14/22	Cleaning, Veneer	Dave Philbert	$199

Payment

PaymentID	Date
12345	03/07/22
12344	06/23/22
12343	01/20/23
12342	12/03/22
12341	08/30/22

Debit Card

DC_number	Exp_date
1234567812345678	03/07/25

9876543298765432	06/23/26
7845647383465627	01/20/23
8563658892636577	12/03/25
7345876435786873	08/30/27

Payment Plan
Num_of_install
3
5
2
6
3

Credit Card	
DC_number	Exp_date
8348756987387689	03/08/25
7860405969839585	06/20/26
9349865983498585	01/4/23
9348956987598398	12/25/25
6234893959827686	08/16/27

Cash	
Amount	Change
10000	35
1234	20
5000	0

4674	76
300	2

Check
Check_ID
645735
289392
834554
356865
934685

Insurance					
Accepted Type	Company Name	Company Addr.	Comp. Phone #	Member ID	Policy
Health	Healthy Living	3519 Olive Street	614-917-7192	12518364	Alpha
Dental	Tooth Shield	4190 Doe Meadow Drive	614-292-2947	74926592	Beta
Dental	Big Bite	161 O Conner Street	614-163-5642	46385638	Delta
Health	Full Health	1700 Dancing Dove Lane	614-092-3477	35284682	Delta
Health	Long Life	1209 Rardin Drive	614-002-2732	19374628	Delta

Allergy					
Severity	Allergen	Last Date Reaction	Reaction	Diagnose Date	Allergy ID
Severe	Alloys	12/02/2015	Skin rash	1/29/2019	1

Mild	Rubber materials	06/21/2018	Difficulty breathing	1/6/2020	2
Moderate	Polymers	08/10/2018	Sneezing	9/20/2022	3
Severe	Acrylates	01/05/2021	Swelling	9/30/2022	4
Severe	Polymers	02/08/2020	Hives	12/13/2022	5

Medication

Dosage	Medication Name	Frequency	Provider	Route of Administration	Start Date	End date	Medication ID
25 mg	Diphenhydramine	Every 6 hours as needed	Dr. Nguyen	Oral	02/15/2022	N/A	10
2 sprays in each nostril	Nasal Corticosteroid spray	Once Daily	Dr. Kim	Nasal	01/07/2021	N/A	11
1-2 vials	Cromolyn Sodium	4 times daily	Dr. Gupta	Inhalation	05/15/2020	05/15/2021	12
1-2 drops in each eye	Antihistamine eye drops	Twice daily	Dr. Patel	Ophthalmic	02/01/2023	02/08/2023	13
10 mg	Loratadine	Once daily	Dr. Gupta	Oral	05/15/2020	N/A	14

Medical History

Last X-ray Date	Surgery Info	Date	Pref. Pharm.	Immunization	Physical Exam	Emergency Contact Info	MH_ID
1/29/2019	Tooth extraction	02/23/22	Kroger	Flu	n/a	3802034096	747
1/6/2020	Dental bone grafts	06/21/22	Walmart	Flu, Covid	Healthy	4052347163	213
9/20/2022	Dental implants	09/20/2022	CVS	Flu, Covid	Healthy	7567568927	643

9/30/2022	Periodontal surgery	09/30/2022	Walmart	Flu, Covid	Healthy	4784349483	856
12/13/2022	Corrective jaw surgery	12/13/2022	Walmart	Flu, Covid	Healthy	7553874863	162

Licensure	
LicenseID	Certifications
123542	Dentistry
245432	Nursing
356455	n/a
467567	n/a
578687	Dentistry

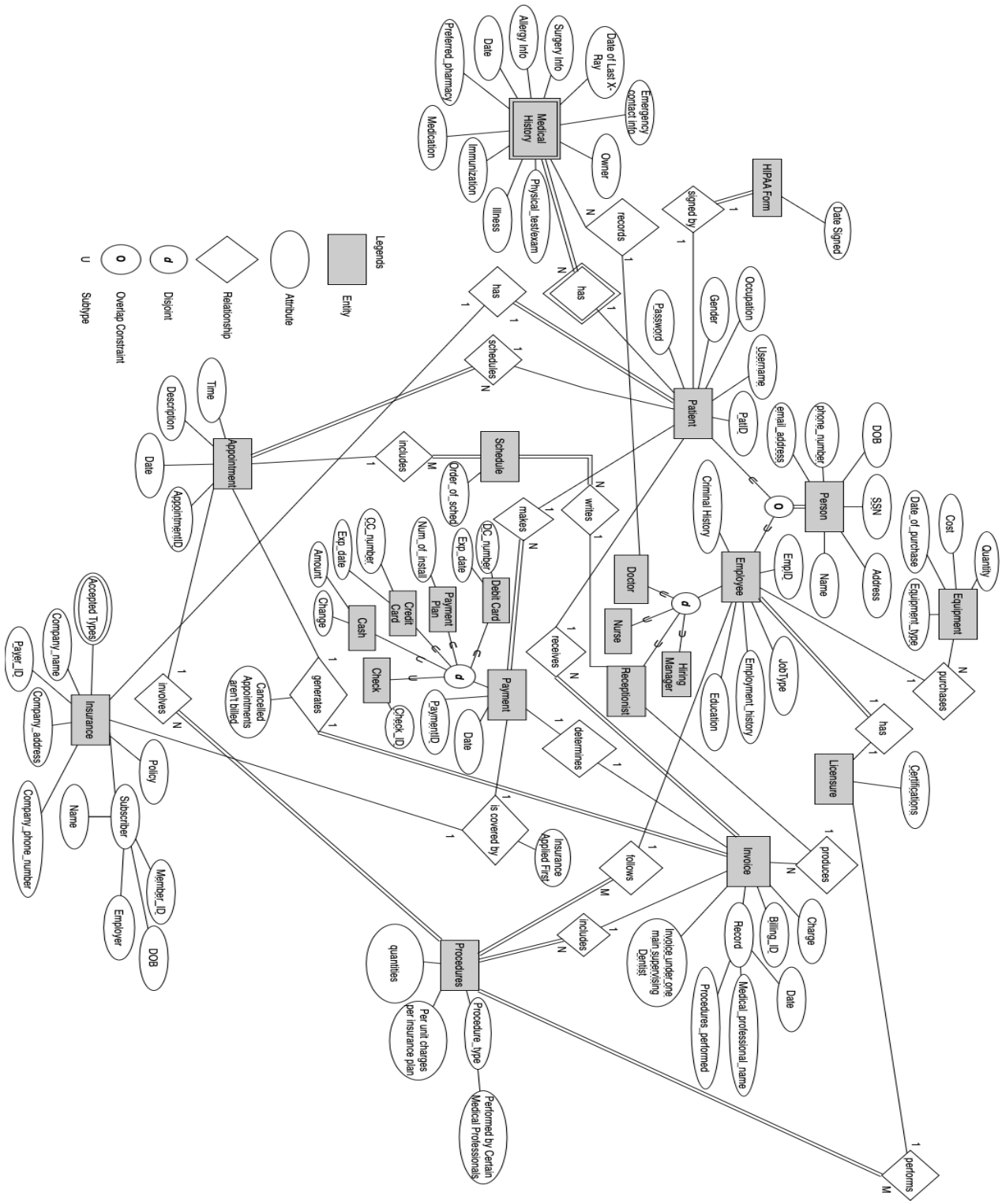
HIPAA Form	
Date Signed	Form ID
7/15 /12	123132
02/20/20	564654
05/03/19	678687
n/a	809890
n/a	324243

Equipment			
Type	Quantity	Cost	Date
Dental Patient Chair	3	$2,099.00	01/01/2023
Sterilization Equipment	2	$1,300.00	03/01/2023
Utility Equipment	3	$435.00	01/01/2023
X-Ray Imaging Instrument	3	$1,099.00	02/01/2023
Dental Operating Lights	3	$160.00	01/01/2023

Operatory Cabinetry	3	$700.00	01/01/2023
Handpieces	3	$299.00	01/01/2023

PART 2

1. ERD 2.0



2. Relational Schema

Step1: Map regular entities

- Person (email_address(PK), phone_number(PK), SSN(PK), DOB, Address, Name)
- Equipment (Date_of_purchase, Equipment_type(PK), Quantity, Cost)
- Employee(EmpID(PK), JobType, Employement_history, Education, Criminal History)
- Patient(PatID(PK), Username, Occupation, Gender, Password)
- HIPAA Form(Form_ID(PK), Date Signed)
- Schedule(Order_of_sched, ScheduleID(PK))
- Appointment (AppointmentID(PK), Time, Description, Date)
- Licensure (Certifications, LicenseID(PK))
- Payment(Date, PaymentID(PK))
- Insurance(Company_name, Member_ID(PK), Company_address, Company_phone_number, Policy)
- Procedure(Procedure_ID(PK), Quantities, Procedure_type, Per unit charges per insurance plan)
- Invoice (Billing ID(PK), Date, Medical_professional_name, Procedures_performed, invoice under one main supervising dentist)
- Allergy(Allergy ID(PK), Severity, Allergen, Last Reaction Date, Reaction, Diagnose Date)
- Medication(Medication ID(PK), Start Date, End Date, Route of Administration, Provider, Dosage, Medication Name, Frequency)

Step2: Weak Entity Types

- Medical history (PatID(FK), MH_ID(PK), Emergency contact info, Date of Last X-Ray, Surgery Info, Date, Preferred_pharmacy, Immunization, Physical_test/exam)

Foreign Key PatID References Patient

Step3: Binary M:1 Relationship

- Schedule(AppID(FK), EmpID(FK), Order_of_sched, ScheduleID(PK))

Foreign Key AppID References Appointment

Foreign Key EmpID References Employee

- Appointment (PatID(FK), AppointmentID(PK), Time, Description, Date)

Foreign Key PatID References Patient

- Payment(PatID(FK), BillingID(FK), Date, PaymentID(PK))

Foreign Key PatID References Patient

Foreign Key BillingID References Invoice

- Equipment (EmpID(FK), Date_of_purchase, Equipment_type(PK), Quantity, Cost)

Foreign Key EmpID References Employee

- Invoice (PatID(FK), EmpID(FK), Billing_ID(PK), Date, Invoice under one main supervising Dentist, Medical_professional_name, Procedures_performed)

Foreign Key PatID References Patient

Foreign Key EmpID References Employee

- Allergy(MH_ID(FK), AllergyID(PK), Severity, Allergen, Last Reaction Date, Reaction, Diagnose Date)

Foreign Key MH_ID References Medical History

- Medical History(EmpID(FK), MH_ID(PK), Emergency contact info, Date of Last X-Ray, Surgery Info, Date, Preferred_pharmacy, Immunization, Physical_test/exam)

Foreign Key EmpID References Employee

- Procedure(Procedure_ID(PK), AppID(FK), EmpID(FK), Billing_ID(FK), LicenseID(FK), Quantities, Procedure_type, Per unit charges per insurance plan)

Foreign Key AppID References Appointment

Foreign Key EmpID References Employee

Foreign Key Billing_ID References Invoice

Step4: Binary 1:1 Relationship

- HIPAA Form(PatID(FK), Form_ID(PK), Date Signed)

