UNIVERSITY
OF TRENTO - Italy

Dipartimento di Ingegneria e Scienza dell'Informazione

– KnowDive Group –

Knowledge Graph Engineering 2022
Trentino Healthcare Project Report

Document Data:	Reference Persons
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Website: https://zehrakorkusuz.github.io/
Resources: https://github.com/Morook97/Trentino_Healthcare_KGE_Project
Presentation: https://www.canva.com/design/DAFWE8f5d2A/QmWwIWmActfnpGtRf-wJlg/view?utm_content=DAFWE8f5d2A&utm_campaign=designshare&utm_medium=link&utm_source=publishsharelink

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Introduction

Healthcare is a complex system involving many different facilities and services. In order to improve the accessibility of the system, it is crucial to have a clear organization of the system knowledge. Clarity of the system provides efficient delivery of services when people admit to the right place at the right time.

Healthcare systems have different stages based on the course of the disease or emergency. Medical treatment or preventive care along with ongoing therapies and residential places for the elderly, disabled people, and people with special needs such as autism or drug addiction. Facilities can be either private or public which means different administrative protocols and differ by the preference of different socioeconomic situations.

Some chronic diseases require consistent check-ups and laboratories and health centers provide the needed tests for the regular care of these people.

Emergencies are particularly a type of category in the healthcare system and the first place to admit is usually a hospital. Since Trentino is surrounded by mountains and hiking, alpinism, and skiing are common sports, these types of emergencies and injuries are common cases in the region.

Also considering the elderly population and Trentino as a developed region, elderly care facilities such as Alzheimer's residences and senior diurnal centers play an important role in providing healthcare services to elderly people in the region.

Purpose and Domain of Interest (DoI)

A service that lays out the complete healthcare facilities available in the Trentino region that helps the patients discover the most suitable options by covering end-to-end healthcare services based on the individual's background and health status, symptoms, complaints, and preventive medicine needs.

DoI: Azienda Provinciale Servizi Sanitari Trento (Healthcare Service Provider Trento District) leveraging the data sources of Parapharmacy, Healthcare Facilities and Blood Test Center between 2014 and 2016.

Data Sources

Knowledge Sources

For knowledge sources and domain specific ontologies, HL7FHIR and for more general registration of the information such as region schema.org are used in building the knowledge graph models.

FHIR is a repository of the knowledge sources with specialization on the healthcare and medical applications such as personal healthcare records. For patient, practitioners and

healthcare facilities; *patient, practitioner and organization* reference ontologies used respectively.

1. **Patient** : *Demographics and other administrative information about an individual or animal receiving care or other health-related services.*

https://build.fhir.org/patient.html

2. **Practioner**: *A person who is directly or indirectly involved in the provisioning of healthcare or related services.*

Dataset identifier	apss_punti-prelievo
Other identifier	N/A
Dataset themes	**Health**
Dataset editor	**Name:** Provincial Company for Health Services **IPA/VAT Code:** apss
Release date	2014-07-28
Date modified	2014-07-28
Geographic coverage	Trento
URI of GeoNames	http://www.geonames.org/3165241/
Dataset languages	Italian
Time extension	**From:** 01-01-2017 **To:** 31-12-2017
Holder	**Name:** Provincial Company for Health Services - APSS **IPA/VAT Code:** apss
Refresh rate	annual
Version of	N/A
Author	**Name:** Open Data - **IPA/IVA Technologies Department:** apss

https://build.fhir.org/practitioner.html

Contact	Open Data - Technology Department
Reference site	http://servizi.apss.tn.it/opendata/PUNTIPREL001_documentazione.pdf
Other Contact	N/A

3. **Organization**: *A formally or informally recognized grouping of people or organizations formed for the purpose of achieving some form of collective action. Includes companies, institutions, corporations, departments, community groups, healthcare practice groups, payer/insurer, etc.*

https://build.fhir.org/organization.html

4. **Region**: *A DefinedRegion is a geographic area defined by potentially arbitrary (rather than political, administrative or natural geographical) criteria. Properties are provided for defining a region by reference to sets of postal codes.*

https://schema.org/DefinedRegion

Data Sources

5. **Open Data Trentino** : 47 dataset related to healthcare and wellbeing related healthcare concerning the Trentino region is published on the website.

https://dati.trentino.it/group/wellbeing

6. **Health Analysis Sampling Points @ Trento** : *List of all sampling points in the area covered by the Provincial Health Services Authority. The address, geographical coordinates, notes and timetable are reported for each office. The telephone number is also provided.* Dataset is released on 2014-07-28.

https://dati.trentino.it/dataset/punti-prelievo

7. **Parapharmacies @ Trento** : *List of all parapharmacies operating in the Province of Trento. The address and geographical coordinates are given for each parapharmacy. The source is the Open Data system of the Ministry of Health, the data is processed by APSS. The original data are published by the Ministry of Health with Open Data License v2.0.* Dataset is released on 2016-05-18 and last modified by 25-05-2018

https://dati.trentino.it/dataset/parafarmacie-pat

8. **Public Heath Facilities @ Trento** : *The dataset contains the list of all public health facilities and those accredited with the Provincial Health Services Authority, including the APSP / RSA. For each structure, the address, the geographical coordinates, the type of structure (ambulatory, residential structure….), and the type of activity are reported. Telephone / fax number is provided. The source is the STS.11 model of the Ministry of Health, the data are processed and integrated by APSS.* Dataset is released on 2016-05-18 and last modified by 12-04-2021
https://dati.trentino.it/dataset/strutture-sanitarie-dell-azienda-sanitaria-e-convenzionate

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Metadata of the Datasets

Table 1: Blood Test Centers Metadata

Table 2: Blood Test Center Metadata Additional Information

Table 3: Healthcare Facilities Metadata

Dataset identifier	apss_strutture-sanitarie-dell-azienda-sanitaria-e-convenzionate
Other identifier	N/A
Dataset themes	**Health**
Dataset editor	**Name:** Provincial Company for Health Services **IPA/VAT Code:** apss
Release date	2016-05-18
Date modified	12-04-2021
Geographic coverage	Trent
URI of GeoNames	http://www.geonames.org/3165241/
Dataset languages	Italian
Time extension	**From:** 01-12-2017 **To:** 31-12-2017
Holder	**Name:** Provincial Company for Health Services - APSS **IPA/VAT Code:** apss
Refresh rate	annual
Version of	N/A
Author	**Name:** Open Data - **IPA/IVA Technologies Department:** apss

Table 4: Healthcare Facilities Additional Information Metadata

Contact	Open Data - Technology Department
Reference site	http://servizi.apss.tn.it/opendata/SANSTRUT001_documentazione.pdf
Other Contact	N/A

Table 5: Parapharmacies Metadata

Dataset identifier	apss_parapharmacies-pat
Other identifier	N/A
Dataset themes	**Health**
Dataset editor	**Name:** Provincial Company for Health Services **IPA/VAT Code:** apss
Release date	2016-05-18
Date modified	25-05-2018
Geographic coverage	Trent
URI of GeoNames	http://www.geonames.org/3165241/
Dataset languages	Italian
Time extension	**From:** 01-01-2017 **To:** 31-12-2017
Holder	**Name:** Provincial Company for Health Services - APSS **IPA/VAT Code:** apss
Refresh rate	annual
Version of	N/A
Author	**Name:** Open Data - **IPA/IVA Technologies Department:** apss

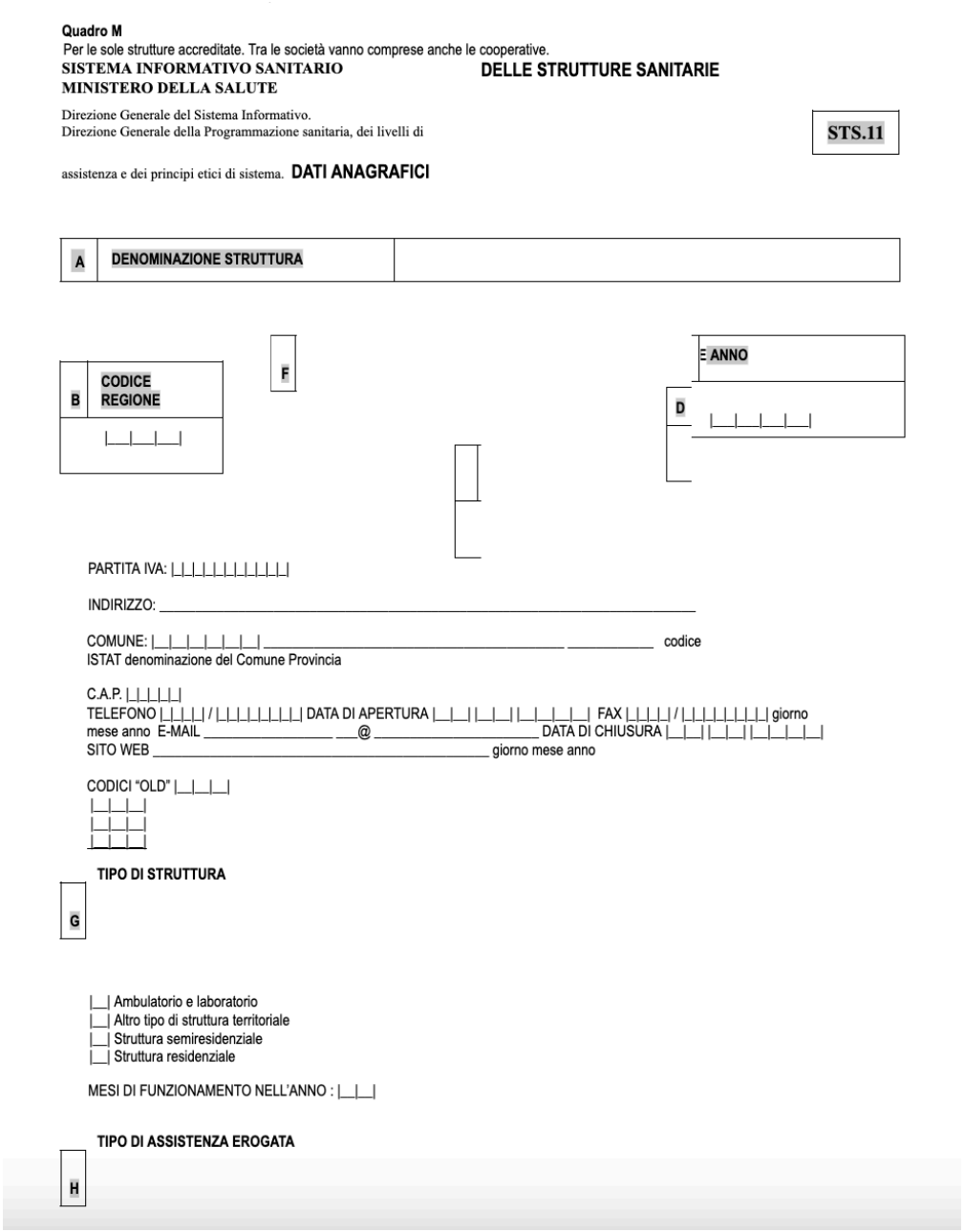
Table 6: Parapharmacies Additional Information Metadata

Contact	Open Data - Technology Department
Reference site	http://servizi.apss.tn.it/opendata/PARAFARM001_documentazione.pdf
Other Contact	N/A

Data Collection Method

Data collection method is explained in the DATI ANAGRAFICI DELLE STRUTTURE SANITARIE file. Information about the facilities collected In the form which format is given below. Entities created through this information.

Image 1: Data Collection Form



Quadro M
Per le sole strutture accreditate. Tra le società vanno comprese anche le cooperative.
SISTEMA INFORMATIVO SANITARIO **DELLE STRUTTURE SANITARIE**
MINISTERO DELLA SALUTE

Direzione Generale del Sistema Informativo.
Direzione Generale della Programmazione sanitaria, dei livelli di assistenza e dei principi etici di sistema. **DATI ANAGRAFICI**

STS.11

A	DENOMINAZIONE STRUTTURA	

B CODICE REGIONE |__|__|__|

F

E ANNO

D |__|__|__|__|

PARTITA IVA: |_|_|_|_|_|_|_|_|_|_|_|

INDIRIZZO: _____

COMUNE: |__|__|__|__|__|__| _____ _____ codice
ISTAT denominazione del Comune Provincia

C.A.P. |_|_|_|_|_|
TELEFONO |_|_|_|_| / |_|_|_|_|_|_|_| DATA DI APERTURA |__|__| |__|__| |__|__|__|__| FAX |_|_|_|_| / |_|_|_|_|_|_|_| giorno
mese anno E-MAIL _____ ___@ _____ DATA DI CHIUSURA |__|__| |__|__| |__|__|__|__|
SITO WEB _____ giorno mese anno

CODICI "OLD" |__|__|__|
__	__	__
__	__	__
__	__	__

TIPO DI STRUTTURA

G

|__| Ambulatorio e laboratorio
|__| Altro tipo di struttura territoriale
|__| Struttura semiresidenziale
|__| Struttura residenziale

MESI DI FUNZIONAMENTO NELL'ANNO : |__|__|

TIPO DI ASSISTENZA EROGATA

H

Purpose Formalization

Scenarios

Scenarios are related to location where and when the incident happens and people seek out healthcare services. All of the locations are attached to the file with the inception sheet.

