University of Toronto
CSC343, Fall 2022

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# Part 1: Queries

1. Frugal doctors

– Generic drugs' DIN, brand(equivalent brand name drugs) and price.

$$PriceofAltGen(DIN, brand, price) :=$$
$$\Pi_{Generic.DIN,Generic.brand,Price.price}\sigma_{\substack{Generic.DIN=Price.DIN \\ \wedge \\ Generic.brand=Product.DIN}}(Generic \times Price \times Product)$$

– Not cheapest alternative generic drugs' DIN, brand, and price.

$$NotCheap(DIN, brand, price) :=$$
$$\Pi_{P1.DIN,P1.brand,P1.price}\sigma_{\substack{P1.price>P2.price \\ \wedge \\ P1.brand=P2.brand}}[(\rho_{P1}PriceofAltGen)\times(\rho_{P2}PriceofAltGen)]$$

– Cheapest alternative generic drugs' DIN.

$$Cheapest(DIN) := \Pi_{PriceofAltGen.DIN}(PriceofAltGen - NotCheap)$$

– The DIN of the brand name drugs that have generic alternative.

$$HaveAlt(DIN) := \Pi_{Product.DIN}\sigma_{Generic.brand=Product.DIN}(Product \times Generic)$$

– The DIN of the brand name drugs that don't have generic alternative(their price may not have been recorded.)

$$NoAltPriceHaveNotChecked(DIN) :=$$
$$[\Pi_{Product.DIN}(Product)] - HaveAlt$$

– The brand name drugs that don't have generic alternative and their price is recorded

$$NoAlt(DIN) :=$$
$$\Pi_{NoAltPriceHaveNotChecked.DIN}\sigma_{\substack{Price.DIN \\ = \\ NoAltPriceHaveNotChecked.DIN}}(NoAltPriceHaveNotChecked \times Price)$$

– Doctors who have prescribed such(the cheapest generic alternative for some brand name drugs or brand name drugs without generic alternative) drugs at least once and the drug's DIN.

$$PrescriptedAtLeastOnce(doctor, DIN) :=$$
$$\Pi_{Prescription.doctor,Prescription.drug}\sigma_{\substack{Prescription.drug=NoAlt.DIN \\ \vee \\ Prescription.drug=Cheapest.DIN}}(Prescription \times NoAlt \times$$

$Cheapest$)

– Doctors who have prescribed such(the cheapest generic alternative for some brand name drugs or brand name drugs without generic alternative drugs) at least twice.

$PrescriptedAtLeastTwice(doctor) :=$

$$\Pi_{T1.doctor}\sigma_{T1.doctor=T2.doctor \wedge T1.drug \neq T2.drug} [\rho_{T1}(PrescriptedAtLeastOnce) \times \rho_{T2}(PrescriptedAtLeastOnce)]$$

– Doctors who have prescribed not cheap generic or brand name that has generic alternative

$NotCheapNotHaveAlt(doctor) :=$

$$\Pi_{Prescription.doctor}\sigma_{\substack{Prescription.drug=HaveAlt.DIN \\ \vee \\ Prescription.drug=NotCheap.DIN}} (Prescription \times HaveAlt \times NotCheap)$$

– Doctors who have prescribed such(the cheapest generic alternative for some brand name drugs or brand name drugs without generic alternative) drugs at least twice and ALSO have prescribed not cheap generic drugs or brand name drugs that has generic alternative

$AlsoNotCheapNotHaveAlt(doctor) :=$
$(PrescriptedAtLeastTwice \cap NotCheapNotHaveAlt)$

– Doctors who have ONLY prescribed the cheapest generic alternative for some brand name drugs or brand name drugs without generic alternative at least twice.

$PrescriptedAtLeastTwiceNotCheapNotHaveAlt(doctor) := (PrescriptedAtLeastTwice - AlsoNotCheapNotHaveAlt)$

2. Price gougers

– Prescription id and OCP number of the pharmacist that filled it in

$FilledOnce(RxID, OCP) := \Pi_{RxID,OCP}(Filled)$

– Prescription id for a generic product and OCP number of the pharmacist that filled it in

$FilledG(RxID, OCP) :=$

$$\Pi_{Filled.RxID,Filled.OCP}\sigma_{\substack{Prescription.RxID=Filled.RxID \\ \wedge \\ Prescription.drug=Generic.DIN}}(Prescription \times Filled \times Generic)$$

– OCP number of the pharmacists who have never filled prescriptions for generic product among who filled any once

$NeverFilledG(OCP) := \Pi_{FilledOnce.OCP}(FilledOnce - FilledG)$

– Name, OCP number, and date of registration of the pharmacists who have never filled a prescription for a generic product, excluding who has never filled in any prescription.

