First complication risk prediction in diabetic patients and temporal risk stratification

METEDA

UNIVERSITÀ POLITECNICA DELLE MARCHE

vision robotics artificial intelligence

CORESEARCH srl

Patent pending

Reasons :

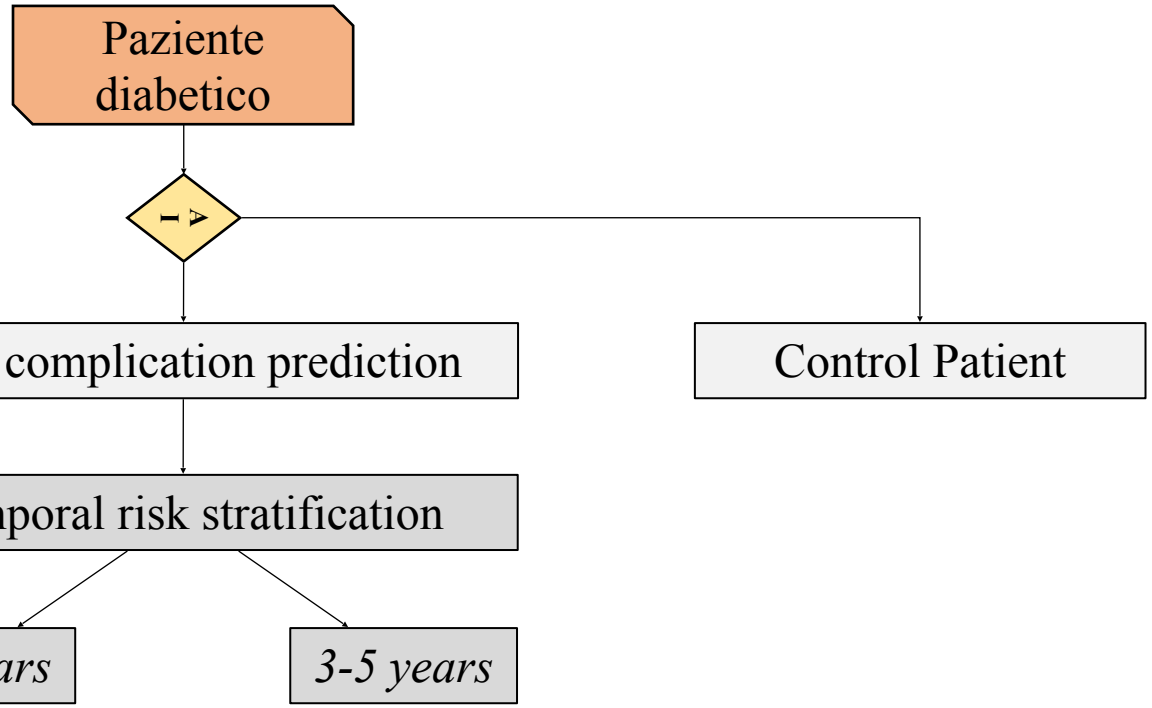
Managing the complications of diabetes requires a significant effort of human and economic resources for the national health system

Prediction of the risk of developing a complication at an early stage plays a key role in an adequate treatment and follow-up of the diabetic patient → Increase in quality of care

Objective: Integration in the electronic medical record (EHR) of a clinical decision support system (CDSS) based on Artificial Intelligence (AI) to help the diabetologist

