AIforCOVID: intelligenza artificiale per la predizione delle complicanze da COVID-19

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Research Operations Manager – Consultant

CDI Centro Diagnostico Italiano, Milano

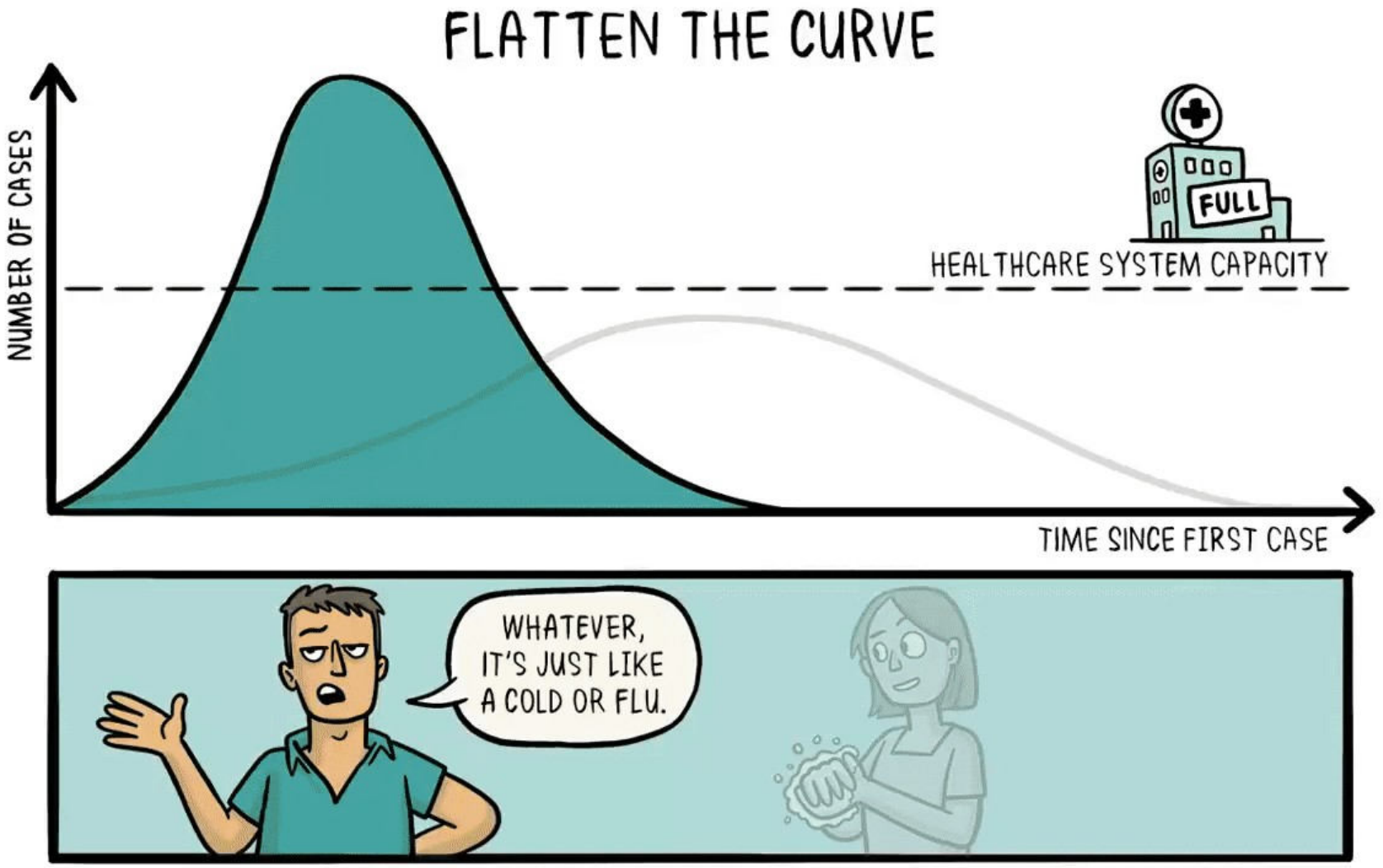
Conflict of Interest

There are no conflicts related to this work.

Scientific Advisor for Bracco Imaging S.p.A.

catch me if you can


All’inizio non sapevamo cosa



Aumentare il numero di letti

Ridurre la diffusione del virus

Migliorare la qualità delle cure

Obiettivo

Sulla base dei dati raccolti al momento del ricovero in PS era possible prevedere se il paziente sarebbe evoluto verso una condizione **moderata** o **severa**?

