Project Title

Medical Equipment Supply and Maintenance

Milestone 2

Group 8

Pooja Ramesh

Sai Varun Kumar Namburi

Ramesh.po@northeastern.edu

Namburi.sai@northeastern.edu

Submission Date: Oct 8th , 2023

Problem Definition:

A real-world challenge faced by the healthcare domain is continuous and reliable availability of equipments. To address the comprehensive management of medical equipment, we integrate supply chain principles in healthcare facilities. To ensure that the supply and maintenance is smooth, we aim to analyze the data primarily focusing on supplier details, revenue generation, maintenance logs, hospitals/ healthcare facilities supplied to, equipment inventory, maintenance scheduling, patient information, allocation of equipments to various departments, and user access records.

EER Diagram:
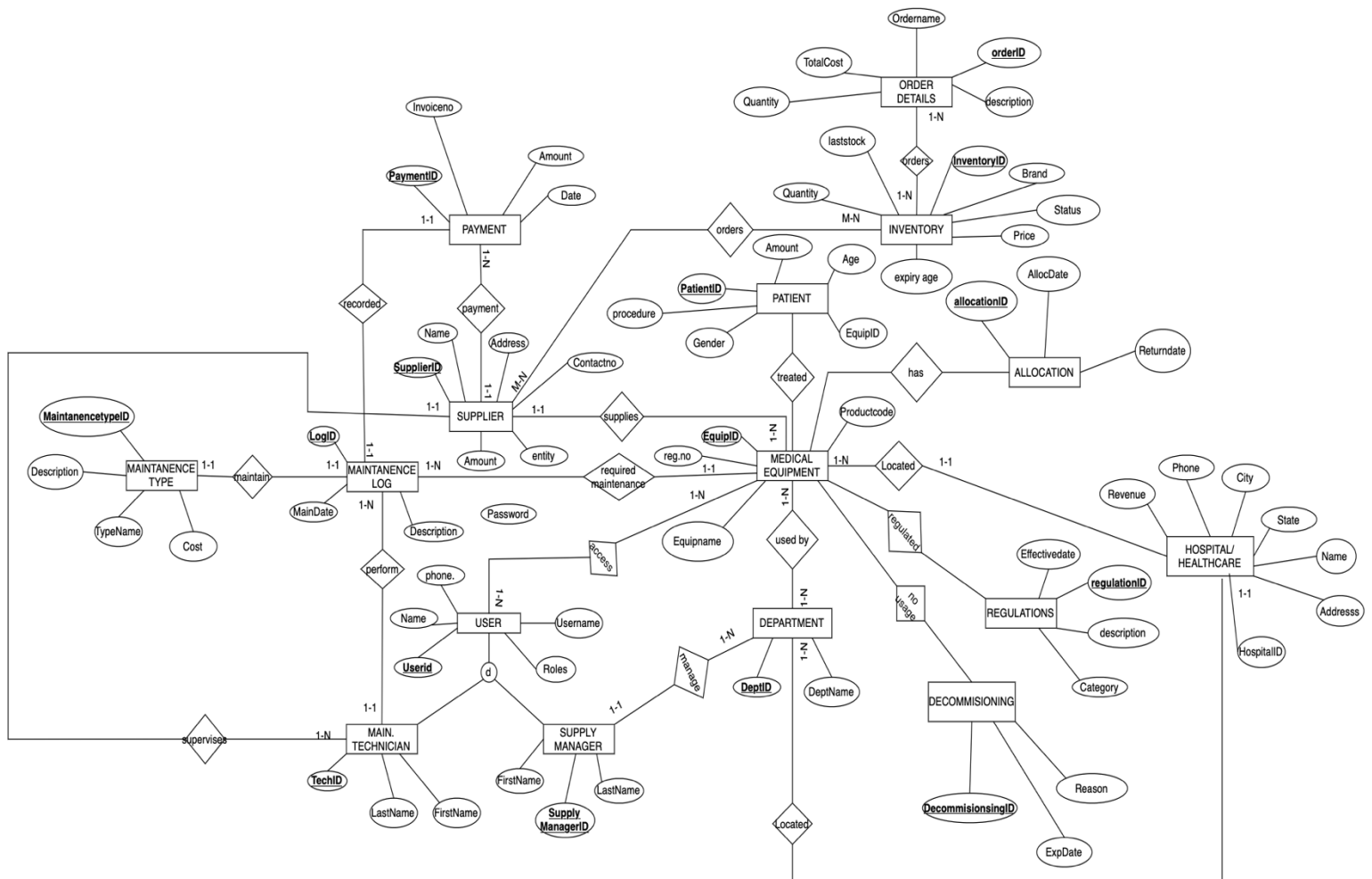
Relational Model:

Bold -> Primary Key; *Italic -> Foreign Key*

- Hospital (**HospitalID**, HospitalName, Address, City, State, Zipcode, PhoneNo, Revenue, *EquipmentID, DepartmentID*)
- Supplier (**SupplierID**, SupplierLastName, SupplierFirstName, SupplierDesignation, SupplierGender, SupplierEntity, SupplierAddress, SupplierCity, SupplierState, SupplierZipcode, SupplierSpeciality, TotalAmount, AmountPaid, AmountOwed)
- MaintenanceTechnician (**TechnicianID**, FirstName, LastName, *ManagerID*)
- Department (**DepartmentID**, DepartmentName, Description)
- Regulations (**RegulationID**, RegulationName, Description, Category, EffectiveDate, ExpirationDate)
- MedicalEquipment (**EquipmentID**, EquipmentName, EquipmentCode, *RegulationID*, *DepartmentID*, *UserID*)
- Decommissioning (**DecommissionID**, *EquipmentID*, DecommissiongDate, Reason)
- Allocation (**AllocationID**, AllocationDate, *DeapartmentID*, ReturnDate, *EquipmentID*)
  MaintenanceType (**MaintenanceTypeID**, MaintenanceTypeName, Description, MaintenanceCost)
- MaintenanceLog (**LogID**, *EquipmentID*, *TechnicianID*, MaintenanceDate, *MaintenanceTypeID*, Description)
- Patients (**PatientID**, Gender, AgeCategory, Description, PaymentAmount, Procedure, *EquipmentID*)
- EquipmentSupplier (*EquipmentID*, *SupplierID*)
- SpareInventory (ItemCode, ItemDescription, PartDescription, IsExpiryDateRequired, MinPrice, MaxPrice, Brand, Status, ExpiryAgeMonth, CurrentStock, SupplierID)
  ItemCode, ItemDescription, PartDescription, SupplierID -> Composite Key
- UserAccess (**UserID**, UserFirstName, UserLastName, Role, PhoneNo)
- SupplierManager (UserID, DepartmentID)
- Orderdetails (OrderID, OrderName, Description, ItemCode, ItemDescription, PartDescription, SupplierID, EquipmentID, TotalCost, Quantity)
- PaymentDetails (**PaymentID**, *SupplierID*, **EquipmentID**, Amount, PurchaseDate, InvoiceNo, *LogID*);