Objective

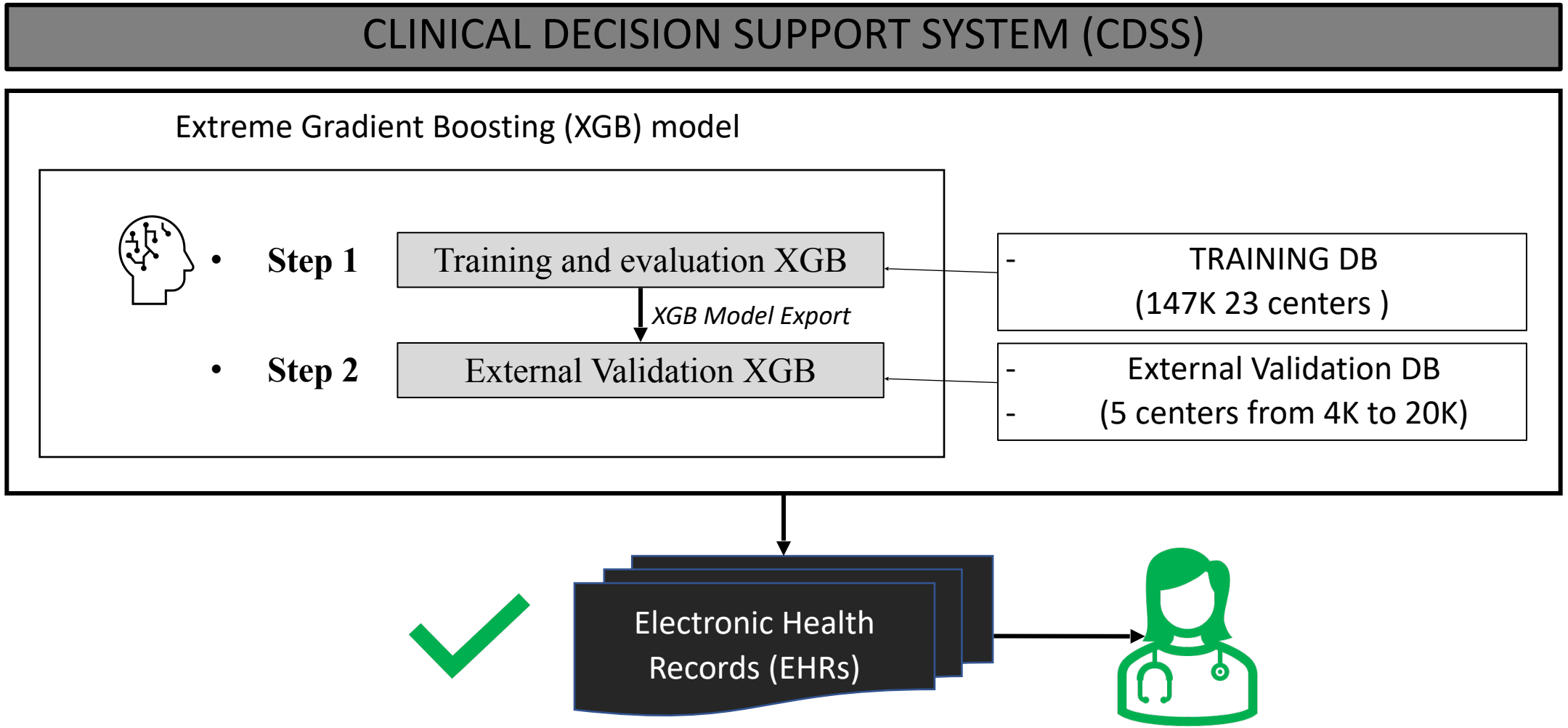
First complication risk prediction in diabetic patients and temporal risk stratification



- **Task 1**
- **Task 2**

Complications:

- Retinopathy
- Cer. Vasculopathy
- Per. Vasculopathty
- Cardiopathy
- Nefropathy
- Neuropathy


CLINICAL DECISION SUPPORT SYSTEM (CDSS)
Extreme Gradient Boosting (XGB) model
• Step 1
Training and evaluation XGB
XGB Model Export
• Step 2
External Validation XGB
- TRAINING DB
(147K 23 centers)
- External Validation DB
- (5 centers from 4K to 20K)
Electronic Health Records (EHRs)

Preprocessing: observational time-window

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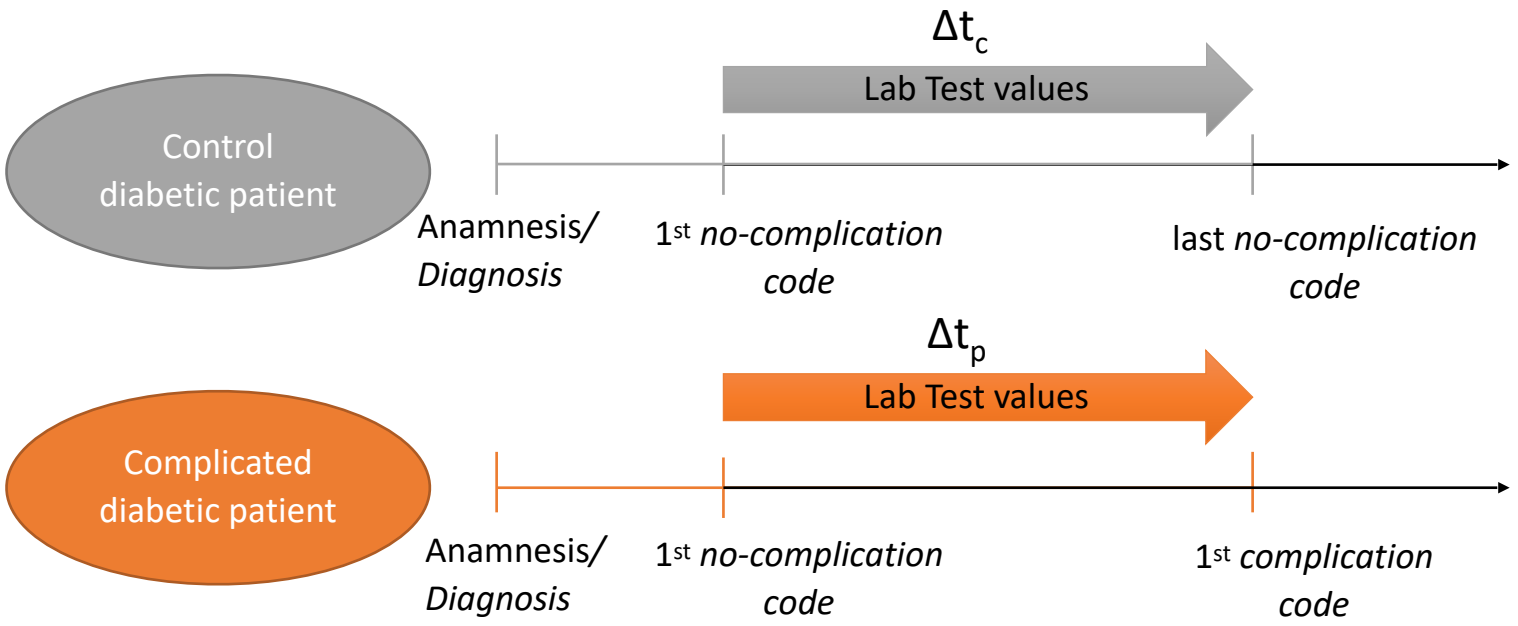
First complication risk prediction in diabetic patients and temporal risk stratification



