RT-CDM: Extending OMOP-CDM for Tomography Imaging Data

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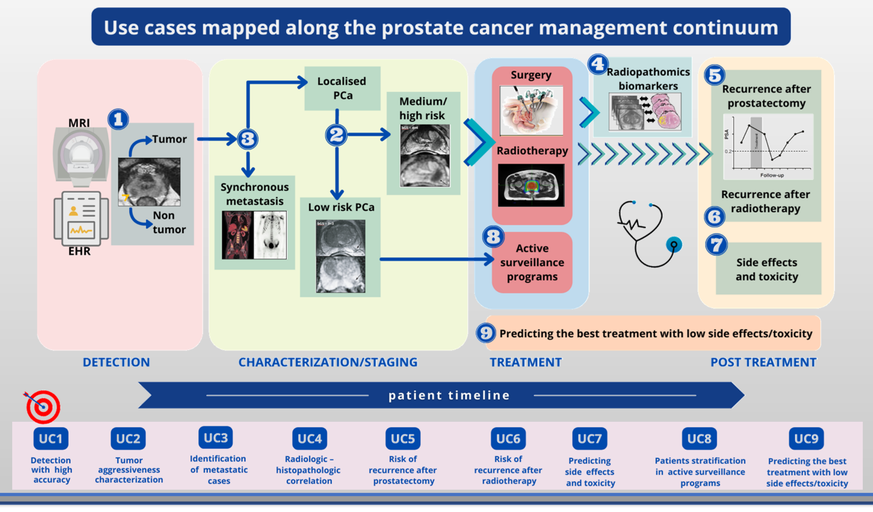
1. Motivation

ProCAncer-I EU project

- The largest dataset of **anonymized** prostate cancer (PCa) **mpMRi** images worldwide
- Develop robust **AI vendor-specific** and **vendor-neutral AI** models for **9 PCa clinical scenarios**

Challenges with the current OMOP-CDM model

- Locate datasets for **UC1** or to develop a **Lesion Segmentation**, **Vendor Specific** (e.g. Siemens) model:
  - For patients with **gleason score >= 3+3 and PIRADS>=3,** retrieve all the **T2w Axial** DICOM series from a **Siemens** scanner with **slice_thickness<=3** and their corresponding **lesion segmentations.**



2. Methods

- Clinical experts defined all clinical, imaging, pathology, and follow-up data that needed to be collected
- Existing approaches on the domain were reviewed along with existing OMOP-CDM extensions (**oncology extension, radiology extension**)
- Iterative discussions between **clinical experts** and **AI model experts** (defined a set of possible queries needed to be addressed)

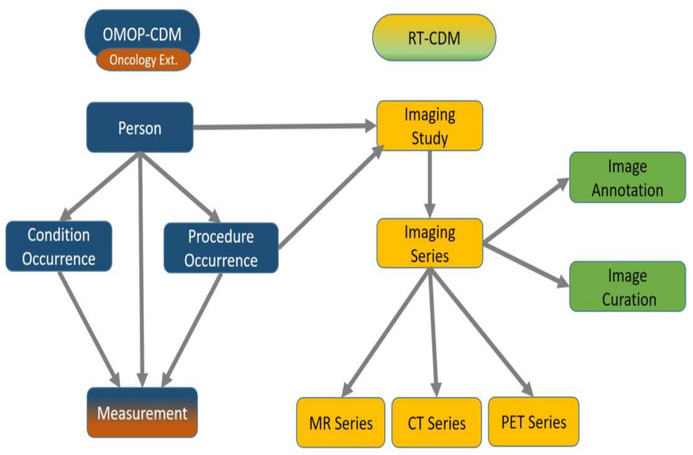
3. Contribution

Our proposed model:

1. Incorporates standardized imaging attributes for the most important DICOM tags as well as measurements derived from medical images for three types of tomography imaging
2. Extends the model for registering annotation and curation processes
3. Allows for utilizing direct annotations on medical images and all levels of the ontology hierarchy of the Radlex lexicon for deducing useful data.

e.g., a lesion is a PI-RADS score=4 could be derived by exploiting the ontology, if lesion characteristics were coded by using Radlex annotations - enabling an image to be associated with specific lesion descriptors.