- Trento, city center, during the week
- Trento, city center, during the weekend
- Trento, outside the city center
- Mezzolombardo, city center, during the weekend
- Folgaria, city center, during the week

Personas

Table 7: Personas

Name	Age	Interests	Usage	Description
John	40	Employees in public administration	overweight person, high blood pressure, pang in the heart	He is admitted to hospital to a cardiovascular medical examination.
Allen	32	Laboratory technician	technician exposed to radiation regularly	He diagnosed with cancer. He goes to the polyclinic for chemotherapy.
Peter	85	Unemployed, Elderly person, Lone person	Lost memory, Social problems, Depression	He goes to Alzheimer Diurnal Center to check for alzheimer and dementia forgetting old friend names and what has been eating during the day
Jennifer	17	Runner, She regularly working out for marathons	Numbness in limb, Loss strength and dexterity in her leg	During her training sessions, she has problems with coordination and balance. She goes to neurology to check up for MS and diseases.
Alex	26	Engineer,	Strong mood alterations, State of starting a lot of activities to a state of isolation, Depression	Alex is diagnosed with bipolar disorder and goes to a mental healthcare centre to receive treatment.
Antonio	13	Middle school student	low socio-economics conditions neighbourhood, regularly abuse drugs group	Antonio also abuses drugs and has addiction problems. He tries to overcome addiction and goes to a antidrug clinic.
Lucia	35	Stay at home wife, Unemployed	3 months pregnant, check up	Lucia goes to the healthcare centre to have a check up on her pregnancy with an ultrasound scan.
Johanna	29	Unemployed, Stay at home mom	9 months pregnant, labour	Johanna enters labour and goes to hospital to deliver the baby.
Pietro	40	Banker	kidney problems, regular care	Pietro goes to the dialysis centre to divert and clean the blood cause for a kidney failure.

Emanuele	17	High school student	Experiencing domestic problems, problems with social interactions, psychological trauma	Emanuele seeks help from family counselling and tells his father abuse him and repeated beat him.
Sarah	18	Ice skater enthusiastic	Fell during the ice skating session, broke her arm	She goes to the hospital and the orthoepic doctor put a plaster cast on is arm.
Giovanni	23	College student, Enjoy Travel	Car accident	He and his friends often goes out for road trip. Giovani has a car accident and the ambulance bring him to the hospital with possible concussion.
Alessio	34	Farmer, grape harvest season	Bee stung, Allergic reaction	Alessio is stung by a bee and has an allergic reaction and goes to hospital for treatment.
Emily	27	Cashier, overweight and has high cholesterol	Blood check-up	Emily goes to the polyclinic to check her cholesterol.
Daniele	8	Child	Bruising on his legs, paleness and fill weak	Daniele after few exam was diagnose leukimia and the doctor send him to the genetic research center.
Carlo	35	Food, Food blogger	Acne problems, problem etnic food	Carlo start having acne problems after eating at a restaurant and goes to hospital to see a dermatologist to understand the cause of this problem
Gabriel	28	Party, PR in a night club	AIDS, sexually transmitted disease	Gabriel since his AIDS tests was positive, his admitted to AIDS Community home shelter.
Davide	42	Doctor in the emergency department	Covid symptoms, breathing problems	Davide results positive and breathing problems. He goes to hospital to get a treatment.
Juliano	36	Play football	Plaster cast remove, rehabilitation	He just removed the plaster cast from his leg. Juliano start the rehabilitation process with physiotherapist. He start doing a part of mobility and after that a strength protocol.
Maria	60	Housewife	Knee pain, surgery	She start knee pain having when she walk up stairs. Maria goes to the hospital to have the meniscus surgery.
Caio	50	Seller	Depress, suicide	The company he work for 25 years fair him. After that he start became depress and think of suicide. Caio go to a psychiatric diurnal center service to overcame is depression.
Alessia	36	Insurance agent	Losing weight, anorexia	She constantly losing weight because of anorexia. Alessia goes to Psychiatric Residence for treatment.
Tony	85	unemployed, elderly person	Wheelchair, alone, unhappy	Tony start going a senior diurnal center to enter in a community of people that have the same problem and help him live a happy life
Rachele	25	Student	Can't sleep, supplement	Rachele go to the pharafarmacy to buy same particular supplement to help her sleep

Giulia	22	Student	Flu, over the counter drug	Giulia go to the pharafarmacy to buy takipirina (paracetamol) for help her heal a little bit.
Alessio	0	-	Machine salesman	He want to check is blood values.
Maria	80	Unemployed, elderly person	Alone, difficulties of movement	Maria goes to Public Social Service Company so she can be feel safe and the service people there can take care of her.
Silvia	15	Middle school student	Behavioral disorders, inability to pay attention, stress, ADHD disorder	Silvia goes to rehabilitation center to have assistance for ADHD disorder and try therapeutic intervention for this illness.
Sergio	83	Unemployed, elderly person	Terminally ill	Sergio goes to the hospice to have emotional support and treatment at the end of is life.
Giovanni	21	Mechanic	Alcoholic, abuse drugs, trauma	Giovanni goes community center to find paces and times to rethink his life and arrive at the enhancement of his abilities and resources.
Mario	53	Insurance agent	Peripheral arterial disease, chronic disorder, periodic treatment	Mario is admitted to hospital for peripheral arterial disease cause by diabetes type 1.

Competency Questions (CQs)

1. John has a high blood pressure and fell pang in the heart. He is admitted to hospital to a cardiovascular medical examination
2. Allen is diagnosed with cancer. He goes to the polyclinic for chemotherapy.
3. Peter has both social problems, depression and memory problems. He goes to Alzheimer Diurnal Center to check for alzheimer and dementia.
4. During her training sessions, she has problems with coordination and balance. She goes to neurology to check up for MS and diseases.
5. Alex is diagnosed with bipolar disorder and goes to a mental healthcare centre to receive treatment.
6. Antonio also abuses drugs and has addiction problems. He tries to overcome addiction and goes to a anti-drug clinic.
7. Lucia goes to the healthcare centre to have a check up on her pregnancy with an ultrasound scan.
8. Johanna enters labour and goes to hospital to deliver the baby.
9. Mario is admitted to hospital for peripheral arterial disease cause by diabetes type 1.
10. Pietro goes to the dialysis centre to divert and clean the blood cause for a kidney failure.
11. Emanuele seeks help from family counseling and tells his father abuse him and repeated beat him.
12. Sarah fell during the ice skating session and she broke her arm. She goes to the hospital and the orthoepic doctor put a cast on is arm.
13. Giovani has a car accident and the ambulance bring him to the hospital with possible concussion.
14. Alessio is stung by a bee and has an allergic reaction and goes to hospital for treatment.
15. Emily goes to the polyclinic to check her cholesterol.
16. Daniele after few exam was diagnose leukemia and the doctor send him to the genetic research center.
17. Carlo start having acne problems after eating at a restaurant and goes to hospital to see a dermatologist to understand the cause of this problem
18. Gabriel since his AIDS tests was positive, his admitted to AIDS Community home shelter.

19. Davide results positive and breathing problems and he goes to hospital to get a treatment.
20. Juliano start the rehabilitation process with physiotherapist. He start doing a part of mobility and after that a strength protocol.
21. Maria goes to the hospital to have the meniscus surgery.
22. Caio go to a psychiatric diurnal center service to overcome is depression
23. Alessia goes to Psychiatric Residence for treatment.
24. Tony start going a senior diurnal center to enter in a community of people that have the same problem and help him live a happy life
25. Rachele goes to the parapharmacy to buy same particular supplement to help her sleep
26. Giulia goes to the parapharmacy to buy paracetamol for help her heal a little bit.
27. Alessio goes to a blood test sampling point to take a sample of blood so that can be analyses in a laboratory
28. Maria goes to Public Social Service Company so she can be feel safe and the serveice people there can take care of her
29. Silvia goes to rehabilitation center to have assistance for ADHD disorder and try therapeutic intervention for this illness.
30. Sergrio goes to the hospice to have emotional support and treatment at the end of is life.
31. Giovanni goes community center to find paces and times to rethink his life and arrive at the enhancement of his abilities and resources.

Entities

Concept of the Entities

1. **Person** as either patient, patient relative or physician
2**. Building**s as type of facility and >department under certain type of facilities like hospital
3. **Event** as admission reason/disease and type of treatment

Some of the entities in the purpose formalization sheet are given below.

Common Entities:
Location, move, adult, young adult, elderly, child
Core Entities:
Hospital, Polyclinic, Alzheimer Diurnal Center, Mental Healthcare Center, Multiple Sclerosis Clinic, Anti-drug clinic, Dialysis Centre, Family Counseling, Laboratory, Genetic Research Center, Psychiatric Diurnal Center, Cardiovascular Diseases, MS, Dug Addiction, Kidney problems, Blood test, Emergency room
Contextual Entities:
heart pain, cardiovascular medical examination, cancer, chemotherapy, bipolar disorder, psychiatric assistance, labor, allergic reaction, food intolerance, meniscus surgery, diurnal, depression, suicide, supplement, behavioral disorder, assistance, therapeutic intervention

Inception

Since the description of the dataset covers the Trento Provence of Trentino region, the columns with redundant information are cleaned and this information is specified in the report.

In order to navigate the patient to the right healthcare facility, the class facility as either private or public and also type of facility such as diurnal center, hospital, healthcare center

etc. were crucial. These information was missing in the dataset and defined by collecting information from the websites of facilities and healthcare authority resources.

While creating the entities in purpose formalization, is the disease/admission reason to hospital emergency or not is defined.

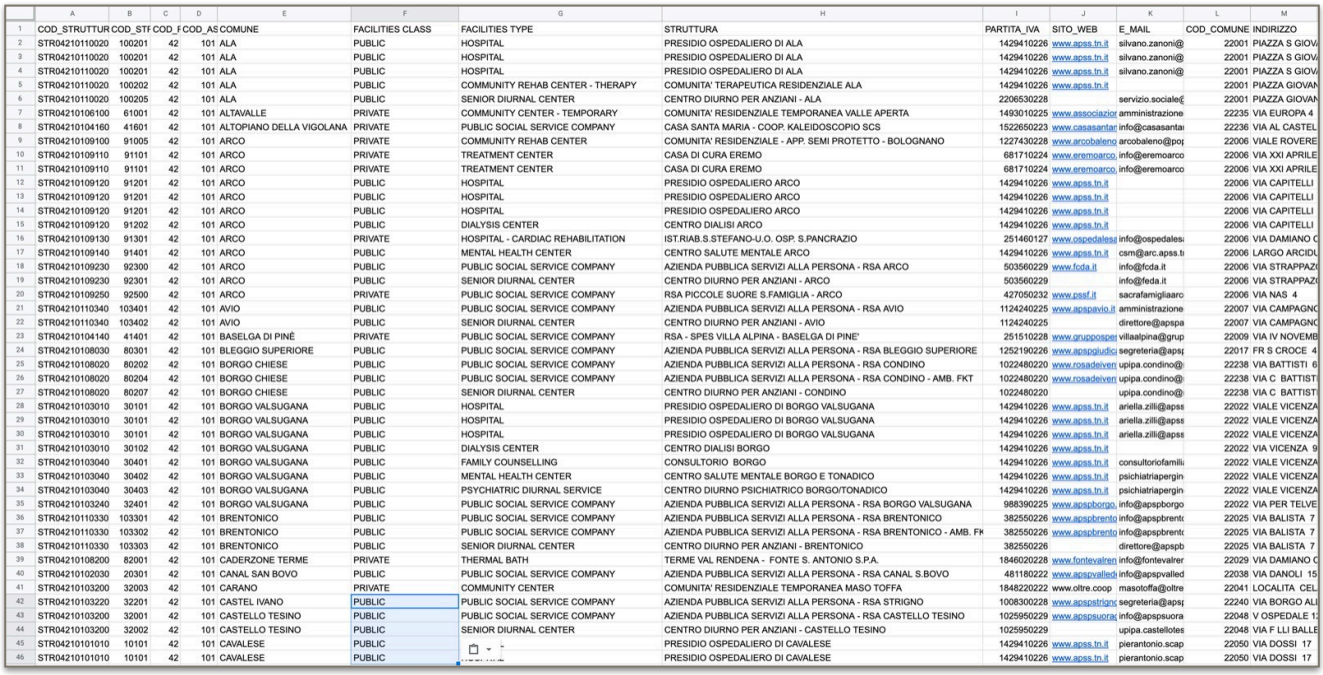
One of the challenges in dataset was that type of facilities were described in Italian. In order to merge with knowledge resources available on schema org, the certain columns in the dataset are standardized in English.

Image 2: Screenshot of the Inception Sheet

The excel file is also added to KOS software and can be found on Github.