Only prescribed exams in the range of the selected observational time-window were considered:

- Prescribed exams between the first no-complication code and the last no-complication code for Control patients
- Prescribed exams between the first no-complication code and the first complication code for Complicated patients

27 LAB TEST specific weight in the forecast **<5% e >1%**

Microalbuminuria
creatinine
uric acid
Fasting blood sugar
BMI
GT range
Triglycerides after 12h fasting
HDL cholesterol
Glycated hemoglobin HbA1c
Systolic pressure
Diastolic blood pressure
SGOT
Cholesterol
GPT

Height
LDL cholesterol
LDL cholesterol (calc)
Age
Weight
Duration of diabetes
Blood sugar after breakfast
Hemoglobin
Waist circumference
Creatinine clearance (calc)
Blood sugar after lunch
Platelets
Creatine Kinase (Serum)

Verifica Esami Predizione IA

È possibile valorizzare gli esami necessari al calcolo della Predizione IA per il paziente selezionato.

	Esame	Valore	Unità	Data	Ultimo valore (un anno)
✗	Clearance Creatinina (calc)		ml/min	14 December 2021	
✗	Colesterolo (calc)		mg/dl	14 December 2021	
✗	Colesterolo HDL		mg/dl	14 December 2021	
✗	Colesterolo LDL		mg/dl	14 December 2021	
✓	Circonferenza vita		cm	14 December 2021	*51 (12/05/2021)*
✓	Colesterolo		mg/dl	14 December 2021	*191 (12/05/2021)*
✓	Emoglob.Glicata HbA1c		%	14 December 2021	*75 (12/05/2021)*
✓	Ac. Urico	6,3	mg/dl	12 May 2021	
✓	Altezza	176	cm	14 December 2021	
✓	BMI	22,9	Kg/m^2	14 December 2021	
✓	Creatinina	22,1	mg/dl	14 December 2021	

✓ Dato disponibile ai fini del calcolo (inserito in data odierna)

✓ Dato disponibile ai fini del calcolo (inserito in una data trascorsa)

✗ Dato non disponibile ai fini del calcolo

Annulla

Salva

IA

Ordinamento Default

- **Diario**
- **Anamnesi**
- **Occhio**
- **Rene**
- **Cuore**
- **Vasi periferici**
- **Nervi periferici**

IA

Calcola ora

30/03/2022 | 01/08/2021 | 11/03/2021

Predizioni

	Probabilità di insorgenza	Probabilità di occorrenza temporale	
Rischio Cardiopatia	Molto alta	Elevata entro 2 anni	Storico Predizioni Cardiopatia
Rischio Retinopatia	Alta	Tra 3 e 5 anni	Storico Predizioni Retinopatia
Rischio Nefropatia	Consistente	Consistente entro 2 anni	Storico Predizioni Nefropatia
Rischio Neuropatia	Molto alta	Elevata entro 2 anni	Storico Predizioni_Neuropatia
Rischio Vasculopatia Cerebrale	Alta	Tra 3 e 5 anni	Storico Predizioni_Vasculopatia Cerebrale
Rischio Vasculopatia Periferica	Consistente	Consistente entro 2 anni	Storico Predizioni_Vasculopatia Periferica

Legenda

Probabilità di insorgenza: Consistente | Alta | Molto alta

Probabilità di occorrenza temporale: Tra 3 e 5 anni | Consistente entro 2 anni | Elevata entro 2 anni

Ultima modifica: Mignini Francesco (30/03/2022 16:48)

The AI algorithm is the only existing one that can be applied to **all** diabetes complications

It is easily **exportable** to other national and international clinical files

To be used as a tool for improving diabetes care and **overcoming clinical inertia**

How much and how could diabetes treatment change according to these new preventive risk assessments **not based only on glycemia and HbA1c**?

