Drug Store Chain Database Design

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CST 363: Intro to Database Systems

January 26th, 2021

Introduction

The goal of this project is to develop a relational database that meets the specified criteria outlined in the provided specifications sheet. According to the client, their drug store chain is growing and needs a sophisticated database to catalog various forms of records across their pharmacies. The client provided a total of twelve informational bullet points to follow when designing the database. Upon analysis of these bullet points, the following seven entities were identified: patient, doctor, pharmaceutical company, drug, pharmacy, prescription, and contract. The bullet points also provide hints regarding the attributes of the entities, the relationships between entities, and cardinality constraints.

To efficiently design the database, the following steps will be taken. First, the customer's list of requirements will be analyzed and formalized into a detailed list of database requirements. Next, an entity relationship (ER) diagram will be drafted. This will allow all parties to visualize the entities of the database and the relationships between them. Then, a relational schema will be drafted to show how keys are related between tables. After, the database and sample records will be coded using MySQL. Once the database is coded, the database will be reviewed once more for normalization. Finally, a list of five SQL statements will be presented to demonstrate that the database works accurately.

In addition to the database, a user-friendly web application will be deployed. This web application provides convenient access to the database, while reducing the number of errors introduced to the database. The web application provides access for doctors, patients, pharmacists, and government agencies. Doctors and patients will have access to prescription data, whereas pharmacists and government entities will be able to see how many drugs are prescribed and sold.

Through this process, our consultancy group will minimize project time and maximize productivity to bring you the product your business requires.

Database Requirements

The following list outlines how the customer's requirements were interpreted and formalized into database requirements:

Requirement: Patients personal information must be collected and include their SSN, name, age, address, and an identifier for their primary care provider.

- Entity: PATIENT with attributes: <u>PatientID</u>, PrimaryCareID, PatientDOB, PatientSSN, PatientFirstName, PatientLastName, and PatientAddress(PatientZip, PatientStreetNumber, PatientStreetName, PatientCity, PatientState), PrimaryCareID.
- Primary Key: PatientID is the primary key, and SSN is a candidate. However, SSN is not used for security reasons.
- Foreign Key: PrimaryCareID, which points to DocID of the patient's primary care physician.
- Note: Date of birth was used instead of age, as it does not have to be recalculated every year.

Requirement: The Doctors attributes that are needed are their SSN, name, specialty, and their years of experience.

- Entity: DOCTOR with attributes: <u>DocID</u>, DocDateHired, DocSpecialty, DocSSN, DocPhoneNumber, DocYearsExperience, and DocName(DocFirstName, DocLastName).
- Primary Key: DocID is the primary key, DocSSN is a candidate. However, DocSSN is not used for security reasons.

- Note: A patient has exactly one primary physician. A doctor has one to many patients. A 1:M relationship exists. Date hired is obtained so that years of experience (which includes previous experience) can be incremented on a yearly basis.

Requirement: Pharmaceutical companies on file need an identifying name and a phone number.

- Entity: PHARMACOMP with attributes: <u>PCName</u> and PCPhoneNumber
- Primary key: PCName is the primary key, no two Pharmaceutical Companies should hold the exact same name because of copyright laws allowing this to be a unique identifier for each pharmaceutical company.

Requirement: Drugs on file need an identifying trade name, their formula, and an identifying name for the pharmaceutical company who procures it.

- Entity: DRUG with attributes: <u>DrugName</u> and DrugFormula, PCName
- Primary key: DrugName is the primary key, no two drugs should have the same name as copyright would prevent such duplication.
- Foreign key: PCName, aka the pharmaceutical company who procures the drug listed.
- DRUG and PHARMACOMP have a (1:M) relationship but the DRUG needs to have a PCName from PHARMACOMP. It is assumed that if PCName no longer exists, all drugs related to the PCName would no longer need to be tracked.

Requirement: Pharmacies on file need to have a name, address, and phone number logged.

- Entity: PHARMACY with attributes: <u>PharmID</u>, PharmName, PharmPhoneNumber, PharmAddress (PharmZip, PharmStreetNumber, PharmStreetName, PharmCity, PharmState)
- Primary key: PharmID is the primary key, as there can be multiple pharmacies running under the same name.

Requirement: Pharmacies sell drugs and have a price for each drug that they sell. Each pharmacy has its own price for each drug which may be different for the same drug.