	Scenarios	Personas	Competency Questions
2	Rovereto in city cer	John is 40 years old, overweight and works at public institution.	John has a high blood pressure and fell pang in the heart. He is admitted to hospital to a cardiovascular medical examination
3	Riva del Garda, during the week	Allen is 32 years old laboratory technician and he works at a nuclear medicine laboratory and is exposed to radiation regularly.	Allen is diagnosed with cancer. He goes to the polyclinic for chemotherapy.
4	Trento in city center, during the week	Peter is 85 years old. He lives alone. He start forgetting old friend names and what has been eating during the day	Peter has both social problems, depression and memory problems. He goes to Alzheimer Diurnal Center to check for alzheimer and dementia.
5	Trento in city cente	Jennifer is 17 years old and a runner. She regularly working out for marathons. She start feel numbness causing loss strength and dexterity in her leg.	During her training sessions, she has problems with coordination and balance. She goes to neurology to check up for MS and diseases.
6	Mezzocorona in the city center, during the week	Alex is a 26 years old engineer and he consistently experiences strong mood alterations and pass from a state of starting a lot of activities to a state of isolation and depression.	Alex is diagnosed with bipolar disporder and goes to a mental healthcare centre to receive treatment.
7	Trento outide the city center, in the evening during the week	Antonio is a 13 years old middle school student. He lives in a neighbourhood with low socio-economics conditions and he is part of group where people regularly abuse drugs.	Antonio also abuses drugs and has addiction problems. He tries to overcome addiction and goes to a antidrug clinic.
8	Predazzo in the city center, during the week	Lucia is 35 years old stay at home wife and she is 3 months pregnant.	Lucia goes to the healthcare centre to have a check up on her pregnacy with an ultrasound scan.
9	Trento in city cente	Johanna is 29 years old stay at home mom and she is 9 months pregnant and stop working since last month.	Johanna enters labour and goes to hospital to deliver the baby.
10		Mario is 53 years old insurance agent. He often goes in Trento to follow a medical treatment for a chronic disorder.	Mario is admitted to hospital for peripheral arterial disease cause by diabetes type 1.
11	Tione in the city center, in the afternoon/evening during the week	Pietro is 40 years old banker. He has kidney problems and requires regular care.	Pietro goes to the dialysis centre to divert and clean the blood cause for a kidney failure.
12	Mezzolombardo in the city center, during the week	Emanuele is 17 years old high school student. He is experiencing domestic problems and have problems with social interactions.	Emanuele seeks help from family counselling and tells his father abuse him and repeated beat him.
13	Mezzolombardo in the city center, during the weekend	Sarah is 18 years old waitress and a ice skater enthusiastic. She like ice skating in the weekends.	Sarah fell during the ice skating session and she broke her arm. She goes to the hospital and the orthoepic doctor put a cust on is arm.
14	Cavalese in city center, during the week	Giovanni is 23 years old college student. He and his friends often goes out for road trip.	Giovani has a car accident and the ambulance bring him to the hospital with possible concussion.
15	Borgo Valsugana in city center, during the week	Alessio is 34 years old farmer. He work in the vineyard during grape harvest season.	Alessio is stung by a bee and has an allergic reaction and goes to hospital for treatment.
16	Trento in the city center, during the week	Emily is 27 years old cashier. She is overweight and has high cholesterol.	Emily goes to the polyclinic to check her cholesterol.
17	Rovereto in the city	Daniele is 8 years old child and experiencing a lot of bruising on his legs, paleness and fill weak.	Daniele after few exam was diagnose leukimia and the doctor send him to the gentic research center.
18	Trento outside the city center	Carlo is 35 years old food blogger. He travel around the country to find particular type of dish so he eat at different restaurants every day.	Carlo start having acne problems after eating at a restaurant and goes to hospital to see a dermatologist to underst the cause of this problem
19	Trento in the city center, on appointment	Gabriel is 28 years old PR in a night club. He contracted a sexually transmitted disease and recently diagnosed with AIDS.	Gabriel since his AIDS tests was positive, his admitted to AIDS Community home shelter.
20	Tione in the city cer	Davide is 42 years old doctor in the emergency department. He started to have covid symptoms.	Davide results positive and breathing problems and he goes to hospital to get a treatment.
21	Malè in the city cen	Juliano is 36 years old football player. He just removed the plaster cast from his leg.	Juliano start the rehabilitation process with physiotherapist. He start doing a part of mobility and after that a strength protocol.
22	Trento in the city ce	Maria is 60 years old housewife. She start having knee pain when she walk up stairs.	Maria goes to the hospital to have the meniscus surgery.
	Borgo Valsugan in the city center		

Image 3: Screenshot of the Final Dataset



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	COD_STRUTTUR	COD_STF	COD_F	COD_AS	COMUNE	FACILITIES CLASS	FACILITIES TYPE	STRUTTURA	PARTITA_IVA	SITO_WEB	E_MAIL	COD_COMUNE	INDIRIZZO
2	STR04210110020	100201	42	101	ALA	PUBLIC	HOSPITAL	PRESIDIO OSPEDALIERO DI ALA	1429410226	www.apss.tn.it	silvano.zanoni@	22001	PIAZZA S GIOV
3	STR04210110020	100201	42	101	ALA	PUBLIC	HOSPITAL	PRESIDIO OSPEDALIERO DI ALA	1429410226	www.apss.tn.it	silvano.zanoni@	22001	PIAZZA S GIOV
4	STR04210110020	100201	42	101	ALA	PUBLIC	HOSPITAL	PRESIDIO OSPEDALIERO DI ALA	1429410226	www.apss.tn.it	silvano.zanoni@	22001	PIAZZA S GIOV
5	STR04210110020	100202	42	101	ALA	PUBLIC	COMMUNITY REHAB CENTER - THERAPY	COMUNITA' TERAPEUTICA RESIDENZIALE ALA	1429410226	www.apss.tn.it		22001	PIAZZA GIOVAN
6	STR04210110020	100205	42	101	ALA	PUBLIC	SENIOR DIURNAL CENTER	CENTRO DIURNO PER ANZIANI - ALA	2206530228		servizio.sociale@	22001	PIAZZA GIOVAN
7	STR04210106100	61001	42	101	ALTAVALLE	PRIVATE	COMMUNITY CENTER - TEMPORARY	COMUNITA' RESIDENZIALE TEMPORANEA VALLE APERTA	1493010225	www.associazior	amministrazione	22235	VIA EUROPA 4
8	STR04210104160	41601	42	101	ALTOPIANO DELLA VIGOLANA	PRIVATE	PUBLIC SOCIAL SERVICE COMPANY	CASA SANTA MARIA - COOP. KALEIDOSCOPIO SCS	1522650223	www.casasantar	info@casasantar	22236	VIA AL CASTEL
9	STR04210109100	91005	42	101	ARCO	PRIVATE	COMMUNITY REHAB CENTER	COMUNITA' RESIDENZIALE - APP. SEMI PROTETTO - BOLOGNANO	1227430228	www.arcobaleno	arcobaleno@poj	22006	VIALE ROVERE
10	STR04210109110	91101	42	101	ARCO	PRIVATE	TREATMENT CENTER	CASA DI CURA EREMO	681710224	www.eremoarco	info@eremoarco	22006	VIA XXI APRILE
11	STR04210109110	91101	42	101	ARCO	PRIVATE	TREATMENT CENTER	CASA DI CURA EREMO	681710224	www.eremoarco	info@eremoarco	22006	VIA XXI APRILE
12	STR04210109120	91201	42	101	ARCO	PUBLIC	HOSPITAL	PRESIDIO OSPEDALIERO ARCO	1429410226	www.apss.tn.it		22006	VIA CAPITELLI
13	STR04210109120	91201	42	101	ARCO	PUBLIC	HOSPITAL	PRESIDIO OSPEDALIERO ARCO	1429410226	www.apss.tn.it		22006	VIA CAPITELLI
14	STR04210109120	91201	42	101	ARCO	PUBLIC	HOSPITAL	PRESIDIO OSPEDALIERO ARCO	1429410226	www.apss.tn.it		22006	VIA CAPITELLI
15	STR04210109120	91202	42	101	ARCO	PUBLIC	DIALYSIS CENTER	CENTRO DIALISI ARCO	1429410226	www.apss.tn.it		22006	VIA CAPITELLI
16	STR04210109130	91301	42	101	ARCO	PRIVATE	HOSPITAL - CARDIAC REHABILITATION	IST.RIAB.S.STEFANO-U.O. OSP. S.PANCRAZIO	251460127	www.ospedalesa	info@ospedalesa	22006	VIA DAMIANO C
17	STR04210109140	91401	42	101	ARCO	PUBLIC	MENTAL HEALTH CENTER	CENTRO SALUTE MENTALE ARCO	1429410226	www.apss.tn.it	csm@arc.apss.t	22006	LARGO ARCIDU
18	STR04210109230	92300	42	101	ARCO	PUBLIC	PUBLIC SOCIAL SERVICE COMPANY	AZIENDA PUBBLICA SERVIZI ALLA PERSONA - RSA ARCO	503560229	www.fcda.it	info@fcda.it	22006	VIA STRAPPAZ
19	STR04210109230	92301	42	101	ARCO	PUBLIC	SENIOR DIURNAL CENTER	CENTRO DIURNO PER ANZIANI - ARCO	503560229		info@fcda.it	22006	VIA STRAPPAZ
20	STR04210109250	92500	42	101	ARCO	PRIVATE	PUBLIC SOCIAL SERVICE COMPANY	RSA PICCOLE SUORE S.FAMIGLIA - ARCO	427050232	www.pssf.it	sacrafamigliaarc	22006	VIA NAS 4
21	STR04210110340	103401	42	101	AVIO	PUBLIC	PUBLIC SOCIAL SERVICE COMPANY	AZIENDA PUBBLICA SERVIZI ALLA PERSONA - RSA AVIO	1124240225	www.apspavio.it	amministrazione	22007	VIA CAMPAGNC
22	STR04210110340	103402	42	101	AVIO	PUBLIC	SENIOR DIURNAL CENTER	CENTRO DIURNO PER ANZIANI - AVIO	1124240225		direttore@apspa	22007	VIA CAMPAGNC
23	STR04210104140	41401	42	101	BASELGA DI PINÈ	PRIVATE	PUBLIC SOCIAL SERVICE COMPANY	RSA - SPES VILLA ALPINA - BASELGA DI PINE'	251510228	www.gruppospes	villaalpina@grup	22009	VIA IV NOVEMB
24	STR04210108030	80301	42	101	BLEGGIO SUPERIORE	PUBLIC	PUBLIC SOCIAL SERVICE COMPANY	AZIENDA PUBBLICA SERVIZI ALLA PERSONA - RSA BLEGGIO SUPERIORE	1252190226	www.apspgludio	segreteria@apsp	22017	FR S CROCE 4
25	STR04210108020	80202	42	101	BORGO CHIESE	PUBLIC	PUBLIC SOCIAL SERVICE COMPANY	AZIENDA PUBBLICA SERVIZI ALLA PERSONA - RSA CONDINO	1022480220	www.rosadeiven	upipa.condino@	22238	VIA BATTISTI 6
26	STR04210108020	80204	42	101	BORGO CHIESE	PUBLIC	PUBLIC SOCIAL SERVICE COMPANY	AZIENDA PUBBLICA SERVIZI ALLA PERSONA - RSA CONDINO - AMB. FKT	1022480220	www.rosadeiven	upipa.condino@	22238	VIA C BATTIST
27	STR04210108020	80207	42	101	BORGO CHIESE	PUBLIC	SENIOR DIURNAL CENTER	CENTRO DIURNO PER ANZIANI - CONDINO	1022480220		upipa.condino@	22238	VIA C BATTIST
28	STR04210103010	30101	42	101	BORGO VALSUGANA	PUBLIC	HOSPITAL	PRESIDIO OSPEDALIERO DI BORGO VALSUGANA	1429410226	www.apss.tn.it	ariella.zilli@apss	22022	VIALE VICENZA
29	STR04210103010	30101	42	101	BORGO VALSUGANA	PUBLIC	HOSPITAL	PRESIDIO OSPEDALIERO DI BORGO VALSUGANA	1429410226	www.apss.tn.it	ariella.zilli@apss	22022	VIALE VICENZA
30	STR04210103010	30101	42	101	BORGO VALSUGANA	PUBLIC	HOSPITAL	PRESIDIO OSPEDALIERO DI BORGO VALSUGANA	1429410226	www.apss.tn.it	ariella.zilli@apss	22022	VIALE VICENZA
31	STR04210103010	30102	42	101	BORGO VALSUGANA	PUBLIC	DIALYSIS CENTER	CENTRO DIALISI BORGO	1429410226	www.apss.tn.it		22022	VIA VICENZA 9
32	STR04210103040	30401	42	101	BORGO VALSUGANA	PUBLIC	FAMILY COUNSELLING	CONSULTORIO BORGO	1429410226	www.apss.tn.it	consultoriofamili	22022	VIALE VICENZA
33	STR04210103040	30402	42	101	BORGO VALSUGANA	PUBLIC	MENTAL HEALTH CENTER	CENTRO SALUTE MENTALE BORGO E TONADICO	1429410226	www.apss.tn.it	psichiatriapergin	22022	VIALE VICENZA
34	STR04210103040	30403	42	101	BORGO VALSUGANA	PUBLIC	PSYCHIATRIC DIURNAL SERVICE	CENTRO DIURNO PSICHIATRICO BORGO/TONADICO	1429410226	www.apss.tn.it	psichiatriapergin	22022	VIALE VICENZA
35	STR04210103240	32401	42	101	BORGO VALSUGANA	PUBLIC	PUBLIC SOCIAL SERVICE COMPANY	AZIENDA PUBBLICA SERVIZI ALLA PERSONA - RSA BORGO VALSUGANA	988390225	www.apspborgo	info@apspborgo	22022	VIA PER TELVE
36	STR04210110330	103301	42	101	BRENTONICO	PUBLIC	PUBLIC SOCIAL SERVICE COMPANY	AZIENDA PUBBLICA SERVIZI ALLA PERSONA - RSA BRENTONICO	382550226	www.apsbrentc	info@apsbrentc	22025	VIA BALISTA 7
37	STR04210110330	103302	42	101	BRENTONICO	PUBLIC	PUBLIC SOCIAL SERVICE COMPANY	AZIENDA PUBBLICA SERVIZI ALLA PERSONA - RSA BRENTONICO - AMB. FK	382550226	www.apsbrentc	info@apsbrentc	22025	VIA BALISTA 7
38	STR04210110330	103303	42	101	BRENTONICO	PUBLIC	SENIOR DIURNAL CENTER	CENTRO DIURNO PER ANZIANI - BRENTONICO	382550226		direttore@apspb	22025	VIA BALISTA 7
39	STR04210108200	82001	42	101	CADERZONE TERME	PRIVATE	THERMAL BATH	TERME VAL RENDENA - FONTE S. ANTONIO S.P.A.	1846020228	www.fontevalren	info@fontevalrer	22029	VIA DAMIANO C
40	STR04210102030	20301	42	101	CANAL SAN BOVO	PUBLIC	PUBLIC SOCIAL SERVICE COMPANY	AZIENDA PUBBLICA SERVIZI ALLA PERSONA - RSA CANAL S.BOVO	481180222	www.apspvalled	info@apspvalled	22038	VIA DANOLI 15
41	STR04210103200	32003	42	101	CARANO	PRIVATE	COMMUNITY CENTER	COMUNITA' RESIDENZIALE TEMPORANEA MASO TOFFA	1848220222	www.oltre.coop	masotoffa@oltre	22041	LOCALITA CEL
42	STR04210103220	32201	42	101	CASTEL IVANO	PUBLIC	PUBLIC SOCIAL SERVICE COMPANY	AZIENDA PUBBLICA SERVIZI ALLA PERSONA - RSA STRIGNO	1008300228	www.apspstrigno	segreteria@apsp	22240	VIA BORGO ALI
43	STR04210103200	32001	42	101	CASTELLO TESINO	PUBLIC	PUBLIC SOCIAL SERVICE COMPANY	AZIENDA PUBBLICA SERVIZI ALLA PERSONA - RSA CASTELLO TESINO	1025950229	www.apspsuora	info@apspsuora	22048	V OSPEDALE 1
44	STR04210103200	32002	42	101	CASTELLO TESINO	PUBLIC	SENIOR DIURNAL CENTER	CENTRO DIURNO PER ANZIANI - CASTELLO TESINO	1025950229		upipa.castelloles	22048	VIA F LLI BALLE
45	STR04210101010	10101	42	101	CAVALESE	PUBLIC		PRESIDIO OSPEDALIERO DI CAVALESE	1429410226	www.apss.tn.it	pierantonio.scap	22050	VIA DOSSI 17
46	STR04210101010	10101	42	101	CAVALESE	PUBLIC		PRESIDIO OSPEDALIERO DI CAVALESE	1429410226	www.apss.tn.it	pierantonio.scap	22050	VIA DOSSI 17