Foreign Key PatID References Patient

- Patient(Member_ID(FK), SSN(PK), PatID(PK), Username, Occupation, Gender, Password)

Foreign Key Payer_ID References Insurance

- Employee(LicenseID(FK), EmpID(PK), JobType, Employement_history, Education, Criminal History)

Foreign Key LicenseID References Licensure

- Invoice (AppID(FK), Billing ID(PK), Date, Invoice under one main supervising Dentist, Medical_professional_name, Procedures_performed)

Foreign Key AppID References Appointment

- Payment(PaymentID(PK), Member_ID(FK), Date)

Foreign Key Member_ID References Insurance

Step5: M:N Relationship

- App_Proc(AppointmentID(FK), ProcedureID(FK))

Foreign Key AppointmentID References Appointment

Foreign Key ProcedureID References Procedure

- All_Med(AllergyID(FK), MedicationID(FK))

Step6: Multi-valued attributes

- Ins_Acctypes(AcceptedTypes, Member_ID$^{(FK)}$)

Foreign Key Member_ID References Insurance

Step 7: n-ary relationships

- None

Step 8a: Mapping Specialization/Generalization

- Doctor(EmpID$^{(PK)}$, SSN$^{(PK)}$)

Primary Key EmpID References Employee

Primary Key SSN References Person

- Nurse(EmpID$^{(PK)}$, SSN$^{(PK)}$)

Primary Key EmpID References Employee

Primary Key SSN References Person

- Receptionist(EmpID$^{(PK)}$, SSN$^{(PK)}$)

Primary Key EmpID References Employee

Primary Key SSN References Person

- Hiring Manager(EmpID$^{(PK)}$, SSN$^{(PK)}$)

Primary Key EmpID References Employee

Primary Key SSN References Person

- Debit Card(PaymentID$^{(PK)}$, Exp_date, DC_number$^{(PK)}$)

Primary Key PaymentID References Payment

- Payment Plan(PaymentID$^{(PK)}$, Num_of_install)

Primary Key PaymentID References Payment

- Credit Card(PaymentID$^{(PK)}$, CC_number$^{(PK)}$, Exp_date)

Primary Key PaymentID References Payment

- Cash(PaymentID(PK), Amount, Change)

Primary Key PaymentID References Payment

- Check(Check_ID(PK), PaymentID(PK))

Primary Key PaymentID References Payment

Step 8d: Subclasses are overlapping with multiple attributes

- Person(PatID(PK), Username, Occupation, Gender, Password, email_address(PK), phone_number(PK), SSN(PK), DOB, Address, Name, EmpID(PK), JobType, Employement_history, Education, Criminal History)

Step 9: Mapping Union types

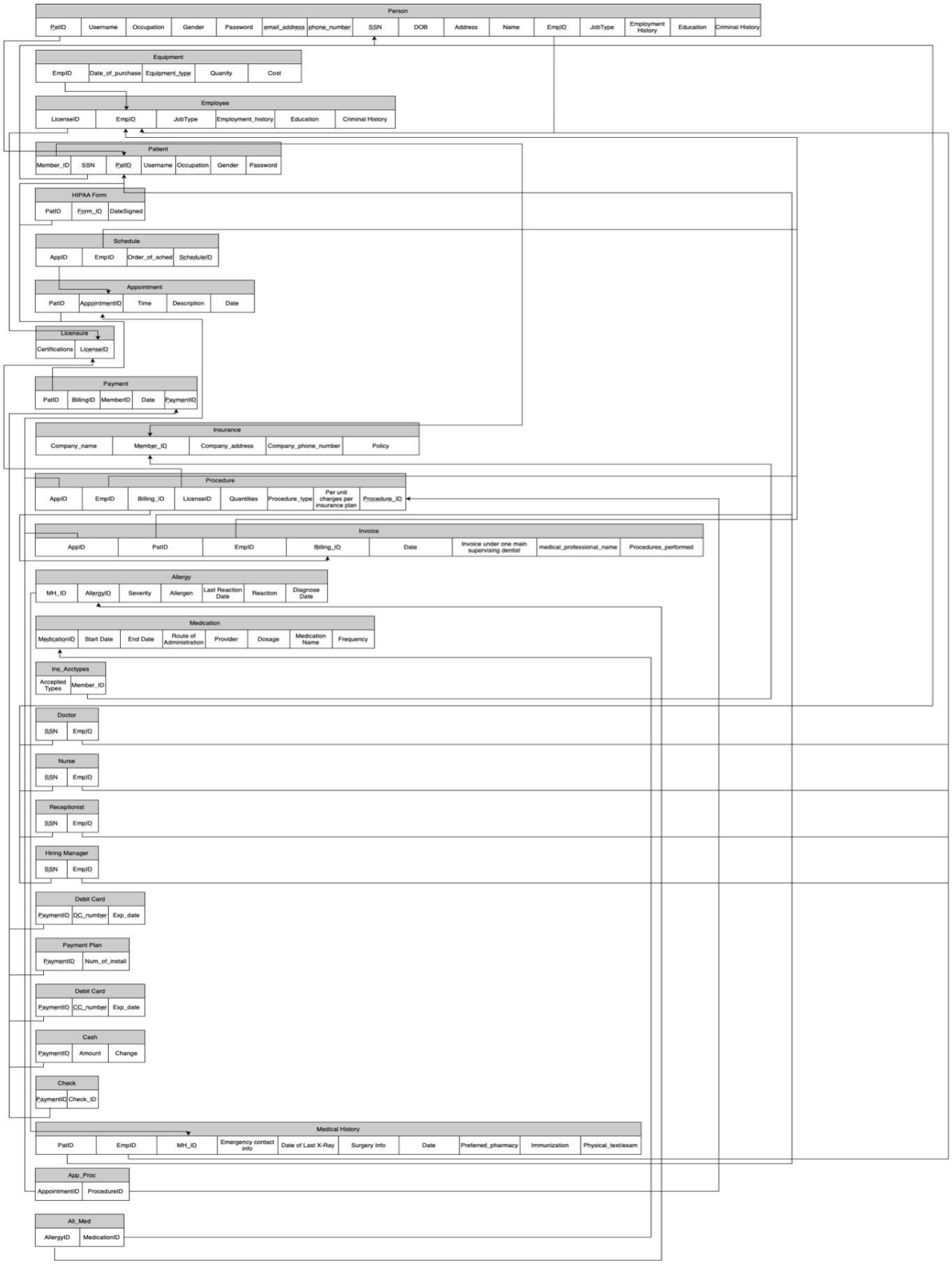
- None

Summary:

- Person(PatID(PK), Username, Occupation, Gender, Password, email_address(PK), phone_number(PK), SSN(PK), DOB, Address, Name, EmpID(PK), JobType, Employement_history, Education, Criminal History)
- Equipment (EmpID(FK), Date_of_purchase, Equipment_type(PK), Quantity, Cost)
- Employee(LicenseID(FK), EmpID(PK), JobType, Employement_history, Education, Criminal History)
- Patient(Member_ID(FK), SSN(PK), PatID(PK), Username, Occupation, Gender, Password)
- HIPAA Form(PatID(FK), Form_ID(PK), Date Signed)
- Schedule(AppID(FK), EmpID(FK), Order_of_sched, ScheduleID(PK))
- Appointment (PatID(FK), AppointmentID(PK), Time, Description, Date)
- Licensure (Certifications, LicenseID(PK))

- Payment(PatID(FK), BillingID(FK), MemberID(FK),Date, PaymentID(PK))
- Insurance(Company_name, Member_ID(PK), Company_address, Company_phone_number, Policy)
- Procedure(Procedure_ID(PK), AppID(FK), EmpID(FK), Billing_ID(FK), LicenseID(FK), Quantities, Procedure_type, Per unit charges per insurance plan)
- Invoice (PatID(FK), EmpID(FK), Billing_ID(PK), AppID(FK), Date, Invoice under one main supervising Dentist, Medical_professional_name, Procedures_performed)
- Allergy(MH_ID(FK), AllergyID(PK), Severity, Allergen, Last Reaction Date, Reaction, Diagnose Date)
- Medication(Medication ID(PK), Start Date, End Date, Route of Administration, Provider, Dosage, Medication Name, Frequency)
- Medical History(PatID(FK), EmpID(FK), MH_ID(PK), Emergency contact info, Date of Last X-Ray, Surgery Info, Date, Preferred_pharmacy, Immunization, Physical_test/exam)
- App_Proc(AppointmentID(FK), ProcedureID(FK))
- All_Med(AllergyID(FK), MedicationID(FK))
- Ins_Acctypes(AcceptedTypes, Member_ID(FK))
- Doctor(EmpID(PK), SSN(PK))
- Nurse(EmpID(PK), SSN(PK))
- Receptionist(EmpID(PK), SSN(PK))
- Hiring Manager(EmpID(PK), SSN(PK))
- Debit Card(PaymentID(PK), Exp_date, DC_number(PK))
- Payment Plan(PaymentID(PK), Num_of_install)
- Credit Card(PaymentID(PK), CC_number(PK), Exp_date)

- Cash(PaymentID$^{(PK)}$, Amount, Change)
- Check(Check_ID$^{(PK)}$, PaymentID$^{(PK)}$)



3. Relational Algebra

a. Create a list of patients and the medications they currently take.

$\pi_{(\text{Name, Age, Medication Name, Date})}(\text{Patient} \bowtie \text{Medication} \bowtie \text{Medical History})$

b. Display patient information for patients who currently have Delta Dental insurance policy.

$\sigma_{\text{Policy=Delta Dental}}((\pi (\text{Person} \bowtie \text{Patient} \bowtie \text{Insurance})$

c. Generate a list of procedures and dates of service performed by doctor Smilow.

$\sigma_{\text{Medical\_professional\_name = Doctor Smilow}} (\pi_{\text{Date, Medical\_professional\_name, Procedures\_performed}}(\text{Invoice}))$

d. Print out a list of past-due invoices with patient contact information. Past due is defined as over 30 days old with a balance over $10.

$\sigma_{\text{Date>30 days AND Charge>\$10}}((\pi_{\text{Date, Charge,PatId, Name, phone\_number,email\_address}}(\text{Invoice} \bowtie \text{Patient} \bowtie \text{Person}))$

e. Find the patients who brought the most revenue in the past year.

$_{\text{Name}}\mathbf{F}_{\text{SUM Charge}}((\pi_{\text{Name,PatID,Date,Charge}}(\text{Person} \bowtie (\text{Patient} \bowtie \text{Payment} \bowtie \text{Invoice})))$

f. Create a list of doctors who performed less than 5 procedures this year.

$\sigma_{\text{Num\_procedures\_performed} < 5}(\rho_{(\text{Medical\_professional\_name, Num\_procedures\_performed})}(_{\text{Medical\_professional\_name}}F_{\text{COUNT Procedures\_performed}} (\pi_{\text{Date, Medical\_professional\_name, Procedures\_performed}}(\text{Invoice}))))$

g. Find the highest paying procedures, procedure price, and the total number of those procedures performed.

