Classification of MS patients into disability levels using deep learning approaches based solely on routinely-acquired MRI

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[1] Multiple Sclerosis Centre of Catalonia (Cemcat), Department of Neurology/Neuroimmunology, Hospital Universitari Vall d'Hebron, Universitat Autònoma de Barcelona, Barcelona, Spain
[2] Section of Neuroradiology, Department of Radiology (IDI), Vall d'Hebron University Hospital, Spain. Universitat Autònoma de Barcelona, Barcelona, Spain
[3] Research institute of Computer Vision and Robotics, University of Girona, Girona, Spain

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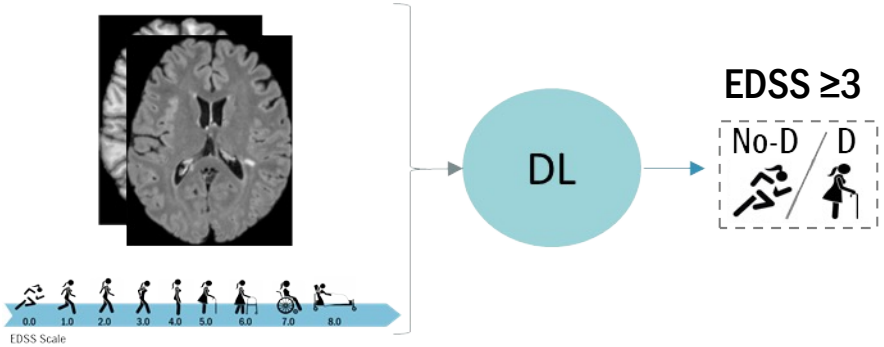
Objectives

- Study the potential of Deep Learning (DL) based models to stratify MS patients based on their EDSS evaluation at any time using a single MRI time-point

- DL approaches analysed:
  - Global
  - Regional



- Compare the performance with a traditional ML algorithm: a Logistic Regression (LR) based on brain volumetric measurements

Methods: Dataset

	Full cohort N = 385	No-disability N = 217	Disability N = 168	*p*-value
Female, n(%)	252 (65)	149 (69)	103 (61)	0.16
Age at CIS, yrs (mean[range])	31.8 [14-50]	32.4 [14-49]	30.1 [14-50]	0.1
Disease duration, yrs (mean[range])	10.4 [0-25]	7.6 [0-22]	14 [0-25]	<0.001
EDSS, median [range]	2.0 [0.0-9.0]	1.5 [0.0-2.5]	4.0 [3.0-9.0]	<0.001