Image 4: Screenshot of the Purpose Formalization with Entities

	A	B	C
1	**Scenarios**	**Personas**	**Competency Questions**
2	Rovereto in city center, during the week	John is 40 years old, overweight and works at public institution.	John has a high blood pressure and fell pang in the he cardiovascular medical examination
3	Riva del Garda, during the week	Allen is 32 years old laboratory technician and he works at a nuclear medicine laboratory and is exposed to radiation regularly.	Allen is diagnosed with cancer. He goes to the polyclin
4	Trento in city center, during the week	Peter is 85 years old. He lives alone. He start forgetting old friend names and what has been eating during the day	Peter has both social problems, depression and memc Alzheimer Diurnal Center to check for alzheimer and d
5	Trento in city center	Jennifer is 17 years old and a runner. She regularly working out for marathons. She start feel numbness causing loss strength and dexterity in her leg.	During her training sessions, she has problems with cc goes to neurology to check up for MS and diseases.
6	Mezzocorona in the city center, during the week	Alex is a 26 years old engineer and he consistently experiences strong mood alterations and pass from a state of starting a lot of activities to a state of isolation and depression.	Alex is diagnosed with bipolar disporder and goes to a receive treatment.
7	Trento outide the city center, in the evening during the week	Antonio is a 13 years old middle school student. He lives in a neighbourhood with low socio-economics conditions and he is part of group where people regularly abuse drugs.	Antonio also abuses drugs and has addiction problems and goes to a antidrug clinic.
8	Predazzo in the city center, during the week	Lucia is 35 years old stay at home wife and she is 3 months pregnant.	Lucia goes to the healthcare centre to have a check up ultrasound scan.
9	Trento in city center, during the weekned	Johanna is 29 years old stay at home mom and she is 9 months pregnant and stop working since last month.	Johanna enters labour and goes to hospital to deliver t
10	Tione in the city center, in the afternoon/evening during the week	Mario is 53 years old insurance agent. He often goes in Trento to follow a medical treatment for a chronic disorder.	Mario is admitted to hospital for peripheral arterial dise
11		Pietro is 40 years old banker. He has kidney problems and requires regular care.	Pietro goes to the dialysis centre to divert and clean th
12	Mezzolombardo in the city center, during the week	Emanuele is 17 years old high school student. He is experiencing domestic problems and have problems with social interactions.	Emanuele seeks help from family counselling and tells repeated beat him.
13	Mezzolombardo in the city center, during the weekend	Sarah is 18 years old waitress and a ice skater enthusiastic. She like ice skating in the weekends.	Sarah fell during the ice skating session and she broke hospital and the orthoepic doctor put a cust on is arm.
14	Cavalese in city center, during the week	Giovanni is 23 years old college student. He and his friends often goes out for road trip.	Giovani has a car accident and the ambulance bring h concussion.
15	Borgo Valsugana in city center, during the week	Alessio is 34 years old farmer. He work in the vineyard during grape harvest season.	Alessio is stung by a bee and has an allergic reaction treatment.
16	Trento in the city center, during the week	Emily is 27 years old cashier. She is overweight and has high cholesterol.	Emily goes to the polyclinic to check her cholesterol.
17	Rovereto in the city center, duirng the week	Daniele is 8 years old child and experiencing a lot of bruising on his legs, paleness and fill weak.	Daniele after few exam was diagnose leukimia and the research center.
18	Trento outside the city center	Carlo is 35 years old food blogger. He travel around the country to find particular type of dish so he eat at different restaurants every day.	Carlo start having acne problems after eating at a rest a dermatologist to underst the cause of this problem
19	Trento in the city center, on appointment	Gabriel is 28 years old PR in a night club. He contracted a sexually transmitted disease and recently diagnosed with AIDS.	Gabriel since his AIDS tests was positive, his admitted shelter.
20	Tione in the city center, duirng the week	Davide is 42 years old doctor in the emergency department. He started to have covid symptoms.	Davide results positive and breathing problems and he treatment.
21	Malè in the city center, duirng the week	Juliano is 36 years old football player. He just removed the plaster cast from his leg.	Juliano start the rehabilitation process with physiother mobility and after that a strength protocol.
22	Trento in the city center, duirng the week	Maria is 60 years old housewife. She start having knee pain when she walk up stairs.	Maria goes to the hospital to have the meniscus surge
23	Borgo Valsugan in the city center, during the week, morning weekend	Caio is 50 years old seller. The company he work for 25 years fair him. After that he start became depress and think of suicide.	Caio go to a psychiatric diurnal center service to overc
24	Pergine Valsugana in the city center, duirng the	Alessia is 36 years old insurance agent. She constantly losing	Alessia goes to Psychiatric Residenceofor treatment.
25	Ala city center, during the week	Tony is 85 years old .He is in wheelchair. He spend all day alone, don't have interaction and for that he feel unhappy..	Tony start going a senior diurnal center to enter in a cc same problem and help him live a happy life

D	E	F
Common Entities	**Core Entities**	**Contextual Entities**
location, move, adult	Hospital, Cardiovascular Diseases	heart pain, overweigth, high blood pressure,cardiovascular medical examination
location, move, adult	Polyclinic, Oncology	cancer, radiation, chemotherapy
location, move, elderly	Alzheimer Diurnal Center, Dementia	depression, social issues, alzheimer, forgetfulness, elderly assistant department, residence
location, move, young adult	Multiple Sclerosis Clinic, MS	coordination problem, neurology, clinical activiy,
location, move, adult, young adult	Psychiatry, Mental Healthcare Center	social Issues, bipolar disorder, psychiatric assistance
location, move, young adult	Dug Addiction, Antidrug clinic	abuse drug, addiction problem, drug addicted, assistence
location, move, adult	Gynecologist, Polyclinic	check-up, ultrasound imaging test
location, move, adult	Obstetrics, Hospital	labor
location, move, adult	Chronic Disorders, Hospital	diabetes type 1,medical treatment, p
location, move, adult	Kidney problems, Dialysis Centre	kidney failure
location, move, young adult	Domestic Problems, Family Counselling	domestic violence, abuse, beatting
location, move, young adult	Orthopedic, Hospital	broke limb, cast
location, move, young adult	Emergency room, Hospital	emrgency, concussion, head trauma
location, move, adult	Allergology/Immunology, Hospital	allergic reaction, bee stung
location, move, adult	Blood test, Laborartory	cholesterol
location, move, child	Genetc Desies, Gentic Research Center	leukimia, laboratory exam
location, move, adult	Dermatologist, Hospital	acne problem, food intollerence
location, move, adult	AIDS test, AIDS Community Home Shelter	sexually transmitted disease
location, move, adult	Pneumology, Hospital	covid symptoms, breathing problems
location, move, adult	Physiotherapy, Polyclinic	broken limb recovery, mobility work, strenght work
location, move, elderly	Surgery, Hospital	meniscus surgery
location, move, adult	Mental Illness, Psychiatric Diurnal Center	diurnal, depression, suiside
location, move, adult	Mental Illness, Psychiatric Residence	anorexia
location, move, elderly	Senior Diurnal Center	diurnal, aggregation point, social service

Informal Modeling

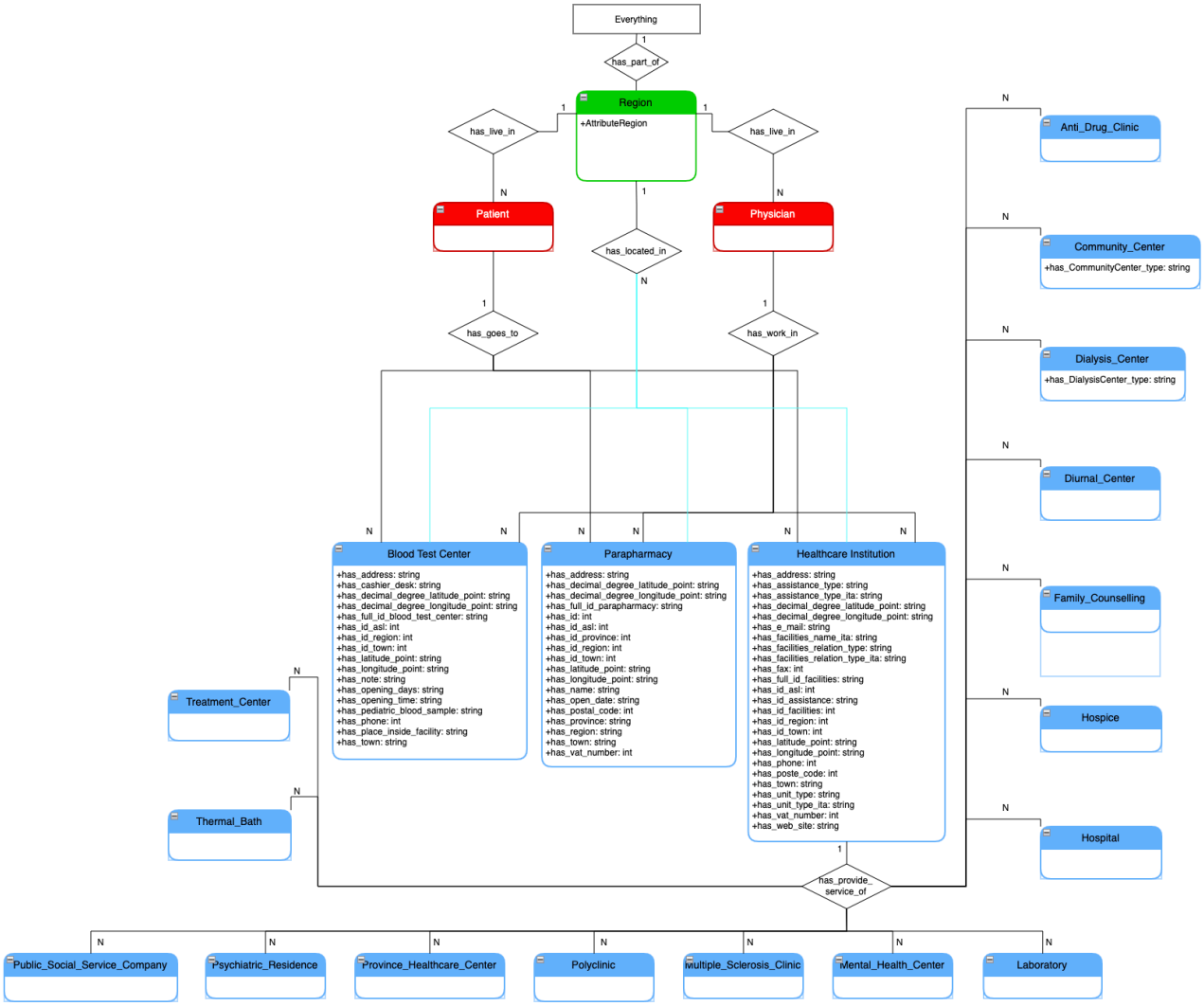
Entity relationship diagram reflects the relationship between entities buildings(healthcare facilities, parapharmacy, blood test center), people (physician and patient) and the region.

Decision I: Since healthcare facilities represent a heterogeneous group of institutions and each institutions may have different parameters, healthcare facilities are presented as subclasses based on the services they offer.

Decision II: While *Senior Diurnal Center*, *Alzheimer Diurnal Center*, *Psychiatric Diurnal Center* and *Dementia Diurnal Center* offer different type of treatment and services to patients; these facilities are shown in the same class as they share common parameters belong to diurnal center. A parameter called *"Type of Diurnal Center"* helps differentiate the type of the diurnal center in the dataset.

Decision III: Similar to Diurnal Center, *Community Rehab Center*, *Temporary Community Center*, *Minor Community Center*, *AIDS Community Center*, *Group Talk Community Center* despite offering different type of services represented under the *Community Center* class. A new variable defined as "*Type of Community Center*" to reflect the type of the services offered by the facility.

