Data Capabilities project QualiFHIR: optimizing care pathways for frail and geriatric patients using FHIR

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CHARLEROI, BELGIQUE-BELGIË

Health
Food Chain Safety
Environment

FHIR-A-THON & FHIR USERS DAYS, 25-26 November 2024

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FHIR

.be

Introduction

- Objective: Enhance geriatric care management by implementing an infrastructure based on the FHIR standards.
- FHIR Infrastructure Goals:
  - Create a **structured dataset** using FHIR and SNOMED CT
    - Enable secure sharing of medical data among project partner hospitals (e.g., Clinique Notre Dame de Grâce de Gosselies)
    - Support the implementation of **clinical decision support algorithms** to detect frailty in elderly patients

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Data: Factors contributing to aging and frailty

- Environmental and Socio-economic Factors:
  - Demographic
  - economic
  - social data (e.g., social support networks, access to healthcare, social participation, safety)
- Behavioral data (e.g., lifestyle habits)
- Dependency and support data (e.g., community and social aid usage)
- Reduced Physiological Reserves
- Comorbidities: affecting mental and physical health
- Frailty indicators: physical activity, nutrition, falls, confusion, fluctuating disability, reduced stress adaptation

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Mapping frailty concepts to SNOMED CT

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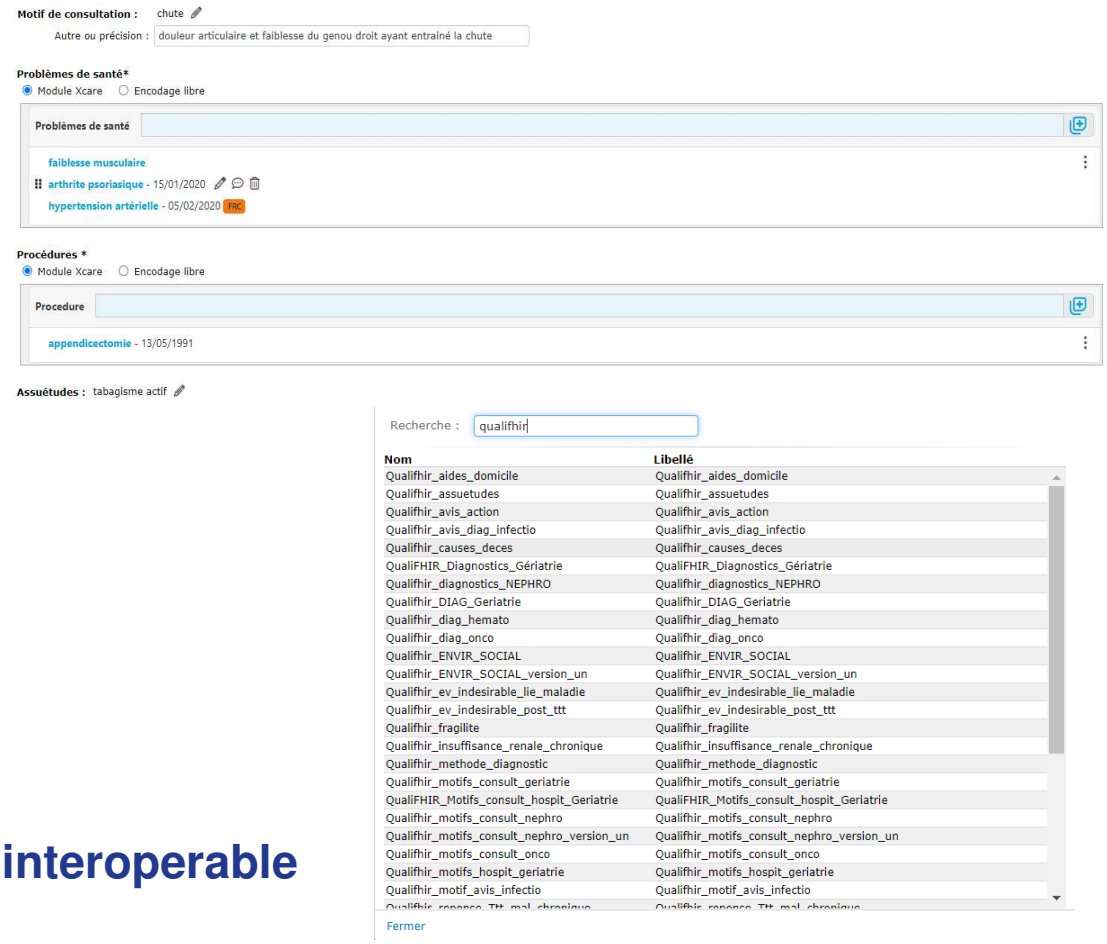
Information Capture Strategy

1. Customizing EHR forms to collect structured data
   - Value Sets: Selection of items with SNOMED CT terminology
   - FHIR Resources:
     - QuestionnaireResponse to record structured responses



=> Information is comprehensive and interoperable

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2. Pipeline traitement automatique du langage

Le second pipeline utilise le Traitement Automatique du Langage avec Le Chat de Mistral AI (7B-instruct) pour extraire des informations à partir **de notes cliniques en texte libre**.

ex. champs : diagnostic et conclusions, histoire de la maladie, etc.