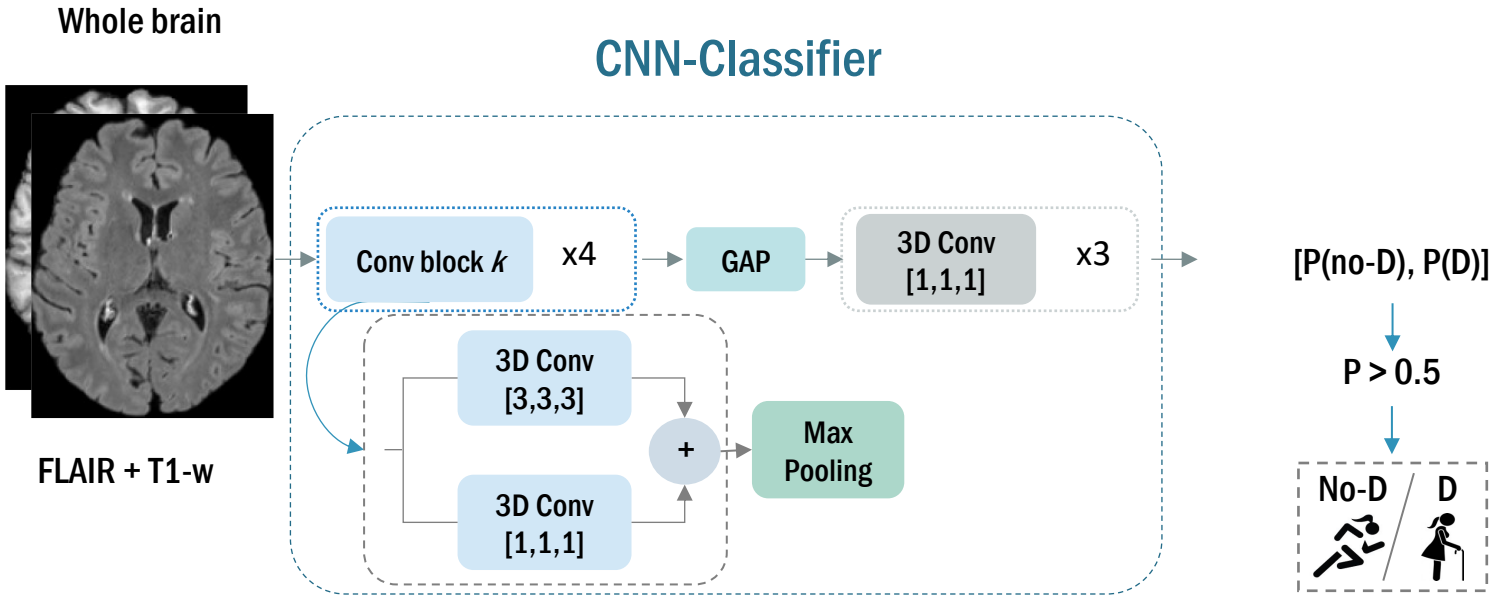
MRI

- 5 different Siemens scanners
- T1-w + FLAIR images

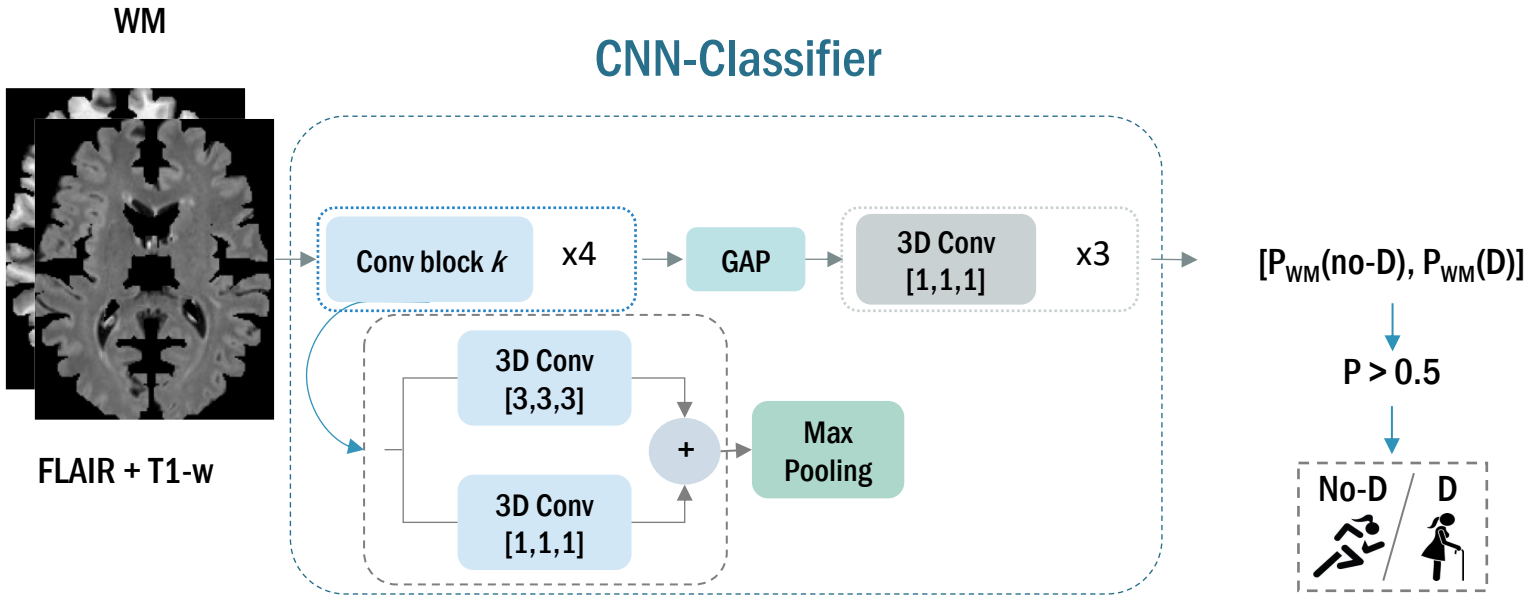
Preprocessing

- Bias correction
- Skull-stripping
- Registration to MNI space
- Min-max intensity normalization