Relational Schema:
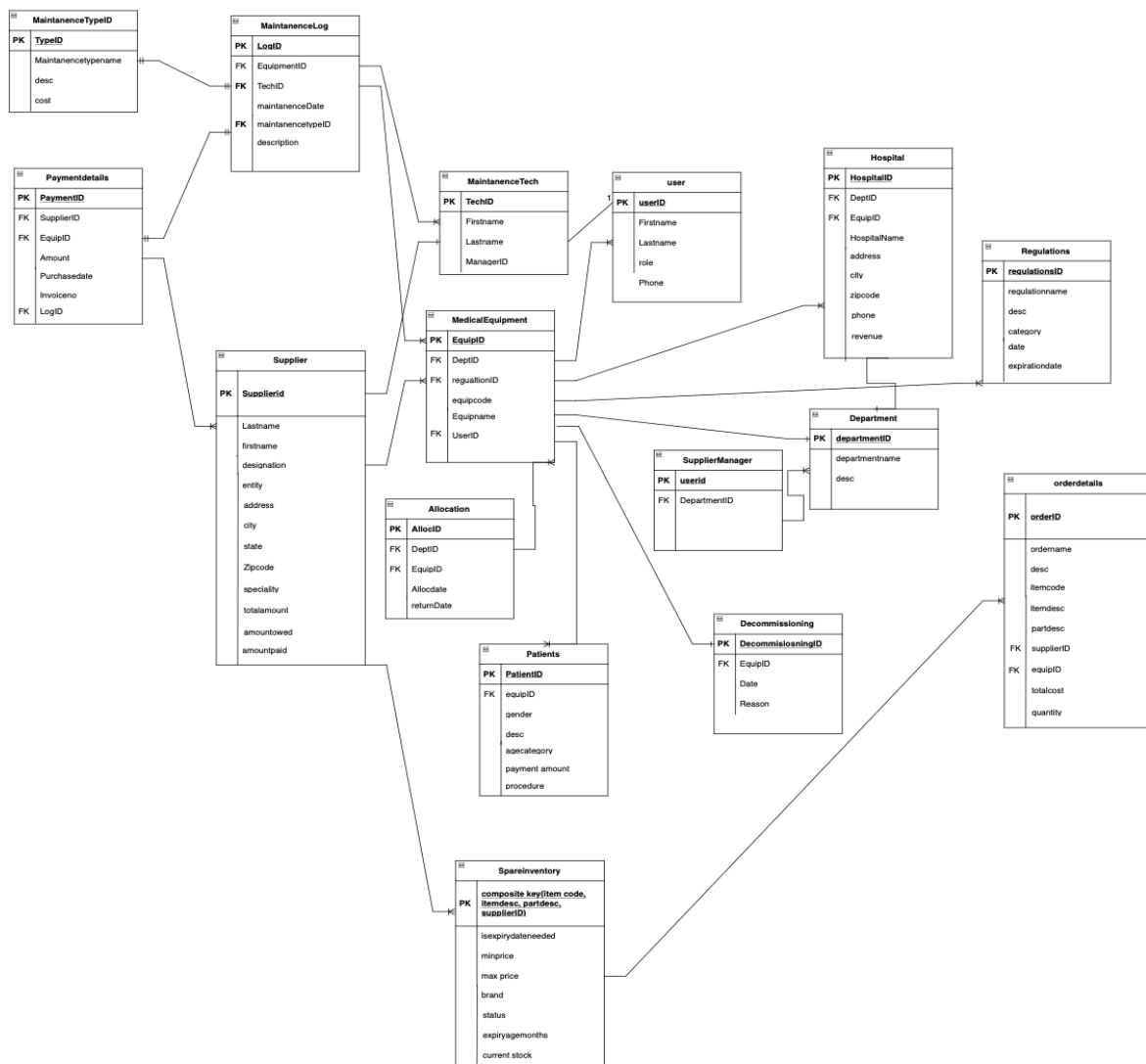
We noticed that we do have a few tables which have attributes which slowly changes over time like **supplier information, equipments, maintenance logs, decommission data**, therefore we have implemented **slowly changing dimensions- type 2** to accommodate and keep track of the various insertions and such updates in the table. The factors that change here include equipment details, contact details of suppliers, expiry of equipments and maintenance logs.
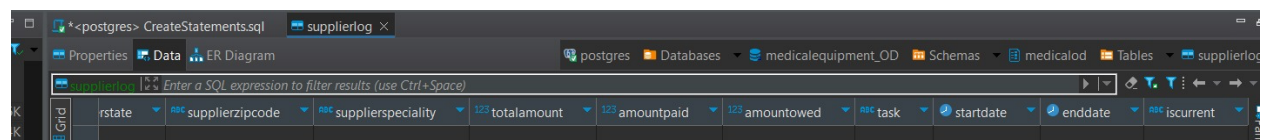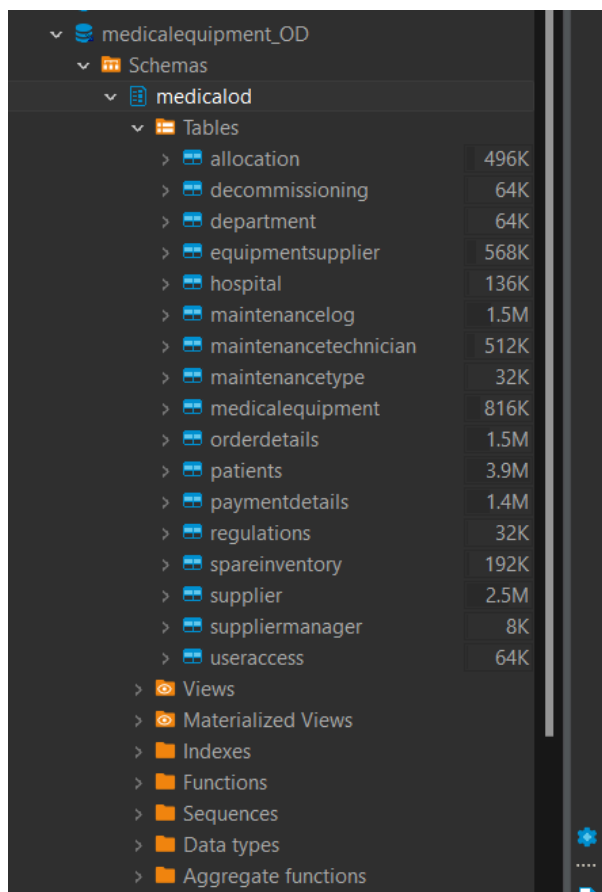
Creation of MedicalOD schema and data population