- Ce pipeline est conçu pour transformer des données hétérogènes en ressources conformes FHIR
- **Développement informatique : réalisé avec un stagiaire ingénieur du CHU de Toulouse : Matisse Bornard**
- Développement pour le projet **QualiFHIR** (gériatrie) et le projet **Osiris** (hémato)
- LLM = 7B-instruct

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Traitement de notes cliniques

Le pipeline repose sur les briques suivantes :

- Extraction automatique de concepts cliniques (Conditions, Observations, Traitements, etc.) (via l'API : Le Chat)
- Structuration de ces concepts dans des **objets intermédiaires** fortement typés (modèles Pydantic)
- **Transformation** de ces objets en **ressources FHIR valides** (Condition, Observation, CarePlan, etc.)
- Enrichissement sémantique avec des terminologies de référence (SNOMED CT) via le serveur multi-terminologies de l'ANS
- Vérification avec le serveur terminologique du **Ministère SPF Santé Publique**
- Export sous forme de ressource FHIR ou Bundle transactionnel pour injection dans notre serveur FHIR

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Texte analysé : « - Allergie vraie sur Aspirine avec commémoratifs d'œdème de Quincke ayant nécessité une hospitalisation. - Rhabdomyolyse sévère compliquée d'une insuffisance rénale aigue terminale sur prise de Crestor. »

Extraction

items=[AllergyItem(type='**Allergy**', criticality='high', category='medication', reactions=[Reaction(substance='**Aspirine**', manifestation=['**œdème de Quincke**', '**hospitalisation**'])]),

Extraction

AllergyItem(type='**Intolerance to substance**', criticality='high', category='medication', reactions=[Reaction(substance='**Crestor**', manifestation=['**rhabdomyolyse sévère**', '**insuffisance rénale aiguë terminale**'])])]

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Confrontation au serveur de terminologie de l'ANS

MINISTÈRE DU TRAVAIL DE LA SANTÉ ET DES SOLIDARITÉS
Liberté
Égalité
Fraternité

AGENCE DU NUMÉRIQUE EN SANTÉ
La transformation commence ici


```
[SNOMED-VERIFY] ATTENTION : Aucun match strict pour 'Aspirine'. Sélection du premier du top 3 : acide acétylsalicylique
[SNOMED-VERIFY] ATTENTION : Aucun match strict pour 'œdème de Quincke'. Sélection du premier du top 3 : angioœdème de Quincke
[{"resourceType": "AllergyIntolerance", "meta": {"profile": ["https://www.ehealth.fgov.be/standards/fhir/allergy/StructureDefinition/be-allergyintoleran
ce"]}, "category": ["medication"], "criticality": "high", "patient": {"identifier": {"system": "https://www.ehealth.fgov.be/standards/fhir/core/NamingSy
stem/ssin", "value": "48050515361"}}, "recorder": {"identifier": {"system": "https://www.ghdc.be/standards/fhir/NamingSystem/inami", "value": "158815715
98"}}, "recordedDate": "2025-09-12T08:59:30.029402+00:00", "clinicalStatus": {"coding": [{"system": "http://terminology.hl7.org/CodeSystem/allergyintole
rance-clinical", "code": "active"}]}, "verificationStatus": {"coding": [{"system": "http://terminology.hl7.org/CodeSystem/allergyintolerance-verificatio
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t": "\u0153d\u00e8me de Quincke"}, {"coding": [{"system": "http://snomed.info/sct", "code": "308540004", "display": "hospitalisation"}], "text": "hospit
alisation"}]}]}, {"resourceType": "AllergyIntolerance", "meta": {"profile": ["https://www.ehealth.fgov.be/standards/fhir/allergy/StructureDefinition/be-
allergyintolerance"]}, "category": ["medication"], "criticality": "high", "patient": {"identifier": {"system": "https://www.ehealth.fgov.be/standards/fh
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em/allergyintolerance-clinical", "code": "active"}]}, "verificationStatus": {"coding": [{"system": "http://terminology.hl7.org/CodeSystem/allergyintoler
ance-verification", "code": "unconfirmed"}]}, "extension": [{"url": "https://www.ehealth.fgov.be/StructureDefinition/be-ext-allergy-type", "valueCodeabl
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g": [{"system": "http://snomed.info/sct", "code": "723189000", "display": "insuffisance r\u00e9nale aigu\u00eb"}], "text": "insuffisance r\u00e9nale aig
u\u00eb terminale"}]}]}]
```


Quand il y a un doute :
après tests:
Le prompt a été affiné
pour ne sélectionner que le premier du top 3
des candidats

Extraction des conditions « allergies » et lien avec le code Snomed CT via le serveur terminologique de l'ANS ensuite vérification avec le serveur du Ministère

	Code SNOMED CT	Display	Valide	Ressource
0	387458008	acide acétylsalicylique	Oui	N/A
1	41291007	angiocedème de Quincke	Oui	N/A
2	609328004	Allergy	Oui	N/A
3	308540004	hospitalisation	Oui	N/A
4	782197009	Intolerance to substance	Oui	N/A
5	387523009	rosuvastatine	Oui	N/A
6	723189000	insuffisance rénale aiguë	Oui	N/A
7	89010004	rhabdomyolyse	Oui	N/A