$\sigma_{\text{MAX Per Unit Charges Per Insurance Plan}}(\pi_{\text{Procedure Type, Per Unit Charges Per Insurance Plan, Quantities}}(\text{Procedures}))$

h. Create a list of all payment types accepted, the number of times each of them was used, and the total amount charged to that type of payment.

$\text{Num\_used} \leftarrow (\pi_{\text{COUNT Date}}(\text{Credit Card})) \text{ X } (\pi_{\text{COUNT Date}}(\text{Debit Card})) \text{ X } (\pi_{\text{COUNT Date}}(\text{Payment Plan})) \text{ X } (\pi_{\text{COUNT Date}}(\text{Cash})) \text{ X } (\pi_{\text{COUNT Date}}(\text{Check}))$

Credit_charge ← $\pi_{\text{SUM Charge}}(\pi_{\text{Date}}(\text{Credit Card})) \text{ X } (\pi_{\text{Charge}}(\text{Invoice}))$

Debit_charge ← $\pi_{\text{SUM Charge}}(\pi_{\text{Date}}(\text{Debit Card})) \text{ X } (\pi_{\text{Charge}}(\text{Invoice}))$

Plan_charge ← $\pi_{\text{SUM Charge}}(\pi_{\text{Date}}(\text{Payment Plan})) \text{ X } (\pi_{\text{Charge}}(\text{Invoice}))$

Cash_charge ← $\pi_{\text{SUM Charge}}(\pi_{\text{Date}}(\text{Cash})) \text{ X } (\pi_{\text{Charge}}(\text{Invoice}))$

Check_charge ← $\pi_{\text{SUM Charge}}(\pi_{\text{Date}}(\text{Check})) \text{ X } (\pi_{\text{Charge}}(\text{Invoice}))$

Check_charge X Debit_charge X Plan_charge X Cash_charge X Check_charge X Num_used

i. List ids and names of insurance plans ever used by patients and how many patients have that plan.

F1←$(\pi_{\text{Company\_name, Payer\_ID}}(\text{Insurance}))$

F2← $_{\text{Company\_name}}F_{\text{COUNT PatID}}(\pi_{\text{PatID}}(\text{Patient})) \bowtie F1$

F1 ⋈ F2

4. Additional Queries

a. Find the procedure that has been performed the most.

$(\sigma_{\text{MAX Quantities}}(\text{Procedures}))$

b. Find the average cost for equipment.

$(\sigma_{\text{AVERAGE Cost}}(\text{Equipment}))$

c. Find the patient that has scheduled the most number of appointments.

F1← $(\pi_{\text{Name}}(\text{Person})) \bowtie (\pi_{\text{PatID}}(\text{Patient}))$

F2←$_{\text{Name}}F_{\text{MAX Date\_Count}}(_{\text{Name}}F_{\text{COUNT Date}}((\pi_{\text{Date}}(\text{Appointment})) \bowtie F1))$

F1 ⋈ F2

5. Specification Sheet

Relation Person

Attribute name	Data Type	Key	Null	Unique	Other Constraints
email_address	String		N	Y	
phone_number	Number		N	Y	
SSN	Number	PK	N	Y	must be 9 digits
DOB	Number		N	N	must be a valid date
Address	String		N	N	must be a valid address
Name	String		N	N	

Relation Equipment

Attribute name	Data Type	Key	Null	Unique	Other Constraints
Date_of_purchase	Number		Y	N	must be a valid date
Equipment_type	String	PK	N	Y	

Quantity	Number		N	N	
Cost	Number		N	N	
EmpID	Number	FK	N	Y	

Relation Employee

Attribute name	Data Type	Key	Null	Unique	Other Constraints
EmpID	Number	PK	N	Y	
JobType	String		N	N	
Employement_history	File		Y	Y	
Education	File		Y	Y	
Criminal History	FIle		Y	Y	
LicenseID	Number	FK	N	Y	

Relation Patient

Attribute name	Data Type	Key	Null	Unique	Other Constraints

PatID	Number	PK	N	Y	
Username	String		N	Y	
Occupation	String		Y	N	
Gender	String		N	N	
Password	String		N	N	must be more than 4 char
Member_ID	Number	FK	N	Y	
SSN	Number	FK	N	Y	

Relation HIPAA Form

Attribute name	Data Type	Key	Null	Unique	Other Constraints
Date Signed	Number		N	N	must be a valid date
Form_ID	Number		N	Y	
PatID	Number	Fk	N	Y	

Relation Schedule

Attribute name	Data Type	Key	Null	Unique	Other Constraints
Order_of_sched	String		N	N	
ScheduleID	Number	PK	N	Y	
EmpID	Number	FK	N	Y	
AppID	Number	FK	N	Y	

Relation
Appointment

Attribute name	Data Type	Key	Null	Unique	Other Constraints
AppID	Number	PK	N	Y	
Time	Number		N	N	Must be a valid time
Description	String		N	N	
Date	Number		N	N	Must be a valid date
PatID	Number	FK	N	Y	

Relation Licensure

Attribute name	Data Type	Key	Null	Unique	Other Constraints
LicenseID	Strings	PK	N	Y	
Certifications	String		N	Y	

Relation Payment

Attribute name	Data Type	Key	Null	Unique	Other Constraints
Date	Number		N	N	must be a valid date
PaymentID	Number	PK	N	Y	
BillingID	Number	FK	N	Y	
PatID	Number	FK	N	Y	
MemberID	Number	FK	N	Y	

Relation Insurance

Attribute name	Data Type	Key	Null	Unique	Other Constraints
Company_name	String		N	N	
Member_ID	Number	PK	N	Y	

Company_address	String		N	N	must be valid address
Company_phone_number	Number		N	N	must be valid phone number
Policy	String		N	N	Must be health types policy

Relation
Procedures

Attribute name	Data Type	Key	Null	Unique	Other Constraints
ProcedureID	Number	PK	N	Y	
AppID	Number	FK	N	Y	
EmpID	Number	FK	N	Y	
BillingID	Number	FK	N	Y	
LicenseID	Number	FK	N	Y	
Quantities	Number		N	N	
Procedure_type	String		N	N	
Per unit charges per insurance plan	String		N	N	

Relation Invoice

Attribute name	Data Type	Key	Null	Unique	Other Constraints
PatID	Number	FK	N	Y	
EmpID	Number	FK	N	Y	
BillingID	Number	PK	N	Y	
AppID	Number	FK	N	Y	
Charge	Number		N	N	
Date	Number		N	N	
Invoice under one main supervising Dentist	Number		N	N	
Dentist Name	String		N	N	
Procedures_performed	String		N	N	

Relation Medical_History

Attribute name	Data Type	Key	Null	Unique	Other Constraints
PatID	Number	FK	N	Y	
EmpID	Number	FK	N	Y	
MH_ID	Number	PK	N	Y	
Emergency Contact info	String		N	N	
Date of Last X-Ray	Number		N	N	Must be valid date
Surgery Info	String		Y	N	
Date	Number		N	N	Must be valid date
Preferred_pharmacy	String		N	N	
Immunization	String		Y	N	
Physical_exam	String		N	N	

Relation Allergy

Attribute name	Data Type	Key	Null	Unique	Other Constraints
MH_ID	Number	FK	N	N	

AllergyID	Number	PK	N	Y	
Severity	String		Y	N	
Allergen	String		Y	N	
Last Reaction Date	Number		Y	N	must be a valid date
Reaction	String		Y	N	
Diagnose Date	Number		Y	N	must be a valid date

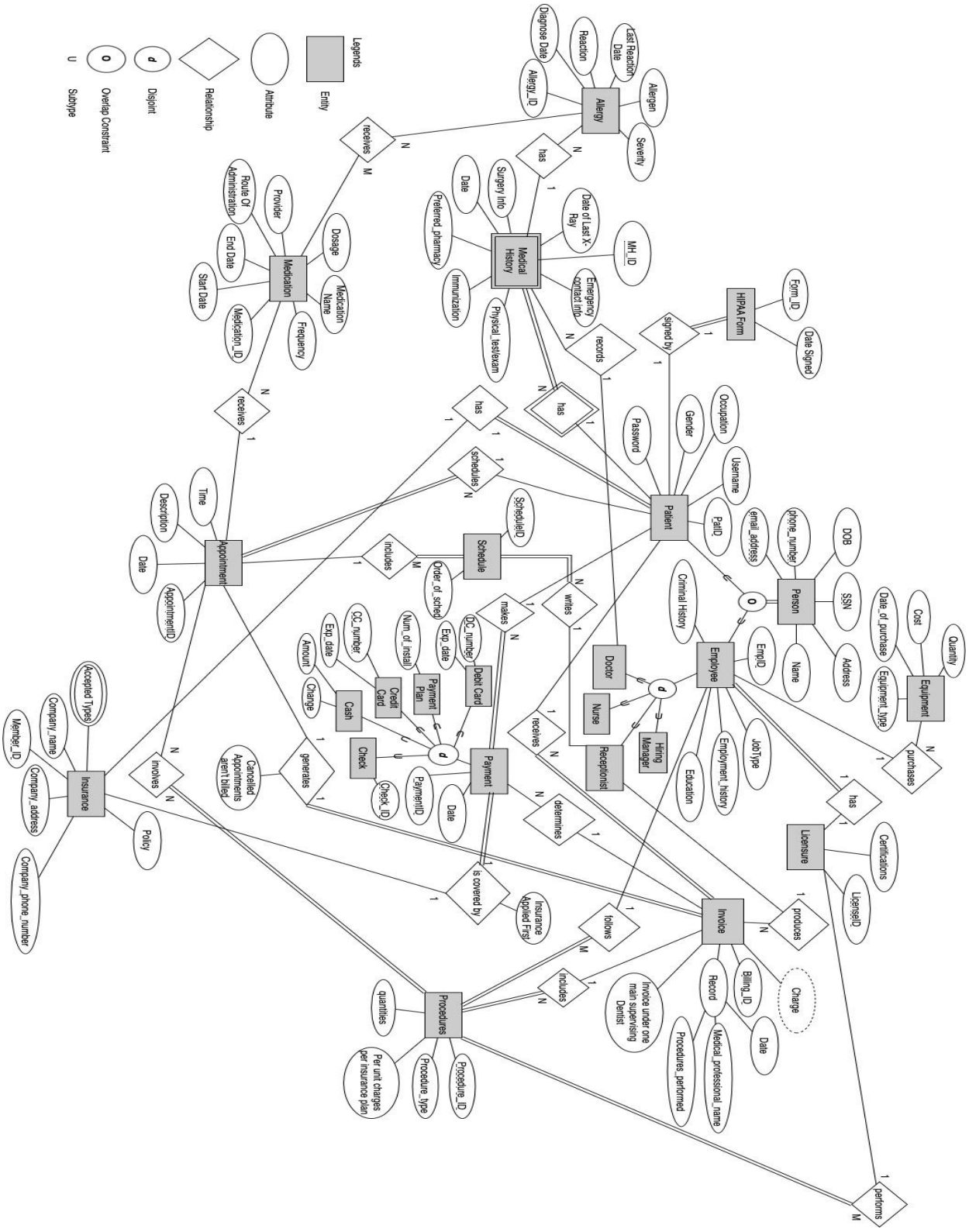
Relation Medication

Attribute name	Data Type	Key	Null	Unique	Other Constraints
Medication ID	Number	PK	N	N	
Start Date	Number		Y	Y	must be a valid date
End Date	Number		Y	N	must be a valid date
Route of Administration	String		Y	N	
Provider	String		Y	N	
Dosage	String		Y	N	
Medication Name	String		Y	N	

Frequency	String	Y	N

PART 3

1. ERD 3.0



Changes made from Part 2:

- Changes made to ERD: Added primary key to HIPAA form, add new entities allergy and medication, changed cardinality for invoice and payment, deleted performed by professional in procedure, changed charge to derived attribute, added procedure ID, added attributes to licensure, removed attribute subscriber in insurance because it will already have information from the patient entity, removed the attribute owner from medical history entity because it already connected to patient entity, and added scheduleID attribute to schedule entity.
- Changes made to Relational Schema: Added medication, added allergy, added app_proc relation, added all_med relation, added medical history relation, removed paymvoice, fix unnecessary PK and FK.
- Changes made to Relational Algebra: Replace and fix joins.