- **Task 1** First complication prediction Step 1 TRAINING DB

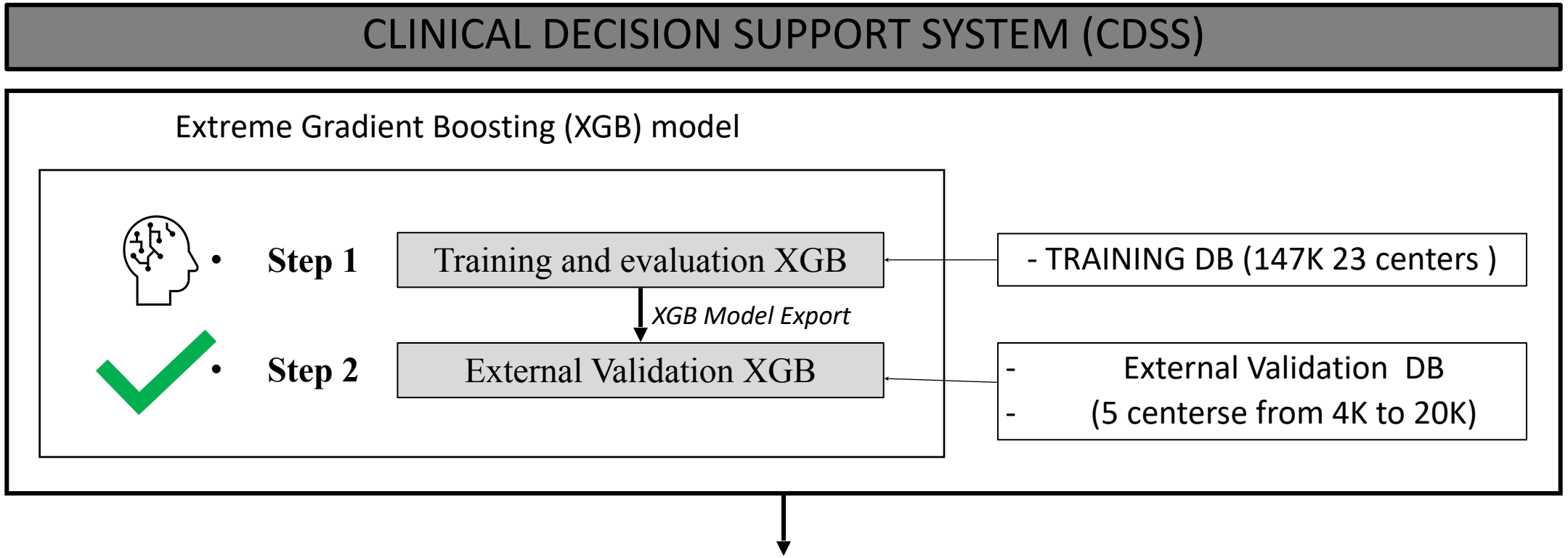
	Accuracy	**Sensitivity (Recall)**	Specificity	**AUC**
Retinopathy	74.1	**82.0**	71.9	**0.857**
Cardiovascular disease	74.8	**70.5**	75.8	**0.817**
Cerebrovascular disease	70.5	**89.1**	59.2	**0.846**
Peripheral vascular disease	80.5	**72.2**	82.1	**0.857**
Nephropathy	89.7	**92.8**	88.0	**0.970**
Sensory-motor neuropathy	76.0	**74.6**	76.4	**0.840**

Top 10 Items

- **Task 2** Temporal risk stratification Step 1 TRAINING DB

Short-term risk→ Complication in 0-2 years Mid-term risk→ Complication in 3-5 years

	Accuracy	**Recall (sensitivity) 0-2 years**	Recall (sensitivity) 3-5 years	**AUC**
Retinopathy	76.7	**83.6**	67.7	**0.861**
Cardiovascular disease	78.8	**85.8**	69.5	**0.871**
Cerebrovascular disease	77.3	**86.4**	64.2	**0.855**
Peripheral vascular disease	76.4	**83.2**	67.5	**0.859**
Nephropathy	78.5	**88.5**	62.2	**0.866**
Sensory-motor neuropathy	77.2	**85.7**	65.4	**0.859**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- **Task 1**

Results of external validation in five centers

Step 2 External Validation DB

	Accuracy Range	**Sensitivity Range**	Specificity Range	**AUC Range**
Retinopathy	57.9-83.5	**58.0-86.3**	52.6-81.7	**0.651-0.932**
Cardiovascular disease	48.5-82.0	**66.4-91.4**	30.4-70.7	**0.629-0.894**
Cerebrovascular disease	58.5-83.9	**63.6-96.9**	12.1-58.3	**0.590-0.860**
Peripheral vascular disease	60.2-75.4	**59.3-77.0**	60.9-76.6	**0.635-0.820**
Nephropathy	73.6-96.8	**76.4-91.6**	71.5-98.3	**0.817-0.979**
Sensory-motor neuropathy	55.5-80.6	**46.9-75.0**	44.1-83.7	**0.628-0.858**