- Entity: SELLS with attributes: DrugName, PharmID, Price
- Primary key: <u>DrugName</u>, <u>PharmID</u>
- Foreign key: Drugname, PharmID
- A pharmacy sells many drugs, and a drug is sold at many pharmacies. A M:N relationship exists.
- Relationship attribute: Price

Requirement: Doctors can prescribe drugs to patients and a doctor may prescribe one or more drugs to several patients. A patient may receive prescriptions from a multitude of doctors. Only the latest prescription is stored for a patient-drug combination. When prescriptions are filled the pharmacy that filled the prescription and the date when the prescription was filled should be logged.

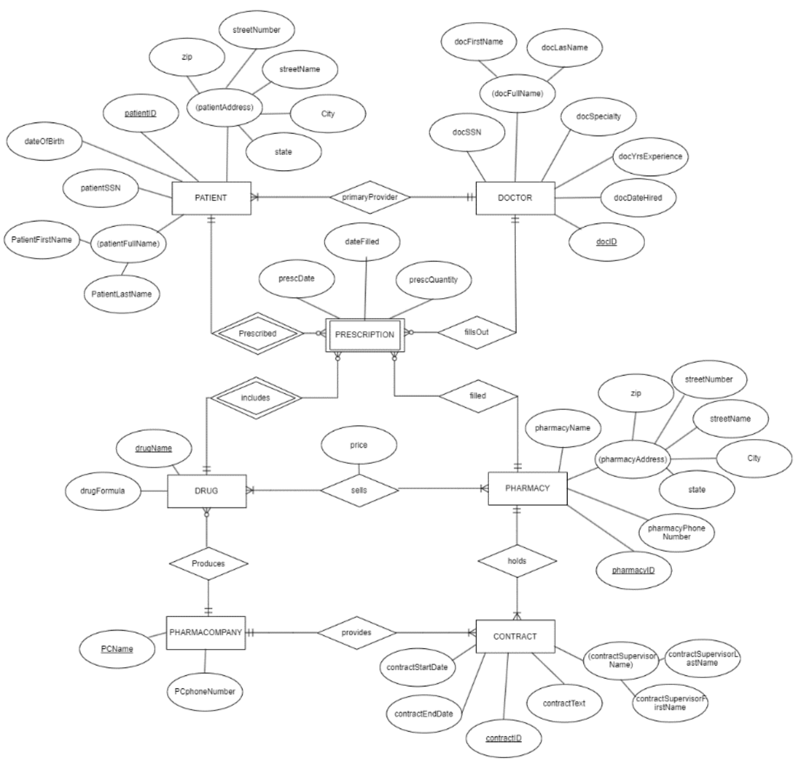
- Entity: PRESCRIPTION with attributes: <u>PatientID</u>, <u>DrugName</u>, PrescDate, PrescQuantity, DocID, PrescDateFilled, PharmacyFilled
- Primary Key: PatientID and DrugName
- Relationships: Doctors create many prescriptions, but prescriptions can only be created by one doctor (1:M). Patients receive many prescriptions, but only one prescription is provided to any given patient (1:M).
- Attributes of note: PatientID and DrugName are both primary keys, as they need to be unique for each record. PrescDateFilled and PharmacyFilled can be null because when a drug is prescribed, it has not yet been filled.
- Foreign Keys: PatientID, DrugName, DocID, PharmacyFilled

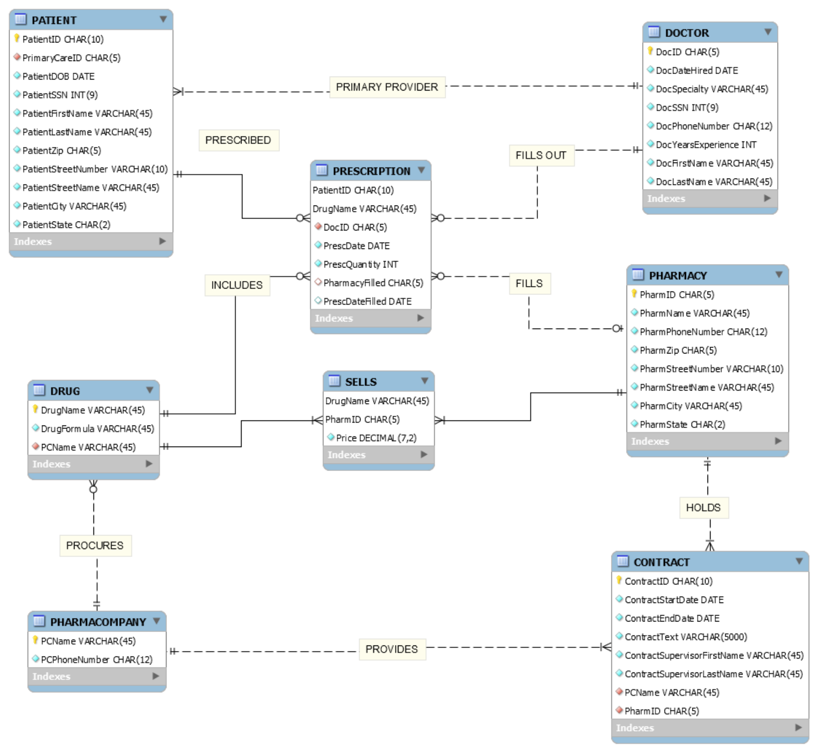
Requirement: Pharmaceutical companies and pharmacies have contracts with one another. A pharmaceutical company may hold many contracts with many pharmacies and vice versa. These contracts should have a start date, end date, and hold the text of the agreement. Each contract should have a supervisor assigned to it by the pharmacy related to the contract. The supervisor can change throughout the lifetime of the contract.