Data population methodologies:

We used various techniques ranging from manual entry to data generation for populating the relational database. We noticed that there are very limited rows in the maintenance type table and hence, we performed insert into statements for the same. For real time transactions and patient data, we found a data simulator called syntea. For most of our tables, we used csv import to populate the data. For details like maintenance log, purchase order details, we generated and cleaned the data using python.
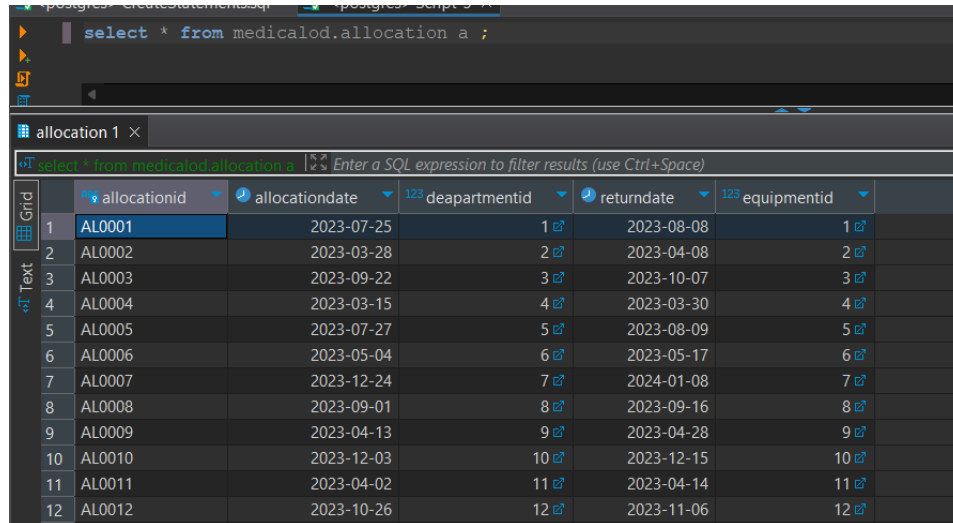
Tables:

1. **Allocation Table:** This table gives the details of allocation of the equipments, allocation date and the return date assigned.

2. **Decommissioning Table:** This outlines the discarded equipments and the corresponding reason.

3. **Department Table:**

4. **Hospital Table:** Contains the comprehensive list of all the hospitals/healthcare facilities along with the details and the amount they spend on supplies.

5. **Maintenance Log Table:** Compiled list of all the technician logs and equipment accessed for maintenance.

```sql
select * from medicalod.maintenancelog m
where maintenancedate < '2023-07-15';
```

maintenancelog 1 ×

select * from medicalod.maintenancelog m where ma... Enter a SQL expression to filter results (use Ctrl+Space)

	logid	equipmentid	technicianid	maintenancedate	maintenancetypeid	description
1	2	4,640	4,331	2023-01-23	2	Disinfection and sterilization
2	5	1,384	1,849	2023-01-26	3	Replaced worn-out components
3	6	2,116	3,374	2023-07-13	3	Routine inspection and cleaning
4	9	3,282	475	2023-02-25	5	Safety inspection and compliance check
5	10	3,995	1,879	2023-05-03	6	Safety inspection and compliance check
6	12	2,859	4,388	2023-06-02	2	Verified calibration accuracy
7	13	1,725	3,174	2023-02-23	9	Calibrated equipment for accuracy
8	14	5,849	2,508	2023-02-21	6	Preventive maintenance
9	15	4,905	3,609	2023-03-10	8	Replaced worn-out components
10	18	2,018	630	2023-04-18	5	Replaced faulty sensor
11	19	2,339	1,252	2023-01-10	7	Performed software update
12	20	5,449	2,640	2023-04-08	1	Disinfection and sterilization
13	21	2,185	2,900	2023-03-11	2	Calibrated equipment for accuracy

6. **Maintenance Technician Table:** List of technicians and their managers who provide the service.

```sql
select * from medicalod.maintenancetechnician m
where managerid > 30;
```

maintenancetechnician 1 ×

select * from medicalod.maintenancetechnician m wh... Enter a SQL expression to filter results (use Ct

	technicianid	firstname	lastname	managerid
1	31	Herbert	Garfield	31
2	32	Ronald	Wilson	32
3	33	Millard	Lincoln	33
4	34	George	McKinley	34
5	35	Richard	Johnson	35
6	36	Grover	Carter	36
7	37	Benjamin	Nixon	37
8	38	Rutherford	Jefferson	38
9	39	Warren	Fillmore	39
10	40	Chester	Jefferson	40