$NOD(name, OCP, date) :=$

$$\Pi_{\substack{name, \\ Pharmacist.OCP, \\ registered}}\sigma_{NeverFilledG.OCP=Pharmacist.OCP}(NeverFilledG \times Pharmacist)$$

3. Potential doctor shopping

– Patients who have been prescribed by two different doctors, if they have, get DIN of the two medications they got from each doctor

$PresAtLeastTwoDoctors(patient, P1DIN, P2DIN) :=$

$$\Pi_{patient,P1.drug,P2.drug}\sigma_{\substack{P1.patient=P2.patient \\ \wedge \\ P1.doctor\neq P2.doctor}}[\rho_{P1}(Prescription) \times \rho_{P2}(Prescription)]$$

– Patients from the first step who have been prescribed two equivalent medication, following the equivalence condition (a)

$DrugsEquivalent1(patient) :=$

$$\Pi_{patient}\sigma_{P1DIN=P2DIN}(PresAtLeastTwoDoctors)$$

– Patients from the first step who have been prescribed two equivalent medications, following the equivalence condition (b), where P1(first drug) is generic and P2(the other one) is brand name

$DrugsEquivalent21(patient) :=$

$$\Pi_{patient}\sigma_{\substack{P1DIN=Generic.DIN \\ \wedge \\ Generic.brand=Product.DIN \\ \wedge \\ Product.DIN=P2DIN}}(PresAtLeastTwoDoctors \times Generic \times Product)$$

– Patients from the first step who have been prescribed two equivalent medications, following the equivalence condition (b), where it is the opposite case

$DrugsEquivalent22(patient) :=$

$$\Pi_{patient}\sigma_{\substack{P2DIN=Generic.DIN \\ \wedge \\ Generic.brand=Product.DIN \\ \wedge \\ Product.DIN=P1DIN}}(PresAtLeastTwoDoctors \times Generic \times Product)$$

– Patients from the first step who have been prescribed two equivalent medications, following the equivalence condition (b)

$DrugsEquivalent2(patient) := (DrugsEquivalent21 \cup DrugsEquivalent22)$

– Patients from the first step, P1DIN(the first drug in a pair), and corresponding brands for each P1DIN, in case both medications are generic and they are equivalent by the condition (c)

$BrandP1(patient, P1DIN, brand) :=$
$\Pi_{patient,P1DIN,brand}\sigma_{Generic.DIN=P1DIN}(PresAtLeastTwoDoctors \times Generic)$

– Patients from the first step, P2DIN(the first drug in a pair), and corresponding brands for each P2DIN, in case both medications are generic and they are equivalent by the condition (c)

$BrandP2(patient, P2DIN, brand) :=$
$\Pi_{patient,P2DIN,brand}\sigma_{Generic.DIN=P2DIN}(PresAtLeastTwoDoctors \times Generic)$

– Patients from the first step who have been prescribed two equivalent medications, following the equivalence condition (c)

$DrugsEquivalent3(patient) :=$
$\Pi_{BrandP1.patient}\sigma_{BrandP1.brand=BrandP2.brand}(BrandP1 \times BrandP2)$

– Patients(specifically their OHIP number) who have been prescribed equivalent medications by two different doctors

$PatientsOHIP(OHIP) := (DrugsEquivalent1 \cup DrugsEquivalent2 \cup DrugsEquivalent3)$

– Such patients' OHIP number, name, and phone number

$PatientsInfo(OHIP, name, phone) :=$
$\Pi_{Patient.OHIP,Patient.name,Patient.phone}\sigma_{Patient.OHIP=PatientsOHIP.OHIP}(Patient \times PatientsOHIP)$

4. Safest ingredient: Impossible.

5. Drug shortage

– Unfilled Presciptions' RxID

$UnfilledPreRxID(RxID) := ([\Pi_{RxID}(Prescription)] - [\Pi_{RxID}(Filled)])$

– Unfilled Presciptions' patients and drugs

$UnfilledPre(patient, drug) :=$

$$\Pi_{\substack{Prescription.patient,\\ Prescription.drug}} \sigma_{Prescription.RxID=UnfilledPreRxID}(Prescription \times UnfilledPreRxID)$$