Methods: Pipeline



Methods: Pipeline



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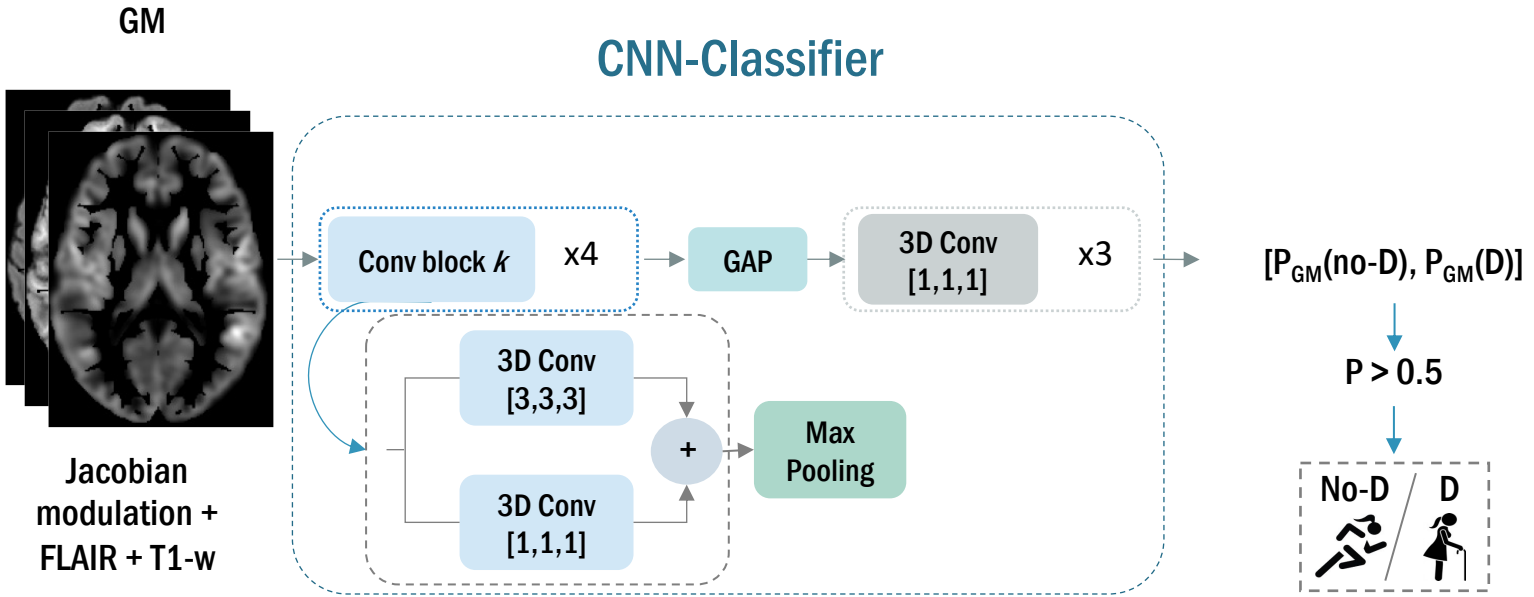