- Entity: CONTRACT with attributes: <u>ContractID</u>, ContractStartDate, ContractEndDate, ContractText, ContractPCName, ContractPharmacyID, and ContractSupervisorName (ContractSuperVisorFirstName and ContractSuperVisorLastName)
- Primary Key: ContractID
- Relationships: A pharmaceutical company can have many contracts, but a contract must be made by one pharmaceutical company (1:M). A pharmacy can have many contracts, but a contract must be held by one pharmacy (1:M).
- Attribute of note: ContractSupervisorName (ContractSuperVisorFirstName and ContractSuperVisorLastName) Each contract needs a supervisor keeping up with the contract, the supervisor does not need to be the same person for the entire length of the contract.

Entity Relationship (ER) Model

The following ER diagrams follow the database requirements outlined in the previous section.



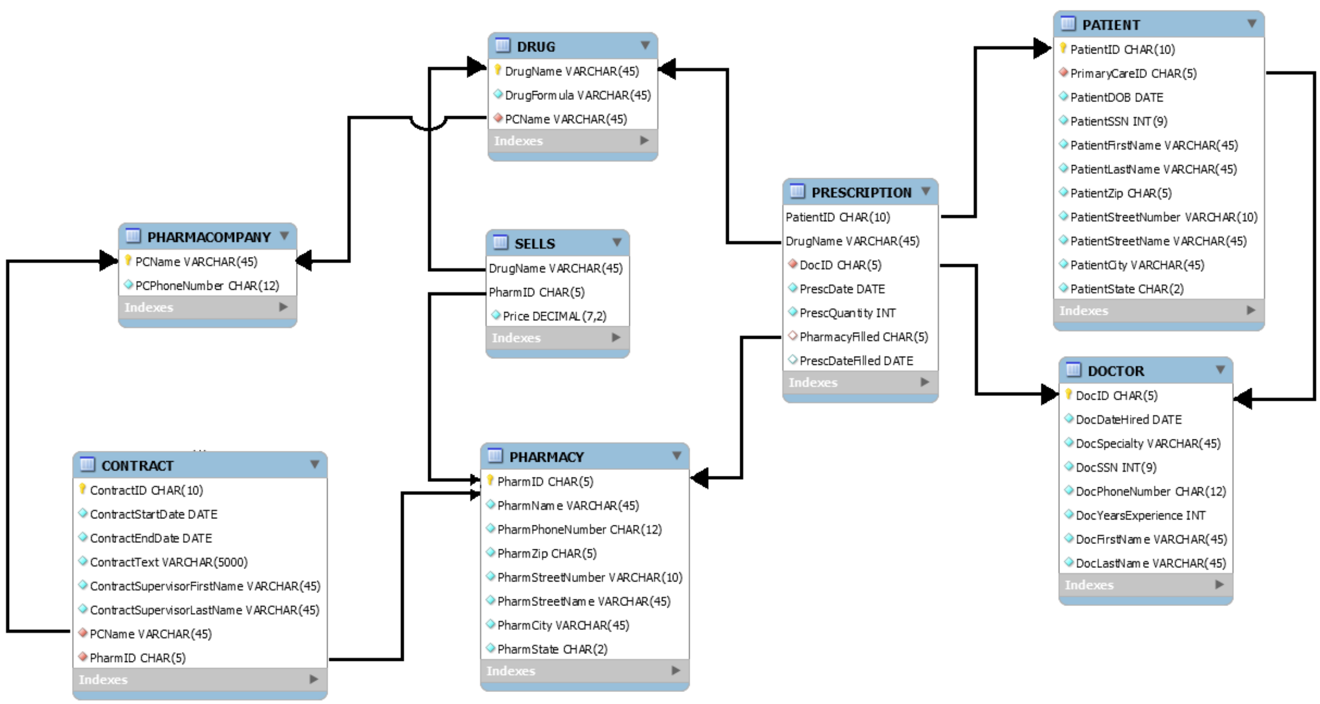


The model on the left is the ER diagram the design group originally developed. The diagram shows the relationships between all entities, and the attributes they contain. One relationship to note is that between PRESCRIPTION, PATIENT, and DRUG. PRESCRIPTION is a weak entity with two foreign keys that are also primary keys. Additionally, the relationship between DRUG and PHARMACY contains a relationship attribute due to the M:N relationship between DRUG and PHARMACY.

The diagram on the right was created using the MySQL ERR Diagram and Model tools. It adheres to the ER diagram on the right and identifies all keys within all tables. The diagram makes it easy to visualize all the attributes of each entity, and the constraints between entities. Note that SELLS becomes a table in this diagram to represent the M:N relationship from the diagram on the left.

Relational Schema

The relational schema below outlines how each table's foreign keys are related. This table is helpful for creating join statements and visualizing the relationship between tables.



Notes on attributes and their constraints:

- All tables have default update options (update restrict) and delete options (delete restrict).
- All date related attributes are presented as DATE data types.
