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AI4Africa 10xDS Program

Training The Next Generation of African Data Scientists

Graduation Ceremony

January 2022

AI4Africa 10xDS Program

6 Months to Become a Data Scientist ready to Solve Africa's Most Pressing Challenges

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Knee Osteoarthritis

Modifying the cellular therapy protocol

Graduation Ceremony

January 2022

Project Team

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Outline

- Context
- Data
- Machine Learning Pipeline
- Results & Outcome
- What's Next?

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Context

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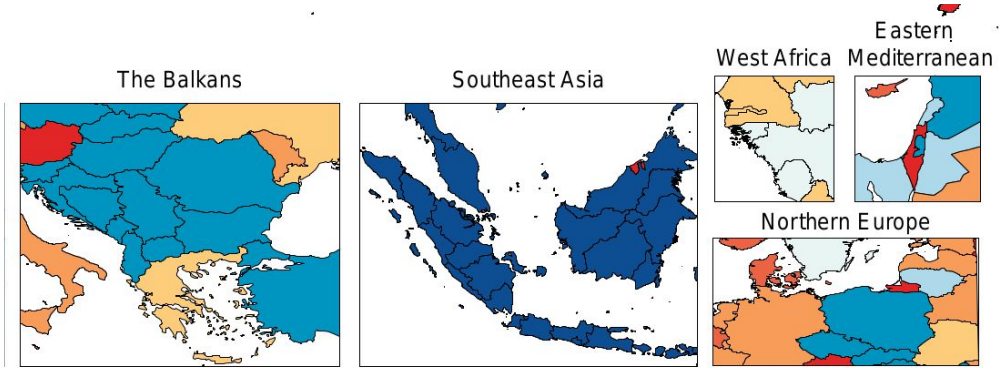
What is Knee Osteoarthritis ?

- **Arthritis:** any disorder that affects the joint
- **Osteoarthritis (OA):** the most common form of arthritis
  - Occurs when the protective cartilage that cushions the ends of the bones wears down over time.

Global Statistics

- Affects millions of people worldwide.