- **Task 2**

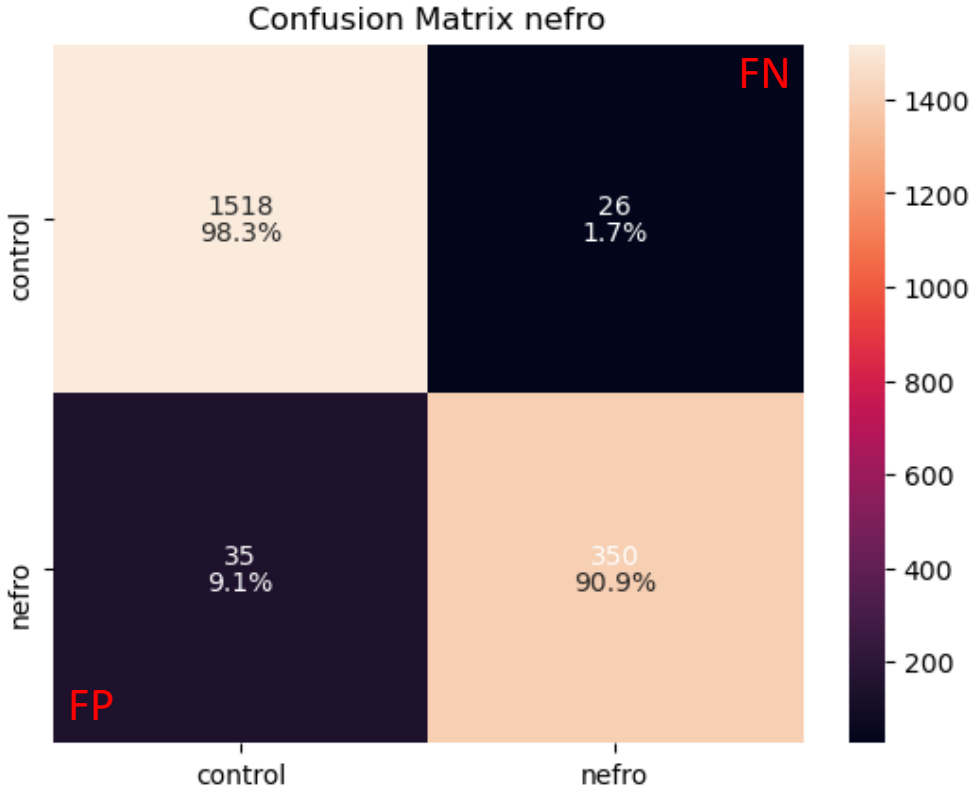
Results of external validation in five centers