4. Results



DICOM Metadata

Tag	Name	Value
(0010,0020)	Patient ID	1422784
(0008,0020)	Study Date	20220828
(0008,1030)	Study Description	MRI PROSTATE W WO CONTRAST
(0008,103E)	Series Description	T2_spc_rst_axial obl_Prostate
(0008,0060)	Modality	MR
(0018,0015)	Body Part Examined	PELVIS
(0018,0050)	Slice Thickness	1.5
(0008,0070)	Manufacturer	SIEMENS
(0008,1090)	Manufacturer's Model Name	Skyra
(0018,5100)	Patient Position	FFS
(0020,000D)	Study Instance UID	1.3.6.1.4.1.58108.1.738...
(0020,000E)	Series Instance UID	1.3.6.1.4.1.58108.1.262...
(0018,0020)	Scanning Sequence	SE
(0020,0011)	Series Number	4
(0020,1041)	Slice Location	53.455810546875
(0028,0030)	Pixel Spacing	0.6640625,0.6640625
(0018,1050)	Spatial Resolution	0.9375
(0008,0008)	Image Type	'ORIGINAL', 'PRIMARY'
(0018,0087)	Magnetic Field Strength	1.5
(0018,1310)	Acquisition Matrix	256, 0, 0, 192
(0018,9087)	Diffusion b-value	-
(0020,0110)	Temporal Resolution	0

Imaging Study

COLUMN	EXAMPLE
imaging_study_id	7654326
person_id	1422784
procedure_occurrence_id	1284758
care_site_id	87451785
radiology_study_date	2022-08-28
protocol_concept_id	3047494
manufacturer_name	SIEMENS
manufacturer_model	Skyra
number_of_images	2485
number_of_series	5
radiology_study_source_id	1.3.6.1.4.1.58108.1.738...
radiology_study_source_name	MRI PROSTATE W WO ...

Imaging Series

COLUMN	EXAMPLE
imaging_series_id	6787546
person_id	1422784
imaging_study_id	7654326
radiology_series_date	2022-08-28
protocol_concept_id	3047494 → MR Prostate WO and W contrast IV
modality_concept_id	RID10312 → Magnetic Resonance Imaging
anatomic_region_concept_id	RID2507 → pelvis
patient_position_concept_id	RID10421 → supine
patient_orientation_concept_id	RID10463 → feet firs
anatomical_plane	RID10579 → axial pl
series_number	4
slice_thickness	1.5
slice_location	53.455810546875
row_spacing	0.6640625
column_spacing	0.6640625
spatial_resolution	0.9375
pixel_data_characteristics	ORIGINAL
patient_exam_characteristics	PRIMARY
num_images	24
series_description_source_value	T2_spc_rst_axial_obl..

MR Series

COLUMN	EXAMPLE
imaging_series_id	6787546
person_id	1422784
echo_type_concept_id	RID10746 → Spin echo
tissue_contrast_concept_id	RID10795 → T2 weighted
repetition_time	3800
echo_time	101
magnetic_field_strength	1.5
frequency_matrix	256
phase_matrix	192
diffusion_bvalue	-
temporal_resolution	0

Image Curation

COLUMN	EXAMPLE
curation_id	3234887
source_imaging_series_id	6787546
source_imaging_study_id	7654326
derived_imaging_series_id	5896754
curation_function	motion correction
curation_method	MANUAL
curation_software	ADV
curation_software_version	3.1.
curator_id	567

Image Annotation

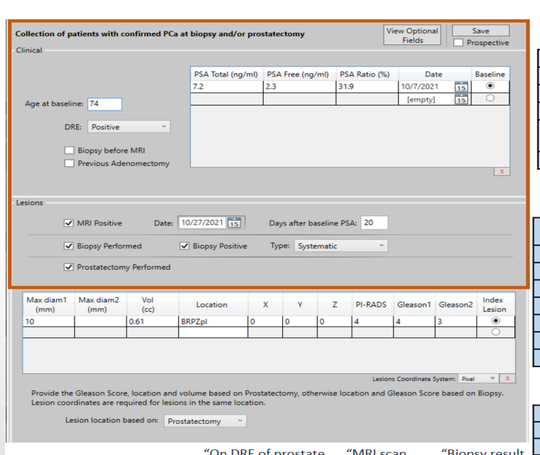
COLUMN	EXAMPLE
annotation_id (PK)	3789764
source_imaging_study_id(FK)	7654326
source_imaging_series_id (FK)	6787546
derived_imaging_series_id	5896888
annotation_datetime	2023-02-01
annotator_id (FK)	5674532
annotation_status	FINAL
annotation_anatomic_location	RID351 → transition zone of prostate
imaging_observation	RID38780 → lesion
annotation_method	MANUAL
annotation_software_name	Quibim Annotation
annotation_software_version	v.1.2
annotation_review_status	-
annotation_reviewer_id (FK)	-
annotation_review_datetime	-