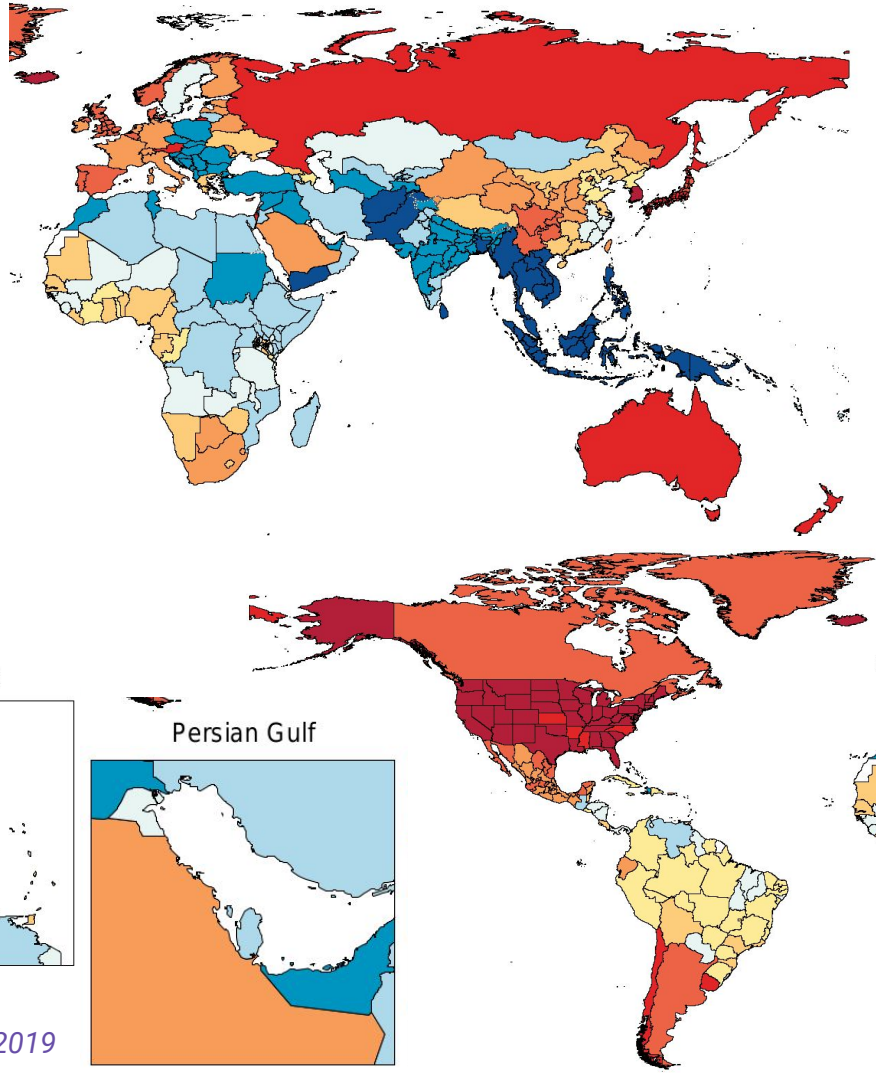
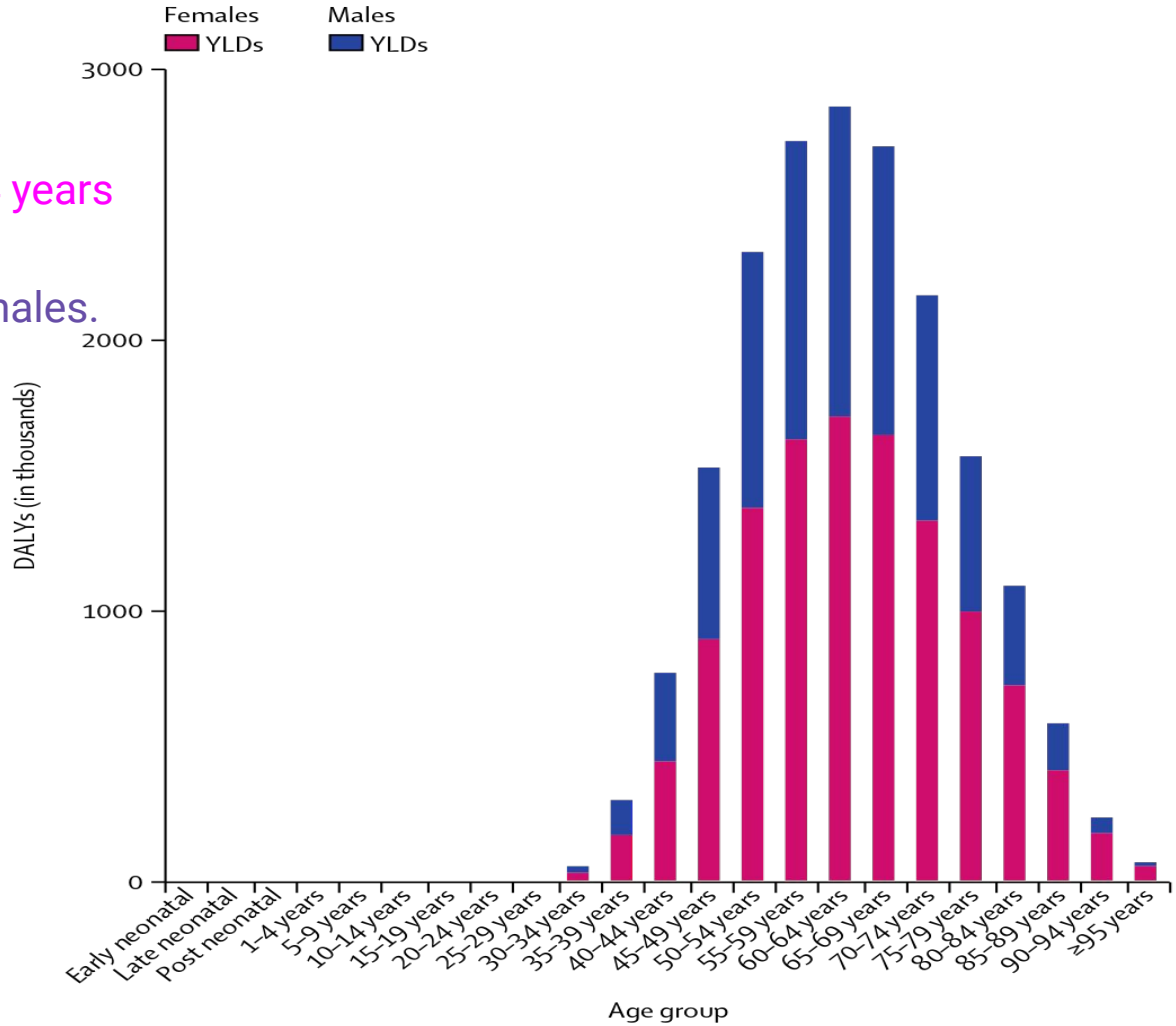


