Radiation Oncology in OHDSI/OMOP

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What is radiation oncology?

- X-rays, gamma rays and other sources of radiation can kill cancerous cells and shrink tumors because of the high energy emission.

- Radiation kills cells by breaking up molecules and causing reactions that damage living cells.

- Radiation therapy or radiotherapy uses x-rays, gamma rays and other sources of radiation to destroy cancer cells.

- Radiation Oncology is the medical practice of treating cancer patients with radiation therapy:

  - Radiotherapy Prescription

  - Radiotherapy Simulation

  - Radiotherapy Planning

  - Radiotherapy Delivery

Types of Radiation Therapy

- Two main types:

    - External Beam Therapy or Teletherapy.

    - Internal Therapy or Brachytheraphy.

External Beam Therapy

- External beam therapy is radiation delivered from a distant source, from outside the body and directed at the patient's cancer site.

- Systems which produce different types of radiation for external beam therapy include:

  - Orthovoltage x-ray machines

  - Cobalt-60 machines

  - Linear accelerators

  - Proton beam machines

  - Neutron beam machines

  - Stereotactic radiation therapy: Gamma Knife and CyberKnife

Internal Radiation Therapy (Brachytherapy)

- Brachytherapy involves placing radiation sources as close as possible to the tumor site. Sometimes, they may be inserted directly into the tumor. The radioactive sources or isotopes are in the form of wires, seeds (or molds), or rods.

- Several types of brachytherapy characterized by different methods of placing radiation inside the body include:

  - Interstitial brachytherapy

  - Intracavitary brachytherapy

  - Intraluminal radiation therapy

  - Radioactively tagged molecules given intravenously

Radiation Therapy Treatment Cycle

- Radiotherapy Prescription

  - Patient consultation, physical examination, clinical history review, pathology review, radiology exams review.

- Radiotherapy Simulation

  - Define the exact location and configuration of the treatment for the cancer or tumor using x-rays, MRI, PET and CT scans. Patient immobilized and placed in the treatment position.

- Radiotherapy Planning

  - Radiation oncologist, physicist and dosimetrist use imaging exams to design the field of radiation therapy treatment.

- Radiotherapy Delivery

  - External Beam: Radiation therapist places the patient in the position for treatment using immobilization devices and delivers the prescribed, simulated and planned radiation doses over the course of multiple days an weeks. 5 times per week over 3 to 9 weeks.

  - Brachytherapy: Less outpatient visits. Delivery of radioisotopes differs based on type of brachtherapy.

What radiation therapy data points do we want to store in OHDSI/OMOP?

- Looked at datapoints tracked in tumor registries: http://datadictionary.naaccr.org/

- Focused on tracking radiation therapy delivery.

- Biased toward tracking external beam therapy.

Tumor Registry Radiation Therapy Datapoints

- Dates

  - RX Date Radiation: Date Radiation Started

    - http://datadictionary.naaccr.org/default.aspx?c=10#1210

    - https://r.details.loinc.org/LOINC/21926-1.html?sections=Comprehensive

    - OHDSI Measurement: 3010872

  - RX Date Radiation Flag

    - http://datadictionary.naaccr.org/default.aspx?c=10#1211

    - https://r.details.loinc.org/LOINC/59555-3.html?sections=Comprehensive

    - OHDSI Measurement: 40762617

  - RX Date Rad Ended: Date Radiation Ended

    - http://datadictionary.naaccr.org/default.aspx?c=10#3220

    - https://r.details.loinc.org/LOINC/42120-6.html?sections=Comprehensive

    - OHDSI Measurement: 3037970

  - RX Date Rad Ended Flag

    - http://datadictionary.naaccr.org/default.aspx?c=10#3221

    - https://r.details.loinc.org/LOINC/59547-0.html?sections=Comprehensive

    - OHDSI Measurement: 40762609

Tumor Registry Radiation Therapy Datapoints (continued)