– DIN of the drug that is At Least Twice Unfilled for two Different Patients(ALTUDP in short)

$ALTUDP(DIN) :=$

$$\Pi_{U1.drug} \sigma_{\substack{U1.patient \neq U2.patient \\ \wedge \\ U1.drug = U2.drug \\ \wedge \\ U1.patient \neq U2.patient}} (\rho_{U1} UnfilledPre \times \rho_{U2} UnfilledPre)$$

– DIN and manufacturer for such brand name drug products

$DINandManuP(DIN, manu) :=$

$$\Pi_{Product.DIN, Product.manufacturer} \sigma_{ALTUDP.DIN=Product.DIN}(ALTUDP \times Product)$$

– DIN and manufacturer for such generic drug products

$DINandManuG(DIN, manu) :=$

$$\Pi_{Generic.DIN, Generic.manufacturer} \sigma_{ALTUDP.DIN=Generic.DIN}(ALTUDP \times Generic)$$

– DIN and manufacturer for such drugs, combined

$DINandManuALL(DIN, manu) := DINandManuP \cup DINandManuG$

6. Protecting drug patents

– DIN of the brand name drug products with the corresponding active ingredient

$PDINIngred(DIN, ingredient) :=$

$$\Pi_{Product.DIN, ingredient} \sigma_{Product.DIN=Contains.DIN}(Product \times Contains)$$

– Pairs of the brand name drugs that have the exact same active ingredients, without the pseudo duplicates

$$NoDups(DIN1, DIN2) :=$$
$$\Pi_{T1.DIN,T2.DIN}\sigma_{T1.ingredient=T2.ingredient \overset{\wedge}{} T1.DIN<T2.DIN}[\rho_{T1}(PDINIngred) \times \rho_{T2}(PDINIngred)]$$

7. Recent narcotics

– Filled prescriptions data(RxID, pharmacist, filled date, filled DIN(drug))

$$FilledPre(RxID, pharmacist, filledDate, filledDIN) :=$$
$$\Pi_{\substack{Filled.RxID,\\ Filled.pharmacist,\\ Filled.date,\\ Presciption.drug}} \sigma_{Filled.RxID=Prescription.RxID}(Filled \times Prescription)$$

– DIN and the name of the brand name drug products that are narcotic

$$NarcoticDIN(NDIN, drugName) :=$$
$$\Pi_{DIN,name}\sigma_{schedule='narcotic'}(Product)$$

– Name of the drug, pharmacist(OCP) who filled, and filled date of the filled prescriptions with brand name narcotic drug product

$$FilledPreN1(drugName, pharmacist, filledDate) :=$$
$$\Pi_{drugName,pharmacist,filledDate}\sigma_{filledDIN=NDIN}(FilledPre \times NarcoticDIN)$$

– Name of the drug, pharmacist(OCP), and filled date of filled prescriptions with generic narcotic drug product

$$FilledPreN1(drugName, pharmacist, filledDate) :=$$
$$\Pi_{\substack{drugName,\\ pharmacist,\\ filledDate}} \sigma_{filledDIN=Generic.DIN \overset{\wedge}{} brand=NDIN}(FilledPre \times NarcoticDIN \times Generic)$$

– Name of the drug, pharmacist(OCP), and filled date of the filled prescription with narcotic drug product, both generic and brand name

$$FilledPreNtotal(drugName, pharmacist, filledDate) := (FilledPreN1 \cup FilledPreN1)$$

– Name of the drug, pharmacist(OCP), and filled date of the non-most recent filled prescriptions among the filled prescription with narcotic drug product

$$NotRecent(drugName, pharmacist, filledDate) :=$$
$$\Pi_{\substack{F1.drugName,\\ F1.pharmacist,\\ F1.filledDate}} \sigma_{F1.pharmacist=F2.pharmacist \overset{\wedge}{} F1.date<F2.date}[\rho_{F1}(FilledPreNtotal) \times \rho_{F2}(FilledPreNtotal)]$$

– Name of the drug, pharmacist(OCP), and filled date of the most recently filled prescriptions by those pharmacists

$MostRecent(drugName, pharmacist, filledDate) := (FilledPreNtotal - NotRecent)$

– Pharmacists' name, OCP number, the name of the narcotics, and the filled date of the filled prescription with narcotic drug product