Provider

COLUMN	EXAMPLE
user_id	5674532
name	Alice Smith
contact info	asmith@hospital.com
organization	The A hospital
expertise	Radiologist
years_of_experience	**10**

5. OMOP & RT-CDM on Prostate Cancer

Data from more than 9,600 patients with more than 69,000 mpMRI series and 5,600,000 images, acquired from the ProCAncer-I platform have already been integrated using the **RT-CDM extension**



Person

Field	Value
person_id	1
gender_concept_id	8507
year_of_birth	1947
person_source_value	PCa-687683705744664 9 1492076290655873086 64
care_site_id	4090166

Visit_Occurrence

Field	Value	"Baseline Visit"	"Baseline Visit-Imaging"
visit_occurrence_id	488651177	411551204	
person_id	1	1	
visit_concept_id	2000000007	2000000009	
visit_start_datetime	1/1/2000	21/1/2000	
visit_end_datetime	1/1/2000	21/1/2000	
visit_source_value	baseline	baseline - MRI	

Procedure_Occurrence

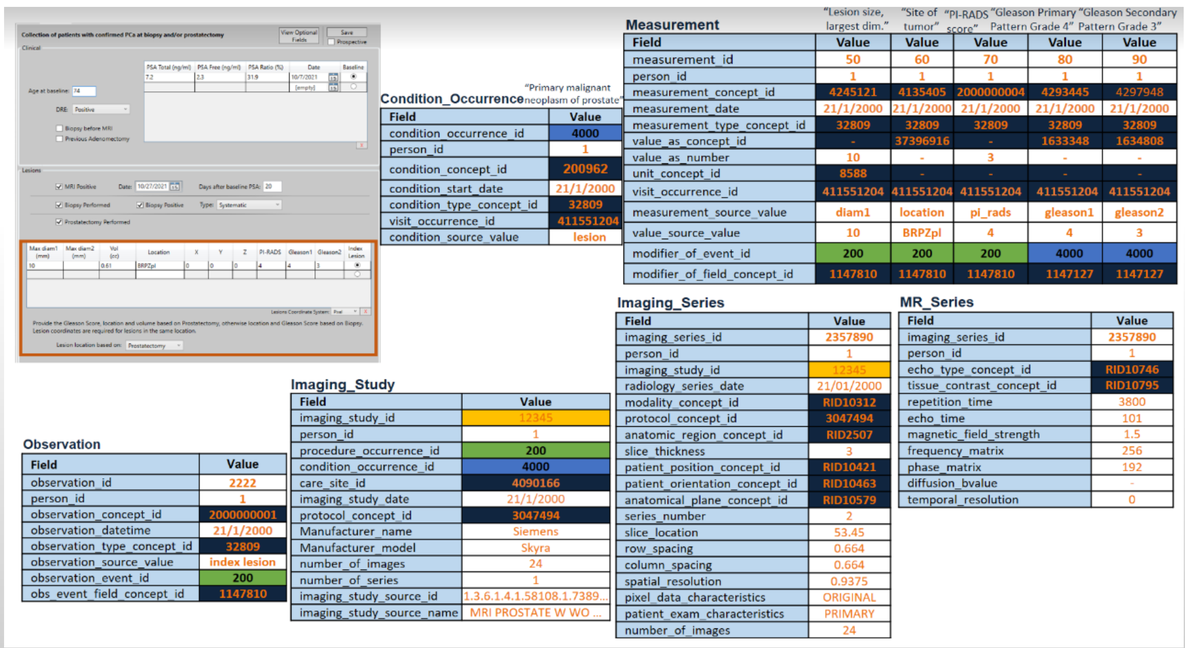
Field	Value	"Digital examination of rectum"	"Multiparametric MRI of prostate"	"Biopsy of prostate"	"Prostatectomy"
procedure_occurrence_id	100	200	300	400	
person_id	1	1	1	1	
procedure_concept_id	4254766	36714087	4278515	4235738	
procedure_datetime	1/1/2000	21/1/2000	21/1/2000	21/1/2000	
procedure_type_concept_id	32809	32809	32809	32809	
modifier_concept_id	0	0	0	0	
visit_occurrence_id	488651177	411551204	411551204	411551204	