- Modality

    - RX Summ—Radiation

        - http://datadictionary.naaccr.org/default.aspx?c=10#1360

        - https://r.details.loinc.org/LOINC/21943-6.html?sections=Comprehensive

        - OHDSI Measurement: 3021037

        - None

        - Beam radiation

        - Radioactive implants

        - Radioisotopes

        - Combination of 1 with 2 or 3

        - Radiation, NOS-method or source not specified

        - Currently allowable for historic cases only; see note below

        - Patient or patient's guardian refused*

        - Radiation recommended, unknown if administered*

        - Unknown if radiation administered

Tumor Registry Radiation Therapy Datapoints (continued)

- Modality

  - Rad--Regional RX Modality: Regional Treatment Modality

    - http://datadictionary.naaccr.org/default.aspx?c=10#1570

    - https://r.details.loinc.org/LOINC/21964-2.html?sections=Comprehensive

    - OHDSI Measurement: 3036808

    - No radiation treatment

    - External beam, NOS

    - Orthovoltage

    - Cobalt-60, Cesium-137

    - Photons (2-5 MV)

    - Photons (6-10 MV)

    - Photons (11-19 MV)

    - Photons (> 19 MV)

    - Photons (mixed energies)

    - Electrons

    - Photons and electrons mixed

    - Neutrons, with or without photons/electrons

    - IMRT

    - Conformal or 3-D therapy

    - Protons

    - Stereotactic radiosurgery, NOS

    - Linac radiosurgery

    - Gamma Knife

    - Brachytherapy, NOS

    - Brachytherapy, Intracavitary, Low Dose Rate (LDR)

    - Brachytherapy, Intracavitary, High Dose Rate (HDR)

    - Brachytherapy, Interstitial, Low Dose Rate (LDR)

    - Brachytherapy, Interstitial, High Dose Rate (HDR)

    - Radium

    - Radio-isotopes, NOS

    - Strontium - 89

    - Strontium - 90

    - Combination modality, specified

    - Combination modality, NOS

    - Other, NOS

    - Unknown

Tumor Registry Radiation Therapy Datapoints (continued)

- Rad--Regional Dose: cGy

  - http://datadictionary.naaccr.org/default.aspx?c=10#1510

  - https://r.details.loinc.org/LOINC/21958-4.html?sections=Comprehensive

  - OHDSI Measurement: 3035859

  - centiGray (cGy)

Tumor Registry Radiation Therapy Datapoints (continued)

- Volume

  - Rad--Treatment Volume

    - http://datadictionary.naaccr.org/default.aspx?c=10#1540

    - https://r.details.loinc.org/LOINC/21961-8.html?sections=Comprehensive

    - OHDSI Measurement: 3020306

    - No radiation therapy, not applicable

    - Eye/orbit

    - Pituitary

    - Brain (NOS)

    - Brain (limited)

    - Head and neck (NOS)

    - Head and neck (limited)

    - Glottis

    - Sinuses

    - Parotid

    - Chest/lung (NOS)

    - Lung (limited)

- Esophagus

- Stomach

- Liver

- Pancreas

- Kidney

- Abdomen (NOS)

- Breast

- Breast/lymph nodes

- Chest wall

- Chest wall/lymph nodes

- Mantle, mini-mantle

- Lower extended field

- Spine

- Skull

- Ribs

- Hip

- Pelvic bones

- Pelvis (NOS)

- Skin

- Soft tissue

- Hemibody

- Whole body

- Bladder and pelvis

- Prostate and pelvis

- Uterus and Cervix

- Shoulder

- Extremities bone, NOS

- Inverted Y

- Spinal cord

- Prostate

- Thyroid

- Lymph node region, NOS

- Other

- Unknown

Tumor Registry Radiation Therapy Datapoints (continued)

- Fractions

  - Rad--No of Treatment:Number of Treatments to this Volume

    - http://datadictionary.naaccr.org/default.aspx?c=10#1520

    - https://r.details.loinc.org/LOINC/21959-2.html?sections=Comprehensive

    - OHDSI Measurement: 3009398

- Location

  - http://datadictionary.naaccr.org/default.aspx?c=10#1550

  - https://r.details.loinc.org/LOINC/21962-6.html?sections=Comprehensive

- OHDSI Measurement: 3035760

- Rad--Location of RX: Location of Radiation Treatment

- No radiation treatment

- All radiation treatment at this facility

- Regional treatment at this facility, boost elsewhere

- Boost radiation at this facility, regional elsewhere

- All radiation treatment elsewhere

- Other, NOS

- Unknown

Tumor Registry Radiation Therapy Datapoints (continued)