- **Moderata:** il paziente viene ricoverato senza necessità di support ventilatorio
- **Severa:** il paziente richiede un support ventilatorio non-invasivo, invasivo o *exitus*.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Centro Diagnostico Italiano

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Regione Lombardia

MILANO, 07 APRILE 2020

marco.alfi@cdi.it

1 

Network of hospitals and research institutions

2 

Study protocol by a multidisciplinary and multicenter team

3 

Documents are sent by the Promoter Center (CDI) to the IRB for approval

4 

CDI's IRB approves the study

5 

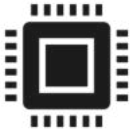
Satellite centers IRB approve study

6 

Collection of anonymous data

7 

Data sent to the main center (CDI)

8 

Data analysis and AI

Data/models-sharing & publication

MILD vs **SEVERE**

Contents lists available at ScienceDirect

Medical Image Analysis

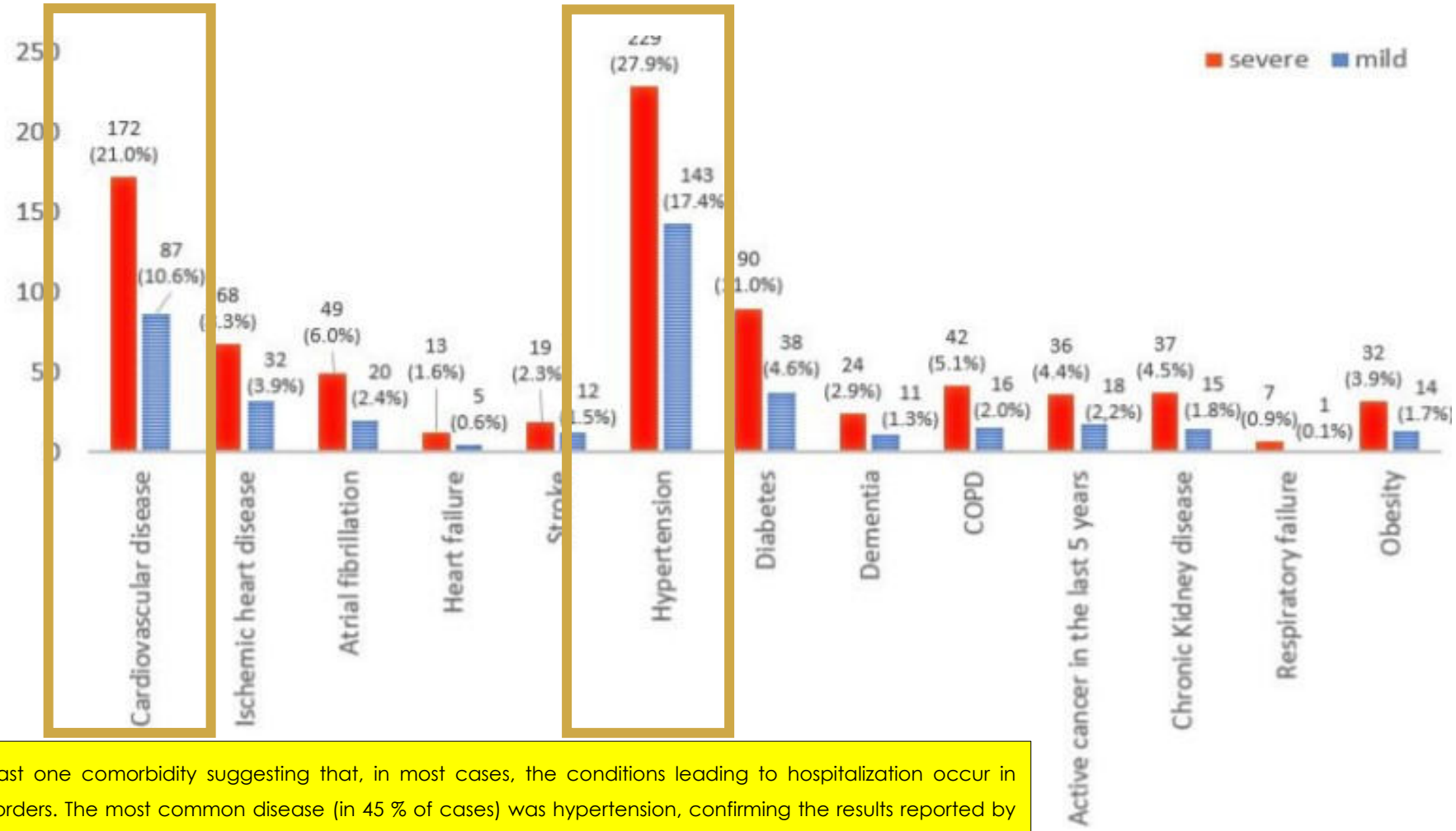
journal homepage: www.elsevier.com/locate/media