7. **Maintenance Type Table:** The various types of maintenance that a medical equipment undergoes.

```
select * from medicalod.maintenancetype m
```

maintenancetype 1 ✕

select * from medicalod.maintenancetype m | Enter a SQL expression to filter results (use Ctrl+Space)

	maintenancetypeid	maintenancetypename	description	maintenancecost
1	1	Preventive Maintenance	Routine maintenance to prevent issues proactively.	500
2	2	Corrective Maintenance	Repair or fix equipment when it malfunctions.	750
3	3	Scheduled Maintenance	Planned maintenance based on a fixed schedule.	1,200
4	4	Emergency Maintenance	Immediate maintenance for critical issues.	980
5	5	Calibration	Adjusting and calibrating equipment for accuracy.	620
6	6	Software Update	Updating equipment software for performance and security.	890
7	7	Cleaning and Sanitization	Cleaning and sanitizing equipment regularly.	1,100
8	8	Hardware Replacement	Replacing hardware components as needed.	950
9	9	Inspection	Regular inspections to identify potential issues.	1,350
10	10	Upgrades	Upgrading equipment for improved functionality.	720

8. **Medical Equipment Table:**

```
select * from medicalod.medicalequipment m ;
```

medicalequipment 1 ✕

select * from medicalod.medicalequipment m | Enter a SQL expression to filter results (use Ctrl+Space)

	equipmentid	equipmentname	equipmentcode	regulationid	departmentid	userid
1	1	Protector, Dental	BRW	R001	1	1
2	2	Stool, Anesthesia	BRX	R002	2	2
3	3	Cabinet, Table And Tray, Anesthesia	BRY	R003	3	3
4	4	Analyzer, Gas, Helium, Gaseous-Phase	BSE	R004	4	4
5	5	Absorber, Carbon-Dioxide	BSF	R005	5	5
6	6	Algesimeter, Powered	BSI	R006	6	6
7	7	Mask, Gas, Anesthetic	BSJ	R007	7	7
8	8	Cuff, Tracheal Tube, Inflatable	BSK	R008	8	8
9	9	Filter, Conduction, Anesthetic	BSN	R009	9	9
10	10	Catheter, Conduction, Anesthetic	BSO	R010	10	10
11	11	Needle, Conduction, Anesthetic (W/Wo Introducer)	BSP	R011	11	11
12	12	Stylet, Tracheal Tube	BSR	R012	12	12
13	13	Catheters, Suction, Tracheobronchial	BSY	R013	13	13
14	14	Gas-Machine, Anesthesia	BSZ	R014	14	14

9. **Order Details Table:** List of orders, along with the item, product codes and the suppliers.

```
select * from medicalod.orderdetails o
where itemdescription = 'Bulbs/ Lamps';
```

orderdetails 1 ✕

select * from medicalod.orderdetails o where itemde | Enter a SQL expression to filter results (use Ctrl+Space)

	orderid	ordername	description	itemcode	itemdescription
1	7	Monitor, Oxygen, Cutaneous, For Uses Other Than For Infant Not U	Description for Monitor, Oxygen, Cutaneous, For Uses Other Than	BP0003	Bulbs/ Lamps
2	10	Non-Continuous Ventilator For Emergency Use	Description for Non-Continuous Ventilator For Emergency Use	BP0003	Bulbs/ Lamps
3	16	Monitor, Oxygen, Cutaneous, For Uses Other Than For Infant Not U	Description for Monitor, Oxygen, Cutaneous, For Uses Other Than	BP0003	Bulbs/ Lamps
4	17	Oximeter	Description for Oximeter	BP0003	Bulbs/ Lamps
5	26	Mask, Oxygen, Non-Rebreathing	Description for Mask, Oxygen, Non-Rebreathing	BP0003	Bulbs/ Lamps
6	29	Analyzer, Gas, Isoflurane, Gaseous-Phase (Anesthetic Concentratic	Description for Analyzer, Gas, Isoflurane, Gaseous-Phase (Anesthe	BP0003	Bulbs/ Lamps
7	30	Needle, Spinal, Short Term, Reprocessed	Description for Needle, Spinal, Short Term, Reprocessed	BP0003	Bulbs/ Lamps
8	31	Bed, Rocking, Breathing Assist Nebulizer, Medicinal, Non-Ventilat	Description for Bed, Rocking, Breathing Assist Nebulizer, Medicin	BP0003	Bulbs/ Lamps
9	37	Device, Rebreathing Tubing, Pressure And Accessories	Description for Device, Rebreathing Tubing, Pressure And Access	BP0003	Bulbs/ Lamps
10	65	Tube, Tracheal, Reprocessed	Description for Tube, Tracheal, Reprocessed	BP0003	Bulbs/ Lamps
11	69	Ventilator, Continuous, Non-Life-Supporting	Description for Ventilator, Continuous, Non-Life-Supporting	BP0003	Bulbs/ Lamps
12	79	Cylinder, Compressed Gas, And Valve	Description for Cylinder, Compressed Gas, And Valve	BP0003	Bulbs/ Lamps
13	83	Anesthesia Kit	Description for Anesthesia Kit	BP0003	Bulbs/ Lamps
14	89	Calculator, Drug Dose	Description for Calculator, Drug Dose	BP0003	Bulbs/ Lamps
15	100	Protector, Dental Stool	Description for Protector, Dental Stool	BP0003	Bulbs/ Lamps