2. Normalization

a. Relation Table Person
   i. Step 1: Converting to 1NF
      - This relation is already in 1nf and the primary key is ssn
   ii. Step 2: Converting to 2NF
      - Already in 2NF because each item is dependant on the SSN
   iii. Step 3: Converting to 3NF
      - Already in 3NF because none of the attributes are depend on each other
   iv. Step 4: Converting to BCNF
      - Also already in BCNF

b. Relation Table Equipment

   R = {EmpID$^{(FK)}$, Date_of_purchase, Equipment_type$^{(PK)}$, Quantity, Cost}

   F = {EmpID → {Date_of_purchase, Equipment_type, Quantity, Cost}; Equipment_type -> {Quantity, Cost}

   i. Step 1: Converting to 1NF
      - The table already satisfies the 1NF because there are no repeating groups. The primary key is equipment_type, each piece of equipment can have only one row. EmpID is a foreign key that refers to another table.

ii. Step 2: Converting to 2NF
- The EmpID, Date_of_purchase, quantity, and cost attributes are not fully functionally dependent on the primary key. EmpID is partially dependent on the primary key, it depends on equipment_type and date_of_purchase.
- Breaking down into two tables where one table will contain a primary key that has attributes that are fully functionally dependent on the primary key. The other table will have attributes that are partially dependent on the primary key.
    - Equipment_type (Equipment_type$^{(PK)}$, Quantity, Cost)
    - Purchase (Equipment_type$^{(FK)}$, Date_of_purchase, EmpID$^{(FK)}$)

iii. Step 3: Converting to 3NF
- There is a transitive dependency between EmpID and Date_of_purchase in the purchase table because EmpID does not depend directly on the primary key, it depends on the equipment_type and date_of_purchase. Split the purchase table into two tables and add a new primary key PurchaseID.
    - Equipment_Type (Equipment_type$^{(PK)}$, Quantity, Cost)
    - Equipment_Purchase (Equipment_type$^{(FK)}$, Date_of_purchase, PurchaseID$^{(PK)}$)
    - Purchase_Details (PurchaseID$^{(FK)}$, EmpID$^{(FK)}$)

iv. Step 4: Converting to BCNF
- No further normalization is required because the Equipment_Type table has a primary key equipment_type and it is the only determinant in the table. The Equipment_Purchase table has one functional dependency {Equipment_type, Date_of_purchase} → PurchaseID and it is a superkey, the table is already in BCNF. The Purchase_Details table has one functional dependency PurchaseID → EmpID and it is the primary key of the table therefore it is already in BCNF.
    - Equipment_Type (Equipment_type$^{(PK)}$, Quantity, Cost)
    - Equipment_Purchase (Equipment_type$^{(FK)}$, Date_of_purchase, PurchaseID$^{(PK)}$)
    - Purchase_Details (PurchaseID$^{(FK)}$, EmpID$^{(FK)}$)

c. Relation Table Employee

R = Employee(LicenseID$^{(FK)}$, EmpID$^{(PK)}$, JobType, Employement_history, Education, Criminal History)

F = {LicenseID → EmpID; EmpID -> JobType; EmpID -> Employment_history; EmpID -> Education; EmpID -> Criminal History}

i. Step 1: Converting to 1NF
- Since Employement_history contains multiple values it violates the 1NF. We need to split the Employment_history column into a

separate table. By splitting, we will now have atomic values in each column of the new tables.
    - Employee (EmpID(PK), LicenseID(FK), JobType, Education, Criminal_history)
    - EmploymentHistory (EmpHistoryID(PK), EmpID(FK), Company, JobTitle, StartDate, EndDate)
- Criminal History will also need changed in this manner
    - Employee (EmpID(PK), LicenseID(FK), JobType, Education)
    - CriminalHistory (CrimHistoryID(PK), EmpID(FK),Date, Crime)

ii. Step 2: Converting to 2NF
- We have to further decompose EmploymentHistory table because there is a partially functionally dependency.
    - Employee(EmpID(PK), LicenseID(FK), JobType, Education)
    - EmploymentHistory(EmpHistoryID(PK), EmpID(FK), CompanyName, StartDate, EndDate)
    - JobTitle(EmpID(PK), JobTitle)
    - CriminalHistory (CrimHistoryID(PK), EmpID(FK),Date, Crime)

iii. Step 3: Converting to 3NF
- No further normalization required
- Employee(EmpID(PK), LicenseID(FK), JobType, Education)
- EmploymentHistory(EmpHistoryID(PK), EmpID(FK), CompanyName, StartDate, EndDate)
- JobTitle(EmpID(PK), JobTitle)
- CriminalHistory (CrimHistoryID(PK), EmpID(FK),Date, Crime)

iv. Step 4: Converting to BCNF
- No further normalization required
- Employee(EmpID(PK), LicenseID(FK), JobType, Education)
- EmploymentHistory(EmpHistoryID(PK), EmpID(FK), CompanyName, StartDate, EndDate)
- JobTitle(EmpID(PK), JobTitle)
- CriminalHistory (CrimHistoryID(PK), EmpID(FK),Date, Crime)

d. Relation Table Patient

R = {Member_ID(FK), SSN(PK), PatID(PK), Username, Occupation, Gender, Password}

F = {{PatID} -> {SSN, Username, Occupation, Gender, Password}; {Member_ID} -> {PatID}; SSN → Occupation}

i. Step 1: Converting to 1NF
- The table satisfies 1NF because each attribute in a relation is atomic and each row in the relation is unique. The table has two primary keys.

- Patient = {Member_ID$^{(FK)}$, SSN$^{(PK)}$, PatID$^{(PK)}$, Username, Occupation, Gender, Password}

ii. Step 2: Converting to 2NF
- We can see that occupation is dependent on PatID. This violates the 2NF since the occupation is not dependent on SSN which is the primary key.
  - Patient = {Member_ID$^{(FK)}$, SSN$^{(PK)}$, PatID$^{(PK)}$, Username, Gender, Password}
  - Patient_Occupation = {SSN$^{(FK)}$, Occupation}

iii. Step 3: Converting to 3NF
- There is a transitive dependency between Member_ID, Username, Gender, and Password attributes. Member_ID is functionally dependent on SSN. Username, Gender, and Password are functionally dependent on Member_ID. We can split into three parts.
  - Patient{Member_ID$^{(FK)}$, SSN$^{(PK)}$, PatID$^{(PK)}$}
  - Patient_Profile{Member_ID$^{(FK)}$, Username, Gender, Password}
  - Patient_Occupation{PatID$^{(FK)}$, Occupation}

iv. Step 4: Converting to BCNF
- All the attributes are already prime and no partial dependencies. There is a transitive dependency exist between Member_ID and Pat_ID through the patient relation. We can decompose.
  - Patient{SSN$^{(PK)}$, PatID$^{(PK)}$}
  - Patient_Profile{Member_ID$^{(FK)}$, Username, Gender, Password}
  - Patient_Occupation{PatID$^{(FK)}$, Occupation, SSN$^{(FK)}$}

e. Relation Table HIPAA Form

R = HIPAA Form(PatID$^{(FK)}$, Form_ID$^{(PK)}$, Date Signed)

F = {PatID$^{(FK)}$ → Date Signed; Form_ID$^{(PK)}$ → PatID, Date_Signed}
- Table already in BCNF.
- HIPAA Form = {PatID$^{(FK)}$, Form_ID$^{(PK)}$, Date Signed}

f. Relation Table Schedule

R = {AppID$^{(FK)}$, EmpID$^{(FK)}$, Order_of_sched, ScheduleID$^{(PK)}$}

F = {AppID$^{(FK)}$, EmpID$^{(FK)}$ → Order_of_sched; ScheduleID$^{(PK)}$ → AppID$^{(FK)}$, EmpID$^{(FK)}$, Order_of_sched}
- The table is already in BCNF
- Schedule = {AppID$^{(FK)}$, EmpID$^{(FK)}$, Order_of_sched, ScheduleID$^{(PK)}$}

g. Relation Table Appointment

R = {PatID$^{(FK)}$, AppointmentID$^{(PK)}$, ProcedureID$^{(FK)}$,Time, Description, Date}

F = {PatID$^{(FK)}$ → AppointmentID$^{(PK)}$; AppointmentID$^{(PK)}$ → {Time, Description, Date}}

i. Step 1: Converting to 1NF
   - Table is already in 1NF

ii. Step 2: Converting to 2NF
   - There is a partial dependency. We can decompose this table.
     - Appointment{$AppointmentID^{(PK)}$, Time, Description, Date}
     - PatientAppointment{$PatID^{(FK)}$, $AppointmentID^{(FK)}$)

iii. Step 3: Converting to 3NF
   - Table is already in 3NF
   - Appointment{$AppointmentID^{(PK)}$, Time, Description, Date}
   - PatientAppointment{$PatID^{(FK)}$, $AppointmentID^{(FK)}$)

iv. Step 4: Converting to BCNF
   - The table is already in BCNF
   - Appointment{$AppointmentID^{(PK)}$, Time, Description, Date}
   - PatientAppointment{$PatID^{(FK)}$, $AppointmentID^{(FK)}$)

h. Relation Table Licensure

R = (Certifications, $LicenseID^{(PK)}$)

F = {$LicenseID^{(PK)}$ → Certifications}

- Table is already BCNF
- {Certifications, $LicenseID^{(PK)}$}

i. Relation Table Payment

R = ($PatID^{(FK)}$, $BillingID^{(FK)}$, $MemberID^{(FK)}$,Date, $PaymentID^{(PK)}$)

- Table is already in BCNF
- Payment = {$PatID^{(FK)}$, $BillingID^{(FK)}$, $MemberID^{(FK)}$,Date, $PaymentID^{(PK)}$}

j. Relation Table Insurance

R = ($Member\_ID^{(PK)}$, Company_address, Company_phone_number, Policy)