AIforCOVID: Predicting the clinical outcomes in patients with COVID-19 applying AI to chest-X-rays. An Italian multicentre study

Paolo Soda[a,*], Natascha Claudia D'Amico[a,b], Jacopo Tessadori[c], Giovanni Valbusa[d], Valerio Guarrasi[a,e], Chandra Bortolotto[f], Muhammad Usman Akbar[c,g], Rosa Sicilia[a], Ermanno Cordelli[a], Deborah Fazzini[b], Michaela Cellina[h], Giancarlo Oliva[h], Giovanni Callea[f], Silvia Panella[i], Maurizio Cariati[j], Diletta Cozzi[k], Vittorio Miele[k], Elvira Stellato[r], Gianpaolo Carrafiello[l,m], Giulia Castorani[n], Annalisa Simeone[o], Lorenzo Preda[f,p], Giulio Iannello[a], Alessio Del Bue[c], Fabio Tedoldi[d], Marco Alí[b,d], Diego Sona[c,q], Sergio Papa[b]

Input data	Approach	Accuracy	Sensitivity	Specificity
Clinical data and CXR images	Handcrafted	$.755 \pm .007$	$.758 \pm .008$	$.753 \pm .013$
	Hybrid	$.769 \pm .054$	$.788 \pm .064$	$.747 \pm .059$
	End-to-end	$.748 \pm .008$	$.745 \pm .017$	$.751 \pm .015$

Risultati



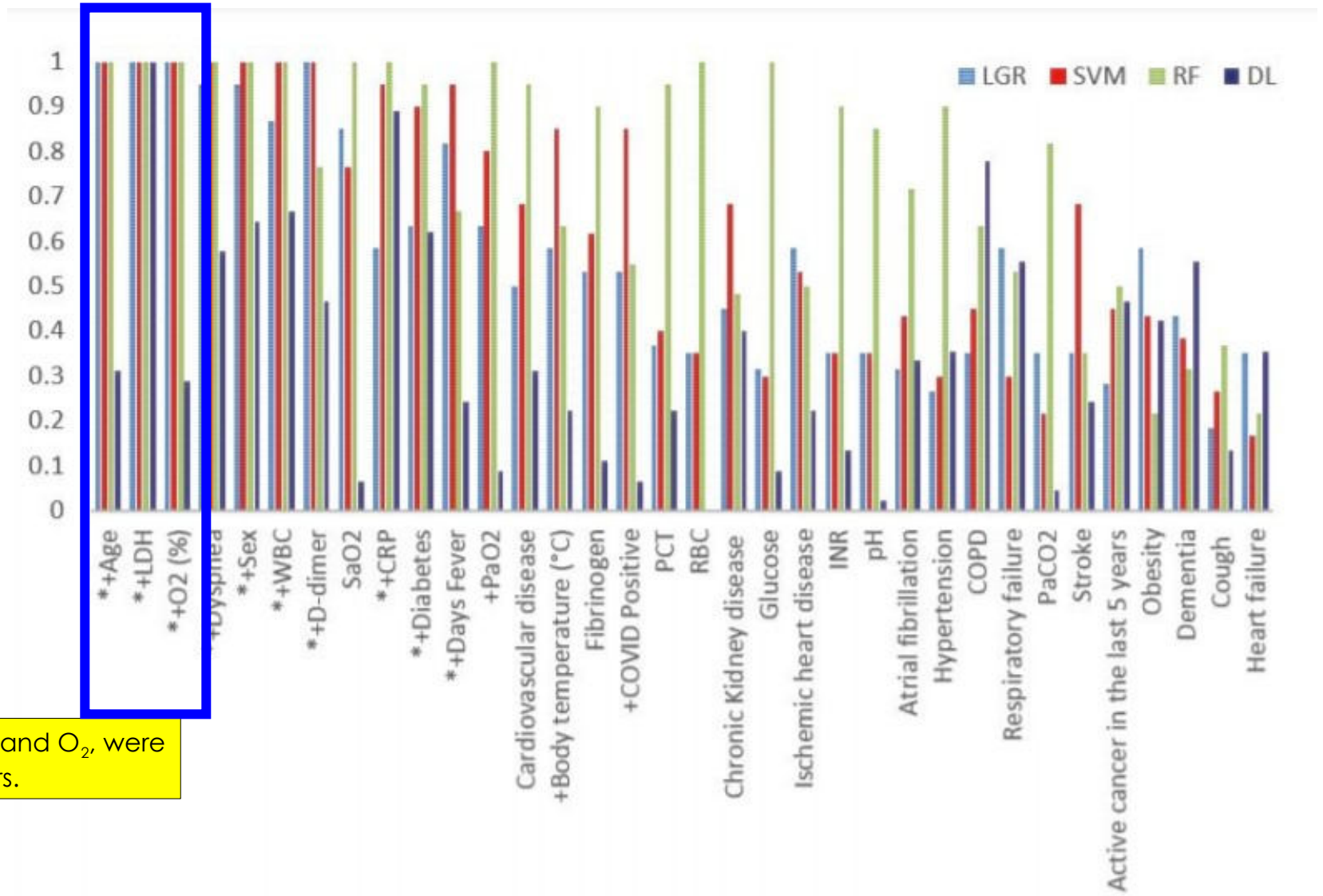
87% of patients had at least one comorbidity suggesting that, in most cases, the conditions leading to hospitalization occur in patients with coexisting disorders. The most common disease (in 45 % of cases) was hypertension, confirming the results reported by Yang et.al. *Prevalence of comorbidities and its effects in patients infected with SARS-CoV-2: a systematic review and meta-analysis*. Int J of Inf Dis, 2020.