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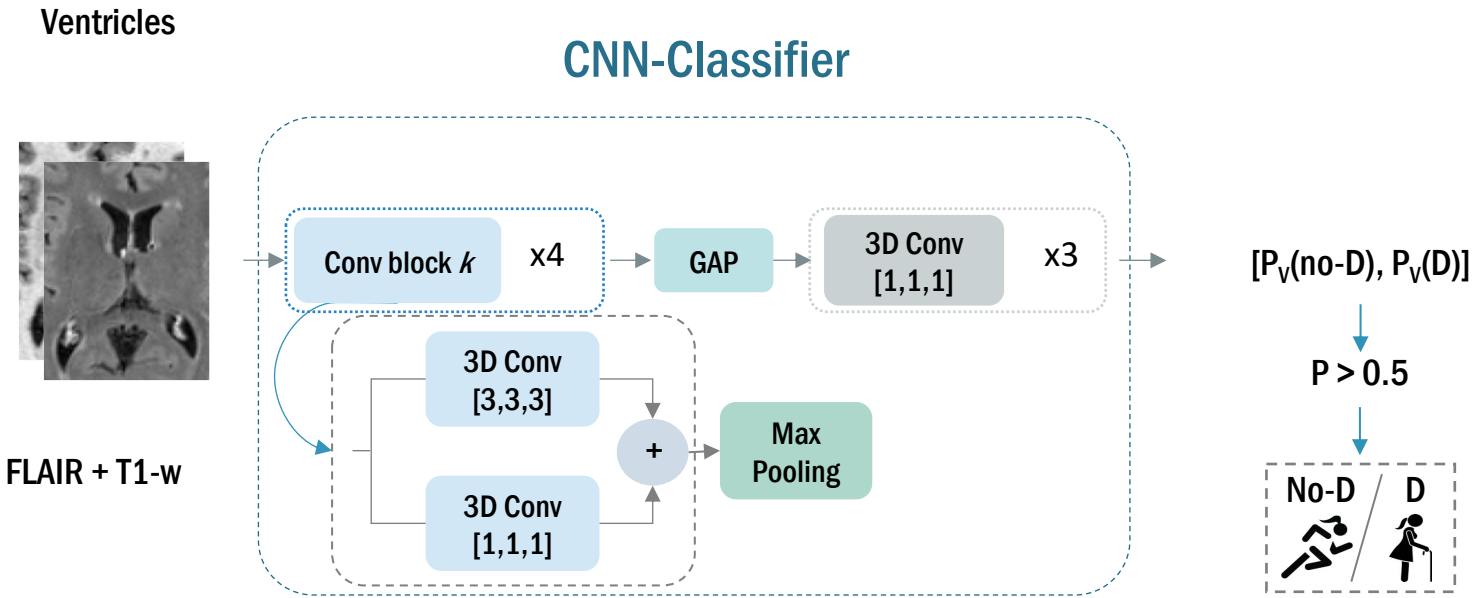

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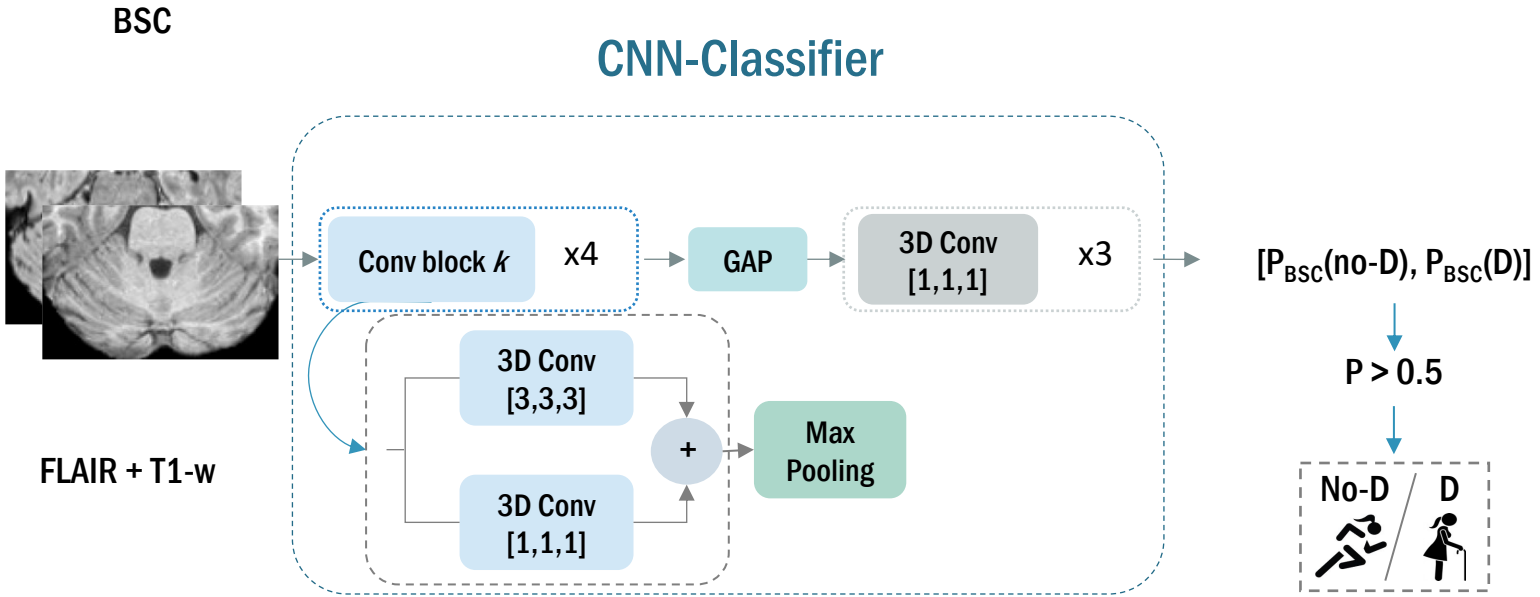