Figure: Age-standardised DALY rates (per 100 000) by location, both sexes, GBD 2019

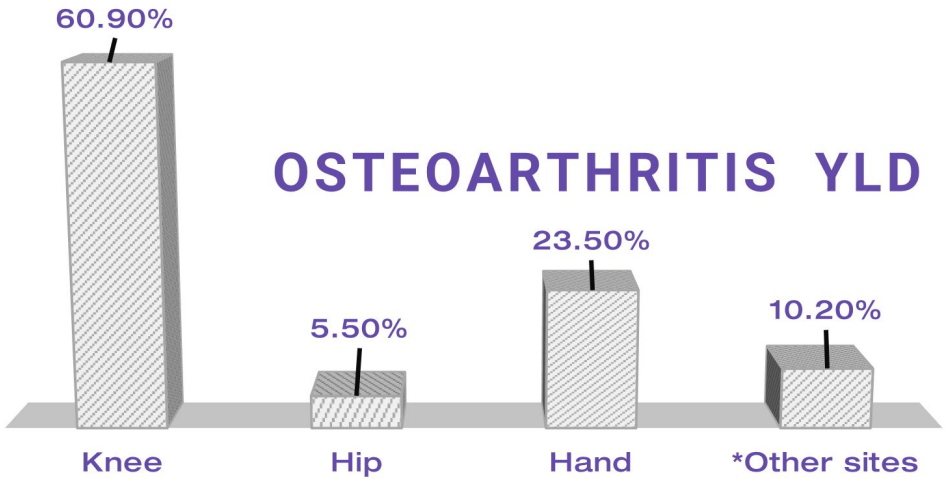
Global Statistics

- Mostly older people (40 – 84 years old).
- Affects more females than males.



Global impact of Knee Osteoarthritis

- **Manifestation:**
  - Symptoms generally include joint pain and stiffness.
  - Joint damage cannot be reversed but there are treatments.



Source: Global Burden of Disease (GBD) 2019, YLDs refers to Years of Healthy life lot due to disability
**Foot, shoulder, wrist*

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The Social and Economic Impacts of Osteoarthritis

TABLE 1. The social and economic impacts of osteoarthritis

Social impact	Economic impact
	Direct costs
Disability and pain (chronic/short-term)	Non-pharmacological/pharmacological treatment
Decreased ability to perform activities of daily living	Caregiver time
Increased depression/anxiety	Hospital resource use
Decreased overall quality of life	Research
	Management of side-effects caused by pharmacological treatments for osteoarthritis
	Indirect costs
	Lost time from work
	Decreased productivity
	Premature mortality
	Disability compensation/ pension/benefits

Knee Injury and Osteoarthritis Outcome Score (KOOS)

- The KOOS is a knee-specific instrument, developed to assess the patients' opinion about their knee and associated problems. It evaluates both short-term and long-term consequences of knee injury..