F = {Company_name → Company_address, company_phone_number, policy; $Member\_ID^{(PK)}$ → Company_address, Company_phone_number, Policy, Company_name}

i. Step 1: Converting to 1NF
   - Change the relationship to better focus on the patient
   - PatientInsurance($PatID^{(FK)}$, $Member\_ID^{(PK)}$, InsurerName, Policy)
   - Insurer($InsurerName^{(FK)}$, Company_address, Company_phone_number)

ii. Step 2: Converting to 2NF
   - Table is already in 2NF

iii. Step 3: Converting to 3NF
   - Table already in 3NF

iv. Step 4: Converting to BCNF
   - Table is already in BCNF
   - PatientInsurance($PatID^{(FK)}$, $Member\_ID^{(PK)}$, InsurerName, Policy)
   - Insurer($InsurerName^{(FK)}$, Company_address, Company_phone_number)

k. Relation Table Procedure
R = Procedure(Procedure_ID$^{(PK)}$, Quantities, Procedure_type, Per unit charges per insurance plan)
F = {Procedure_ID$^{(PK)}$ →Quantities, Procedure_type, Per unit charges per insurance plan; Step 1: Converting to 1NF
   - The table is already in 1NF
   i. Step 2: Converting to 2NF
      - Table is already in 2NF
   ii. Step 3: Converting to 3NF
      - Table is already in 3NF
   iii. Step 4: Converting to BCNF
      - Table is already in BCNF

l. Relation Table Invoice
R = (PatID$^{(FK)}$, EmpID$^{(FK)}$, Billing_ID$^{(PK)}$, AppID$^{(FK)}$, Date, Invoice under one main supervising Dentist, Medical_professional_name, Procedures_performed)
   i. Step 1: Converting to 1NF
      - Table is already in 1NF
   ii. Step 2: Converting to 2NF
      - Table is already in 2NF
   iii. Step 3: Converting to 3NF
      - Table is already in 3NF
   iv. Step 4: Converting to BCNF
      - Table is already in BCNF

m. Relation Table Allergy
R = (MH_ID$^{(FK)}$, AllergyID$^{(PK)}$, Severity, Allergen, Last Reaction Date, Reaction, Diagnose Date)
   i. Step 1: Converting to 1NF
      - Table is already in 1NF
   ii. Step 2: Converting to 2NF
      - Table is already in 2NF
   iii. Step 3: Converting to 3NF
      - Table is already in 3NF
   iv. Step 4: Converting to BCNF
      - Table is already in BCNF

n. Relation Table Medication
R = (Medication ID$^{(PK)}$, Start Date, End Date, Route of Administration, Provider, Dosage, Medication Name, Frequency)
   i. Step 1: Converting to 1NF
      - Table is already in 1NF
   ii. Step 2: Converting to 2NF
      - Table is already in 2NF
   iii. Step 3: Converting to 3NF
      - Table is already in 3NF

iv. Step 4: Converting to BCNF
- Table is already in BCNF

o. Relation Table Medical History
R = (PatID$^{(FK)}$, EmpID$^{(FK)}$, MH_ID$^{(PK)}$, Emergency contact info, Date of Last X-Ray, Surgery Info, Date, Preferred_pharmacy, Immunization, Physical_test/exam)
i. Step 1: Converting to 1NF
- Table is already in 1NF
ii. Step 2: Converting to 2NF
- Table is already in 2NF
iii. Step 3: Converting to 3NF
- Table is already in 3NF
iv. Step 4: Converting to BCNF
- There are functional dependencies between the foreign keys and the primary keys. We can decompose the table
- MedicalHistory0 {MH_ID$^{(PK)}$, Emergency contact info, Date of Last X-Ray, Surgery Info, Date, Preferred_pharmacy, Immunization, Physical_test/exam}
- MedicalHistory1 {PatID$^{(FK)}$, EmpID$^{(FK)}$, MH_ID$^{(PK)}$}

p. Relation Table App_Proc
R = (AppointmentID$^{(FK)}$, ProcedureID$^{(FK)}$)
- Is already in BCNF

q. Relation Table All_Med
R = (AllergyID$^{(FK)}$, MedicationID$^{(FK)}$)
- Is already in BCNF

r. Relation Table Ins_Acctypes
R = (AcceptedTypes, Member_ID$^{(FK)}$)
- Is already in BCNF

s. Relation Table Doctor
R = Doctor(EmpID$^{(PK)}$, SSN$^{(PK)}$)
- Is already in BCNF

t. Relation Table Nurse
R = (EmpID$^{(PK)}$, SSN$^{(PK)}$)
- Is already in BCNF

u. Relation Table Receptionist
R = (EmpID$^{(PK)}$, SSN$^{(PK)}$)
- Is already in BCNF

v. Relation Table Hiring Manager
R = (EmpID$^{(PK)}$, SSN$^{(PK)}$)
- Is already in BCNF

w. Relation Table Debit Card
R = (PaymentID$^{(PK)}$, Exp_date, DC_number$^{(PK)}$)

- Is already in BCNF

x. Relation Table Payment Plan

R = (PaymentID$^{(PK)}$, Num_of_install)

- Is already in BCNF

y. Relation Table Credit Card

R = (PaymentID$^{(PK)}$, CC_number$^{(PK)}$, Exp_date)

- Is already in BCNF

z. Relation Table Cash

R = (PaymentID$^{(PK)}$, Amount, Change)

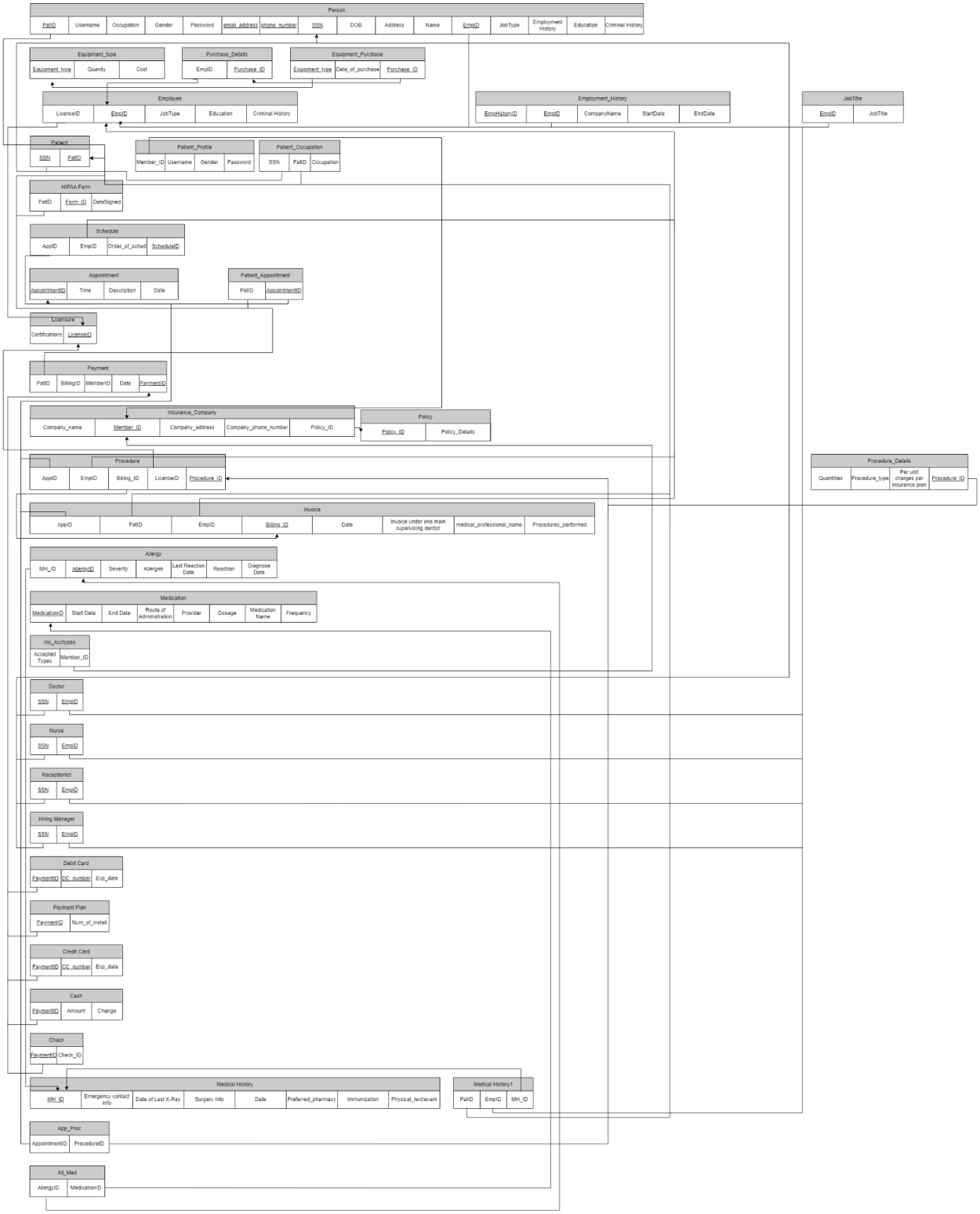
- Is already in BCNF

aa. Relation Table Check

R = (Check_ID$^{(PK)}$, PaymentID$^{(PK)}$)

- Is already in BCNF

3. Final Relational Schema After Normalization



4. SQL Queries For Relational Algebra

a. Create a list of patients and the medications they currently take. Sort your list by patient's last name and medication name in alphabetical order. Include other applicable details such as date prescribed and dosage.

```
SELECT Name, Age, Medication_Name, Date
FROM Patient, Medication, Medical History;
```

b. Display patient information for patients who currently have Delta Dental insurance policy.

```
SELECT * FROM Person, Patient, Insurance
WHERE Policy = Delta_Dental;
```

c. Generate a list of procedures and dates of service performed by doctor Smilow.

```
SELECT Medical_professional_name, Procedures_performed, Date
FROM Invoice WHERE Medical_professioal_name = Doctor Smilow;
```

d. Print out a list of past due invoices with patient contact information. Past due is defined as over 30 days old with a balance over $10.

```
SELECT Date, Charge, PatId, Name, Phone_number, Email_address
FROM Invoice, Patient, Person
WHERE Date-Current_Date > 30 AND Charge > 10;
```

e. Find the patients who brought the most revenue in the past year. You can define how many records you want to display in the result of this query.

```
SELECT Name, PatID, SUM(Charge)
FROM (SELECT Name, PatID, Date, Charge
        FROM Person, Patient, Invoice
        WHERE Date-Current_Date <366)
GROUP BY PatID;
```

f. Create a list of doctors who performed less than 5 procedures this year.

```
SELECT Medical_professional_name, COUNT(Medical_procedures_performed)
as Num_procedures
FROM((SELECT Date, Medical_professional_name, Procedures_performed
        FROM Invoice
        WHERE Date-Current_Date <366))
```

```
GROUP BY Medical_professional_name
WHERE Num_procedurese <5;
```

g. Find the highest paying procedures, procedure price, and the total number of those procedures performed. Sort your list with the highest paying procedures showing at the top of
your list.

```
SELECT Procedure_Type, Per_unit_charges_per_insurance_plan, quantities
FROM Procedures
ORDER BY per_unit_charges_per_insurace_plan DESC;
```

h. Create a list of all payment types accepted, number of times each of them was used, and total amount charged to that type of payment.

```
SELECT Charge
FROM Invoice
```

i. Find the name of the most popular insurance plan currently used by the patients.

```
SELECT Company_name, COUNT(PatID)
FROM(SELECT Company_name, Payer_ID, PatID
        FROM Insurance, Patient)
GROUP_BY Company_name;
```

5. Additional Queries

a. Find the procedure that has been performed the most.

```
SELECT Procedure_Tpe, Max(Quantities)
FROM Procedures;
```

b. Find the average cost for equipment.