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Création de la ressource « AllergyIntolerance » FHIR
Envoi et récupération vers/à partir du serveur FHIR

```
Allergie créée avec succès.
ID FHIR généré : 336
Location header : http://10.30.3.6:5080/fhir/AllergyIntolerance/336/_history/1
```

```
Statut HTTP : 201
Réponse brute :
{
  "resourceType": "AllergyIntolerance",
  "id": "336",
  "meta": {
    "versionId": "1",
    "lastUpdated": "2025-09-12T09:07:04.310+00:00",
    "source": "#ZxOFUAe81fJQw1xg",
    "profile": [ "https://www.ehealth.fgov.be/standards/fhir/allergy/StructureDefinition/be-allergyintolerance" ]
  },
  "extension": [ {
    "url": "https://www.ehealth.fgov.be/StructureDefinition/be-ext-allergy-type",
    "valueCodeableConcept": {
      "coding": [ {
        "system": "http://snomed.info/sct",
        "code": "609328004",
        "display": "Allergy"
      } ],
      "text": "Allergy"
    }
  } ],
  "clinicalStatus": {
    "coding": [ {
      "system": "http://terminology.hl7.org/CodeSystem/allergyintolerance-clinical",
      "code": "active"
    } ]
  },
  "verificationStatus": {
    "coding": [ {
      "system": "http://terminology.hl7.org/CodeSystem/allergyintolerance-verification",
      "code": "confirmed"
    } ]
  },
  "category": [ "medication" ],
  "criticality": "high",
  "code": {
    "coding": [ {
      "system": "http://snomed.info/sct",
      "code": "387458008",
      "display": "acide acétylsalicylique"
```

```
      "criticality": "high",
      "code": {
        "coding": [ {
          "system": "http://snomed.info/sct",
          "code": "387458008",
          "display": "acide acétylsalicylique"
        } ],
        "text": "Aspirine"
      },
      "patient": {
        "reference": "Patient/335"
      },
      "recordedDate": "2025-09-11T15:00:00+00:00",
      "recorder": {
        "identifier": {
          "system": "https://www.ghdc.be/standards/fhir/NamingSystem/inami",
          "value": "15881571598"
        }
      },
      "reaction": [ {
        "substance": {
          "coding": [ {
            "system": "http://snomed.info/sct",
            "code": "387458008",
            "display": "acide acétylsalicylique"
          } ],
          "text": "Aspirine"
        },
        "manifestation": [ {
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            "code": "41291007",
            "display": "angioœdème de Quincke"
          } ],
          "text": "œdème de Quincke"
        }, {
          "coding": [ {
            "system": "http://snomed.info/sct",
            "code": "308540004",
            "display": "hospitalisation"
          } ],
          "text": "hospitalisation"
        } ]
      } ]
    }
```

```
Allergies trouvées pour le patient (ID FHIR = 335) :

ID de l'allergie : 336
Substance : Aspirine
Type : Allergy
Réactions : ['œdème de Quincke', 'hospitalisation']
```

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Focus sur « conditions » et « syndromes gériatriques »

```
Texte analysé : nan ;  Maladies chroniques actives :
*/ Antécédent de flutter auriculaire.
*/ Insuffisance rénale chronique stade IIIb selon KDIGO.
*/ alcoolisme
*/ angine traitée par céfuroxime par médecin traitant
*/ Syndrome inflammatoire et sub-fébrilité sur une poussée d'arthrite rhumatoïde,
automédication aux corticoïdes, purpura de Bateman, fragilité cutanée secondaire aux corticoides
*/ Déclin fonctionnel.
avec polyarthrite rhumatoïde.
*/ Dénutrition modérée.
*/ Carence en fer.
*/ troubles cognitifs avec
MMSE 24/30.
```

```
items=[ConditionItem(code='Antécédent de flutter auriculaire', clinical_status='inactive', body_site=None, onset=None, abatement=None), ConditionItem(co
de='Insuffisance rénale chronique stade IIIb selon KDIGO', clinical_status='active', body_site=None, onset=None, abatement=None), ConditionItem(code='al
coolisme', clinical_status='active', body_site=None, onset=None, abatement=None), ConditionItem(code='angine', clinical_status='resolved', body_site=Non
e, onset=OnsetAbatement(kind='string', value='traitée récemment par céfuroxime'), abatement=None), ConditionItem(code='Syndrome inflammatoire', clinical
_status='active', body_site=None, onset=None, abatement=None), ConditionItem(code='sub-fébrilité', clinical_status='active', body_site=None, onset=None,
abatement=None), ConditionItem(code="poussée d'arthrite rhumatoïde", clinical_status='active', body_site=None, onset=None, abatement=None), ConditionIte
m(code='automédication aux corticoïdes', clinical_status='active', body_site=None, onset=None, abatement=None), ConditionItem(code='purpura de Bateman',
clinical_status='active', body_site=None, onset=None, abatement=None), ConditionItem(code='fragilité cutanée secondaire aux corticoïdes', clinical_statu
s='active', body_site=None, onset=None, abatement=None), ConditionItem(code='Déclin fonctionnel', clinical_status='active', body_site=None, onset=None,
abatement=None), ConditionItem(code='polyarthrite rhumatoïde', clinical_status='active', body_site=None, onset=None, abatement=None), ConditionItem(code
='Dénutrition modérée', clinical_status='active', body_site=None, onset=None, abatement=None), ConditionItem(code='Carence en fer', clinical_status='act
ive', body_site=None, onset=None, abatement=None), ConditionItem(code='troubles cognitifs', clinical_status='active', body_site=None, onset=OnsetAbateme
nt(kind='string', value='MMSE 24/30 (évaluation actuelle)'), abatement=None)]
```