How do we evaluate the knee injury?

- Through a survey including 5 subscales of questions
  - Knee pain
  - Symptoms
  - Physical function in the daily life
  - Physical function while doing sports
  - Quality of life
- Each question have 5 different answers, given a score ranges from 0 to 4.
- From each questionnaire a KOOS score ranges from 0 to 100 is computed.
- Hundred indicates no problem and Zero indicates the worst possible case.

Data

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Dataset

- From Al-Neelain Stem Cells Center (ASCC) in Sudan
- Al-Neelain Stem Cells Center (ASCC) is the first center in Sudan for stem cells research at Al-Neelain University.
- The ASCC provided data from 75 patients with osteoarthritis under the cellular therapy protocol approved by the center.
- Patients treated under the umbrella of the governmental service.

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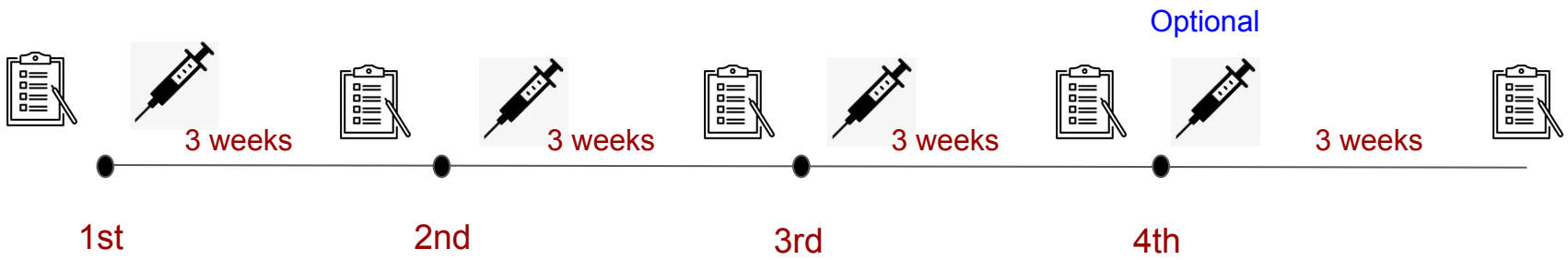
Cellular Therapy Protocol

- 4 stages (injections)
- The 4th injection is optional
- The period between injections is three weeks
- Each questionnaire should be filled before each injection
- Each patient have 4 filled **paper** questionnaire.
- Advance protocol (no dropbacks).



Data (76 patients)

Main information about each patient

ID	Age	Gender	Chronic Disease	Knee	WBC	RBCs	HGB	HCT	MCV	MCH	MCHC	PLTs	...
0	46	Female	None	Left	5.41	4.8	10.6	33.9	38.1	26.1	31.4	210.3	...

Questionnaires

	ID	knee	S1	S2	S3	S4	S5	S6	S7	P1	...	A17	SP1	SP2	SP3	SP4	SP5
0	1.0	left	Never	sometimes	Never	Always	Always	None	None	Always	...	Mild	Extreme	Extreme	Extreme	Extreme	extreme
1	NaN	NaN	Never	rarely	rarely	sometimes	sometimes	None	None	daily	...	Mild	Extreme	Extreme	Extreme	Extreme	extreme
2	NaN	NaN	sometimes	sometimes	sometimes	sometimes	sometimes	Moderate	moderate	daily	...	Mild	Extreme	Extreme	Extreme	Severe	Extreme
3	NaN	NaN	rarely	sometimes	sometimes	sometimes	sometimes	Moderate	Mild	daily	...	Mild	Extreme	Extreme	Extreme	Severe	Extreme