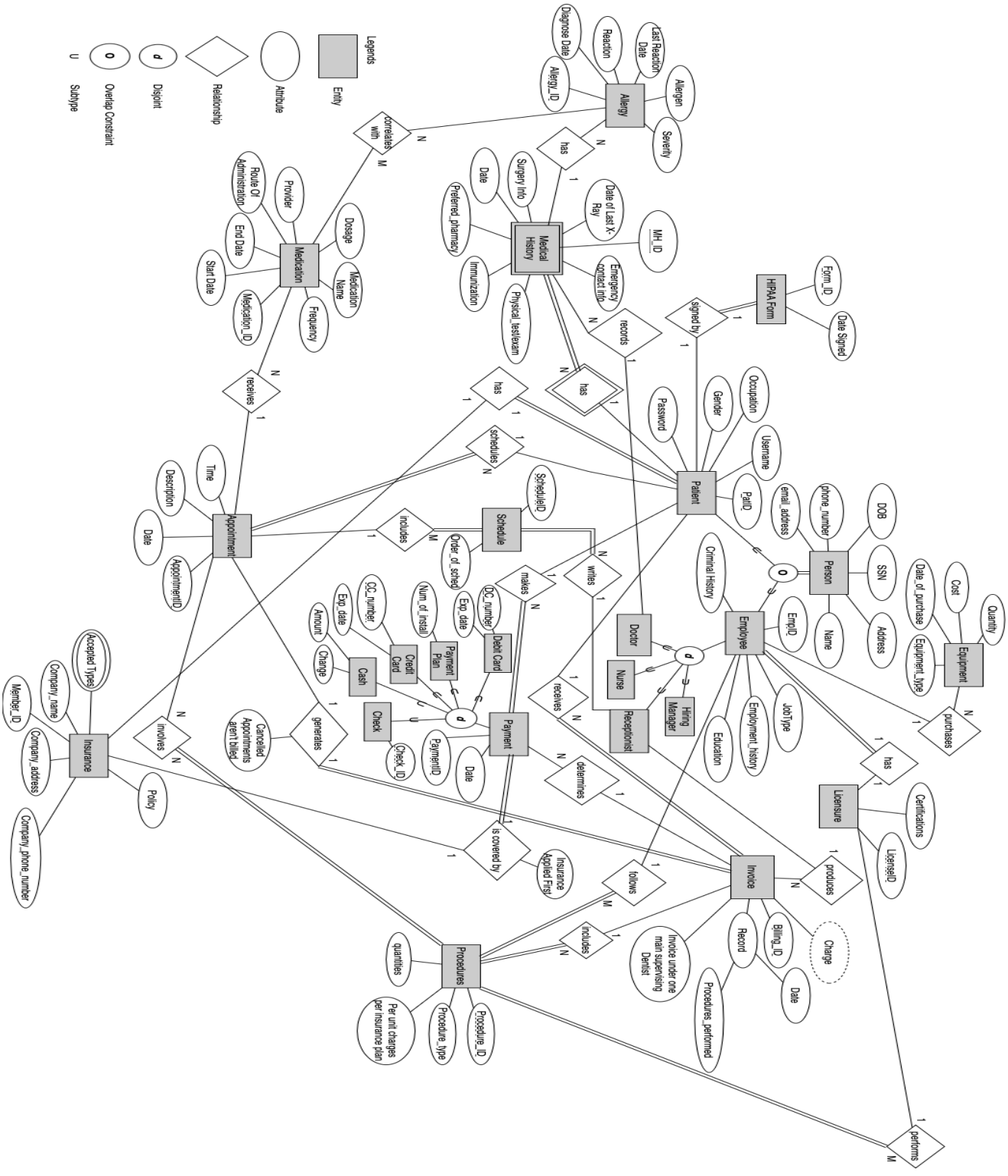
```
SELECT AVG(Cost)
FROM Equipment;
```

c. Find the patient that has scheduled the most number of appointments.

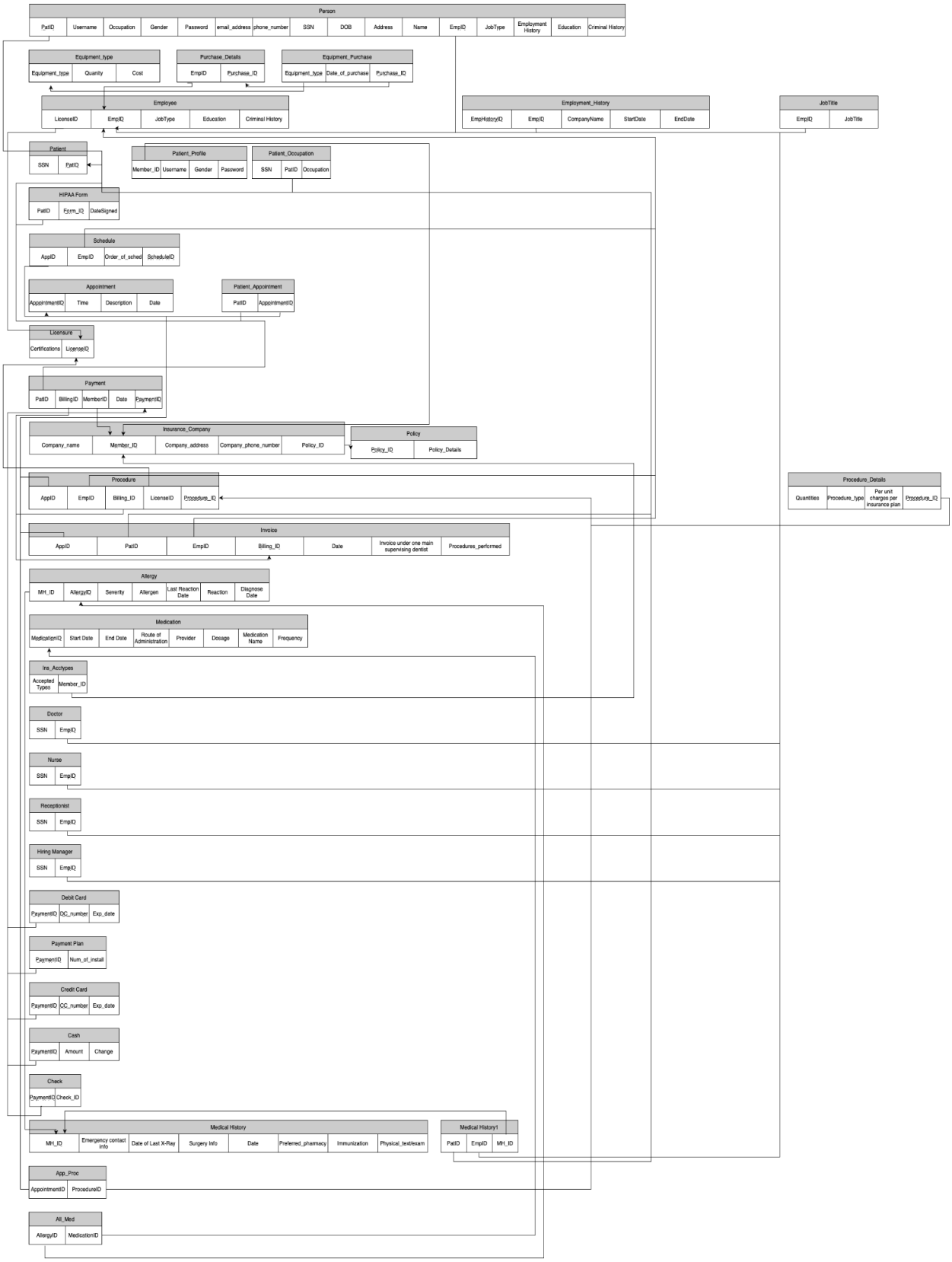
```
SELECT Name, PatID, Count(Date)
FROM (SELECT * FROM Person, Patient, Appointment)
GROUP BY PatId;
```

PART 4

ERD 4.0


Legends
Entity
Attribute
Relationship
d
Disjoint
O
Overlap Constraint
U
Subtype
Allergy
Diagnose Date
Reaction
Last Reaction Date
Allergen
Severity
Allergy_ID
correlates with
has
Medical History
Surgery Info
Date of Last X-Ray
MH_ID
Emergency contact info
Physical_test/exam
Immunization
Preferred_pharmacy
Date
records
HIPAA Form
Form_ID
Date Signed
signed by
Medication
Route Of Administration
Provider
Dosage
Medication Name
Frequency
Medication_ID
End Date
Start Date
receives
Patient
Password
Gender
Occupation
Username
PatID
has
schedules
Appointment
Description
Time
Date
AppointmentID
Schedule
ScheduleID
Order_of_sched
includes
writes
makes
Person
email_address
phone_number
DOB
SSN
Address
Name
Criminal History
Employee
EmpID
Doctor
Nurse
Receptionist
Hiring Manager
JobType
Employment_history
Education
Equipment
Cost
Quantity
Date_of_purchase
Equipment_type
purchases
Licensure
Certifications
LicenseID
Insurance
Accepted Types
Company_name
Member_ID
Company_address
Company_phone_number
Policy
involves
generates
Cancelled Appointments aren't billed
Payment
Cash
Credit Card
Debit Card
Check
CC_number
Exp_date
Amount
Charge
Num_of_Install
Payment Plan
Check_ID
PaymentID
Date
determines
is covered by
Insurance Applied First
Invoice
produces
follows
Billing_ID
Record
Charge
Date
Invoice under one main supervising Dentist
Procedures_performed
includes
Procedures
quantities
Per unit charges per insurance plan
Procedure_type
Procedure_ID
performs

Complete Relational Schema



6. Relational Algebra Updated

j. Create a list of patients and the medications they currently take.

$\pi_{(\text{Name, Age, Medication Name, Date})}(\text{Patient} \bowtie \text{Medication} \bowtie \text{Medical History})$

k. Display patient information for patients who currently have Delta Dental insurance policy.

$\sigma_{\text{Policy=Delta Dental}}((\pi (\text{Person} \bowtie \text{Patient} \bowtie \text{Insurance})$

l. Generate a list of procedures and dates of service performed by doctor Smilow.

$\sigma_{\text{Medical\_professional\_name = Doctor Smilow}} (\pi_{\text{Date, Medical\_professional\_name, Procedures\_performed}}(\text{Invoice}))$

m. Print out a list of past-due invoices with patient contact information. Past due is defined as over 30 days old with a balance over $10.