- All phone number attributes are constrained to 12 characters to allow for dashes between sections of the phone number. It is assumed that these are local numbers and do not need a foreign country extension.
- All SSN attributes are constrained to nine digits as American SSNs only go to nine digits, it is assumed all patients have an American SSN.
- All addresses are comprised of the following attributes: Zip constrained to 5 characters, Street Number constrained to 10 characters, Street Name constrained to 45 characters, City constrained to 45 characters, and State constrained to 2 characters. This allows for almost anyone's address to be input into the database as the longest address the team found was shorter than the longest allowable address. It is assumed that all addresses refer to locations within the United States of America.

- All attributes are required (NOT NULL) for all tables except for PRESCRIPTION (prescription date filled and pharmacy filled). A prescription can exists and not yet be fulfilled so these attributes must be allowed to be left blank.

The following statements describe how the tables were created in SQL, along with minor notes not referenced above:

```
CREATE TABLE doctor
  (
     docid              CHAR(5) NOT NULL,
     docdatehired        DATE NOT NULL,
     docspecialty       VARCHAR(45) NOT NULL,
     docssn             INT(9) NOT NULL,
     docphonenumber     CHAR(12) NOT NULL,
     docyearsexperience INT NOT NULL,
     docfirstname       VARCHAR(45) NOT NULL,
     doclastname        VARCHAR(45) NOT NULL,
     PRIMARY KEY (docid)
  );
```

-- Note: docid is restricted to five characters as this allows a flexible doctor identification key.

```
CREATE TABLE pharmacy
(
     pharmid           CHAR(5) NOT NULL,
     pharmname         VARCHAR(45) NOT NULL,
     pharmphonenumber  CHAR(12) NOT NULL,
     pharmzip          CHAR(5) NOT NULL,
     pharmstreetnumber VARCHAR(10) NOT NULL,
     pharmstreetname   VARCHAR(45) NOT NULL,
     pharmcity         VARCHAR(45) NOT NULL,
     pharmstate        CHAR(2) NOT NULL,
     PRIMARY KEY (pharmid)
  );
```