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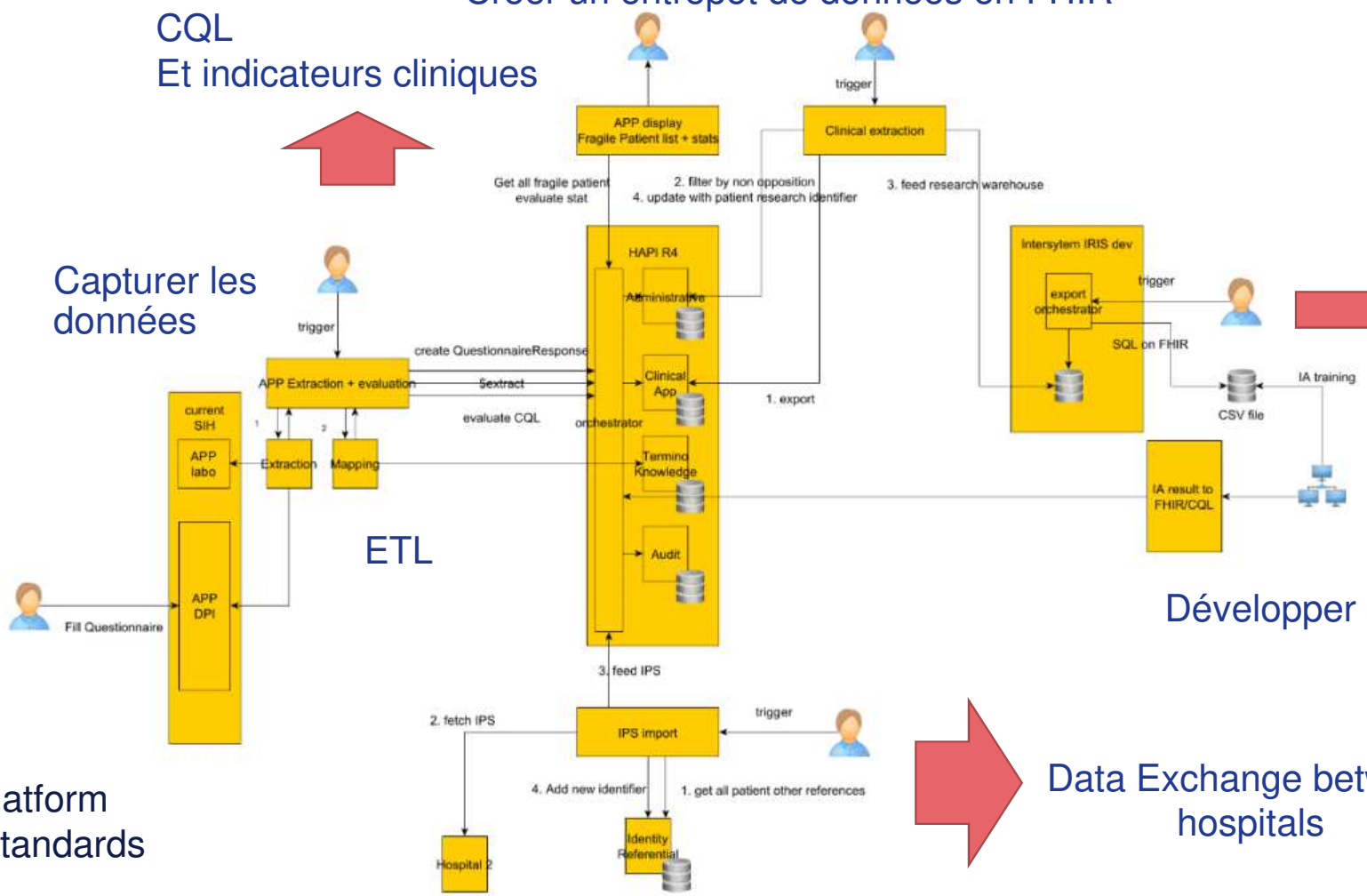
Sources of Data and infrastructure

Créer un entrepôt de données en FHIR

CQL
Et indicateurs cliniques



Capturer les données

ETL

Analyse des données
Tableau de bord
Data et AI

Développer des algorithmes d'IA

Data platform
FHIR standards

Data Exchange between hospitals

Gérer les flux de données entre hôpitaux

Catalog of FHIR Profiles:

- IPS: International Patient Summary
- PCF: Primary Care FHIR
- SDC: Structured Data Capture

	A	B	C	D	E
1	**Profil DataCatalog**	**Héritage BE**	**Héritage IPS**	**Héritage PCF**	**Héritage SDC**
2	PR-AllergyIntolerance		x		
3	PR-AuditEvent				
4	PR-Condition	x	x		
5	PR-Consent			x	
6	PR-DiagnosticReport		x		
7	PR-Library				
8	PR-Measure				
9	PR-MeasureReport				
10	PR-Observation	x	x		
11	PR-PatientAdm	x			
12	PR-PatientClinical	x			
13	PR-Person				
14	PR-Procedure		x		
15	PR-Questionnaire				x
16	PR-QuestionnaireResponse				x
17	PR-StructureMap				

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Each profile plays a crucial role in standardizing data for **consistency** across our network

Terminology server

Essential for harmonizing data and supporting FHIR-based interoperability :

- Snowstorm provides **real-time access to SNOMED CT**
- Snowstorm **can help standardize input data** => this ensures that data feeding the model is precise and consistent
- Snowstorm allows **to make translations** from Snomed CT codes

=> - improvement in the quality and interoperability

- the foundations of decision support and analysis in the care

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Data Exchange

test exchanges on three patients across two hospitals from our network (Charleroi Metropole) with results aggregated and labeled in English

	CNDG (y)	Grand Hôpital de Charleroi (x)
Patient: Qualifhir_test_CQL Oscar	NaN	Prostatitis (disorder) SCTID: 9713002 9713002 | Prostatitis (disorder) | en Prostatitis (disorder) en Prostatitis en Inflammation of prostate On 12/08/24
Patient: Qualifhir_test_CQL Phil	Pyelonephritis (disorder) SCTID: 45816000 45816000 | Pyelonephritis (disorder) | en Pyelonephritis (disorder) en Pyelonephritis On 02/09/24	Pyelonephritis (disorder) SCTID: 45816000 45816000 | Pyelonephritis (disorder) | en Pyelonephritis (disorder) en Pyelonephritis On 09/09/24
Patient: Qualifhir_test_CQL Madeleine	Pyelonephritis (disorder) SCTID: 45816000 45816000 | Pyelonephritis (disorder) | en Pyelonephritis (disorder) en Pyelonephritis On 02/09/24	Community acquired pneumonia (disorder) SCTID: 385093006 385093006 | Community acquired pneumonia (disorder) | en Community acquired pneumonia (disorder) en Community acquired pneumonia en CAP - community acquired pneumonia On 03/05/24

In Jupyter Notebook

	mydata_identifiant_du_patient	mydata_nom	mydata_prenom	mydata_Libelle_DICO_DIAGNOSTIC	SNOMED_Code_x	dico_Libelle_DICO_DIAGNOSTIC	SNOMED_Code_y
0		QUALIFHIR_TEST_CQL	OSCAR	prostatite	9713002	NaN	NaN
1		QUALIFHIR_TEST_CQL	PHIL	pyÃ©lonÃ©phrite	45816000	pyÃ©lonÃ©phrite	45816000.0
2		QUALIFHIR_TEST_CQL	MADELEINE	pneumonie communautaire	385093006	pyÃ©lonÃ©phrite	45816000.0