$PNameOCPdrugNameDate(name, OCP, filledDate, drugName) :=$
$\Pi_{name,OCP,filledDate,drugName}\sigma_{pharmacist=OCP}(MostRecent \times Pharmacist)$

8. Patients at risk

– Prescriptions' ID, doctor, prescribed drug's ingredient, date, patient(OHIP)

$PreWithIngred(RxID, doctor, ingredient, date, patient) :=$
$$\Pi_{\substack{RxID,doctor,\\ingredient,date,patient}} \sigma_{\substack{[drug=Generic.DIN \\ \wedge \\ brand=Product.DIN \\ \wedge \\ Contains.DIN=Product.DIN] \\ \vee \\ [drug=Product.DIN \\ \wedge \\ Product.DIN=Contains.DIN]}} (Product \times Generic \times Contains \times Prescription)$$

– The doctors' ID and the dates they prescribed those drugs to a patient

$RiskyDoctors(doctor, date) :=$
$$\Pi_{T1.doctor,T1.date}\sigma_{\substack{T1.doctor=T2.doctor \\ \wedge \\ T1.RxID \neq T2.RxID \\ \wedge \\ T1.date=T2.date \\ \wedge \\ T1.patient=T2.patient \\ \wedge \\ T1.ingredient=Interaction.ingredient1 \\ \wedge \\ T2.ingredient=Interaction.ingredient2}} (\rho_{T1}(PreWithIngred) \times \rho_{T2}(PreWithIngred) \times Interaction)$$

9. Many generics : Impossible

10. Long-time customers

– Non most senior pharmacists' OCP, name, and registered date

$NotSenior(OCP, name, registered) :=$
$\Pi_{P1.OCP,P1.name,P1.registered}\sigma_{P1.registered>P2.registered}(\rho_{P1}Pharmacist \times \rho_{P2}Pharmacist)$

– The most senior pharmacists' OCP, name, and registered date

$Senior(OCP, name, registered) := (Pharmacist - NotSenior)$

– Non most junior pharmacists' OCP, name, and registered date

$NotJunior(OCP, name, registered) :=$
$\Pi_{P1.OCP,P1.name,P1.registered}\sigma_{P1.registered<P2.registered}(\rho_{P1}Pharmacist \times \rho_{P2}Pharmacist)$

– The most junior pharmacists' OCP, name, and registered date

$Junior(OCP, name, registered) := (Pharmacist - NotJunior)$

– Pharmacist, filled date, and patient of the filled prescription

$FilledPre(pharmacist, date, patient) :=$
$\Pi_{\substack{Filled.pharmacist,\\ Filled.date,\\ patient}}\sigma_{Prescription.RxID=Filled.RxID}(Filled \times Prescription)$

– The most junior pharmacists' OCP, filled date of the prescription, and the patient

$PatientsofJunior(date, patient) :=$
$\Pi_{date,patient}\sigma_{OCP=pharmacist}(Junior \times FilledPre)$

– Non earliest filled date of the patients of the most junior pharmacists and the patient's OHIP number

$NotEarliestDateJunior(date, patient) :=$
$\Pi_{P1.date,P1.patient}\sigma_{\substack{P1.date<P2.date \\ \wedge \\ P1.patient=P2.patient}}(\rho_{P1}PatientsofJunior \times \rho_{P2}PatientsofJunior)$

– Earliest filled date of the patients of the most junior pharmacists and the patient's OHIP number

$EarliestDateJunior(date, patient) := (PatientsofJunior - NotEarliestDateJunior)$

– The most senior pharmacists' OCP, filled date of the prescription, and the patient

$PatientsofSenior(date, patient) :=$
$\Pi_{date,patient}\sigma_{OCP=pharmacist}(Senior \times FilledPre)$

– Non earliest filled date of the patients of the most senior pharmacists and the patient's OHIP number

$NotEarliestDateSenior(date, patient) :=$
$\Pi_{P1.date,P1.patient}\sigma_{\substack{P1.date<P2.date \\ \wedge \\ P1.patient=P2.patient}}(\rho_{P1}PatientsofSenior \times \rho_{P2}PatientsofSenior)$

– Earliest filled date of the patients of the most senior pharmacists and the patient's OHIP number

$EarliestDateSenior(date, patient) := (PatientsofSenior - NotEarliestDateSenior)$

– The OHIP number of the patients who have been served by both the most Junior/Senior Pharmacists, the earliest date on which they had a prescription filled by a most JUNIOR pharmacist, and the earliest date on which they had a prescription filled by a most SENIOR pharmacist