-- Note: pharmid is restricted to five characters as this allows a flexible doctor identification key.

```
CREATE TABLE pharmacompany
  (
     pcname        VARCHAR(45) NOT NULL,
     pcphonenumber CHAR(12) NOT NULL,
     PRIMARY KEY (pcname)
  );
```

```
CREATE TABLE patient
  (
     patientid            CHAR(10) NOT NULL,
     patientdob           DATE NOT NULL,
     patientssn           INT(9) NOT NULL,
     patientfirstname     VARCHAR(45) NOT NULL,
```

```
    patientlastname     VARCHAR(45) NOT NULL,
    patientzip          CHAR(5) NOT NULL,
    patientstreetnumber VARCHAR(10) NOT NULL,
    patientstreetname   VARCHAR(45) NOT NULL,
    patientcity         VARCHAR(45) NOT NULL,
    patientstate        CHAR(2) NOT NULL,
    primarycareid       CHAR(5) NOT NULL,
    PRIMARY KEY (patientid),
    FOREIGN KEY (primarycareid) REFERENCES doctor(docid)
  );

-- Note: patientid is restricted to 10 characters, allowing for flexible patient identification.
```

```
CREATE TABLE contract
  (
    contractid                     CHAR(10) NOT NULL,
    contractstartdate              DATE NOT NULL,
    contractenddate                DATE NOT NULL,
    contracttext                   VARCHAR(5000) NOT NULL,
    contractsupervisorfirstname VARCHAR(45) NOT NULL,
    contractsupervisorlastname  VARCHAR(45) NOT NULL,
    pcname                         VARCHAR(45) NOT NULL,
    pharmid                        CHAR(5) NOT NULL,
    PRIMARY KEY (contractid),
    FOREIGN KEY (pcname) REFERENCES pharmacompany(pcname),
    FOREIGN KEY (pharmid) REFERENCES pharmacy(pharmid),
    CHECK (contractstartdate <= contractenddate)
  );
-- Note: contractid is restricted to 10 characters, allowing for flexible contract identification. contractext is
-- limited to 5000 characters allowing for ample description of the contract's terms while discouraging
-- overly convoluted wording.
```

```
CREATE TABLE drug
  (
    drugname    VARCHAR(45) NOT NULL,
    drugformula VARCHAR(45) NOT NULL,
    pcname      VARCHAR(45) NOT NULL,
    PRIMARY KEY (drugname),
    FOREIGN KEY (pcname) REFERENCES pharmacompany(pcname)
  );
```

```
CREATE TABLE prescription
  (

    patientid        CHAR(10) NOT NULL,
    drugname         VARCHAR(45) NOT NULL,
    prescdate        DATE NOT NULL,
    prescquantity    INT NOT NULL,
    docid            CHAR(5) NOT NULL,
```

```
    prescdatefilled DATE,
    pharmacyfilled  CHAR(5),
    PRIMARY KEY (patientid, drugname),
    FOREIGN KEY (patientid) REFERENCES patient(patientid),
    FOREIGN KEY (drugname) REFERENCES drug(drugname),
    FOREIGN KEY (docid) REFERENCES doctor(docid),
    FOREIGN KEY (pharmacyfilled) REFERENCES pharmacy(pharmid)
  );
-- Note: quantity is an unrestricted int to allow for flexible prescriptions.
```

```
CREATE TABLE sells
  (
    drugname VARCHAR(45) NOT NULL,
    pharmid  CHAR(5) NOT NULL,
    price    NUMERIC(7, 2) NOT NULL,
    PRIMARY KEY (drugname, pharmid),
    FOREIGN KEY (drugname) REFERENCES drug(drugname),
    FOREIGN KEY (pharmid) REFERENCES pharmacy(pharmid)
  );
-- Note: price is restricted to two decimal places as following American currency restrictions.
```

Normalized Relational Schema

One of the main challenges in designing the database was ensuring that all relations were in their normalized form. It was the goal of the database design team to normalize all tables to Boyce-Codd normal form (BCNF). In this normalized form, tables contain no functional dependencies other than full key functional dependencies. As shown in the previous diagrams, almost all tables were able to be normalized to BCNF.

There were several steps taken to ensure that the relational schema was in normalized form. The first step was to use a relational database as a starting point. By using a relational database, every row becomes unique and no column can contain multiple values. This automatically establishes the database as normalized in 1NF form. To convert the tables to 2NF, the design team had to ensure that no table contained partial functional dependencies. All tables were created with a full key functional dependency, which establishes the tables in the database as being in 2NF normalized form.

Most tables were also able to be brought up to 3NF normalized form. That is, most tables do not contain transitive functional dependencies in addition to being in 2NF. Note that the candidate key of SSN in the PATIENT and DOCTOR relations do not create a transitive dependency, as transitive dependencies only occur between non-key columns. It was decided that tables PATIENT and PHARMACY will remain in 2NF form (address attributes create transitive dependencies). This was done to improve database performance and reduce the complexity of the design.

Aside from the tables, the rest of the tables were able to be normalized to BCNF. Every table was revised to ensure that only the primary key/candidate keys fully determine the other columns.

SQL Queries

Using this database, many interesting queries can be made. The following five queries can be used to gather and analyze information about the drug chain:

QUERY 1: *List the name of the patient, pharmacy id, and prescription filled date for all patients who have filled their prescriptions at any CVS or Walgreens*

```
SELECT p.patientfirstname,
       p.patientlastname,
       ph.pharmid,
       rx.prescdatefilled
FROM   patient p
       INNER JOIN prescription rx
               ON p.patientid = rx.patientid
       INNER JOIN pharmacy ph
               ON rx.pharmacyfilled = ph.pharmid
WHERE  ph.pharmname IN ( 'CVS', 'Walgreens' );
```

The query above is of interest because it allows a drug chain to see how many prescriptions were filled at the specified pharmacies. This data can be refined to show how many prescriptions were filled at any given store on any range of days.