- 1 row =>

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Importance of the Project

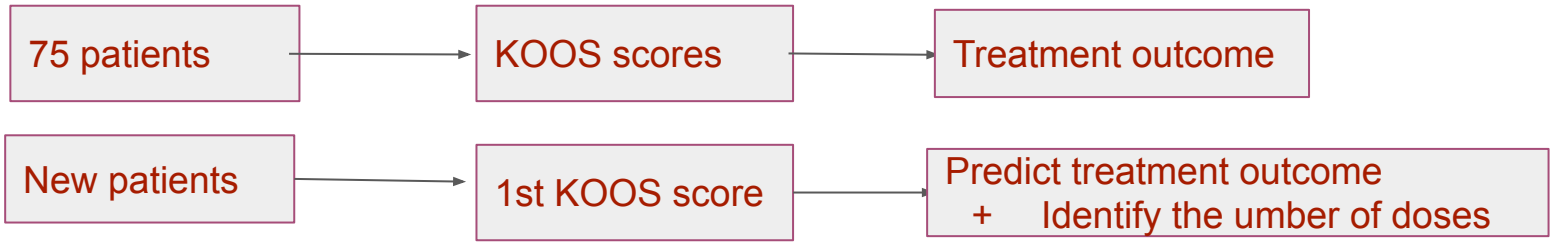
- Ongoing research project at Al-Neelain stem cells center, Sudan.
- This project will enable the stem cells centre in Sudan to tailor their Cellular Therapy protocol effectively
- Osteoarthritis can not be treated with antibiotics since the joints has no veins or arteries.
- Caused by: diabetes, trauma, stairs, obesity, football,smoking, …

- Africa have a young population 60%, results from this project can help us foresee a possible solution to a problem that is yet to come.

Problem and purpose

Problem

1. Calculate the KOOS score
2. Evaluate the outcome of the treatment for each patient and some statistics
3. Predict the score of success before starting the treatment
4. Identify the number of doses needed for recovery



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Purpose of the project:

1. To assess and determine the proper protocol of cellular therapy (KOA) based on the grade of (OA) and the improvement and healing of cartilage.
2. Good income for the patient (informative).
3. Digitalizing the process.
4. Data analysis system together with the Machine learning model.
5. Accuracy and evidence based knowledge .
6. Standard scientific background among sudanese.

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Data Analysis & Machine Learning Pipeline