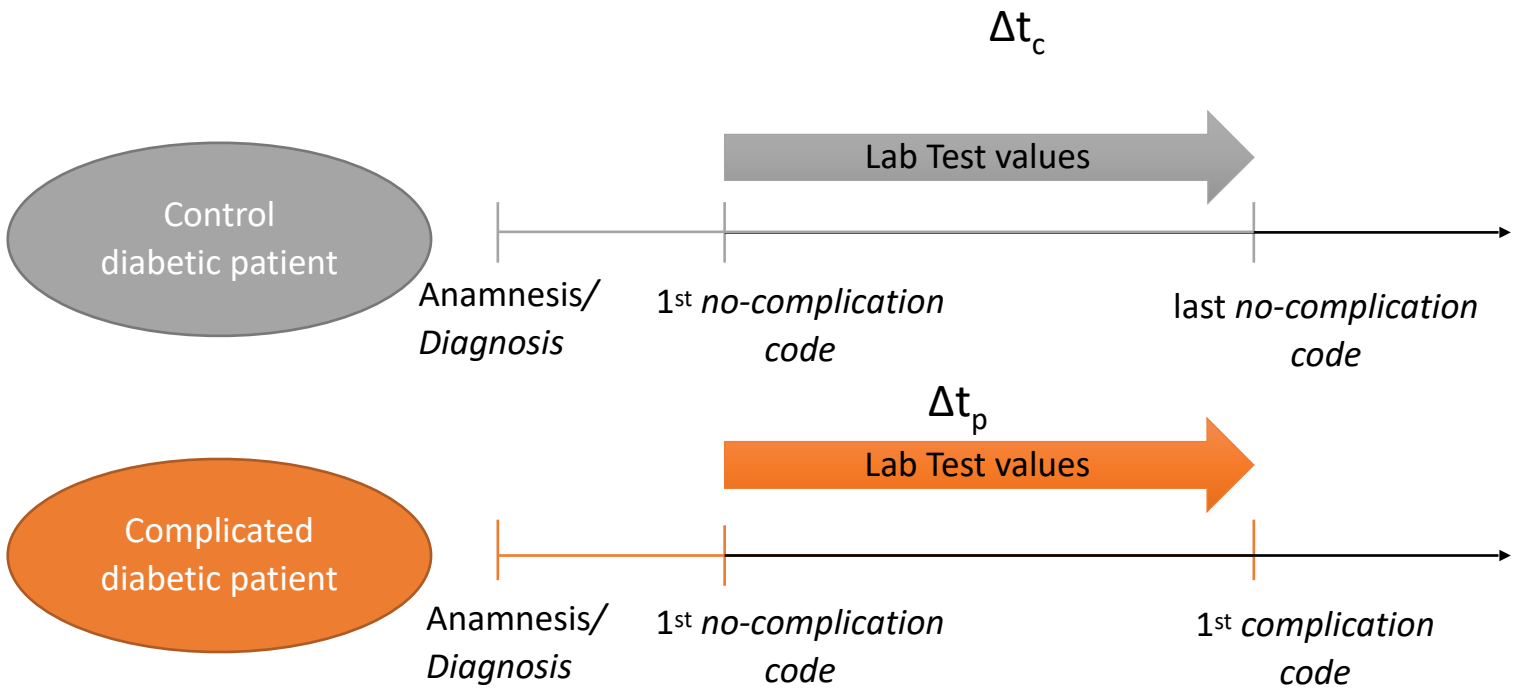
Step 2 External Validation DB

	Accuracy Range	**Sensitivity 0-2 years Range**	Sensitivity 3-5 years Range	**AUC Range**
Retinopathy	66.0-88.6	**58.4-95.7**	52.7-83.9	**0.730-0.953**
Cardiovascular disease	66.1-86.3	**85.6-93.0**	39.8-81.1	**0.747-0.947**
Cerebrovascular disease	65.4-85.9	**73.0-93.9**	36.2-82.4	**0.730-0.939**
Peripheral vascular disease	64.7-79.2	**75.4-93.2**	34.5-69.8	**0.635-0.820**
Nephropathy	65.4-86.0	**86.4-98.3**	30.5-73.5	**0.715-0.939**
Sensory-motor neuropathy	62.4-80.0	**67.3-95.8**	22.7-63.5	**0.690-0.928**

- **Task 1** First complication prediction – **Nephropathy Example** (ID4 center)

Ranking	Importance	Lab test (predictors)	Missing values
#1	4.54 %	Microalbuminuria	1.35 %
#2	4.43 %	Ac. Urico	52.98 %
#3	4.29 %	Creatinina	35.72 %
#4	4.05 %	Colesterolo LDL (calc)	62.42 %
#5	3.83 %	Glicemia a digiuno	2.18 %
#6	3.74 %	Gamma GT	56.40 %
#7	3.74 %	Emoglob.Glicata HbA1c	0.41 %
#8	3.71 %	Trigliceridi post 12h dig.	37.12 %
#9	3.59 %	Pressione Sistolica	52.26 %
#10	3.57 %	Colesterolo HDL	40.80 %





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NO IMPROVEMENT !!

This means that the AI model is strong and is not substantially affected by the cleaning upstream of the data

Conclusion: clinicians are unable to always identify the reasons

Expected benefits

The predictive algorithm can represent an important tool to help the clinician in identifying patients who need more attention and more frequent monitoring, thus helping to improve the therapeutic appropriateness and timeliness of interventions, with a view to **reducing the therapeutic inertia**.

This would produce both clinical and economic benefits, linked to the improvement of care.

Training and evaluation XGB: Complications codes

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Step 1: DB 200K

Per. Vasculopathy	
-3046	Non Arteriopatia arti inferiori
-3047	Arteriopatia obliterante arti inferiori
-3048	I Stadio di Leriche-Fontaine (clinico-strumentale asintomatico)
-3049	II Stadio di Leriche-Fontaine (claudicatio)
-3050	III Stadio di Leriche-Fontaine (dolore a riposo)
-3051	IV Stadio di Leriche-Fontaine (lesione trofica)
-3052	Rivascolarizzazione
-3053	By pass
-3054	Angioplastica
-3080	Piede Vasculopatico
-3209	Arteriopatia obliterante arti inferiori-IV Stadio di Leriche-Fontaine-gangrena

Cer. Vasculopathy	
-3091	Non Vasculopatia Cerebrale
-3092	TIA (sintomatologia di durata inferiore alle 24 h)
-3093	Ictus (sintomatologia superiore alle 72 h)
-3094	Ictus (sintomatologia superiore alle 72 h) - Ischemico
-3095	Ictus (sintomatologia superiore alle 72 h) - Emorragico
-3096	Ateromasia vasi epiaortici
-3097	Con stenosi <60%
-3098	Con stenosi >60%
-3227	Ictus (sintomatologia superiore alle 72 h) - Ischemico - con esiti funzionali
-3228	Ictus (sintomatologia superiore alle 72 h) - Ischemico - senza esiti funzionali
-3229	Ictus (sintomatologia superiore alle 72 h) - Emorragico - con esiti funzionali
-3230	Ictus (sintomatologia superiore alle 72 h) - Emorragico - senza esiti funzionali
-3231	Encefalopatia multi infartuale