QUERY 2: *List the doctors, the doctor ids, their years of experience, and the number of prescriptions they have given out in the year 2020*

```
SELECT rx.docid,
       d.docfirstname,
       d.doclastname,
       d.docyearsexperience,
       Count(*) AS rxGiven
FROM   prescription rx
       INNER JOIN doctor d
               ON rx.docid = d.docid
WHERE  rx.prescdate LIKE '2020%'
GROUP  BY rx.docid;
```

The query above can be used by analysts to inspect the quantity of drugs prescribed by doctors. Analysts can check if a doctor is giving out too many drugs in any given year. They can also see if there is a correlation between a doctor’s years of experience and the number of drugs they prescribe.

QUERY 3: *Display the average price of all the drugs sold by a specific pharmaceutical company given that the average price is greater than the average of all the drugs.*

```
WITH avgprice(pharmacompname, avgdrugprice)
     AS (SELECT phc.pcname,
                Avg(s.price)
         FROM   sells s
                INNER JOIN drug d
                        ON s.drugname = d.drugname
                INNER JOIN pharmacompany phc
                        ON phc.pcname = d.pcname
         GROUP  BY phc.pcname)
SELECT pharmacompname,
       avgdrugprice
FROM   avgprice
WHERE  avgdrugprice > (SELECT Avg(price) FROM sells);
```

This query allows an analyst to see which pharmaceutical companies are most expensive to purchase drugs from. This query can be further customized to display average drug prices across companies. This data can then be used to make sales decisions.

QUERY 4: *Display the total count of contracts that a pharmacy has with a specific pharmaceutical company.*

```
SELECT ph.pharmname,
       phc.pcname,
       Count(*) AS contractcount
FROM   contract c
       INNER JOIN pharmacompany phc
               ON phc.pcname = c.pcname
       INNER JOIN pharmacy ph
               ON ph.pharmid = c.pharmid
GROUP  BY ph.pharmname,
          phc.pcname;
```

This query shows all the pharmacies and the number of contracts that they have with any given pharmaceutical company. It can be used to quickly inspect which pharmaceutical companies provide the most contracts to pharmacies. This data can then be used for negotiation efforts.

QUERY 5: *Display a list of patient names who were prescribed drugs by Blackmart and who's prescription was filled by Walgreens. Include the drug name and formula name they were prescribed.*

```
SELECT p.patientfirstname,
       p.patientlastname,
       rx.drugname,
       d.drugformula
FROM   patient p
       INNER JOIN prescription rx
               ON p.patientid = rx.patientid
       INNER JOIN drug d
               ON rx.drugname = d.drugname
       INNER JOIN pharmacy ph
               ON rx.pharmacyfilled = ph.pharmid
WHERE  d.pcname = 'Blackmart'
       AND ph.pharmname = 'Walgreens';
```

This query can be used to see how many customers filled their prescriptions with drugs sold from a specific pharmaceutical company. It can then be further customized to provide data from specific stores or regions. This data can then be used to make future sales negotiations.

Web Application Requirements

After creating the database, the next step is to develop a web application for user-friendly access to the database. According to the client's directions, four criteria were identified:

1. A doctor should be able to create a new prescription for a patient.
    a. Input: doctor name, doctor SSN, patient name, patient SSN, drug name, quantity.
    b. Output: prescription data, prescription id. Pharmacy data is left empty.
2. A patient should be able to request for a prescription to be filled.