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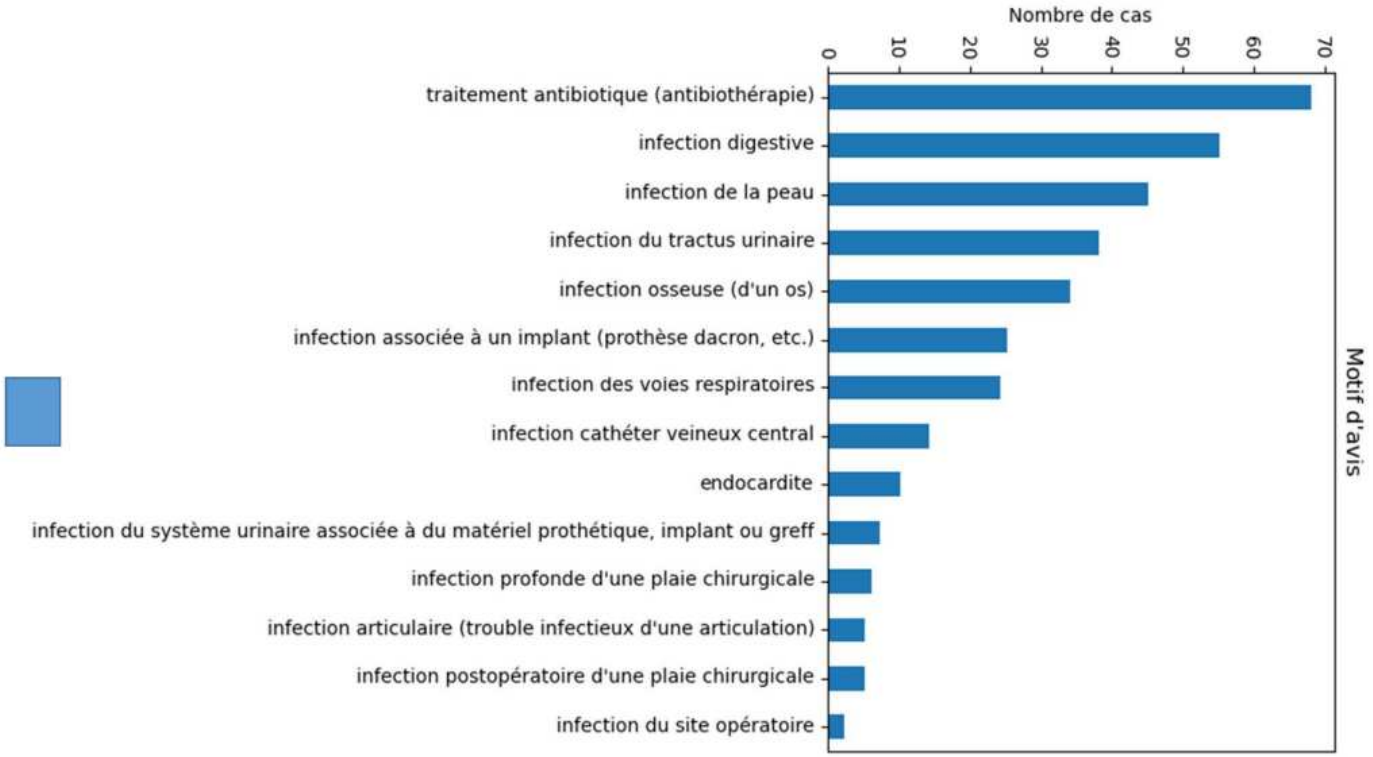
Ex. d’analyses statistiques

Motifs 340 (75% de remplissage)



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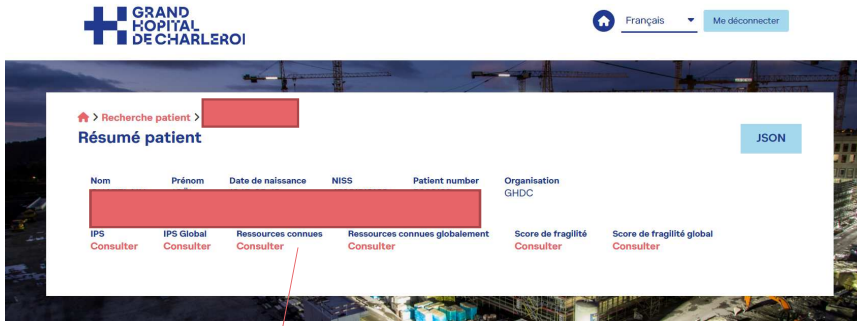
Consultation des données

Clic = Json

Exemple avec Laboratoire



Epstein-Barr virus serologic test

Value: Positif

Status: final

Category: Laboratory

virus de l'herpès simplex humain

Value: Positif

Status: final

Category: Laboratory

toxoplasmose

Value: Positif

Status: final

Category: Laboratory

Confirmatory test for HTLV antibody

Value: Inconnu

Status: final

Category: Laboratory

prélèvement de moelle osseuse

Status: final

Category: Laboratory

lymphome envahissant la moelle osseuse

Status: final

Category: Laboratory

Tumor immunophenotyping status

Status: final

Category: Laboratory

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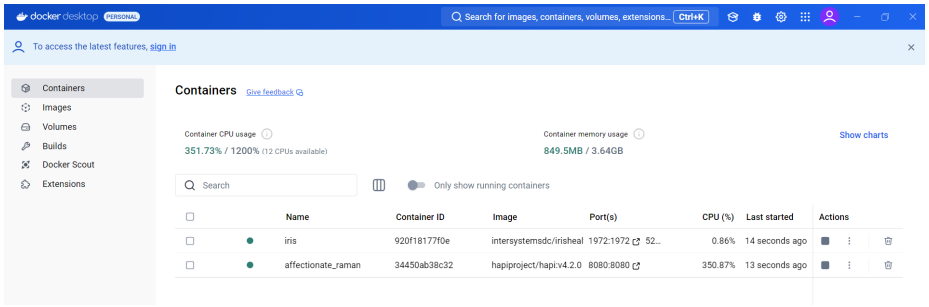
InterSystems IRIS Data Platform



Integration with AI and IRIS Data Platform:

- The HAPI FHIR server acts as an external data source for IRIS
- Data is processed by IRIS: - to model
  - to store
- Python Compatibility: allows us to query and extract data directly via IRIS APIs for machine learning and data analysis

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Avis de l’expert du ministère

Note de l’expert : **Bart de Cuypere**

- Status of the project is OK. Solution is valid for all kinds of resources.
- Nice elements are the extensive use of Questionnaires with SDI and CQL. Although very similar to SHIFT, it is far more vulnerable to terminology related issues because of its use of SDI and CQL with "fix" some business rules to (a set of pre-agreed) codes.
- This works well in this case because of the limited set of hospitals involved, but might be a threat for upscaling.
- A particularly interesting aspect is the use of an "annuaire", which is a component that is largely comparable with the "MetaHub".
- In combination with SHIFT, this way of working could be the starting point for a HUB/MetaHUB on FHIR.
- No immediate follow-up necessary, warning for scalability to a larger set of hospitals.