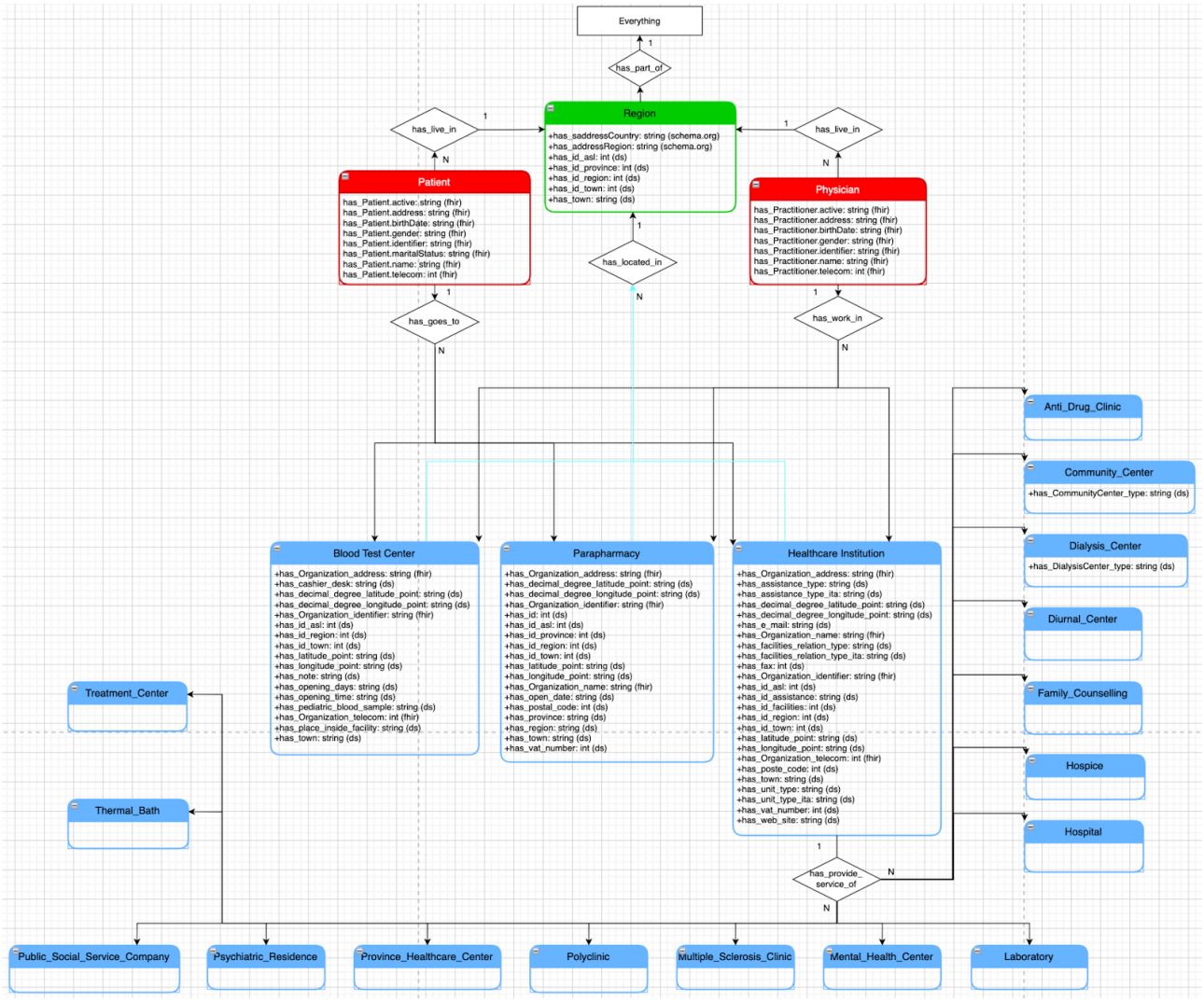
Diagram I: Database Schema UML



Formal Modeling

In order to generalize the model in accordance with the purpose we defined in earlier phases, we aligned reference ontologies with our previously developed teleology.

Diagram II: Formal Modelling Phase Teleontology Diagram
Diagram includes the final properties included in the datasets after reference ontologies are matched.



In our data sources and knowledge sources covering our purpose; there are 4 types of entities. Parapharmacies, healthcare facilities and blood sampling centers are *organizations* available in our data sources. Also *patients* as a beneficiary of the services provided and *practitioners* as ones providing the services are taken into account leveraging knowledge resources. We used *Region* ontology to map spatial context in our dataset.

Alignment of the reference ontologies to our teleology is explained under the language alignment section.

Table 8: Reference Ontologies

In the table, reference ontologies included in the formal modeling, source of the ontologies and description of the ontologies are given.

Source of the Reference Ontology	Reference Ontology	Description
schema.org	Region	*DefinedRegion* is a geographic area defined by potentially arbitrary (rather than political, administrative or natural geographical) criteria. Properties are provided for defining a region by reference to sets of postal codes.
FHIR	Organization	A formally or informally recognized grouping of people or organizations formed for the purpose of achieving some form of collective action. Includes companies, institutions, corporations, departments, community groups, healthcare practice groups, payer/insurer, etc.
	Patient	Demographics and other administrative information about an individual or animal receiving care or other health-related services.
	Practitioner	*Practitioner* covers all individuals who are engaged in the healthcare process and healthcare-related services as part of their formal responsibilities and this Resource is used for attribution of activities and responsibilities to these individuals.

Ontologies contains wide range of parameters and not all of them is included in the final model. For those properties selected from the reference ontology and potential matching properties available in our teleology are described in more detail below.

Table 9: Organization Entity Type Alignment of Ontology & Teleology

For instance, we used organization reference ontology from fair for organization classes available in dataset such as facilities, parapharmacy and blood test center. In these classes, identity column is mapped with has_fhir:Organization.identifier in the reference ontology.

Organization ontology (FHIR)	Our teleology	Description of the Propopery
has_fhir:Organization.identifier	has_full_id_facilities has_full_id_parapharmacy has_full_id_blood_test_center	Identifies this organization across multiple systems
has_fhir:Organization.address	has_address	An address for the organization
has_fhir:Organization.telecom	has_phone	A contact detail for the organization
has_fhir:Organization.name	has_name (reffering to Healthcare Facility name) has_parapharmacy_name	Name used for the organization

-	has_ds:cashiers_desk has_ds:decimal_degree_latitude_point has_ds:decimal_degree_longitude_point has_ds:id_province has_ds:id_region has_ds:id_town has_ds:latitude_point has_ds:longitude_point has_ds:id_asl has_ds:note has_ds:open_days has_ds:open_times has_ds:pediatric_boold_sample has_ds:town	Data properties preserved in the Blood Test Centers and not found in the reference ontology
-	has_ds:decimal_degree_latitude_point has_ds:decimal_degree_longitude_point has_ds:id_province has_ds:id_region has_ds:id_town has_ds:latitude_point has_ds:longitude_point has_ds:id_asl has_ds:id_parapharmacy has_ds:open_date has_ds:postal_code has_ds:town	Data properties preserved in the Parapharmacy and not found in the reference ontology
-	has_ds:assistance_type_ita has_ds:CommunityCenter_type has_ds:decimal_degree_latitude_point has_ds:decimal_degree_longitude_point has_ds:DiurnalCenter_type has_ds:e_mail has_ds:facilities_relation_type_ita has_ds:facilities_type has_ds:fax has_ds:id_asl has_ds:id_province has_ds:id_assistance_type has_ds:id_facilities has_ds:id_province has_ds:id_region has_ds:id_town has_ds:latitude_point has_ds:longitude_point has_ds:postal_code has_ds:town has_ds:unit_type has_ds:unit_type_ita has_ds:vat_number has_ds:web_site	Data properties preserved in the Healthcare Facilities and not found in the reference ontology

Table 10: Patient Entity Type Alignment of Ontology & Teleology

In patient entity type, since we didn't have available datasets we covered main properties that can identify the patients in the future in case of an available dataset.

Patient Ontology (FHIR)	Our Teleology	Description
fhir:Patient.identifier		These data properties are not available in our data sources but we decided to import into our knowledge graph to include beneficiary party of these services provided by healthcare facilities.
fhir:Patient.active		
fhir:Patient.name		
fhir:Patient.telecom		

fhir:Patient.gender		
fhir:Patient.birthDate		
fhir:Patient.address		
fhir:Patient.maritalStatus		

Table 11: Practitioner Entity Type Alignment of Ontology & Teleology

Practioner wasn't among the available datasets. We wanted to include to create a more sustainable model in case of available datasets in the future, patient datasets can be accessed and relationships between patients and practioneers can be established easier.

Patient Ontology (FHIR)	**Our Teleology**	**Description**
Practitioner.identifier		These data properties are not available in our data sources but we decided to import because we want to include the providers taking part in the healthcare services.
Practitioner.active		
Practitioner.name		
Practitioner.telecom		
Practitioner.address		
Practitioner.gender		
Practitioner.birthDate		

Table 12: Region Entity Type Alignment of Ontology & Teleology

Region ontology

DECISION: Definition of the region ontology one of the challenging points for us to describe the identifier either as Trento region with code 42 or each town as unique identifier. We decided to use town_id as a unique identifier since it will querying easier and cover our CQs if we want to search particular type of facilities in a given region.

Region ontology (schema.org)	Our teleology	Description
has_schema.org:addressRegion	has_ds:region	A DefinedRegion is a geographic area defined by potentially arbitrary (rather than political, administrative or natural geographical) criteria. Properties are provided for defining a region by reference to sets of postal codes. Examples: a delivery destination when shopping. Region where regional pricing is configured.

Table 13: Metadata of the Formal Modeling

ACTION: Metadata of the formal modeling is updated because of the alignment issue we encountered with the mapping of the ontology and dataset due to ":" causing some bug in the KOS tool. In order to resolve the problem, definitions in the ontology such as "fhir:" removed from properties and added in the tag section.

File Name	Description	Created Date	Modified Date	URL
Trentino Healthcare-4v0-changelog--2022-12-07_15:23:08.xlsx	Definition object properties and data properties of the formal phase	07/12/2022	20/12/2022	https://github.com/Morook97/Trentino_Healthcare_KGE_Project/blob/main/Teleologies/Formal%20Modeling/Trentino_Healthcare_KGE_Project-4v0-changelog--2022-12-16_06:15:10.xlsx
Trentino Healthcare-5v0-Trentino_Healthcare_Teleontology.owl	Teleontology of Trentino Healthcare	07/12/2022	20/12/2022	

LANGUAGE ALIGNMENT

In the following paragraph, we explain the procedure we implement for using the Universal Knowledge Core (UKC). This procedure can permit the transformation of Annotation from the informal term present in the teleontology to a formal concept that can have these 3 main characteristics:

- Representing each informal concept in the teleontology with the unique identifier (GID) from UKC, thus, rendering each concept formal and absorbing conceptual diversity
- We align the existing concepts with their equivalents in the UKC Concept Core (CC) and extend the UKC CC by adding (only) the new concepts (with new GIDs), thus, absorbing conceptual as well as language diversity.
- Due to the Language Concept (LC), each concept can also be rendered multilingually, thus opening up the possibility to adapt the teleontology in any language or culture.

This procedure of aligning the concept of the word used in our teleontology to the UKC is done by iTelos methodology through KOS2 website during the Formal phase.
In this methodology, we are working with a semi-automatic annotator tool that, after the upload of our teleontology, presents a page with all the terms (concepts) representing classes, relations, and attributes. Each term is semi-automatically searched in the UKC Knowledge Base (UKC KB) via the annotator tool, and the step will result in one of the following two scenarios:

1. Synonymous Match between the teleontology concept and a synonymous concept found in the UKC KB

2. There is no semantic match between the teleontology concept and any concept present in the UKC KB

For our case, We go through the second scenario for defining each concept representing classes, relations, and attributes because the definition generated by the UKC KB didn't match the meaning of our concept regarding each term.
The result of all this is the alignment of all the concepts with their equivalent part in the UKC KB and each term is annotated with a unique Global Identifier GID.

In the following table are present all the definitions of classes, properties, and attributes We associate with each term (concept).

Table 14: Word Alignment & Description

Note: original UKC KB states the information if the word has a description already, No means that we defined the word based on our dataset.

Word	Description	Original UKC KB
Laboratory	It is a particular Healthcare Facility similar to a Polyclinic. That means there are present equipment for the diagnosis belonging to various specialist sectors.	No
Family_Counselling	It is a particular Healthcare Facility where is provide a type of psychological counseling (psychotherapy) that can help family members improve communication and resolve conflicts	No
Province_Healthcare_Center	It is a particular Healthcare Facility specialized in the supply of diagnostic imaging services and specialist visits	No
Anti_Drug_Clinic	It is a particular Healthcare Facility where is create a safer and healthier environment through coordinated efforts to prevent use and treat dependency of illicit drugs	
Organization_Blood_Test_Center	Blood Test Center is a facility where a nurse or a doctor take blood sample to be later analyzed for a particular test	No
Organization_Parapharmacy	Parapharmacy is a commercial activity, where it is possible to purchase parapharmaceuticals and pharmaceutical products, commonly called SOP and OTC, for which there is no obligation to submit a specific medical prescription	No
Everything	a thing of any kind	Yes
Organization_Healthcare_Facilities	building where medicine is practiced	Yes
Mental_Health_Center	It is a particular Healthcare Facility specialized in the treatment of mental disorders	No
Polyclinic	It is a particular Healthcare Facility with a variety of equipment for the diagnosis and treatment of diseases belonging to various specialist sectors.	No
Public_Social_Service_Company	It is a particular Healthcare Facility dedicated to non-self-sufficient elderly people, but also to disabled adults, who need full-time medical, nursing and rehabilitation assistance.	No
Dialysis_Center	It is a particular Healthcare Facility where they treat renal disease and renal dysfunction problem	No
Thermal_Bath	Thermal baths are pools of water with mineral properties at various extreme temperatures that aim to recalibrate your body, relax your mind and recharge your spirit.	No