$\sigma_{\text{Date>30 days AND Charge>\$10}}((\pi_{\text{Date, Charge,PatId, Name, phone\_number,email\_address}}(\text{Invoice} \bowtie \text{Patient} \bowtie \text{Person}))$

n. Find the patients who brought the most revenue in the past year.

$_{\text{Name}}\mathbf{F}_{\text{SUM Charge}}((\pi_{\text{Name,PatID,Date,Charge}}(\text{Person} \bowtie (\text{Patient} \bowtie \text{Payment} \bowtie \text{Invoice})))$

o. Create a list of doctors who performed less than 5 procedures this year.

$\sigma_{\text{Num\_procedures\_performed} < 5}(\rho_{(\text{Medical\_professional\_name, Num\_procedures\_performed})}(_{\text{Medical\_professional\_name}}F_{\text{COUNT Procedures\_performed}} (\pi_{\text{Date, Medical\_professional\_name, Procedures\_performed}}(\text{Invoice}))))$

p. Find the highest paying procedures, procedure price, and the total number of those procedures performed.

$\sigma_{\text{MAX Per Unit Charges Per Insurance Plan}}(\pi_{\text{Procedure Type, Per Unit Charges Per Insurance Plan, Quantities}}(\text{Procedures}))$

q. Create a list of all payment types accepted, the number of times each of them was used, and the total amount charged to that type of payment.

$\text{Num\_used} \leftarrow (\pi_{\text{COUNT Date}}(\text{Credit Card})) \text{ X } (\pi_{\text{COUNT Date}}(\text{Debit Card})) \text{ X } (\pi_{\text{COUNT Date}}(\text{Payment Plan})) \text{ X } (\pi_{\text{COUNT Date}}(\text{Cash})) \text{ X } (\pi_{\text{COUNT Date}}(\text{Check}))$

Credit_charge ← $\pi_{\text{SUM Charge}}(\pi_{\text{Date}}(\text{Credit Card})) \text{ X } (\pi_{\text{Charge}}(\text{Invoice}))$

Debit_charge ← $\pi_{\text{SUM Charge}}(\pi_{\text{Date}}(\text{Debit Card})) \text{ X } (\pi_{\text{Charge}}(\text{Invoice}))$

Plan_charge ← $\pi_{\text{SUM Charge}}(\pi_{\text{Date}}(\text{Payment Plan})) \text{ X } (\pi_{\text{Charge}}(\text{Invoice}))$

Cash_charge ← $\pi_{\text{SUM Charge}}(\pi_{\text{Date}}(\text{Cash})) \text{ X } (\pi_{\text{Charge}}(\text{Invoice}))$

Check_charge ← $\pi_{\text{SUM Charge}}(\pi_{\text{Date}}(\text{Check})) \text{ X } (\pi_{\text{Charge}}(\text{Invoice}))$

Check_charge X Debit_charge X Plan_charge X Cash_charge X Check_charge X Num_used

r. List ids and names of insurance plans ever used by patients and how many patients have that plan.

F1←$(\pi_{\text{Company\_name, Payer\_ID}}(\text{Insurance}))$

F2← $_{\text{Company\_name}}F_{\text{COUNT PatID}}(\pi_{\text{PatID}}(\text{Patient})) \bowtie$ F1

F1 ⋈ F2

Changes made from Part 3:

- ERD:
  - Removed the primary key for the email address and phone number for Person.
  - Removed SSN as the primary key for Person.
  - Removed medical profession name in Invoice as it is already stored in EmpID.
  - Changed the relationship between allergy and medication.
- Complete Relational Schema:
  - Removed the relationship of SSN as the primary key and foreign key of tables.
  - Removed the primary key email address and phone number for Person.
  - Remove the column medical profession name for Invoice.
  - Added relationship of memberID, and billingID for Payment table with Insurance_company table and invoice table as foreign key.
- RA: Updated based on changes above
- Normalization:
  - Updated based on comments
  - Added Criminal History Table
  - Fixed Insurance issues
  - Removed unnecessary info from procedure table

    - Added ProcedureID to appointment
- Create SQL:
    - Removed one of the insurance company tables created twice.
    - Added policy_details table with primary key policy_id.
    - Fix create for Payment table by removing EmpID as foreign and adding PatID, BillingID, and MemberID as the foreign key that references the respective tables.
    - Fixed the double SSN primary key for the doctor, nurse, and receptionist. Removed the SSN as a foreign key. As there is already an empID for the foreign key.
- Insert SQL
    - Insert data into all tables.
- Select SQL
    - Fixed Select SQL to work.

Indexes To Be Used

1. B-Tree Index
    a. B-Tree Index is best for ranged queries and efficient access to the database. Since the business is a dental office, it is possible that the owner wants to look at the range of appointments for a patient. The B-tree index will be located in the Patient ID column and return all the appointments that correlate with the Patient ID without having to search the entire database.

    ```
    CREATE INDEX index_patient
    ON Patient (PatID);
    ```

2. Hash-index
    a. Hash index is best for fast lookup using specific values. It is possible that the owner wants to search all the payments on a particular date. This would help the owner with balancing his books and managing his taxes quickly.

    ```
    CREATE INDEX index_payment
    ON Payment (Date);
    ```

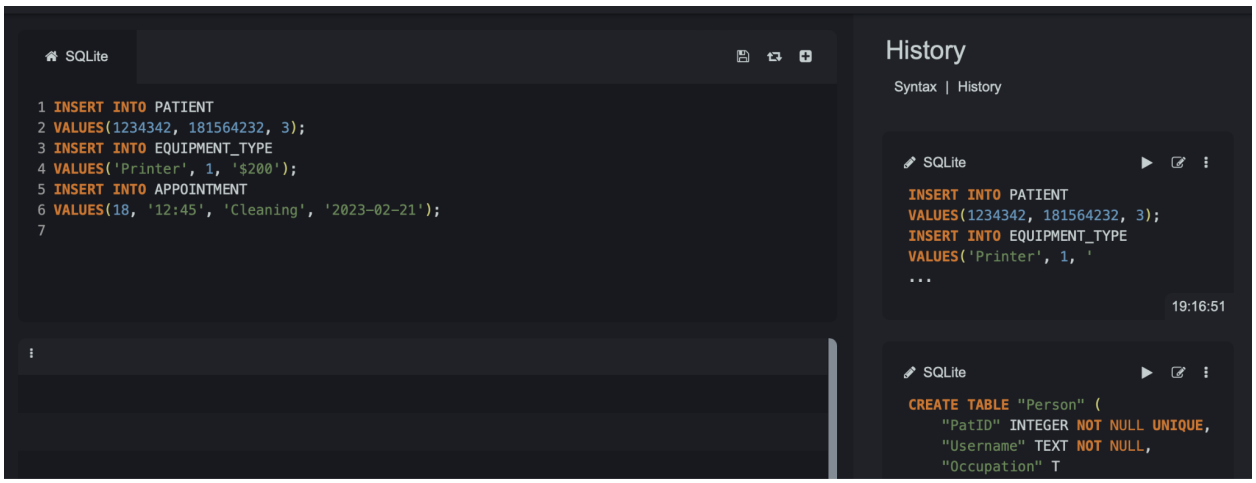
Views

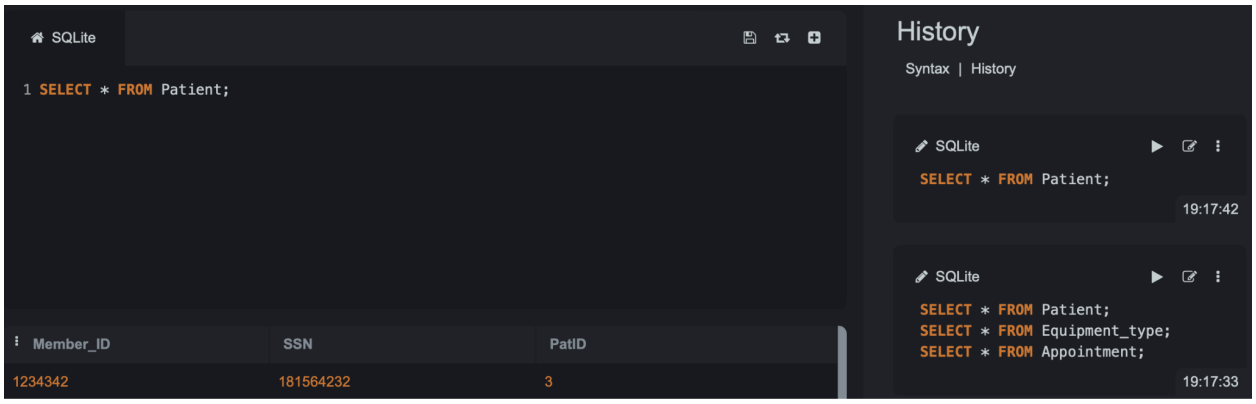
- View One
    - Finding which insurances pay the most for a procedure
      CREATE VIEW Insurance_procedure AS
      SELECT Procedure_ID, Per_unit_charges_per_insurance_plan, Insurance_Name
      FROM (PatID, Procedure_ID, Appointment_ID, Per_unit_charges_per_insurance_plan, Insurer, FROM PATIENT, APPOINTMENT, PROCEDURE, PATIENTINSURANCE GROUP BY Procedure_ID) GROUP BY Insurance_Name