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Challenges

- Physician adherence to structured data (SNOMED CT)
- Optimal data extraction
- Maintenance requirements
- Technical limitations with our EHR system

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Équipe IT de QualiFHIR

- ETL : Samuel Aldeguer
- FHIR : Frédérik Liénard
- Chefs de projet : Arnaud Charlier et Dr Marie Detrait
- Sponsor : Ir Pierre Jacmin

Partenaires :

Consultant : Fyrstain (HL7 FHIR)

- NLP : EarlyTracks → terminé

Hôpitaux : Clinique Notre Dame de Grâce, CHR de Mouscron

Cross-Over : CH Mont Legia et RSW (- Cozo-SHIFT-)

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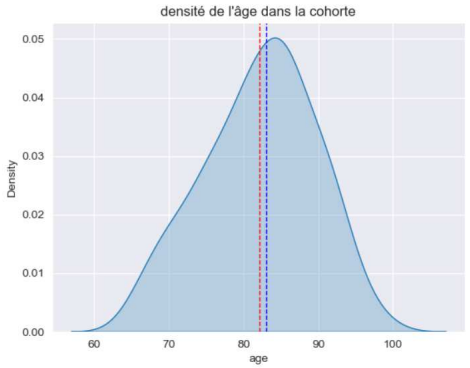
Clinical Research Framework for AI:

- **Retrospective phase approved by Ethics Committee G2-2024-E012**
- **Dataset for model training:**
  - Sample Size: 160 geriatric patients (May, 2023)
  - Inclusion Criteria: Patients aged over 65, both outpatients and inpatients
- **Characteristics**



Male: n=71 (44%) and Female: n=89 (56%)
Frailty: 70%
Social Vulnerability: 43%
Infection: 56% (pneumonia, urinary tract infection)
Patients requiring adaptation of living arrangements: 71%
Discharge: Return home 33% and Nursing Home 29%
Mortality: 16.8%
Age: Mean: 82 years, Median: 83 years [65–99]
Median Follow-up: 14 months [1–156]

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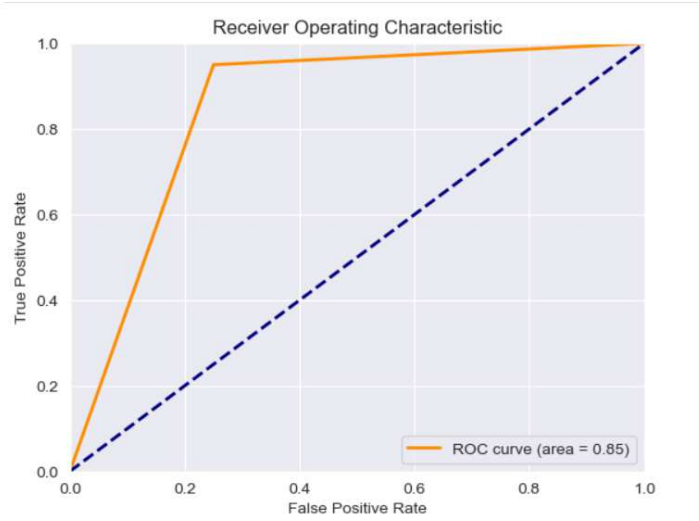
Training an artificial neural network (ANN) model

Accuracy: 88%
Roc-auc: 0,85
Recall: 95%
F1-score: 86%



Training set : 80%
Validation set : 20%
Test set : several unknown patients

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With Keras and TensorFlow

LIME for explainability

« Why should I trust you ? » Explaining the predictions of any classifier. Marco Tulio Ribeiro et al. (University of Washington, Seattle, 2016) **=> LIME**

LIME ('Local interpretable model **agnostic** explanations'): Enables making an individual decision understandable (local, flexible) without relying on the model's internal structure