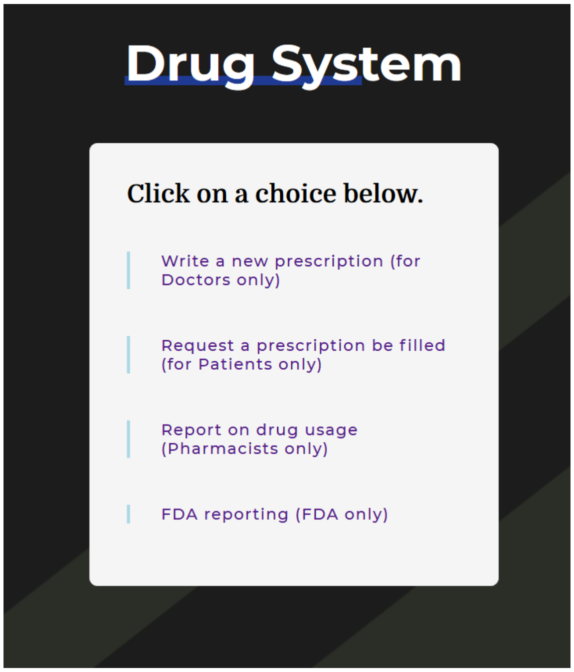
    a. All prescription data should be filled at this point, and the user should also be shown the prescription data, current date, and total cost.
3. A pharmacy manager should be able to pull up a report about the quantity of drugs that have been used to fill prescriptions.
    a. A list of drugs and quantities sold should be displayed.
    b. Input: pharmacy ID, start date, end date
4. An FDA official should be able to find how many drugs a doctor has prescribed.
    a. A list of the drug quantity sold by a doctor.
    b. Input: drug name(may be partial) and date range.

Note: Due to the change in requirements, an adjustment had to be made to the table "prescription". Our database design team has updated the table to include a prescription id (rxid), which has become the primary key. This change was done to accommodate the client's needs of including a prescription id in the web application.

User Client

The following screenshots detail how the front end works. Note that some pages contain a design, whereas others are plain. The web design is a work in progress and is meant to detail possible front-end designs.

Main Menu



The user is initially presented with four links in the main menu.

The first link sends the user to the *New Prescription Form* page where doctors will fill in the blank spaces with their data and the patient's data. Two outcomes are possible:

Error entry

Rx:	3EIEAOHGZN
Doctor:	343456789
Name:	Alberto Lucas
Patient:	431589482
Name:	ed smith
Drug:	aspirin
Quantity:	15
Pharmacy:	
Name:	
Address:	
Phone:	
Date Filled:	
Cost: $	0.0

ERROR! Please go back and ensure that the information you have entered is correct. If you continue to get an error, contact your system administrator with the following message:

Cannot add or update a child row: a foreign key constraint fails (\`drugchain\`.\`prescription\`, CONSTRAINT \`prescription_ibfk_1\` FOREIGN KEY (\`patientid\`) REFERENCES \`patient\` (\`patientid\`))

Success

Rx:	KK41BXZV2D
Doctor:	523456749
Name:	Gabriel DeLeon
Patient:	514303095
Name:	Luke Skywalker
Drug:	supermana
Quantity:	10
Pharmacy:	
Name:	
Address:	
Phone:	
Date Filled:	
Cost: $	0.0

For submissions with incorrect (left) an error message is presented with a description of the first error found. For a successful input (right) a new prescription form is created with the information provided leaving the Date filled and the Pharmacy Name empty.

The patient may request the prescription filled from the second link in the main menu:

Request prescription input screen

Request Prescription be filled.

Enter pharmacy name and address and prescription Rx number.

Rx:

Patient Name:

Pharmacy Name:

Pharmacy Address:

Request Fill for Prescription

SUCCESS

Rx:	KK41BXZV2D
Doctor:	523456749
Name:	Gabriel DeLeon
Patient:	514303095
Name:	Luke Skywalker
Drug:	supermana
Quantity:	10
Pharmacy:	WAG01
Name:	Walgreens
Address:	62455 Hello st. Pasadena CA 46345
Phone:	909-863-4567
Date Filled:	2021-02-02
Cost: $	350.0

ERROR ENTRY

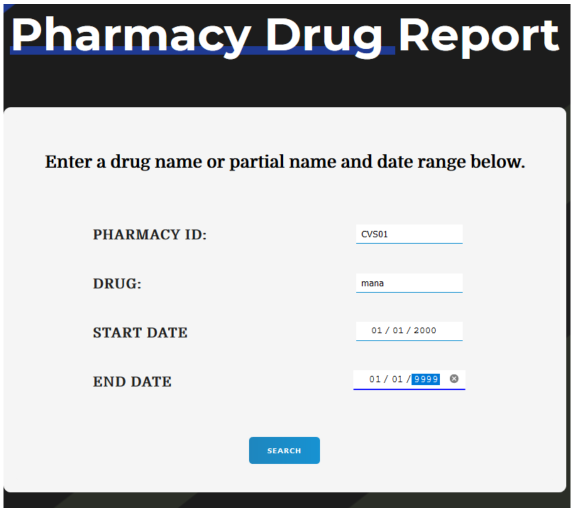
Rx:	KK41BXZV2D
Doctor:	0
Name:	
Patient:	
Name:	Luke Skywalker
Drug:	
Quantity:	0
Pharmacy:	WAG01
Name:	Walgreens
Address:	62455 Hello st. Pasadena CA 46345
Phone:	909-863-4567
Date Filled:	
Cost: $	0.0