10. Patients Table:


```
select * from medicalod.patients p ;
```

patients 1

select * from medicalod.patients p

patientid	gender	agecategory	description	paymentamount	procedure	equipmentid
1	Male	Between 25-35 years old	Hospital bed, semi-electric (head and foot adjustment), with any type side rails,	80	9	3,236
2	Male	Between 55-65 years old	Hospital bed, semi-electric (head and foot adjustment), with any type side rails,	100	3	2,632
3	Male	Above 65 years old	Walker, folding, wheeled, adjustable or fixed height	80	4	1,231
4	Male	Between 35-45 years old	Seat attachment, walker	20	3	5,266
5	Male	Between 45-55 years old	Commode chair, mobile or stationary, with fixed arms	90	3	5,042
6	Male	Under 25 years old	Gel or gel-like pressure pad for mattress, standard mattress length and width	250	2	867
7	Male	Between 35-45 years old	Hospital bed, semi-electric (head and foot adjustment), with any type side rails,	80	20	2,791
8	Male	Between 55-65 years old	Hospital bed, semi-electric (head and foot adjustment), with any type side rails,	100	5	4,535
9	Male	Between 45-55 years old	Portable gaseous oxygen system, rental; includes portable container, regulator, f	20	6	4,846
10	Male	Between 55-65 years old	Nebulizer, with compressor	10	4	2,530

11. Payment Details Table: Contains the details of the supply and maintenance total costs of medical equipments from each supplier.


```
select * from medicalod.paymentdetails p
```

paymentdetails 1

select * from medicalod.paymentdetails p

paymentid	supplierid	equipmentid	amount	purchasedate	invoiceno	logid
1	1	1	1,899	18,894.85	2023-06-12	INV-00001	1
2	2	2	3,611	2,831.04	2023-06-16	INV-00002	2
3	3	3	5,192	14,667.99	2023-03-03	INV-00003	3
4	4	4	2,797	93,940.7	2023-10-01	INV-00004	4
5	5	5	2,948	18,335.55	2023-02-05	INV-00005	5
6	6	6	5,596	3,948.64	2023-10-11	INV-00006	6
7	7	7	3,430	56,000.97	2023-06-01	INV-00007	7
8	8	8	3,364	9,062.53	2023-08-25	INV-00008	8
9	9	9	4,334	6,507.85	2023-10-24	INV-00009	9
10	10	10	5,494	301,050.59	2023-06-25	INV-00010	10
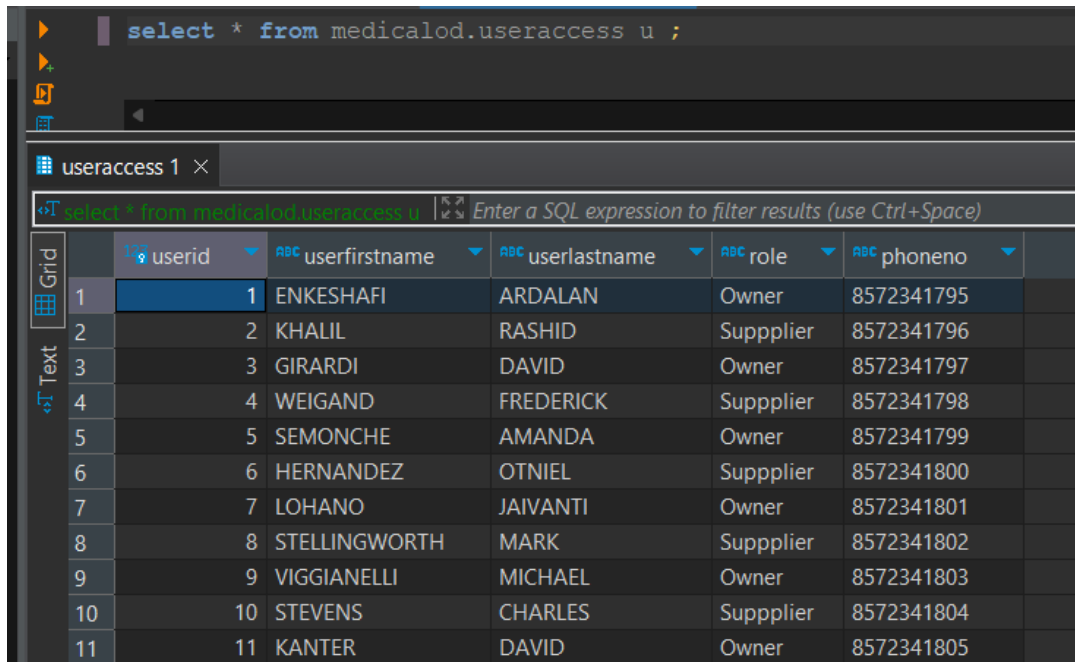
12. Regulations Table: List of maintenance regulations and codes to be met and followed for medical equipment.


```
select * from medicalod.regulations r ;
```