Coll, LI. et al ✉ lcoll@cem-cat.org

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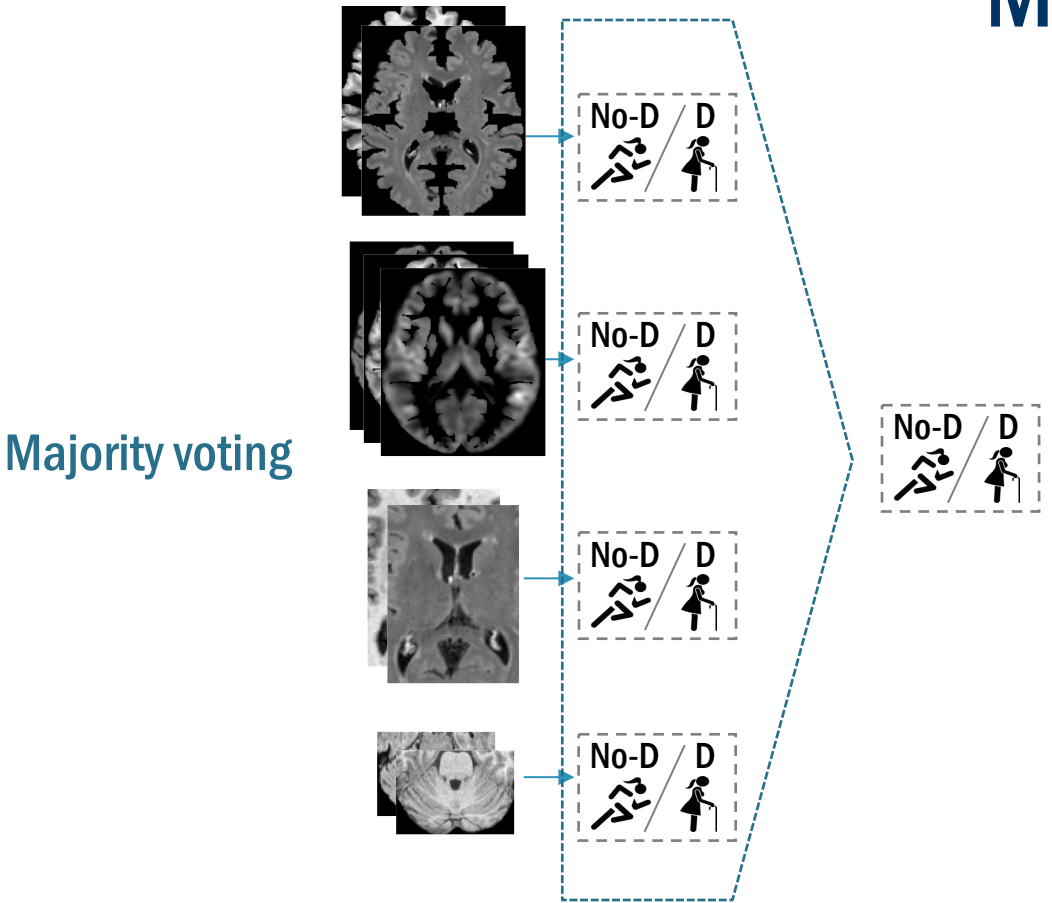
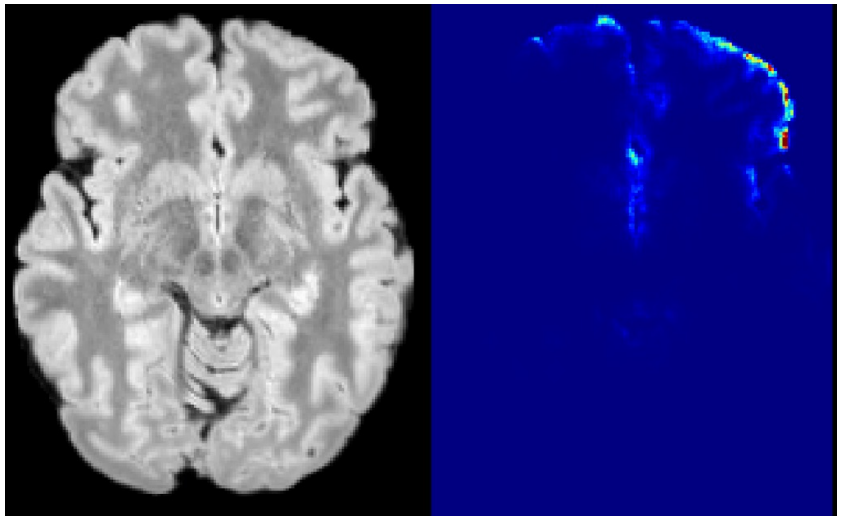