Retinopathy	
-3001	Non Retinopatia Diabetica
-3002	Retinopatia Diabetica non Proliferante
-3003	Retinopatia Diabetica Preproliferante
-3004	Retinopatia Diabetica Proliferante
-3005	Retinopatia Diabetica Proliferante - Complicata
-3006	Maculopatia Diabetica
-3007	Retinopatia Diabetica Laser trattata
-3008	Retinopatia Ipertensiva
-3009	Glaucoma
-3011	Cecità
3013	Cecità - Da altre cause
-3016	Fluorangiografia - Patologica
-3201	Retinopatia Diabetica non Proliferante - laser trattata
-3202	Retinopatia Diabetica Proliferante - laser trattata
-3203	Oftalmopatia Diabetica Avanzata
-3204	Oftalmopatia Diabetica Avanzata - laser trattata
-3205	Cecità - Da Diabete - monooculare
-3206	Cecità - Da Diabete - bioculare
-3207	Cecità - Da altre cause - monooculare
-3208	Cecità - Da altre cause - bioculare
-3256	Retinopatia Diabetica Preproliferante - laser trattata

Nephropathy	
-3017	Non nefropatia diabetica (albuminuria<30 mg/24 h o <20 µg/min o <30 mg/g creatinina o <3 mg/mmol creatinina)
-3018	Nefropatia incipiente (albuminuria 30-300 mg/24 h o 20-200 µg/min o 30-300 mg/g creatinina o 3-30 mg/mmol creatinina)
-3019	Nefropatia conclamata (albuminuria >300 mg/24 h o >200 µg/min o >300 mg/g creatinina o >30 mg/mmol creatinina)
-3020	Insufficienza Renale cronica
-302	

Training and evaluation XGB: Complications codes

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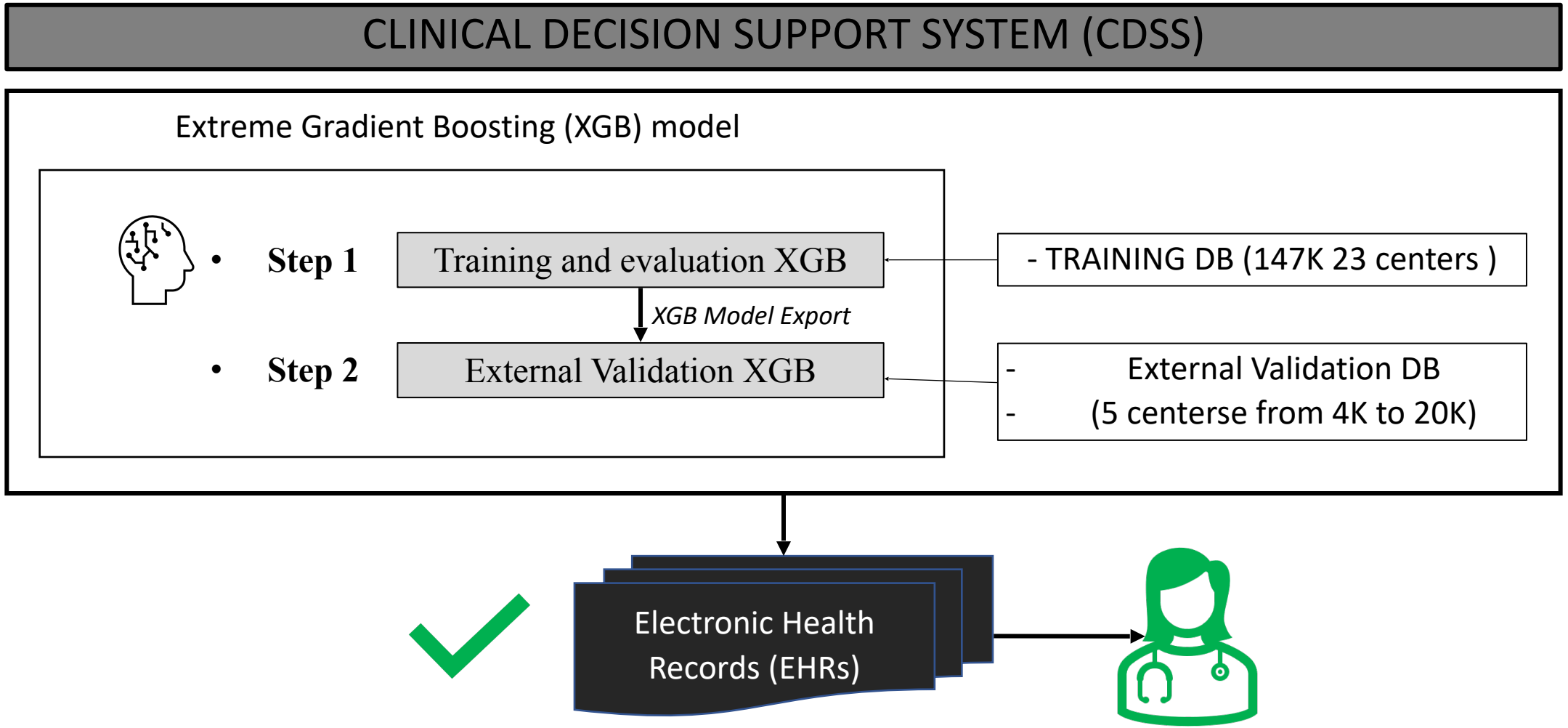
Step 1: DB 200K