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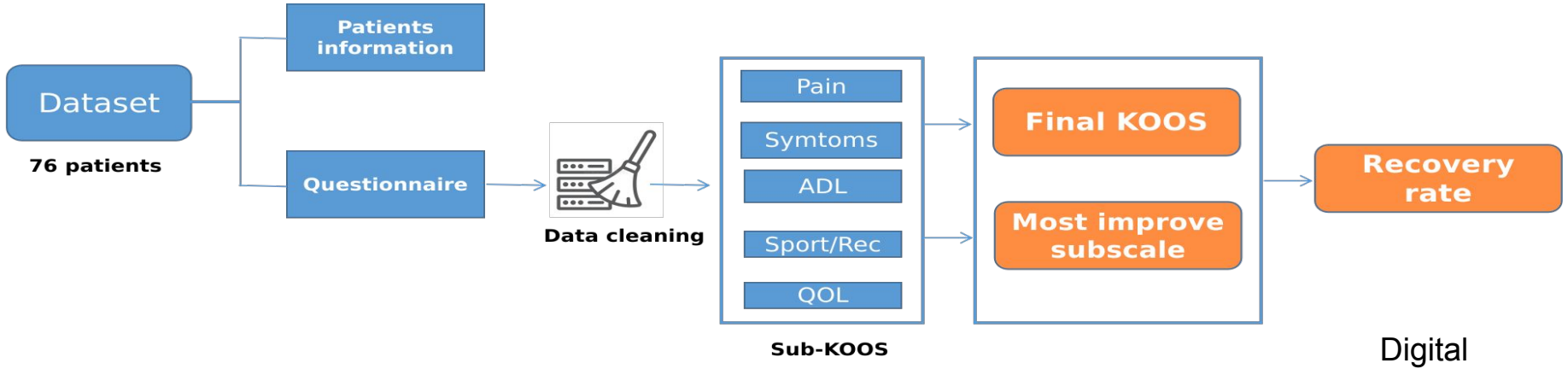
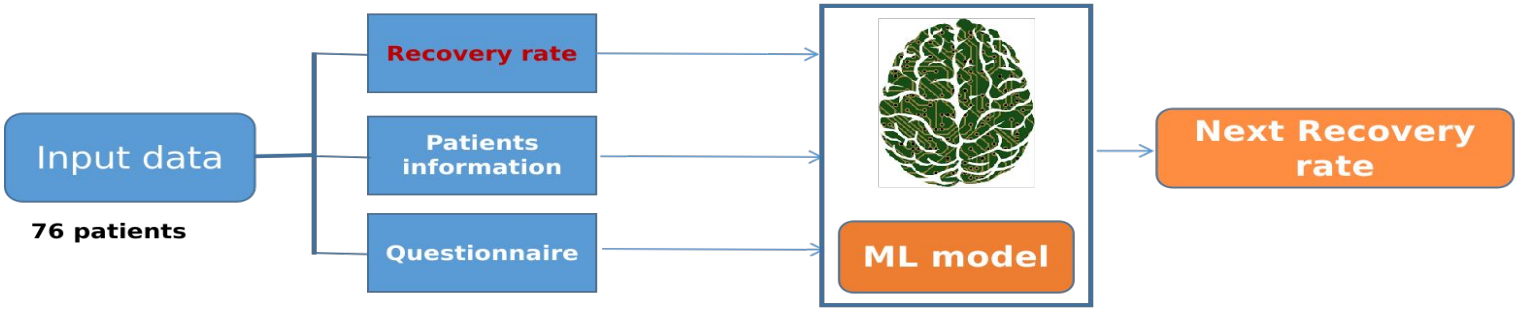
Global pipeline

Grade + BMI + MRI report



Digital
Automatic
Form
Compute
K.Score



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Data analysis process

How to compute the KOOS ?

Subscale	Number of questions	Required answers
Pain	9	5
Symptoms	7	4
ADL	17	9
Sport	5	3
QOL	4	2

Assign the following scores to the boxes:

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐
0	1	2	3	4

KOOS Calculations

- To compute the KOOS score we need first to compute the subscales KOOS.

$$100 - \frac{\text{Mean Score } (P1 - P9) * 100}{4} = \text{KOOS PAIN}$$

$$100 - \frac{\text{Mean Score } (S1 - S7) * 100}{4} = \text{KOOS SYMPTOMS}$$

$$100 - \frac{\text{Mean Score } (A1 - A17) * 100}{4} = \text{KOOS ADL}$$

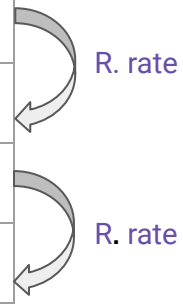
$$100 - \frac{\text{Mean Score } (SP1 - SP5) * 100}{4} = \text{KOOS SPORT/REC}$$

$$100 - \frac{\text{Mean Score } (Q1 - Q4) * 100}{4} = \text{KOOS QOL}$$

Recovery Rate Calculations

- Assume that for each patient we do have

1st KOOS	Before 1st injection
2nd KOOS	After the 1st injection, before 2nd injection
3rd KOOS	After the 2nd injection, before 3rd injection
4th KOOS	After the 3rd injection, before 4th injection