- Boost

    - Rad--Boost RX Modality

        - http://datadictionary.naaccr.org/default.aspx?c=10#3200

        - https://r.details.loinc.org/LOINC/42128-9.html?sections=Comprehensive

        - OHDSI Measurement: 3031539

        - No boost treatment

        - External beam, NOS

        - Orthovoltage

        - Cobalt-60, Cesium-137

        - Photons (2-5 MV)

        - Photons (6-10 MV)

- Photons (11-19 MV)

- Photons (> 19 MV)

- Photons (mixed energies)

- Electrons

- Photons and electrons mixed

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- Brachytherapy, Intracavitary, LDR

- Brachytherapy, Intracavitary, HDR

- Brachytherapy, Interstitial, LDR

- Brachytherapy, Interstitial, HDR

- Radium

- Radio-isotopes, NOS

- Strontium - 89

- Strontium - 90

- Other, NOS

- Unknown

Tumor Registry Radiation Therapy Datapoints (continued)

- Boost Dose

  - Rad--Boost Dose cGy

    - http://datadictionary.naaccr.org/default.aspx?c=10#3210

    - https://r.details.loinc.org/LOINC/42119-8.html?sections=Comprehensive

    - OHDSI Measurement: 3032272

Normalizing to standard vocabularies?

- NAACCR does not normalize radiotherapy datapoints or value sets to standardized vocabularies.

- NAACCR has been mapped into LOINC.

- Look elsewhere:

  - AUA AQUA Quality Registry. Maps high-level therapy types to standardized vocabularies.

    - Received interstitial prostate brachytherapy

    - EBRT

  - National Radiation Oncology Registry

    - http://www.roinstitute.org/What-We-Do/Research-Projects/National-Radiation-Oncology-Registry.aspx

    - An aborted effort but might have done some work mapping radiation oncology datapoints to standardized vocabularies.

    - Developing a national radiation oncology registry: From acorns to oaks: https://www.ncbi.nlm.nih.gov/pubmed/24674031

Radiation Oncology CPT/ HCPCS Procedure Codes

- Prescription

  - CPT: 99201 – 99255

- Simulation

  - CPT: 77280 – 77295

- Planning

  - CPT: 77261 – 77263

  - CPT: 77300 – 77370

- Delivery

  - CPT: 77401 – 77418

  - HCPCS: G6002 – G6015

- Map Delivery CPT/HCPCS codes to NAACCR modalities.

Implementation

- Some SQL to pull radiation therapy delivery datapoints from a radiation oncology EMR.