regulations 1

select * from medicalod.regulations r

regulationid	regulationname	description	category	effectivedate	expirationdate
R001	Medical Equipment Maintenance - 2023	Standards for medical equipment maintenance in 2023	Maintenance	2023-01-01	2023-12-31
R002	Supply Chain Guidelines - 2023	Guidelines for medical equipment supply in 2023	Supply	2023-03-15	2023-12-31
R003	Equipment Maintenance Best Practices	Best practices for medical equipment maintenance	Maintenance	2021-05-10	2024-12-31
R004	Procurement Regulations - 2022	Regulations for equipment procurement in 2022	Supply	2022-02-01	2023-12-31
R005	Maintenance Reporting Standards	Standards for reporting maintenance activities	Maintenance	2020-12-15	2025-12-31
R006	Equipment Supply Code of Ethics	Code of ethics for medical equipment suppliers	Supply	2019-06-20	2023-12-31
R007	Equipment Inspection Guidelines	Guidelines for inspecting medical equipment	Maintenance	2018-03-01	2023-12-31
R008	Procurement Transparency Act	Act promoting transparency in equipment procurement	Supply	2020-08-01	2024-12-31
R009	Equipment Calibration Standards	Standards for calibrating medical equipment	Maintenance	2019-11-15	2025-12-31
R010	Supply Chain Sustainability Practices	Sustainability practices for equipment supply	Supply	2021-04-05	2023-12-31

13. Spare Inventory Table:

```
select * from medicalod.spareinventory s ;
```

	itemcode	itemdescription	partdescription	isexpirydaterequired	minprice	maxprice	brand
1	BP0018	Motors/ Micromotors/ Carbon brushes	Flow motor	Yes	500	800	Common
2	BP0025	Sensors/ Detectors	O2 Sensor OOM202	Yes	280	380	Common
3	BP0005	Casing/ Covers/ Brackets/ Latches/ Part Holders	Door 22MM Bubble C.Holder 4008SV10	No	800	826	Fresenius
4	BP0001	Batteries/ UPS	Battery Pack Fot Tec 7731K	Yes	650	1,400	Nihon Ko
5	BP0025	Sensors/ Detectors	DATEX OHMEDA Spo2 FINGER SENSOR Trusignal (TS-F-D)	Yes	385	393	
6	BP0025	Sensors/ Detectors	FLOW TRANDUCER GE	Yes	450	790	Ge
7	BP0003	Bulbs/ Lamps	Bulb 12v 30w	Yes	127	130	Haag-Str
8	BP0001	Batteries/ UPS	Battery AA (Alkaline)	Yes	1	2	Energizer
9	BP0011	Equipment Specific Parts	Label Remover	No	25	60	Common
10	BP0003	Bulbs/ Lamps	Bulb 12v 100w (64623 HLX)	Yes	85	550	Osram