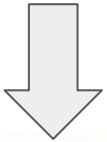


- To know if the patient is recovering we need to subtract as follows

2nd KOOS - 1st KOOS
3rd KOOS - 2nd KOOS
4th KOOS - 3rd KOOS

	ID	knee	S1	S2	S3	S4	S5	S6	S7	P1	...	A17	SP1	SP2	SP3	SP4	SP5
0	1.0	left	Never	sometimes	Never	Always	Always	None	None	Always	...	Mild	Extreme	Extreme	Extreme	Extreme	extreme
1	NaN	NaN	Never	rarely	rarely	sometimes	sometimes	None	None	daily	...	Mild	Extreme	Extreme	Extreme	Extreme	extreme
2	NaN	NaN	sometimes	sometimes	sometimes	sometimes	sometimes	Moderate	moderate	daily	...	Mild	Extreme	Extreme	Extreme	Severe	Extreme
3	NaN	NaN	rarely	sometimes	sometimes	sometimes	sometimes	Moderate	Mild	daily	...	Mild	Extreme	Extreme	Extreme	Severe	Extreme
5	2.0	Right	Sometimes	Sometimes	Sometimes	Never	Sometimes	Sever	Mild	Always	...	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme

5 rows × 44 columns



ID	Count	Min_KOOS	Max_KOOS	Mean_KOOS	Recover_rate	grade	First_score	Last_score
1	4	38.248	43.930	41.5165	-3.404	--	43.93	40.53
2	4	18.720	39.796	25.8995	21.076	++	18.72	39.80
3	4	24.114	41.180	29.1775	17.066	++	24.11	41.18
4	4	58.022	65.570	61.7305	1.254	++	64.32	65.57
5	4	71.912	89.366	81.6570	17.454	++	71.91	89.37

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Machine Learning Pipeline

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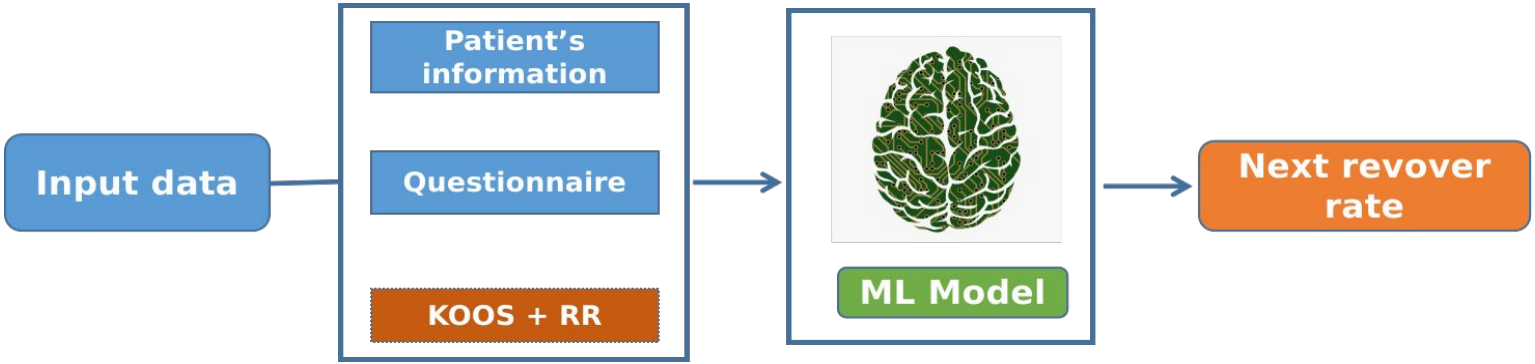
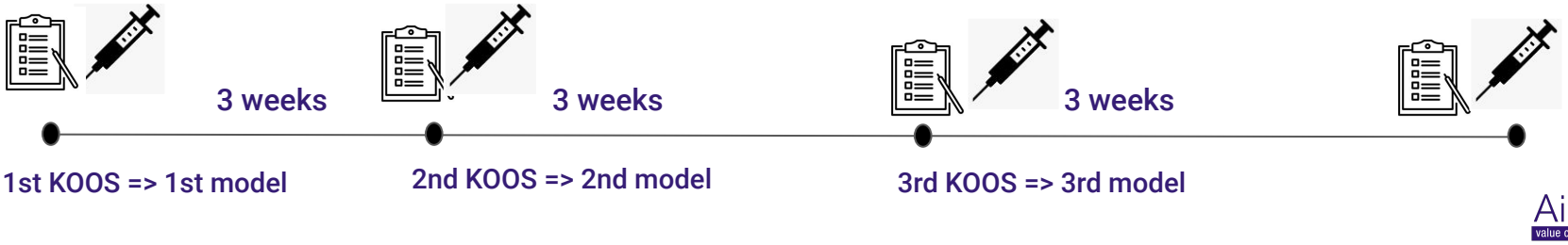
Machine learning pipeline