  - https://gist.github.com/mgurley/e3c675f6e8e4c54016539b5d9dced4e1

Oncology Data Model (first swipe)
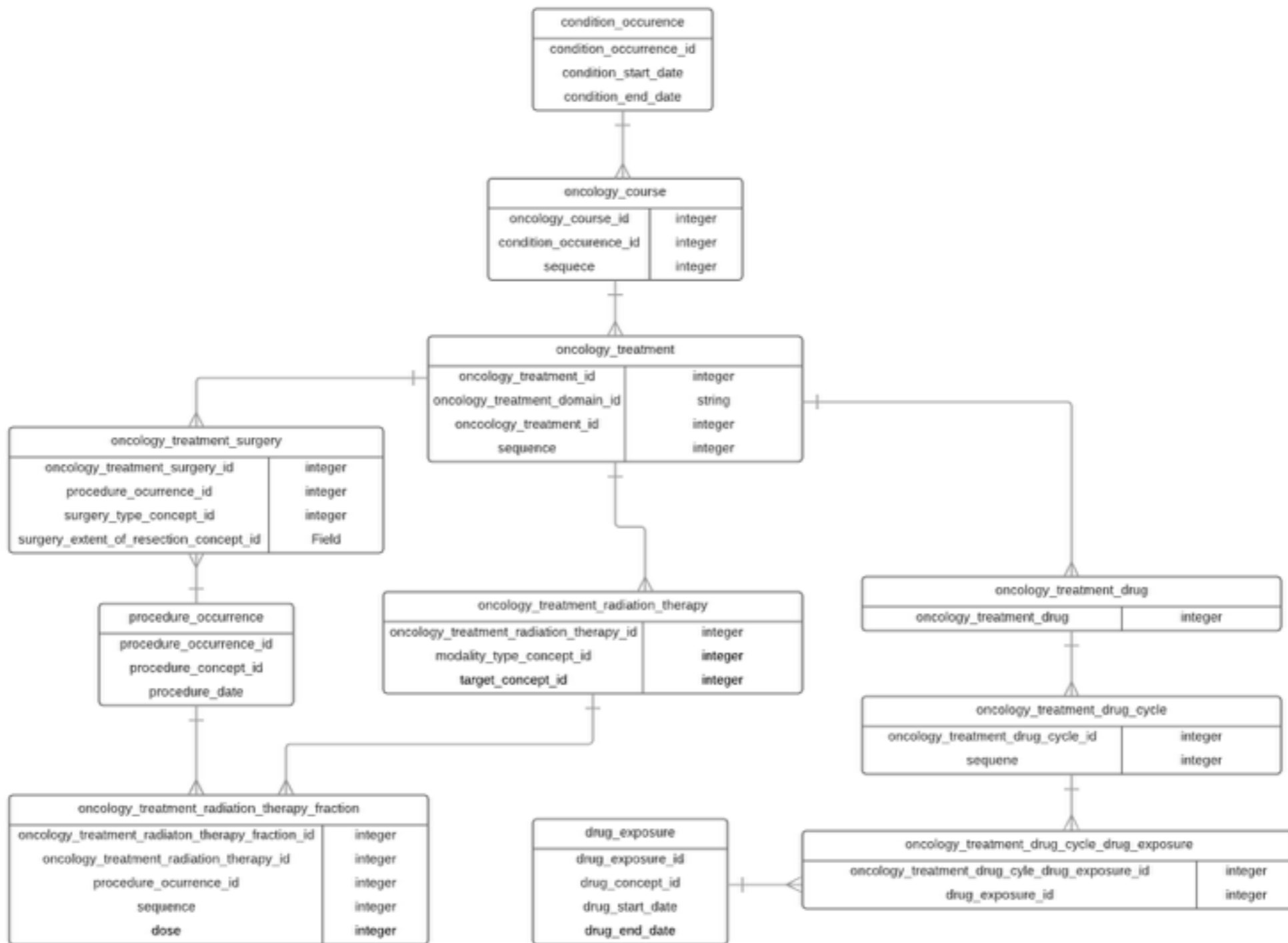
Oncology Data Model (first swipe continued)

- We want to capture the intentional stance between a treatment course and an oncology diagnosis.

- Treatment courses are sequenced.

- A treatment course can comprise one or more treatments.   Sequenced. Example: first course treatment for Glioblastoma:

    - Surgical resection (1)

    - External beam radiation therapy (2)

    - Avastin regimen (3)

- Polymorphic relationship between oncology_treatment table and oncology_treatment_x tables.

- procedure_occurrence only has a procedure_date and procedure_datetime.

- Do we want to model each radiotherapy fraction?

- Do we want to model each drug regimen cycle?

- How do we want to model drug regimens?

Datapoints Beyond Radiation Therapy Delivery?

- What about datapoints covering radiotherapy prescription, simulation and planning?

- For example, simulation (from Andrew Miller https://uow.academia.edu/AndrewMiller

Patient
  Diagnosis
    Stage
      Intent
        Modalities
          Radiation
            Radiotherapy Simulation
              Target Volume
                Technique
                  PlanningVolumes
                    PlanningTreatmentVolume
                      ClinicalTargetVolume
                        GrossTumourVolume

Stereotactic Radiosurgery datapoints?

- American Association of Neurological Surgeons starting a Stereotactic Radiosurgery registry: http://thejns.org/doi/pdf/10.3171/2015.1.JNS142466

- Data dictionary and data model Quintiles.