Community_Center	It is a particular Healthcare Facility where set of individuals who share the same environment and forming a recognizable group are united by a common interest, disability, disease, rehab process and therapy	No
Multiple_Scelorsis_Clinic	It is a particular Healthcare Facility where is treat the Multiple Sclerosis (MS) disease	No
Psychiatric_Residence	It is a particular Healthcare Facility where patients with psychiatric disorders live while receiving treatment	No
Practitioner	Someone who practices a medical profession like a doctor and work in a particular Healthcare structure	No
Diurnal_Center	It is a particular Healthcare Facility that ensures that non self-sufficient elderly people are able to carry out daytime activities, with functions of a psycho-social-welfare nature, maintaining the potential and autonomy of the social - personal relationships.	No
has_part_of	Connection between a general spatial location (define by word Everything) to a specific Region	No
has_provide_service_to	Connection between the concept of Healthcare facilities and the type of service a facility can provide. For example Healthcare facilities provide service to Hospital, Polyclinic, etc.	No
has_lives_in	Connection that define where a Patient and Practitioner live inside the Region	No
has_goes_to	Connection between a Patient and the possible facility that can be useful for a particular need of the patient	No
has_works_in	Connection between the practitioner and the facility where he/she can work	No
has_locates_in	Connection between the Region and the location where are placed a particular Healthcare Structure like Blood Test Center, Parapharmacy, Healthcare Facilities	No
has_open_date	The first day the Parapharmacy was open	No
has_decimal_degree_latitude_point	Angle in decimal degree referring to the latitude point	Yes
has_e_mail	Messages distributed by electronic means from one computer user to one or more recipients via a network.	Yes
has_town	Name of the Town	No
has_Practitioner_telecom	Doctor phone number	No
has_Organization_telecom	Organization (Healthcare Institution, Blood Test Center, Paraphramacy) phone number	No
has_Patient_telecom	Patient phone number	No
has_fax	Healthcare Institution fax number	No
has_Practitioner_birthDate	Doctor (Practitioner) birth date	No

has_Patient_birthDate	Patient birth date	No
has_Practitioner_gender	Practitioner gender	No
has_Patient_gender	Patient gender	No
has_web_site	a computer connected to the internet that maintains a series of web pages on the World Wide Web	Yes
has_longitude_point	the angular distance between a point on any meridian and the prime meridian at Greenwich	Yes
has_latitude_point	an imaginary line around the Earth parallel to the equator	Yes
has_Practitioner_address	Practitioner address	No
has_Patient_address	Patient address	No
has_Organization_address	Organization (Healthcare Institution, Blood Test Center, Parapharmacy) address	No
has_Patient_active	Patient medical record define present or not inside a Healthcare Institution, Blood Test Center	No
has_Practitioner_active	Practitioner record is present or not inside a Organization (Healthcare Institution, Blood Test Center, Parapharmacy)	No
has_Practitioner_name	Practitioner name	No
has_facilities_relation_type_ita	Define if the Healthcare Facility belong to the National Health System in italian language	No
has_assistance_type_ita	Type of assistance provide by the Healthcare System define in italian language	No
has_id_assistance_type	Identifier code of the type of assistance provide by a Healthcare Institution	No
has_unit_type	Classification of the main use of the department inside a Healthcare Institution	No
has_unit_type_ita	Classification of the main use of the department inside a Healthcare Institutions in italian language	No
has_Practitioner_identifier	Practitioner identifier	No
has_Organization_identifier	Identifier that characterize the Organization (Healthcare Institution, Blood Test Center, Parapharmacy)	No
has_Patient_identifier	Patient identifier	No
has_Patient_name	Patient name	No
has_decimal_degree_longitude_point	Angle in decimal degree referring to a longitude point	No
has_id_province	Acronym of the Province	No
has_open_times	The time of the day the Blood Test Center is open	No
has_cashiers_desk	The presence of a office in the Blood Test Center where there is the possibility to pay for the exams done in that facility	No

has_facilities_type	Definition of the category the Healthcare Institution belong	No
has_pediatric_boold_sample	Blood Sample that can be done to children below the age of 6 years old	No
has_note	a brief written record	Yes
has_id_parapharmacy	Identifier code referring to a particular Healthcare Institution	No
has_id_facilities	Identifier code referring to a particular Healthcare Institution	No
has_open_days	The day of the week the Blood Test Center is open	No
has_postal_code	a code of letters and digits added to a postal address to aid in the sorting of mail	No
has_vat_number	Identifier code that a subject have for referring to an activity, business or otherwise, relevant for the purposes of indirect taxation	No
has_Patient_maritalStatus	Patient marital status	No
has_addressCountry	Acronym of the Country	No
has_Organization_name	Name of the Organization (Healthcare Institution, Parapharmacy)	No
has_id_region	Identifier of the Region	No
has_DiurnalCenter_type	Define the classification of the possible service the Diurnal Center can provide	No
has_CommunityCenter_type	Define the classification of the possible service the Community Center can provide	No
has_id_town	Identifier code relate to a Town	No
has_id_asl	Identification code referring to Local Health Unit present in the Region	No
has_addressRegion	Name of the Region	No
Treatment_Center	It is a particular Healthcare Facility where can be provide specialist visits and diagnostic tests, targeted therapeutic pathways and surgical interventions	No

At the end of the word alignment section, we retrieved ETG leveraging the iTelos methodology where all the classes, properties and attributes name are modify with the UKC KB.

Image 5: ETG Class Hierarchy (Screenshot of the ontology)

In the image you can see the classes as 3 types of organization and subclasses under the healtcare facilities, patient, practitioner and region entities.

Image 6: ETC Object Property (Screeshot of the ontology)

Object properties are defined as relationships mapped out in the entity relationship diagram in the formal modeling part.

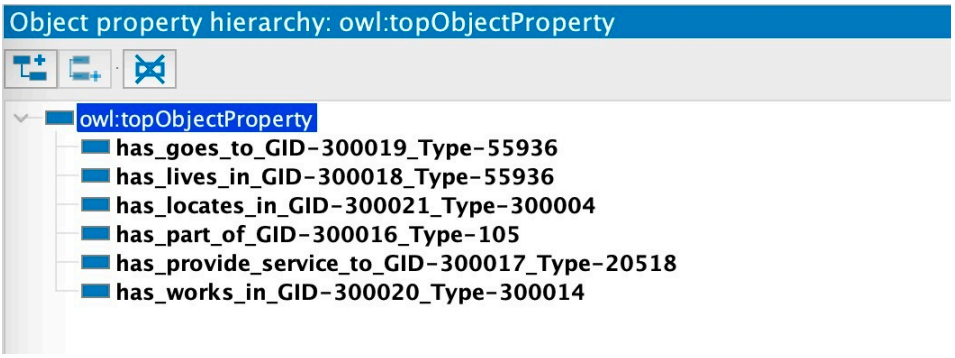


Image 7: ETG Data Property (Screenshot of the ontology)

Final data properties are shown below and which dataset has which property can also be extracted from the definition to map in the data integration section.

Outcome Exploitation

Trentino Healthcare Knowledge Graph provides access to type of facilities in different regions and ability to search and filter by the parameters such as pediatric blood sample. Detailed steps in order to create the knowledge graph such as data integration and potential use cases through queries and query results are explained in this section.

8. Data Integration

In order to integrate datasets, those available in our data source, modified sources and created ones such as patient and practitioner.

In the data integration part, we encountered several issues from software bugs to some mistakes in the ontology. Using the KarmaLinker software, we imported the ETG file retrieved from KOS and the available datasets.

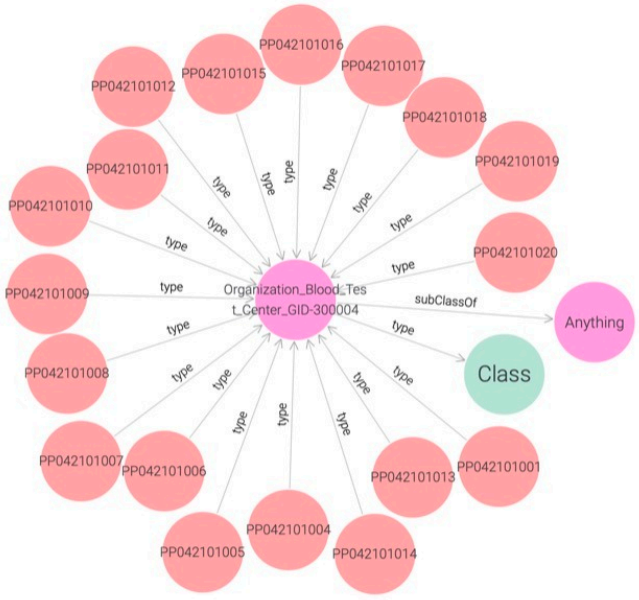
ACTION 1: We realized that in the former part, there was an issue with the direction of the object properties that was a problem in the data integration. We redefined the data properties with direction shown in the entity diagram for mapping

ACTION 2: To integrate the dataset with multiple classes, we decided to create multiple columns that contains a unique id for each class. The dataset was the healthcare facilities dataset and the subclasses was types of healthcare facilities like community center, diurnal center, healthcare center and so on.

ACTION 3: Because patient and practitioner datasets were empty, having empty id column causing some problems with saving the dataset, we created random sample to map the datasets.

ACTION 4: Another decision we made was creating a common identifier to merge the columns between datasets. For patient and practitioner we created one column for each dataset/entity type since the identifier information was in different format. An alternative option would be to create a common identifier format for each organization dataset.

Knowledge Graph



After mapping the datasets with the final ETG file, we imported data models created in the Karma to GraphDB software to visualize the graph and query the graph.

Image 8: Organization Blood Test Center Entities in the Knowledge Graph

9. Outcome Evaluation Statistics

This section aims to provide a description of the KGE process outcome. Here you have to report the final Knowledge Graph information statistics (like, number of etypes and properties, number of entities for each etype, and so on). Moreover this section has to provide a description for the KG possible exploitation, like examples of queries executed, execution time, and so on.

The total number of classes, objects and attributes present in our final Knowledge Graph are :

- Total number of class: 23
- Total number of object properties: 6
- Total number of data properties: 51

Below are the total number of objects and attributes for each class/etype present in our final Knowledge Graph for common and core entities.
We divide the class/etype like in the beginning of the project with Common, Core and Contextual entities and like they are represented in the ER Diagram Model.

COMMON ENTITIES
The number of elements present in the Region dataset we create for lack of that information is correlated to the number of id_town present in the datasets of: Parapharmacy, Blood Test Center and Healthcare Facilities taken only one time so that not considering the repetition of a id_town in a particular dataset.

etype: Region_GID-46452	• number of data properties: 7 • number of object properties: 3 • Total number of town present in the dataset: 78

The number of elements present in the Patient and Practitioner dataset is correlated to the number of FULL_ID_FACILITIES present in the Healthcare Institution dataset that define the number of patients and practitioners that those 2 categories can goes/work.

etype: Patient_GID-55936	• number of data properties: 8 • number of object properties: 3 • Total number of facility a patient can goes are: 250 Healthcare Facilities, 33 Parapharmacy, 61 Blood Test center

etype: Practitioner_GID-300014	• number of data properties: 8 • number of object properties: 3 • Total number of facility a practitioner can work on are: 250 Healthcare Facilities, 33 Parapharmacy, 61 Blood Test center

CORE ENTITIES

Below are the total number of objects and attributes for each class/etype present in our final Knowledge Graph. Also We add the number of Healthcare structures present in each datasets.

etype: Organization_Parapharmacy_GID-300005	• number of data properties: 17 • number of object properties: 3 • Total number of facility present in the dataset: 33

etype: Organization_Blood_Test_Center_GID-300004	• number of data properties: 17 • number of object properties: 3 • Total number of facility present in the dataset: 61

etype: Organization_Healthcare_Facilities_GID-20518	• number of SubClass: 16 • number of data properties: 25 • number of object properties: 3 • Total number of facility present in the dataset: 250

Organization_Healthcare_Facilities_GID-20518 is described by hierarchy as the father class and the following etypes are defined as son classes in which they inherit the data properties of the father. Only two of these son classes have specific data properties used to define the typology of that structure like General, Grup, AID and so on.

etype: Anti_Drug_Clinic_GID-300003	• number of data properties inherit from father class: 25 • number of object properties: 3 • Total number of this type of facility: 3
etype: Community_Center_GID-300011	• number of data properties inherit from father class: 25 • number of data properties of the class: 1 • Total number of data properties: 26 • number of object properties: 3 • Total number of this type of facility: 26
etype: Dialysis_Center_GID-300009	• number of data properties inherit from father class: 25 • number of object properties: 3 • Total number of this type of facility: 7
etype: Diurnal_Center_GID-300015	• number of data properties inherit from father class: 25 • number of data properties of the class: 1 • Total number of data properties: 26 • number of object properties: 3 • Total number of this type of facility: 39
etype: Family_Counselling_GID-300001	• number of data properties inherit from father class: 25 • number of object properties: 3 • Total number of this type of facility:12

etype: Hospice_GID-3613	• number of data properties inherit from father class: 25 • number of object properties: 3 • Total number of this type of facility: 3
etype: Hospital_GID-43695	• number of data properties inherit from father class: 25 • number of object properties: 3 • Total number of this type of facility: 30
etype: Laboratory_GID-300000	• number of data properties inherit from father class: 25 • number of object properties: 3 • Total number of this type of facility: 2
etype: Mental_Health_Center_GID-300006	• number of data properties inherit from father class: 25 • number of object properties: 3 • Total number of this type of facility: 10
etype: Multiple_Scelorsis_Clinic_GID-300012	• number of data properties inherit from father class: 25 • number of object properties: 3 • Total number of this type of facility: 1
etype: Polyclinic_GID-300007	• number of data properties inherit from father class: 25 • number of object properties: 3 • Total number of this type of facility: 16
etype: Province_Healthcare_Center_GID-300002	• number of data properties inherit from father class: 25 • number of object properties: 3 • Total number of this type of facility: 7
etype: Psychiatric_Residence_GID-300013	• number of data properties inherit from father class: 25 • number of object properties: 3 • Total number of this type of facility: 7
etype: Public_Social_Service_Company_GID-300008	• number of data properties inherit from father class: 25 • number of object properties: 3 • Total number of this type of facility: 72
etype: Thermal_Bath_GID-300010	• number of data properties inherit from father class: 25 • number of object properties: 3 • Total number of this type of facility: 7
etype: Treatment_Center_GID-300068	• number of data properties inherit from father class: 25 • number of object properties: 3 • Total number of this type of facility: 8

THE KG'S EVALUATION
In the final part of the project We have to evaluate the quality of our knowledge Graph. For this particular part iTelos provides different criteria to evaluate the explicit and implicit goal of a KGE project.

To define the explicit goal we are looking into the purpose asking:" How the Competency Queries written in the beginning of the process are fulfilled?". So that we can evaluate the schema layer and the data layer.

F the implicit goal we are looking for reusability comparing the Entities Type Graph with a Reference ontology.

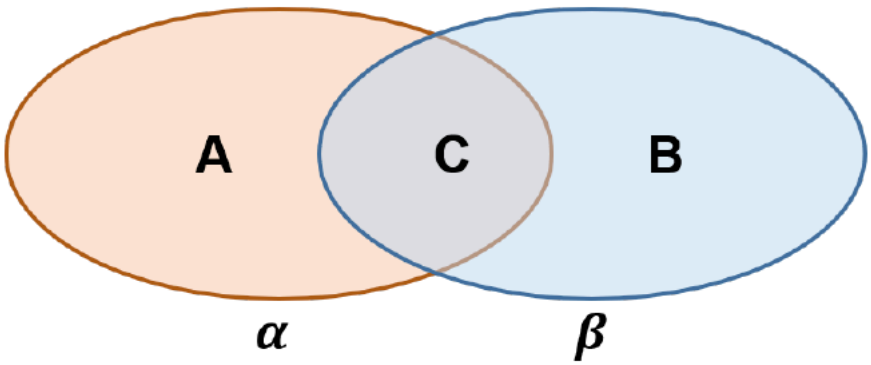
To guide the process of evaluating the final Knowledge Graph, iTelos provides a set of metrics We need to calculate once for The Knowledge layer and once for the Data layer.