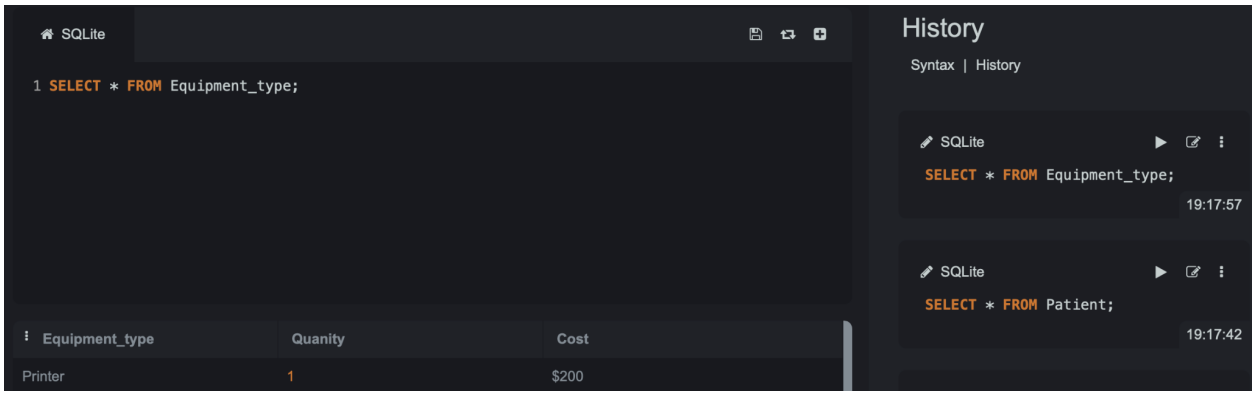
- View Two

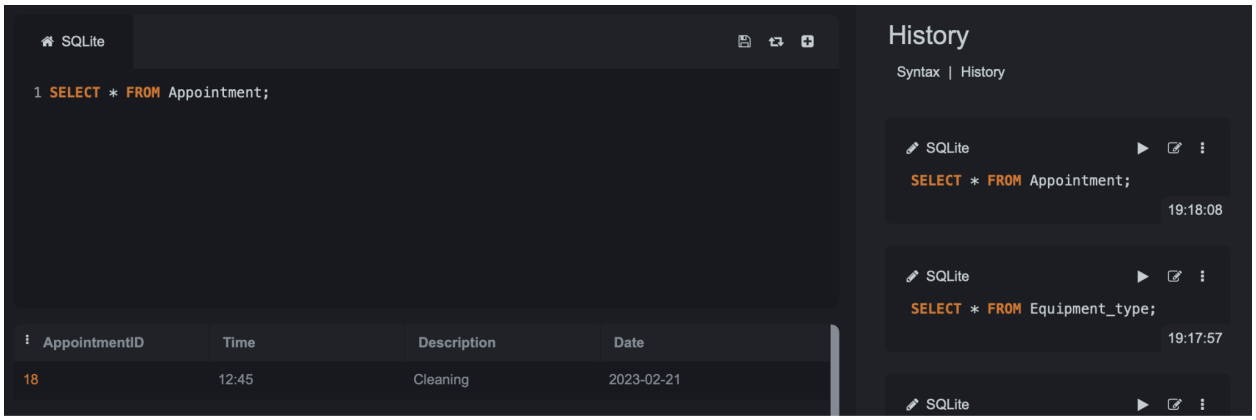
```
CREATE VIEW Patient_Age AS
SELECT
        Case when DOB > 2003 then '< 20'
                When DOB < 2003 and DOB > 1983 '>20 <40
                When DOB < 1983 then '>40'
        End AgeRange
        COUNT (*) as CountByAges
FROM
(SELECT PatID, SSN, DOB FROM PATIENT, PERSON)
GROUP BY AgeRange
```

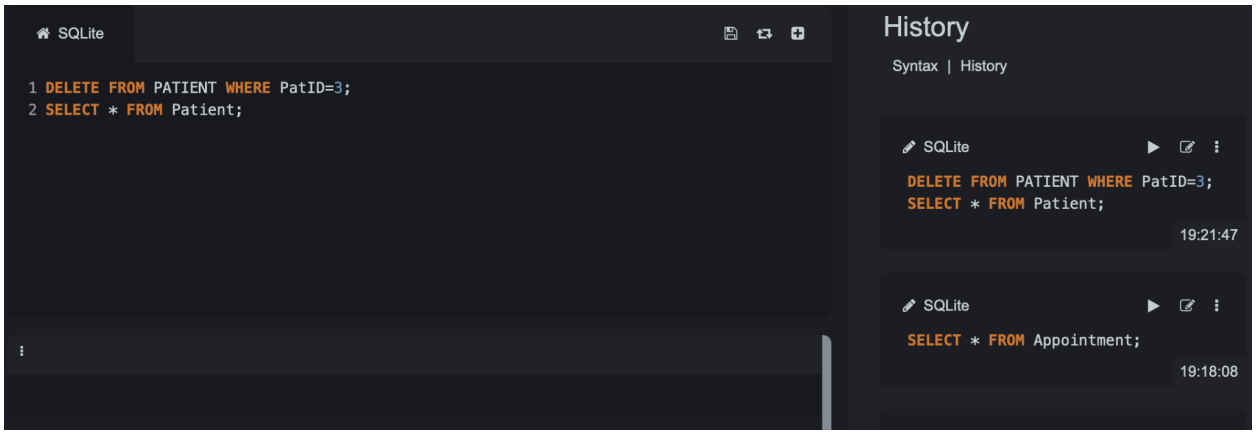
Sucessfull Insert Delete Queries Pictures

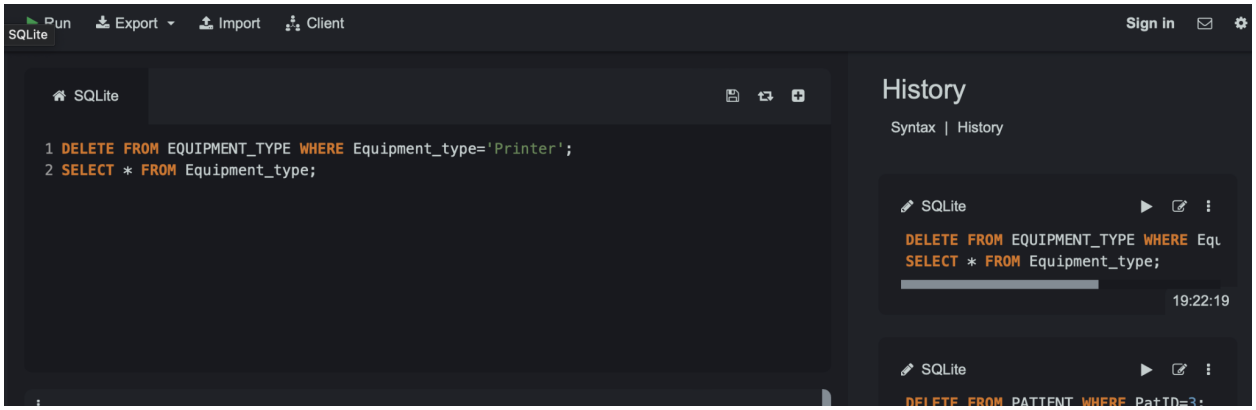


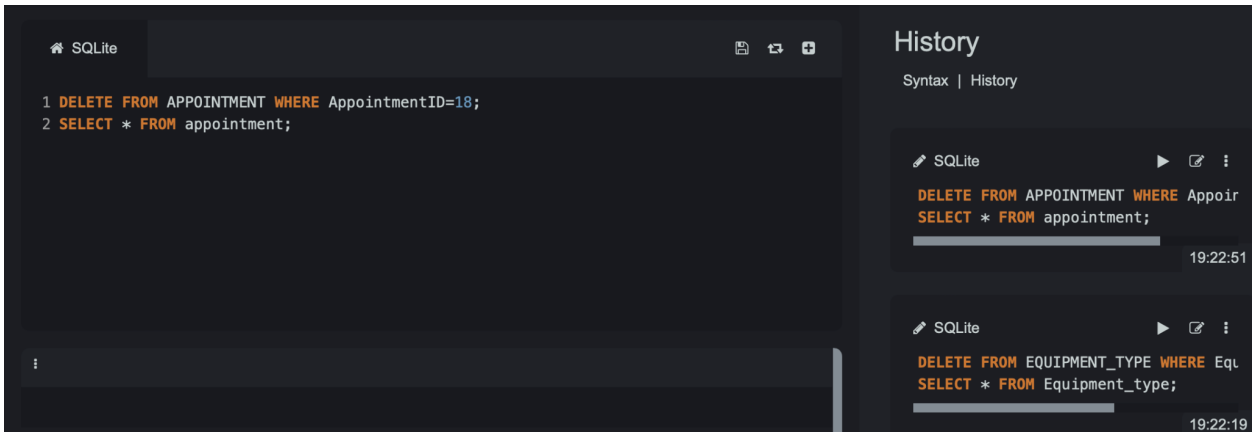

SQLite
1 SELECT * FROM Patient;
Member_ID
SSN
PatID
1234342
181564232
3
History
Syntax | History
SQLite
SELECT * FROM Patient;
19:17:42
SQLite
SELECT * FROM Patient;
SELECT * FROM Equipment_type;
SELECT * FROM Appointment;
19:17:33


SQLite
1 SELECT * FROM Equipment_type;
Equipment_type
Quanity
Cost
Printer
1
$200
History
Syntax | History
SQLite
SELECT * FROM Equipment_type;
19:17:57
SQLite
SELECT * FROM Patient;
19:17:42


SQLite
1 SELECT * FROM Appointment;
AppointmentID
Time
Description
Date
18
12:45
Cleaning
2023-02-21
History
Syntax | History
SQLite
SELECT * FROM Appointment;
19:18:08
SQLite
SELECT * FROM Equipment_type;
19:17:57
SQLite


SQLite
1 DELETE FROM PATIENT WHERE PatID=3;
2 SELECT * FROM Patient;
History
Syntax | History
SQLite
DELETE FROM PATIENT WHERE PatID=3;
SELECT * FROM Patient;
19:21:47
SQLite
SELECT * FROM Appointment;
19:18:08





Transaction

- Transaction 1:

  Update HIPAA Form

  1. Read Join Person Patient and HIPAA
  2. Write Update Form_ID
  3. Write Update Date Signed

     BEGIN TRANSACTION:

     SELECT * FROM PERSON, PATIENT, HIPAA

     WHERE Pat_ID = Desired_Pat_ID as HIPUP

UPDATE OR ROLLBACK HIPUP

SET Form_ID = New_Form_ID

Set Date_Signed = Current_Date

COMMIT;

This is crucial to update together because Form ID is dependent on Date Signed and queries in between would result in a dirty read.

- Transaction 2

  Charge for X-Ray

  1. Read Join Person Patient Invoice
  2. Insert Invoice
  3. Read Medical_History
  4. Update Date of Last X-Ray

  BEGIN TRANSACTION

  SELECT * FROM PERSON, PATIENT, INVOICE

  WHERE Pat_ID = Desired_Pat_ID as IN

  INSERT OR ROLLBACK INTO IN

  VALUES(Charge, Date, Invoice under one main supervising Dentist, Dentist Name, Procedures_performed)

  SELECT Date_of_last_x-ray FROM MEDICAL_HISTORY

Where Pat_ID = Desired_Pat_ID as X

UPDATE OR ROLLBACK X

SET Date_of_last_x-ray = current_date

COMMIT:

If this is not updated in medical history then patients could be treated incorrectly and the procedure could not be covered by insurance if it is not recorded properly.

Resources

[1] Thompson, April. “Dental Office Patient Registration Prior to Dental Appointment.” *As The Drill Turns*, As The Drill Turns, 21 Oct. 2022, https://asthedrillturns.com/2019/09/21/dental-office-patient-registration/.

[2] Unitek College. “Step-by-Step Master's Guide to Dental Billing & Insurance.” *Unitek College*, Unitek College Https://Www.unitekcollege.edu/Wp-Content/Uploads/2017/07/Unitek-College-Logo-01.Svg, 17 Oct. 2022, https://www.unitekcollege.edu/blog/step-by-step-guide-to-dental-billing-and-insurance/.

[3] Unitek College. “Step-by-Step Master's Guide to Dental Appointment Scheduling.” *Unitek College*, Unitek College Https://Www.unitekcollege.edu/Wp-Content/Uploads/2017/07/Unitek-College-Logo-01.Svg, 17 Oct. 2022, https://www.unitekcollege.edu/blog/step-by-step-guide-to-dental-appointment-scheduling/.

[4] Mers, Tony. “Essential Equipment to Have in Your Dental Office.” *Henry Schein*, 8 Jan. 2020, https://dentalpracticetransitions.henryschein.com/essential-equipment-to-have-in-your-dental-office/.