Three Regression models



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Methodology - Approach

Data set size: 75 patients

- training set: 80% (60 patients)
- testing set: 20% (15 patients)

Candidate models :

- XGBoost
- LightGBM

Model selection: cross validation + repeated K Fold

- models: default parameters
- 3 folds
- 5 repetitions
- neg_root_mean_squared_error

Selected model:

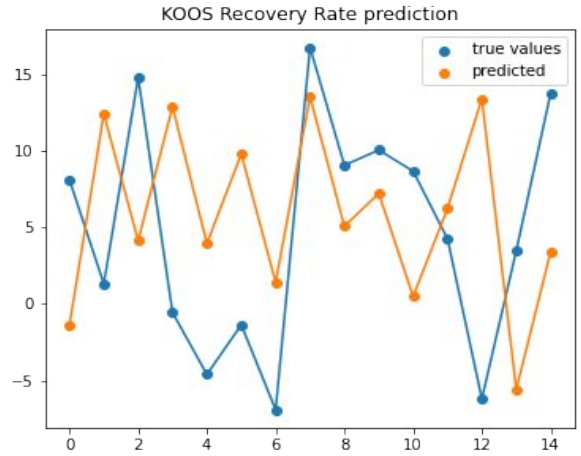
- LightGBM

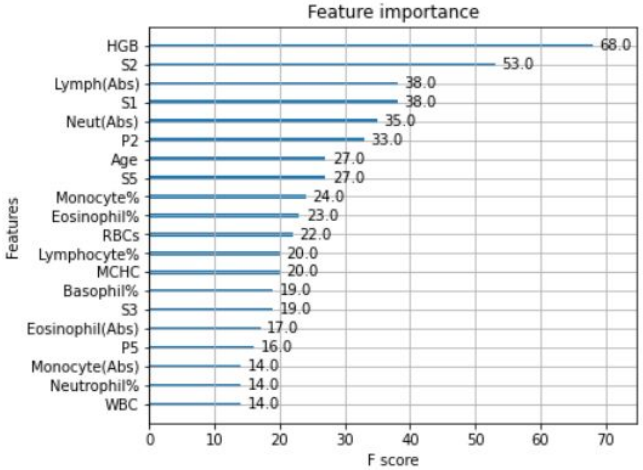
Hyperparameters tuning

- GridSearchCV

Hyperparameters:

- n_estimator = 100
- reg_lambda = 2
- boosting_type = 'gbdt'





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Results & Outcome

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Results & Outcome

Conclusion

- A digitized way to compute the KOOS
- The treatment if effective (**72 patients improved**)
- The most improve subscale is **Sport/Rec** why ?
- A predictive model
- A way to get the most informative variables

Limits

- Training data size

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What’s Next ?

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Next steps

- Collecting patient’s MRI, BMI and Osteoarthritis grades
- Model 2 and 3
- RR or KOOS prediction
- More parameters turning
- Explore another architecture (NN, …)
- Dimensionality reduction

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Thank You For Your Attention !

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