Cardiopathy	
-3024	Non Cardiopatia
-3025	Cardiopatia Ischemica
-3026	Cardiopatia Ischemica - Asintomatica (strumentale)
-3027	Cardiopatia Ischemica - Angina stabile
-3028	Cardiopatia Ischemica - Angina instabile
-3029	Infarto miocardico pregresso
-3030	Rivascolarizzazione
-3031	Rivascolarizzazione - By pass Coronarico
-3032	Rivascolarizzazione - Angioplastica Percutanea
-3033	Rivascolarizzazione - Arterectomia
-3034	Rivascolarizzazione - Stent Coronarico
-3035	Rivascolarizzazione - Trombolisi
-3036	Insufficienza Cardiaca
-3038	Insufficienza Cardiaca - Classe II NYHA (attività ordinaria asintomatica)
-3039	Insufficienza Cardiaca - Classe III NYHA (attività minore sintomatica)
-3040	Insufficienza Cardiaca - Classe IV NYHA (sintomatologia a riposo)
-3041	Ipertensione Arteriosa (riscontro per 3-6 mesi di valori PAO >130/86 mmHg)
-3042	Ipertensione Arteriosa (riscontro per 3-6 mesi di valori PAO >130/86 mmHg) - Stadio I (assenza di danni d'organo)
-3043	Ipertensione Arteriosa (riscontro per 3-6 mesi di valori PAO >130/86 mmHg) - Stadio II (insufficienza ventricolare sinistra o aterosclerosi o microalbum.)
-3044	Ipertensione Arteriosa (riscontro per 3-6 mesi di valori PAO >130/86 mmHg) - Stadio III (danno d'organo conclamato)
-3045	Altre Cardiopatie
-3099	Ipertrofia Ventricolare Sinistra
-3100	Ipertrofia Ventricolare Sinistra - Documentata ECG
-3101	Ipertrofia Ventricolare Sinistra - Documentata Ecocardiogramma

Neuropathy	
-3055	Non Neuropatia
-3056	Polineuropatia sensitivo motoria simmetrica distale
-3057	Polineuropatia sensitivo motoria simmetrica distale - Dolorosa
-3058	Polineuropatia sensitivo motoria simmetrica distale - Dolorosa - Complicata (da Ulcera, Gangrena, Charcot, Amputazioni)
-3059	Polineuropatia sensitivo motoria simmetrica distale - Anestetica
-3060	Polineuropatia sensitivo motoria simmetrica distale - Anestetica - Complicata (da Ulcera, Gangrena, Charcot, Amputazioni)
-3061	Neuropatia Autonomica
-3062	Neuropatie asimmetriche
-3063	Neuropatie asimmetriche - Mononeuropatia
-3064	Neuropatie asimmetriche - Mononeuropatia - Solo alterazioni neurofisiologiche
-3065	Neuropatie asimmetriche - Mononeuropatia - Sintomatica
-3066	Neuropatie asimmetriche - Mononeuropatia - Complicata (da Ulcera, Gangrena, Charcot, Amputazioni)
-3067	Neuropatie asimmetriche - Multineuropatia
-3068	Neuropatie asimmetriche - Multineuropatia - Solo alterazioni neurofisiologiche
-3069	Neuropatie asimmetriche - Multineuropatia - Sintomatica
-3070	Neuropatie asimmetriche - Multineuropatia - Complicata (da Ulcera, Gangrena, Charcot, Amputazioni)
-3071	Neuropatie asimmetriche - Radicolopatia
-3072	Neuropatie asimmetriche - Radicolopatia - Solo alterazioni neurofisiologiche
-3073	Neuropatie asimmetriche - Radicolopatia - Sintomatica
-3074	Neuropatie asimmetriche - Radicolopatia - Complicata (da Ulcera, Gangrena, Charcot, Amputazioni)
-3075	Neuropatie asimmetriche - Neuropatia dolorosa acuta
-3076	Neuropatie asimmetriche - Neuropatia da insulina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