14. Supplier Table:

```
select * from medicalod.supplier s
where supplierstate = 'IL';
```

	stname	supplierfirstname	supplierdesignation	suppliergender	supplierentity	supplieraddress	suppliercity	supplierstate	suppl
1		ERIN	M.D.	F	Individual	240 E HURON ST	CHICAGO	IL	6061129
2		ANOOPA	MD	F	Individual	5841 S MARYLAND AVE	CHICAGO	IL	6063714
3		HERMAN	M.D.	M	Individual	9977 WOODS DR	SKOKIE	IL	6007710
4		DEEPAK	M.D.	M	Individual	530 NE GLEN OAK AVE	PEORIA	IL	6163700
5		ERNESTO	MD	M	Individual	3525 W PETERSON AVE	CHICAGO	IL	6065933
6		JILL	MD	F	Individual	6831 N PEARTREE LN	PEORIA	IL	6161524
7		SALVA	M.B.B.S.	F	Individual	101 N WALNUT ST	PINCKNEYVILLE	IL	6227410
8		TASHA	N.P.	F	Individual	2614 W JEFFERSON ST	JOLIET	IL	6043564
9		SANDEEP	M.D.	M	Individual	4700 W 95TH ST	OAK LAWN	IL	6045325
10		LORI	M.D.	F	Individual	500 HEALTH CENTER DR	MATTOON	IL	6193892

15. Supplier Manager Table: Contains details of the supply chain manager for each supplier.

```
select * from medicalod.suppliermanager s ;
```

	userid	departmentid
1	10	1
2	11	2
3	12	3
4	13	4
5	14	5
6	15	6
7	16	7
8	17	8
9	18	9
10	19	10
11	20	11

16. **User Access Table:** Master user table which indicates the role and access permissions the manager, technicians or the hospital staff have to the medical equipment.

	userid	userfirstname	userlastname	role	phoneno
1	1	ENKESHAFI	ARDALAN	Owner	8572341795
2	2	KHALIL	RASHID	Suppplier	8572341796
3	3	GIRARDI	DAVID	Owner	8572341797
4	4	WEIGAND	FREDERICK	Suppplier	8572341798
5	5	SEMONCHE	AMANDA	Owner	8572341799
6	6	HERNANDEZ	OTNIEL	Suppplier	8572341800
7	7	LOHANO	JAIVANTI	Owner	8572341801
8	8	STELLINGWORTH	MARK	Suppplier	8572341802
9	9	VIGGIANELLI	MICHAEL	Owner	8572341803
10	10	STEVENS	CHARLES	Suppplier	8572341804
11	11	KANTER	DAVID	Owner	8572341805

Warehouse Design Proposal:

Problem Definition:

Our main aim is to implement a comprehensive data solution to by creating a centralize repository for all equipment related data. This will help in ensuring proactive maintenance, cost control, inventory optimization and regulate compliance. Here, we further aim to create a scheduling table which will regularize maintenance schedules for each equipment and follow the regulation. Furthermore, category/department wise segregation of equipments will ease the process of tracking and ensure the entire system is reliable.

Dimensions:

The centralized data warehouse will contain key dimensions like **time dimensions** (dateofexpiry, regulationexpirydate, maintanencedate, orderdate) which will further give us the hierarchy levels like year -> quarter -> month ->day, **geographical dimensions** here indicate and give us the hierarchy like State -> city ->zipcode-> streetaddress, **Equipment dimensions** (equipmentID, equipment name, productcode, brand) , **User Dimension** which contains everyone who have access to the medical equipments like Owner / Staff -> Supplier -> Technician part of every healthcare facility/hospital. Next, along with equipment, we also have the inventory of the spare parts required to be constantly replaced or maintain a medical equipment. So, the **inventory dimension** further has item description -> product description -> brand -> status.

Facts:

To ensure that we provide optimum maintenance and scheduling, we create a **maintenance fact** which have dimensions such as Time, equipment, and user, and include the measures regarding the costs which include the maintenance cost, parts/ supply cost, technician service cost and the maintenance type cost. This ensures that we have one target table which consolidates all the details regarding the equipments, and the costs expended for each. Secondly, we emphasize on optimum cost control, for which we create a **Order Fact**, which consists of Time, supplier and equipment dimensions and total cost of all equipment and quantities as the measure. As mentioned before, one of our priorities was to have a department wise segregation of equipments with respect to their categories and time, for which we create an **allocation fact**. Finally, we create a **Payment Fact** which helps in cost optimization where we have the various costs as measures.

This multidimensional model allows easy exploration of equipment data for analysis from various perspectives. Another suggestion which we aim to do is to create a alerts and notification to the owners of the equipments to indicate the maintenance or expiry. Each dimension here represents a different aspect of data, and we can analysis critical aspects of healthcare operations.