Measurement

Field	Value	"Total PSA level"	"Free prostate specific antigen level"	"Free:total PSA ratio"
measurement_id	10	20	30	
person_id	1	1	1	
measurement_concept_id	44793131	4194418	4215704	
measurement_date	1/1/2000	1/1/2000	1/1/2000	
measurement_type_concept_id	32809	32809	32809	
value_as_concept_id	-	-	-	
value_as_number	7.2	2.3	31.9	
unit_concept_id	8842	8842	8554	
measurement_source_concept_id	0	0	0	
visit_occurrence_id	488651177	488651177	488651177	
measurement_source_value	PSA Total	PSA Free	PSA Ratio	
value_source_value	7.2	2.3	31.9	

Condition_Occurrence

Field	Value	"On DRE of prostate abnormality detected"	"MRI scan abnormal"	"Biopsy result abnormal"
condition_occurrence_id	1000	2000	3000	
person_id	1	1	1	
condition_concept_id	43531580	4059669	4013824	
condition_start_date	1/1/2000	21/1/2000	21/1/2000	
condition_type_concept_id	32809	32809	32809	
condition_status_concept_id	0	0	0	
visit_occurrence_id	488651177	411551204	411551204	
condition_source_value	DRE positive	MRI positive	Biopsy positive	



Condition_Occurrence

Field	Value	"Primary malignant neoplasm of prostate"
condition_occurrence_id	4000	
person_id	1	
condition_concept_id	200962	
condition_start_date	21/1/2000	
condition_type_concept_id	32809	
visit_occurrence_id	411551204	
condition_source_value	lesion	

Measurement

Field	Value	"Lesion size, largest dim."	"Site of tumor"	"PI-RADS score"	"Gleason Primary Pattern Grade 4"	"Gleason Secondary Pattern Grade 3"
measurement_id	50	60	70		80	90
person_id	1	1	1		1	1
measurement_concept_id	4245121	4135405	2000000004		4293445	4297948
measurement_date	21/1/2000	21/1/2000	21/1/2000		21/1/2000	21/1/2000
measurement_type_concept_id	32809	32809	32809		32809	32809
value_as_concept_id	-	37396916	-		1633348	1634808
value_as_number	10	-	3		-	-
unit_concept_id	8588	-	-		-	-
visit_occurrence_id	411551204	411551204	411551204		411551204	411551204
measurement_source_value	diam1	location	pi_rads		gleason1	gleason2
value_source_value	10	BRPZpl	4		4	3
modifier_of_event_id	200	200	200		4000	4000
modifier_of_field_concept_id	1147810	1147810	1147810		1147127	1147127

Observation

Field	Value
observation_id	2222
person_id	1
observation_concept_id	2000000001
observation_datetime	21/1/2000
observation_type_concept_id	32809
observation_source_value	index lesion
observation_event_id	200
obs_event_field_concept_id	1147810

Imaging_Study

Field	Value
imaging_study_id	12345
person_id	1
procedure_occurrence_id	200
condition_occurrence_id	4000
care_site_id	4090166
imaging_study_date	21/1/2000
protocol_concept_id	3047494
Manufacturer_name	Siemens
Manufacturer_model	Skyra
number_of_images	24
number_of_series	1
imaging_study_source_id	1.3.6.1.4.1.58108.1.7389...
imaging_study_source_name	MRI PROSTATE W WO ...

Imaging_Series

Field	Value
imaging_series_id	2357890
person_id	1
imaging_study_id	12345
radiology_series_date	21/01/2000
modality_concept_id	RID10312
protocol_concept_id	3047494
anatomic_region_concept_id	RID2507
slice_thickness	3
patient_position_concept_id	RID10421
patient_orientation_concept_id	RID10463
anatomical_plane_concept_id	RID10579
series_number	2
slice_location	53.45
row_spacing	0.664
column_spacing	0.664
spatial_resolution	0.9375
pixel_data_characteristics	ORIGINAL
patient_exam_characteristics	PRIMARY
number_of_images	24

MR_Series

Field	Value
imaging_series_id	2357890
person_id	1
echo_type_concept_id	RID10746
tissue_contrast_concept_id	RID10795
repetition_time	3800
echo_time	101
magnetic_field_strength	1.5
frequency_matrix	256
phase_matrix	192
diffusion_bvalue	-
temporal_resolution	0

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This project has received funding from the European Union's Horizon 2020 Research and innovation programme under grant agreement No 952159