$PatientDates(OHIP, dateJ, dateS) :=$

$$\Pi_{\substack{EarliestDateSenior.patient,\\ EarliestDateJunior.date,\\ EarliestDateSenior.date}} \sigma_{EarliestDateSenior.patient = EarliestDateJunior.patient}(EarliestDateSenior \times EarliestDateJunior)$$

– The OHIP number of the patients who have been served by both the most Junior/Senior Pharmacists, their name, the earliest date on which they had a prescription filled by a most Junior pharmacist, and the earliest date on which they had a prescription filled by a most Senior pharmacist

$\Pi_{OHIP,name,dateJ,dateS}(PatientDates \bowtie Patient)$

11. Lots of competition
    – Manufacturer and the DIN of their brand name drugs(Condition 1)

    $ManufactProd(manufacturer, DIN) := \Pi_{manufacturer,DIN}(Product)$

    – Manufacturers that manufactures a generic drug alternative for each brand-name drug they make(Condition 2)

    $ManufactAlt(manufacturer) :=$

    $$\Pi_{ManufactProd.manufacturer} \sigma_{\substack{brand=ManufactProd.DIN \\ \wedge \\ Generic.manufacturer=ManufactProd.manufacturer}} (Generic \times ManufactProd)$$

    – Manufactuerers that every one of their brand-name drugs has a generic alternative that is manufactured by some other company(Condition 3)

    $ManufactAltFromOther(manufacturer) :=$

    $$\Pi_{ManufactProd.manufacturer} \sigma_{\substack{ManufactProd.manufacturer \neq Generic.manufacturer \\ \wedge \\ Generic.brand=ManufactProd.DIN}} (Generic \times ManufactProd)$$

    – Manufactuerers that satisfy all three conditions

    $SatisfyingManufactNames(manufacturer) :=$
    $(ManufactProd \cap ManufactAlt \cap ManufactAltFromOther)$

## Part 2: Additional Integrity Constraints

1. Symmetry:
   – All pseudo duplicates ingredients that are in Interaction

   $PseudoDuplicates(ingredient1) :=$

   $$\Pi_{I1.ingredient1} \sigma_{\substack{I1.ingredient1=I2.ingredient2 \\ \wedge \\ I1.ingredient2=I2.ingredient1}} (\rho_{I1} Interaction \times \rho_{I2} Interaction)$$

– All Pseudo Duplicates should appear in ingredient1 of Interaction
$(\Pi_{ingredient1} Interaction) - PseudoDuplicates = \emptyset$

2. Don't surpass those with seniority: IMPOSSIBLE

3. Brand Name First:
   – Prescriptions for Generic drugs
   $GenPres(doctor, brand, date) :=$
   $\Pi_{doctor,brand,date}\sigma_{drug=DIN}(Prescription \times Generic)$

   – Prescriptions for Brand Name Drugs $BrandPres(doctor, DIN, date) :=$
   $\Pi_{doctor,DIN,date}\sigma_{drug=DIN}(Prescription \times Product)$

   – Comparing Dates of Generic and Brand Name Drugs

   $Early(doctor) :=$
   $\Pi_{BrandPres.doctor}\sigma_{\substack{GenPres.date>BrandPres.date \\ \wedge\ BrandPres.DIN=GenPres.brand \\ \wedge\ BrandPres.doctor=GenPres.doctor}}(BrandPres \times GenPres)$

   – All of the doctors should satisfy the brand-name first condition

   $[\Pi_{doctor}(GenPres) - Early] = \emptyset$

4. Don't over-prescribe narcotics:
   – Drugs prescribed on same day to same patient by same doctor

   $AllDrugsSameDay(DIN) := \Pi_{P1.drug}\sigma_{\substack{P1.doctor=P2.doctor \\ \wedge\ P1.patient=P2.patient \\ \wedge\ P1.date=P2.date \\ \wedge\ P1.drug=P2.drug \\ \wedge\ P1.RxID\neq P2.RxID}}(\rho_{P1}Prescription \times \rho_{P2}Prescription)$

   – Brand-name Narcotic Drugs cannot be prescribed on same day to same patient by same doctor

   $\Pi_{ALLDrugsSameDay.DIN}\sigma_{\substack{schedule='narcotic' \\ \wedge\ ALLDrugsSameDay.DIN=Product.DIN}}(ALLDrugsSameDay \times Product) = \emptyset$