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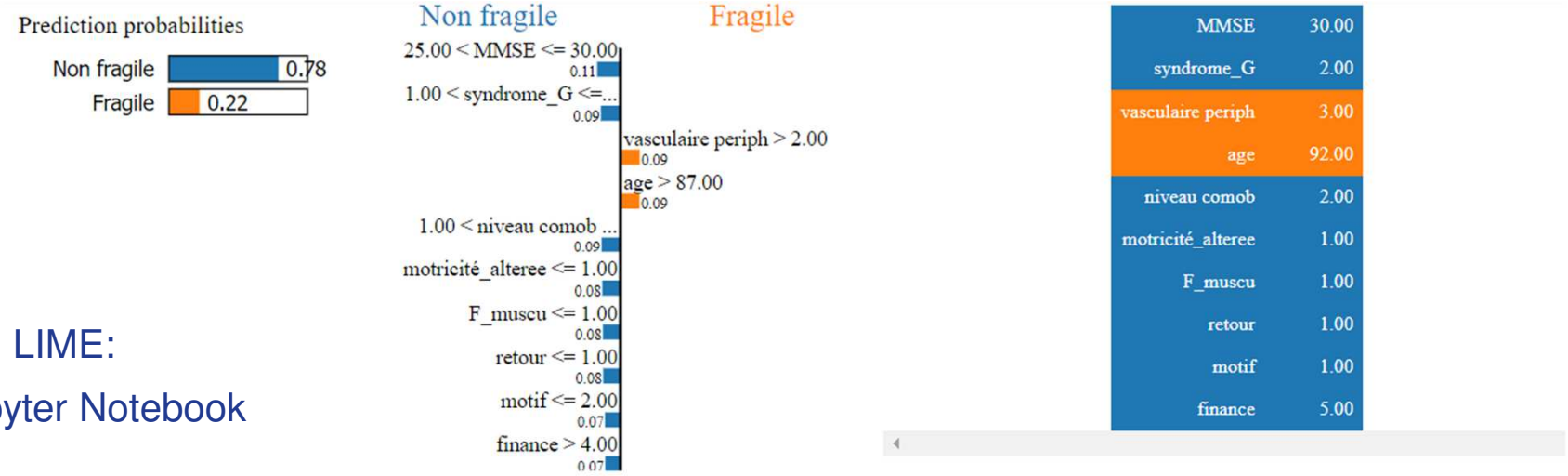
Collection (EHR) → Standardization (FHIR) → AI Algorithm → Clinically Usable Outcome

Qualifhir-test John 92 ans => not a fragile patient (probability : 78%)

Meet John, a 92-year-old patient in generally good clinical condition but with mild chronic renal failure
John regularly receives geriatric and nephrologic care at the Grand Hôpital de Charleroi



Explicability with LIME:

In Jupyter Notebook

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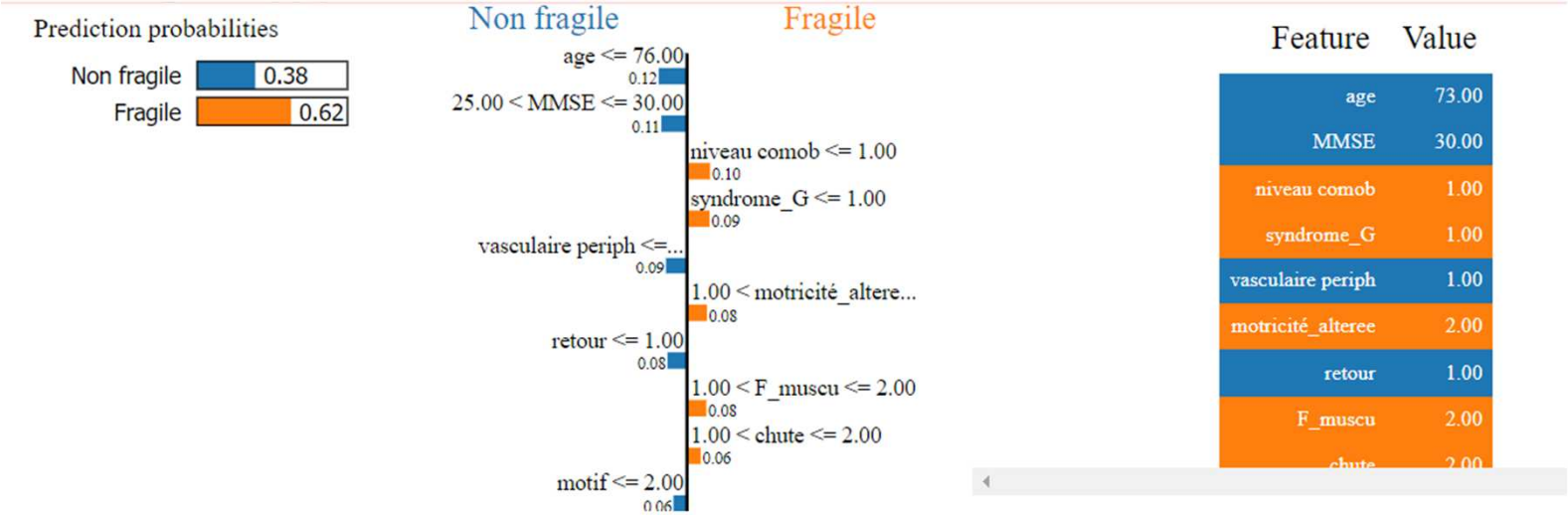
Qualifhir-test William 73 ans => Fragile patient (probability : 62%)

William, a 73-year-old patient suffering from psoriasis arthritis, hypertension and multiple conditions

In Jupyter Notebook

Explicability with LIME:



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Conclusion

The QualiFHIR FHIR infrastructure demonstrates:

- How a standardized, secure data architecture
  - supports data exchange between hospitals
  - enables clinical decision-making tools using AI
- Potential benefits for geriatric care are significant
- The next steps include
  - refining models with more data (-> n= 1000, n = 10 000)
  - refining models for other specific areas
  - developing a dedicated application for geriatricians
  - expanding the infrastructure to other clinical domains

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Thank you !

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