The evaluation of the Knowledge layer goes through the calculation of the Coverage, defining how much a portion of knowledge is covered by a KG.

The valuation of the Data Layer goes through to understand how "dense" or "connected" is the KG, meaning how much the entities and the data properties are connected to each other.

THE EVALUATION OF THE KNOWLEDGE LAYER
To evaluate the Knowledge layer we have to calculate the Coverage of our final KG and understand what is this calculation.
Definition: The Coverage is computed as the ratio between the intersection of α and β and the whole α sets:
Cov = (α ∩ β)/α = C/(A + C)
Where: α is a portion of knowledge to be verified, β is the KG's Knowledge layer.

Image 9: Example of Coverage



For calculate the Coverage to evaluate the Knowledge Layer of our KG We have to measure:
1. (ETG vs CQs) How much the ETG covers the Entities and properties extracted from the CQs.
2. (ETG vs Reference Ontologies) How much the ETG covers theetypes, and properties, extracted from the reference ontologies

1. ETG vs CQs
ETYPE COVERAGE WITH CQs
CQE: CQE is the number of etypes extracted from the CQs.

CQE = 20 from Core entities

ETGE: ETGE is the number of etypes of the ETG

ETGE = 1 from Region + 1 from Patient (+ 1 from Practitioner) + 1 from Parapharmacy + 1 from Blood Test Center + 16 from Healthcare Facilities = 20

CQE ∩ ETGE: Entities in common between CQs and ETG = 14

The entities in common are: Hospital, Polyclinic, Diurnal Center, Multiple Sclerosis Clinic, Mental Healthcare Center, Antidrug clinic, Dialysis Centre, Family Counseling, Laboratory, Parapharmacy, Blood Test Center, Public Social Service Company, Hospice, Community Center

CovE(CQE) = (CQE ∩ ETGE) / CQE = 14 / 20 = 0,7

PROPERTY COVERAGE WITH CQs

CQp: CQp is the number of properties extracted from the CQs.

CQp = 3 from Common Entities + 27 from Core Entities + 68 from Contextual Entities = 98

ETGp: ETGp is the number of properties of the ETG.

ETGp = 7 from Region + 8 from Patient (+ from Practitioner) + 17 from Parapharmacy +17 from Blood Test Center + 27 from Healthcare Facilities = 76

CQp ∩ ETGp: Properties in common between CQs and ETG = 7

CovP(CQp) = (CQp ∩ ETGp) / CQp = 7 / 98 = 0,07

2. ETG vs Reference Ontologies

ETYPE COVERAGE WITH REFERNCE ONTOLOGY

ROE: ROE is the number of etypes extracted from the ROs.

ROE = Region_GID-46452, Patient_GID-55936, (Practitioner_GID-300014), Organization_Healthcare_Facilities_GID-20518, Organization_Blood_Test_Center_GID-300004, Organization_Parapharmacy_GID-300005 = 5 (+1)

ETGE: ETGE is the number of etypes of the ETG.

ETGE = Region_GID-46452, Patient_GID-55936, (Practitioner_GID-300014), Organization_Blood_Test_Center_GID-300004, Organization_Parapharmacy_GID-300005, Organization_Healthcare_Facilities_GID-20518, Anti_Drug_Clinic_GID-300003, Community_Center_GID-300011, Dialysis_Center_GID-300009, Diurnal_Center_GID-300015, Family_Counselling_GID-300001, Hospice_GID-3613, Hospital_GID-43695, Laboratory_GID-300000, Mental_Health_Center_GID-300006, Multiple_Scelorsis_Clinic_GID-300012, Polyclinic_GID-300007, Province_Healthcare_Center_GID-300002, Psychiatric_Residence_GID-300013, Public_Social_Service_Company_GID-300008, Thermal_Bath_GID-300010, Treatment_Center_GID-300068 = 5 (+1) + 16 = 21

ROE ∩ ETGE = Etype in common between RO and ETG = 5

CovE(ROE) = (ROE ∩ ETGE) / ROE = 5 / 5 = 1

PROPERTY COVERAGE WITH REFERENCE ONTOLOGY

ROp: ROp is the number of properties extracted from the ROs.

ROp = 14

ETGp: ETGp is the number of properties of the ETG.

ETGp = 43 (+8)

ROp ∩ ETGp = Properties in common between RO and ETG = 14

Covp(ROp) = (ROp ∩ ETGp) / ROp = 14 / 43 = 0.33

Our results of coverage are so little and don't seem to have a good coverage between the entities and properties extracted during the purpose formalization with respect to the entities and properties created during the creation of the ETG looking at the first criteria. Also in the second criteria We are not performing so well with the relation between our ETG and the Reference Ontology.

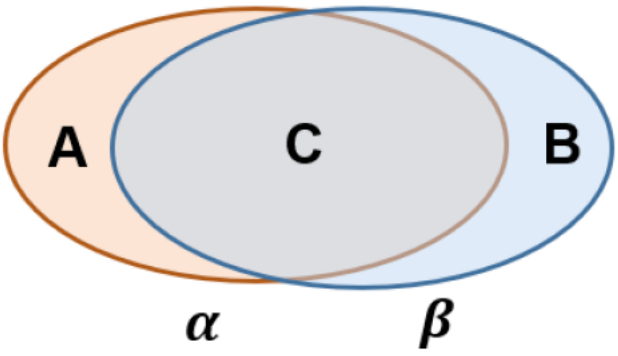
For the miss match in their first criteria of result it depends on the entities and properties extracted during the purpose formalization that are not that general but are specific in each CQ. Also they do not align with all the other specific properties taken from each dataset.

For example in the Common entities we extract location, move and age in base of the patient is a child, young adult, adult and elderly person. Instead in ETG We describe the patient with birthDate property, the location with the address where the patient lives and the address of the Healthcare structure. Also to define the movement of the patient to the Healthcare structure We use an object properties goes_to.

For the miss match in their second criteria of result it depends on the insufficient presence of Reference Ontology in the current state of art. So for solving that problem we extract only the part that suits our project and purpose completing with our etype and properties.

For example if we take the Reference Ontology of Region from schema.org the representation of that etype are not perfectly match with our characteristic of Region fro our purpose but it is the better version and have same data properties in common respect to the other present in schema.org or other reference ontology site.

In the end of the evaluation of the coverage for our Knowledge layer the score of matching with our previous CQs is 0,7. For us it seems correct because questioning the KG through GrapgDB with same SPARQL Query the graph has only missed 4 CQs in a total of 31 CQs.
Image 10: Final Coverage



Final KG Coverage = 0,7

THE EVALUATION OF DATA LAYER
For evaluating the Data Layer of our final KG We have to understand how "dense" or "connect" is this layer. So in the end we can understand how much the elements present in the KG are connected and what each datasets contribute to the KG for make it more connected with a possibility to insert in future other datasets.
For that evaluation the connectivity ha define two dimensions:

1. Entity connectivity: How much the entities are connected to each other.
2. Property connectivity: How much the entities are connected to their properties.

1. ENTITY CONNECTIVITY

For the entity connectivity you have to measures:

- The number of entities E(T) for each etype T in the KG.

  Summation of the numbers of E(T) = Region etype 80 have entities, Patient etype 250 have entities, (Practitioner etype have 250 entities), Healthcare Facilities etype have 250 entities, Parapharmacy etype have 33 entities, Blood Test Center etype have 61 entities = 674 entities

- The number of object property values not null Op(T), for each etype T in the KG.

  Summation of the numbers of Op(T) = Region etype have 4(+1) object properties multiplied for entities from: Patient etype + (Practitioner etype) + Healthcare Facilities etype + Parapharmacy etype + Blood Test Center etype. Patient etype have 3 object property multiply for entities from: Healthcare Facilities etype + Parapharmacy etype + Blood Test Center etype, (Practitioner etype have 3 object property multiply for entities from: Healthcare Facilities etype + Parapharmacy etype + Blood Test Center etype), Healthcare Facilities etype have 16 object property multiply for entities from all is son classes (TOT= 250), Parapharmacy etype have 0 object property, Blood Test Center etype 0 object property = 1189

2. PROPERTY CONNECTIVITY:

For the property connectivity you have to measures:

- The number of data property values not null Dp(T), for each etype T in the KG.

  Summation of the numbers of Dp(Tk) = Region etype have 7 data property multiply for entities in this class, Patient etype have 8 data property multiply for entities in this class, (Practitioner etype have 8 data property multiply for entities in this class), Healthcare Facilities etype have 25 data property multiply for entities in this class, Parapharmacy etype have 17 data property multiply for entities in this class, Blood Test Center etype 17 data property multiply for entities in this class = 7*80 + 8*250 + (8*250) + 25*250 + 17*33 + 17*61 = 10408

Image 10: A table of CQs covered in the queries

While queries enable access to database with an ease, we covered 28 out of 31 CQs in the project. Those are not covered often due to lack of contextual entities in the dataset and highlighted in red in the table below.

Scenarios	Personas	CQs Number	Competency Questions	FACILITY CODE	FACILITY TYPE	PATIENT DATSET NAME	TOWN
Rovereto in city center, during the week	John is 40 years old, overweight and works at public	1	John has a high blood pressure and fell pang in the heart. He is admitted to hospital to a	STR042101100101S01,	Hospital	Name_115, Name_116, Name_117	Rovereto
Riva del Garda, during the week	Allen is 32 years old laboratory technician and he works at a	2	Allen is diagnosed with cancer. He goes to the polyclinic for chemotherapy.	STR042101091001S01	Polyclinic	Name_146	Riva del Garda
Trento in city center, during the week	Peter is 85 years old. He lives alone. He start forgetting old	3	Peter has both social problems, depression and memory problems. He goes to	STR042101052020S09	Diurnal Center (Alzheimer)	Name_83	Trento
Trento in city center	Jennifer is 17 years old and a runner. She regularly working	4	During her training sessions, she has problems with coordination and balance. She	STR042101052026S01	MS	Name_133	Trento
Mezzocorona in the city center, during the	Alex is a 26 years old engineer and he consistently	5	Alex is diagnosed with bipolar disporder and goes to a mental healthcare centre to	STR042101050402S05	Mental healthcare centre	Name_127	Mezzocorona
Trento outide the city center, in the evening	Antonio is a 13 years old middle school student. He lives in a	6	Antonio also abuses drugs and has addiction problems. He tries to overcome addiction	STR042101051600S06, STR04	Antidrug clinic	Name_1, Name_2, Name_3	Trento
Predazzo in the city center, during the week	Lucia is 35 years old stay at home wife and she is 3 months	7	Lucia goes to the healthcare centre to have a check up on her pregnacy with an	STR042101010501S01, STR04	Polyclinic	Name_134, Name_135	Predazzo
Trento in city center, during the weeknd	Johanna is 29 years old stay at home mom and she is 9	8	Johanna enters labour and goes to hospital to deliver the baby.	STR042101050101S01, STR04	Hospital	Name_98, Name_101, Name_103	Trento
	Mario is 53 years old insurance agent. He often goes in	9	Mario is admitted to hospital for peripheral arterial disease cause by diabetes type 1.		Hospital		
Tione in the city center, in the	Pietro is 40 years old banker. He has kidney problems and	10	Pietro goes to the dialysis centre to divert and clean the blood cause for a kidney failure.	STR042101080105S01	Dialysis Centre	Name_34	Tione
Mezzolombardo in the city center, during the	Emanuele is 17 years old high school student. He is	11	Emanuele seeks help from family counselling and tells his father abuse him and	STR042101050404S04	Family Counselling	Name_80	Mezzolombardo
Mezzolombardo in the city center, during the	Sarah is 18 years old waitress and a ice skater enthusiastic.	12	Sarah fell during the ice skating session and she broke her arm. She goes to the	STR042101050401S01	Hospital	Name_102	Mezzolombardo
Cavalese in city center, during the week	Giovanni is 23 years old college student. He and his friends	13	Giovani has a car accident and the ambulance bring him to the hospital with possible	STR042101010101S01, STR04	Hospital	Name_91, Name_92, Name_93	Cavalese
Borgo Valsugana in city center, during the	Alessio is 34 years old farmer. He work in the vineyard during	14	Alessio is stung by a bee and has an allergic reaction and goes to hospital for treatment.	STR042101030101S01, STR04	Hospital	Name_94, Name_95, Name_96	Borgo Valsugana
Trento in the city center, during the week	Emily is 27 years old cashier. She is overweight and has high	15	Emily goes to the polyclinic to check her cholesterol.	STR042101051200S03, STR04	Laboratory	Name_121, Name_122	Trento
Rovereto in the city center, duirng the week	Daniele is 8 years old child and experiencing a lot of bruising	16	Daniele after few exam was diagnose leukimia and the doctor send him to the genetic	in Rovereto only community cer	Community Center		Rovereto
Trento outside the city center	Carlo is 35 years old food blogger. He travel around the	17	Carlo start having acne problems after eating at a restaurant and goes to hospital to see	STR042101050101S01, STR04	Hospital	Name_98, Name_99, Name_100, Name_101, Name_102,	Trento
Trento in the city center, on appointment	Gabriel is 28 years old PR in a night club. He contracted a	18	Gabriel since his AIDS tests was positive, his admitted to AIDS Community home	STR042101052023S07	Community Center (AIDS)	Name_19	Trento
Tione in the city center, duirng the week	Davide is 42 years old doctor in the emergency department.	19	Davide results positive and breathing problems. He goes to hospital to get a treatment.	STR042101080101S01, STR04	Hospital	Name_108, Name_109, Name_110	Tione
Malè in the city center, during the week	Juliano is 36 years old football player. He just removed the	20	Juliano start the rehabilitation process with physiotherapist. He start doing a part of	STR042101070101S01	Polyclinic	Name_144	Malè
Trento in the city center, during the week	Maria is 60 years old housewife. She start having knee pain	21	Maria goes to the hospital to have the meniscus surgery.	STR042101050101S01, STR04	Hospital	Name_98, Name_101, Name_103	Trento
Borgo Valsugan in the city center, during the	Caio is 50 years old seller. The company he work for 25 years	22	Caio go to a psychiatric diurnal center service to overcam is depression.	STR042101030403S05	Diurnal Center (Psychiatric)	Name_42	Borgo Valsugana
Pergine Valsugana in the city center, duirng the	Alessia is 36 years old insurance agent. She constantly losing	23	Alessia goes to Psychiatric Residence for treatment.	In Pergine there isn't a commun	Community Center (Temporary/Rehab)		Pergine Valsugana
Ala city center, during the week	Tony is 85 years old .He is in wheelchair. He spend all day	24	Tony start going a senior diurnal center to enter in a community of people that have the	STR042101100205S09	Diurnal Center (Senior)	Name_69	Ala
Folgaria in the city center, duirng the week (mo	Rachele is 25 years old student. She can sleep at night	25	Rachele go to the pharafarmacy to buy same particular supplement to help her sleep	PFA042101008788	Parapharmacy	Name_13	Folgaria
Arco in the city center, all week	Giulia is 22 years old student. She have a little bit of flu.	26	Giulia go to the pharafarmacy to buy takpirina for help her heal a little bit.	PFA042101010308, PFA042101	Parapharmacy	Name_16, Name_18	Arco
Lavis in the city center, during the week only in	Alessio is 30 years old machine salesman. He want to check	27	Alessio goes to a blood test sampling point to take a sample of blood so that can be	PP042101020	Blood Test Center	Name_20	Lavis
Cles in the city center, during the week	Maria is 80 years old and she live alone at her house. She	28	Maria goes to Public Social Service Company so she can be feel safe and the servece	STR042101060501S09	Public Social Service Company	Name_202	Cles
Riva del Garda in the city center, during the we	Silvia is 15 years old middle school student. She start having	29	Silvia goes to rehabilitation center to have assistance for ADHD disorder and try	In Riva del Garda isn't present a	Community Center (Rehab)		Riva del Garda
Mori in the city center, Tue-Wen-Thu between	Sergio is 83 years old and terminally ill. He live at home and	30	Sergio goes to the hospice to have emotional support and treatment at the end of is life.	STR042101103103S12	Hospice	Name_90	Mori
Levico terme in the city center	Giovanni is 21 years old mechanic. He is an alcoholic. Also	31	Giovanni goes community center to find paces and times to rethink his life and arrive at	STR042101040503S05	Community Center (General)	Name_5	Levico terme