Results: quantitative

		Accuracy	Sensitivity	Specificity
CNN-Classifier	Whole brain	0.79 ± 0.04	0.76	0.81
	WM	0.78 ± 0.06	0.74	0.82
	GM	**0.81 ± 0.04**	**0.79**	0.81
	Ventricles	0.76 ± 0.06	0.76	0.76
	BSC	0.76 ± 0.06	0.68	0.84
	Majority voting	0.80 ± 0.04	0.76	**0.84**
+ lesion load	LR-Classifier	0.77 ± 0.07	0.68	0.87

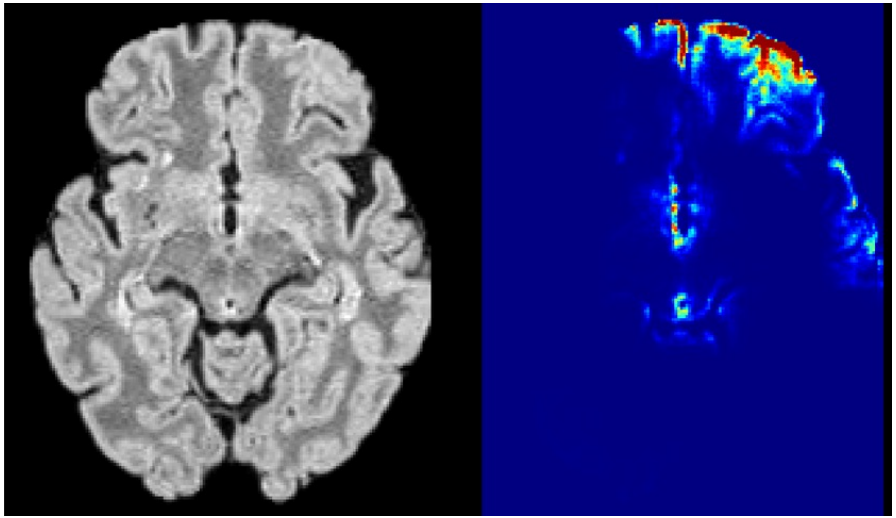
Results: qualitative

FLAIR | Attention map



No-Disability status (EDSS 0.0)

FLAIR | Attention map



Disability status (EDSS 6.0)

Conclusions

- Our DL-based models:
  - Successfully stratified MS patients based on their EDSS evaluation solely with a single time-point multimodal MRI scan
  - Were able to provide information about the physiopathological mechanisms responsible for the accumulation of disability in MS
  - Provide superior accuracy and sensitivity than a (traditional) machine learning LR-model based on volumetric measurements

- Clinically, these DL-based models may be useful to plan therapeutic or preventive interventions at a hospital level

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