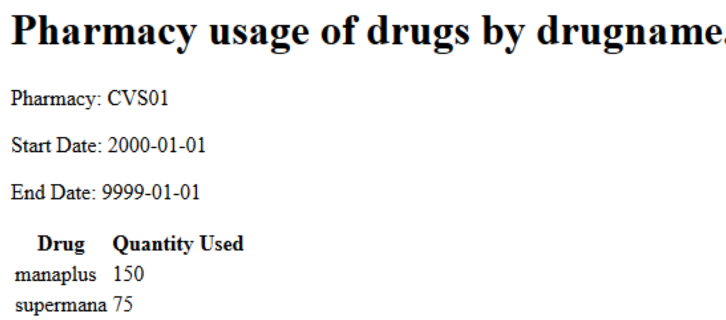
Error: patient name does not match prescription id, or prescription id already filled!

Above are the possible results from a patient requesting for a prescription to be filled. The user inputs the given information and if all the information matches, the Rx to the Patient Name and the Pharmacy Name to the Pharmacy Address then we have a successful output. Otherwise, an error has been made and an attempt to explain the error is presented at the bottom of the prescription.

The third link in the main menu allows the user to search for how many of a given drug any given pharmacy has fulfilled:

Pharmacy drug report input screen *Pharmacy drug report*

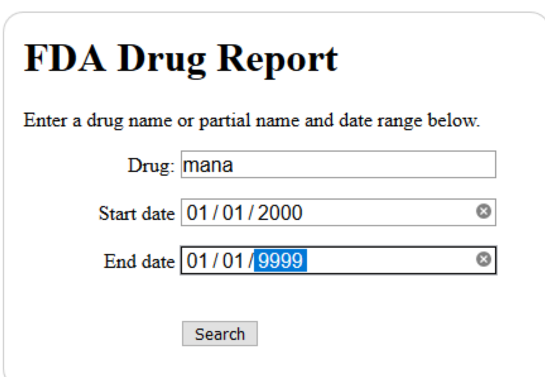


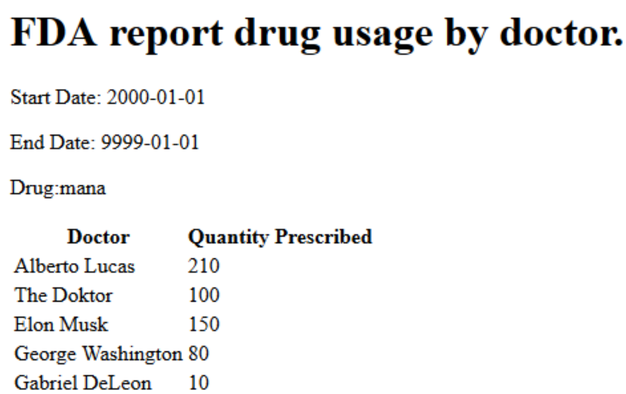


Using the information provided the drug name and total quantity fulfilled is presented along with the original search parameters. If no results are found the text under drug and quantity used will be blank.

The last link in the main menu will pull up a report on how many of a drug doctors have prescribed.

FDA drug report user input screen *FDA drug report*





The user inputs the name of the drug or a portion of the name of the drug they wish to set as the parameter along with a date range. The results show the doctor's full name along with how many of that drug they have prescribed to patients in the set date range.

Conclusion

The database created for this drug chain was designed according to all the specified objectives. Various iterations of design were completed to create a database that collects high quality data. To design the database, the customer's specifications were first broken down into formal specifications. Afterwards, a highly detailed ER diagram was drafted using the formalized details. Next, a relational schema was created to show how keys are related between tables. Using these diagrams, the SQL database was coded. At this stage, many relations were normalized to create a more efficient database design. After designing the database, many sample records were added to test several query statements.

Once the database was verified to produce correct data, the engineering team decided to implement a web application to indirectly access the database. Our team created a user-friendly UI to fulfill four tasks, which allow users to access different information for different needs without exposing sensitive information held within the database.

The database's design allows for great flexibility in the queries that are made to it. Five sample queries are provided to demonstrate the power and flexibility inherent in the database. Data analysts can create detailed reports with the data obtained from the database. Through these reports, a company can make more informed decisions about its future.