Entities in common between CQs and ETG	Properties in common between CQs and ETG
Hospital	has_CommunityCenter_type_GID-300064_Type-300011
Polyclinic	has_DiurnalCenter_type_GID-300063_Type-300015
Alzheimer Diurnal Center	has_facilities_type_GID-300053_Type-20518
Multiple Sclerosis Clinic	has_Organization_address_GID-300036_Type-300004
Mental Healthcare Center	has_Patient_address_GID-300035_Type-55936
Antidrug clinic	has_Practitioner_address_GID-300034_Type-300014
Dialysis Centre	has_unit_type_GID-300043_Type-20518
Family Counselling	has_goes_to_GID-300019_Type-55936
Laborartory	
Parapharmacy	
Blood Test Center	
Public Social Service Company	
Hospice	
Community Center	

QUERIES RELATED TO HEALTHCARE FACILITIES

By changing the commented/uncommented parts more specific queries on healthcare facilities can run. For example filtering facilities with facility type Diurnal Center or Senior Community Center under the Community Center group.

Query 1: Sparkql query for Healthcare Trentino Knowledge Graph to Access to Healthcare Facilities

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX etype: <http://knowdive.disi.unitn.it/etype#>
PREFIX onto: <http://www.ontotext.com/>
PREFIX : <http://www.semanticweb.org/andreamoro/ontologies/2022/10/untitled-ontology-24#>
select ?IDFacility ?Patient_name ?Facility_type ?Town ?CC ?CCtype ?DC ?DCtype
where {
    #query pattern to define variables to the classes, object, attributes in the schema

    #Patient
    ?IDPatient rdf:type etype:Patient_GID-55936 .
    ?IDPatient etype:has_Patient_name_GID-300048_Type-55936 ?Patient_name .

    #Facility
    ?IDFacility rdf:type etype:Organization_Healthcare_Facilities_GID-20518 .
    ?IDFacility etype:has_facilities_type_GID-300053_Type-20518 ?Facility_type .
    ?IDFacility etype:has_Organization_name_GID-300061_Type-300005 ?Facility_name .
    ?IDFacility etype:has_assistance_type_ita_GID-300041_Type-20518 ?Facility_assistance .
    ?IDFacility etype:has_town_GID-300025_Type-46452 ?Town .

    #Patient goes to Facility
    ?IDPatient etype:has_goes_to_GID-300019_Type-55936 ?IDFacility .


   #Apply filter to select the type of facility and where is locate it
   FILTER regex(?Facility_type, "DIURNAL") . #Select type of facility
   #FILTER regex(?Facility_assistance, "ATTIVITA` CLINICA") . #Select the type of assiance the
facility can provide
    FILTER regex(?Town, "TRENTO") . #Select the location of the facility (town)

    {#Community Center
        select ?IDFacility ?CC ?CCtype
        where{
            ?CC rdf:type etype:Community_Center_GID-300011 .
            ?IDFacility etype:has_provide_service_to_GID-300017_Type-20518 ?CC .
            OPTIONAL{
                      #?CC etype:has_CommunityCenter_type_GID-300064_Type-300011 ?CCtype .
                      #FILTER regex(?CCtype, "GENERAL") .
            } .
       }
    }

    {#Diurnal Center
           select ?IDFacility ?DC ?DCtype
           where{
               ?DC rdf:type etype:Diurnal_Center_GID-300015  .
               ?IDFacility etype:has_provide_service_to_GID-300017_Type-20518 ?DC .
                   OPTIONAL{
                     #?DC etype:has_DiurnalCenter_type_GID-300063_Type-300015 ?DCtype .
                     #FILTER regex(?DCtype, "SENIOR") .
               } .
           }
     }

}
```

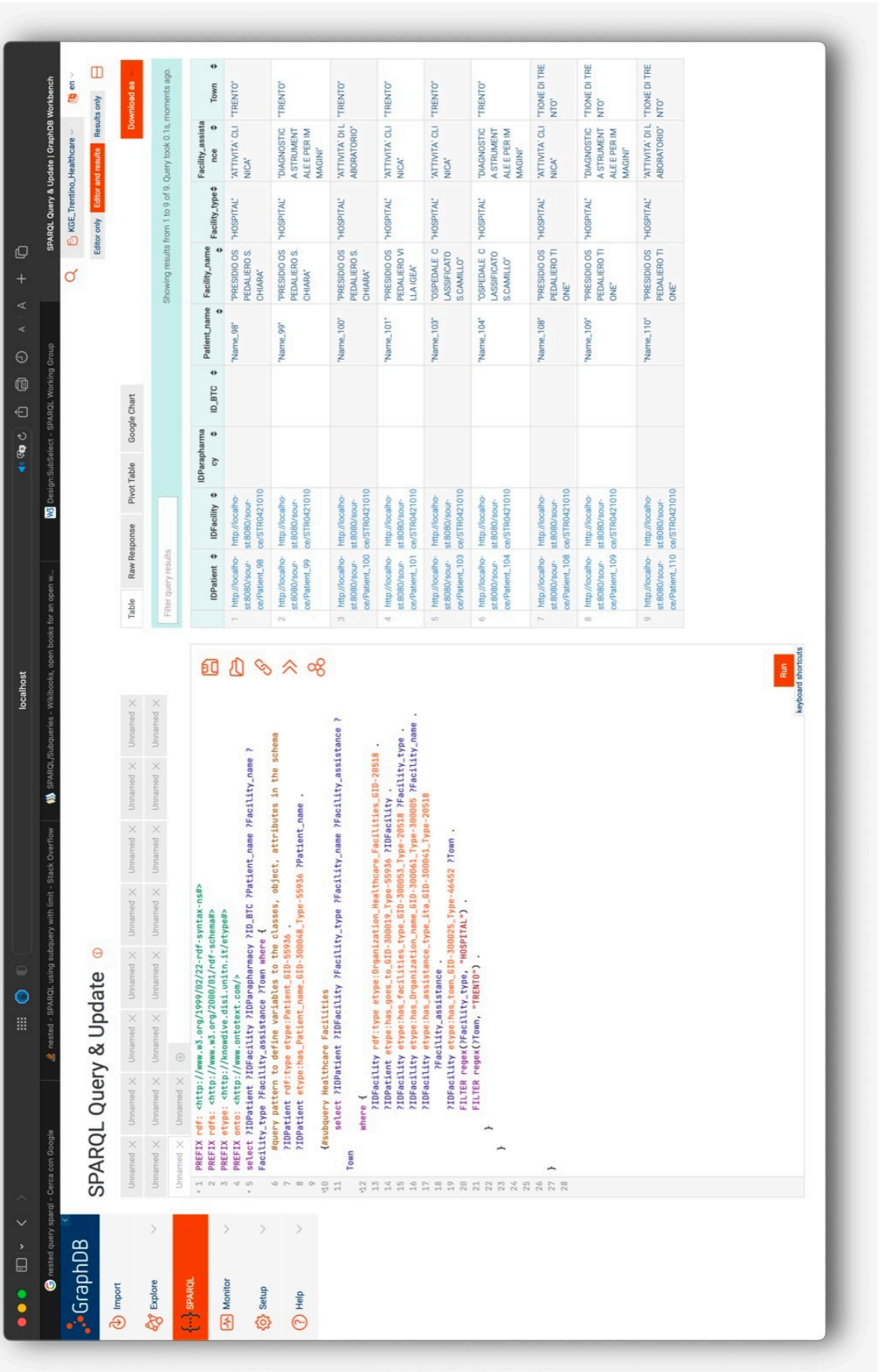
Query 2: Sparkql query for Healthcare Trentino Knowledge Graph to Access to Parapharmacies

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX etype: <http://knowdive.disi.unitn.it/etype#>
PREFIX onto: <http://www.ontotext.com/>
PREFIX : <http://www.semanticweb.org/andreamoro/ontologies/2022/10/untitled-ontology-24#>
select ?IDPara ?IDPatient ?Para_name ?PatientName ?Town ?Address
where {
   #query pattern to define variables to the classes, object, attributes in the schema

   #Patient
   ?IDPatient rdf:type etype:Patient_GID-55936 .
   ?IDPatient etype:has_Patient_name_GID-300048_Type-55936 ?PatientName .

   #Parapharmacy
   ?IDPara rdf:type etype:Organization_Parapharmacy_GID-300005  .
   ?IDPara etype:has_Organization_name_GID-300061_Type-300005 ?Para_name .
   ?IDPara etype:has_Organization_address_GID-300036_Type-300004 ?Address .
   ?IDPara etype:has_town_GID-300025_Type-46452 ?Town .

   #Patient goes to Parapharmacy
   ?IDPatient etype:has_goes_to_GID-300019_Type-55936 ?IDPara .

   FILTER regex(?Town, "ARCO") . #Select the location of the facility (town)
}
```

Query 3: Sparkql query for Healthcare Trentino Knowledge Graph to Access to Blood Test Centers

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX etype: <http://knowdive.disi.unitn.it/etype#>
PREFIX onto: <http://www.ontotext.com/>
PREFIX : <http://www.semanticweb.org/andreamoro/ontologies/2022/10/untitled-ontology-24#>
select ?IDbtc ?IDPatient ?Patient_name ?Town ?Address ?Note
where {
   #query pattern to define variables to the classes, object, attributes in the schema

   #Patient
   ?IDPatient rdf:type etype:Patient_GID-55936 .
   ?IDPatient etype:has_Patient_name_GID-300048_Type-55936 ?Patient_name .

   #Facility
   ?IDbtc rdf:type etype:Organization_Blood_Test_Center_GID-300004  .
   ?IDbtc etype:has_Organization_address_GID-300036_Type-300004 ?Address.
   ?IDbtc etype:has_note_GID-34863_Type-300004 ?Note .
   ?IDbtc etype:has_town_GID-300025_Type-46452 ?Town .

   #Patient goes to Facility
   ?IDPatient etype:has_goes_to_GID-300019_Type-55936 ?IDbtc .

   FILTER regex(?Town, "LAVIS") . #Select the location of the facility (town)
}
```

Image 11: An example of running a sparkle query to access to healtcare facilities located in the given region: i.e. Hospitals (a type of facility) located in Trento region - Screenshot of GraphDB Query on Trentino Healthcare Knowledge Graph



Conclusion & Open Issues

Since the beginning of the project, as much as covering the domain, reusability and potential extension of the projects have been the main concerns. In order to improve reusability, healthcare domain is researched extensively and potential ontologies are adapted and sample datasets in patient and practitioner class are created to to map/align the datasets.

Reusability is maintained with the integration of reference ontologies, while created datasets can help to extend the project with discovery of datasets common in the healthcare domain and new relationships can be established.

The project respected the scheduling as expected somehow bugs in Karma and expiration of Github token caused us to spend almost over a week more time in the project.

Open Issues

- While project covers the CQs, in order to extend the potential use cases, a relationship between patient and practitioner can be established. This practice helps visualize the number of patient per doctor in a facility, and provides insights to better distribute the healthcare resources.
- Causes of the admission is not given in datasets but important in order to make healthcare facilities more accessible based on the purpose of admission and these information can be available in the future and knowledge graph can be expanded.

APPENDIX: TABLES; DIAGRAMS AND IMAGES

REFERENCES

1. Knowledge Graph Engineering 2022 - Trento University
2. GraphDB Documentation
3. GraphDB - Embedded Queries
4. Use Similarity Search with Embedded Queries - Stackoverflow
5. Trentino - Open Access Data