Risultati

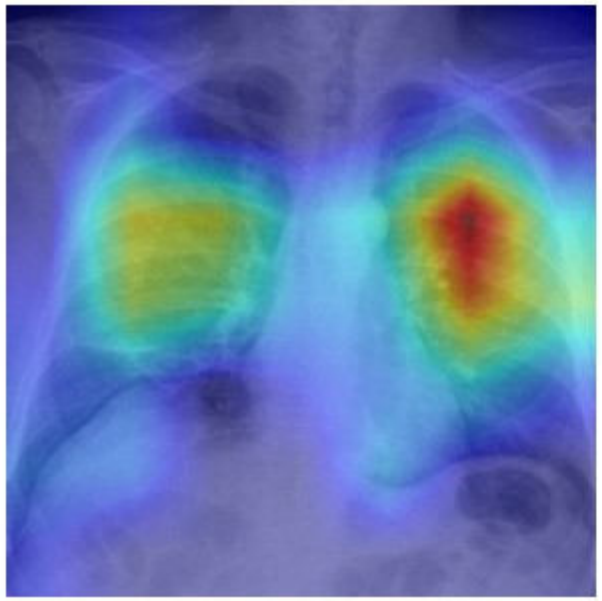
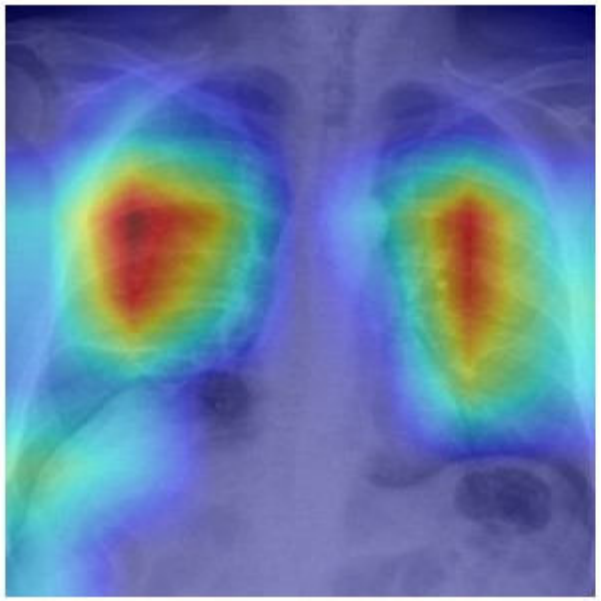
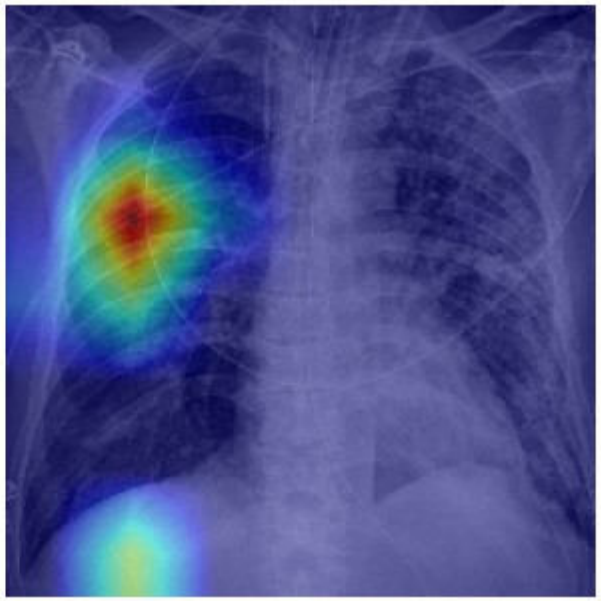
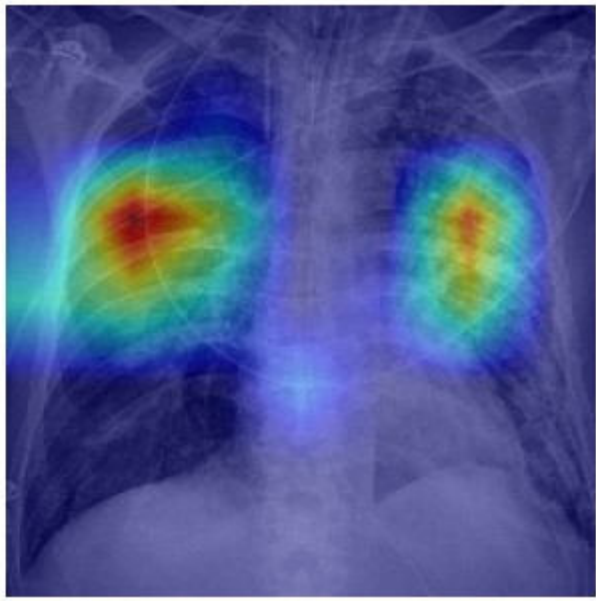
Name	Description	Overall-population	Mild-group (A)	Severe-group (B)	A vs B p-value	Missing data (%)
Active cancer in the last 5 years	Patient had active cancer in the last 5 years (% reported)	7%	5%	8%	<0.05†	1.4
Age	Patient's age (years)	64; 54-77	60; 49-72	70; 60-79	<0.001*	0
Atrial Fibrillation	Patient had atrial fibrillation (% reported)	9%	5%	11%	<0.001†	2.2
Body temperature (°C)	Patients temperature at admission (in °C)	38; 37-38	38; 37-38	38; 37-38	0.171	8.8
Cardiovascular Disease	Patient had cardiovascular diseases (% reported)	35%	23%	40%	<0.001†	1.7
Chronic Kidney disease	Patient had chronic kidney disease (% reported)	6%	4%	9%	<0.01†	1.4
COPD	Chronic obstructive pulmonary disease (% reported)	7%	4%	10%	<0.01†	1.4
Cough	Cought (%yes)	54%	59%	50%	<0.05†	0.5
CRP	C-reactive protein concentration (mg/dL)	57; 24-119	42; 17-75	103; 48-163	<0.001*	3.5
Days Fever	Days of fever up to admission (days)	3; 2-4	3; 2-4	3; 2-3	0.289	10.96
D-dimer	D-dimer amount in blood	632; 352-1287	549; 262-909	820; 438-2056	<0.001*	77.6
Death+	Death of patient occurred during hospitalization for any cause	168	0	168	-	-
Dementia	Patient had dementia (% reported)	4%	3%	6%	0.087	1.8
Diabetes	Patient had diabetes (% reported)	16%	10%	21%	<0.001†	1.4
Dyspnea	Patient had intense tightening in the chest, air hunger, difficulty breathing, breathlessness or a feeling of suffocation (%yes)	50%	37%	62%	<0.001†	0.4
Fibrinogen	Fibrinogen concentration in blood (mg/dL)	607; 513-700	550; 473-658	615; 549-700	<0.001*	73.6
Glucose	Glucose concentration in blood (mg/dL)	110; 96-130	104; 93-121	114; 101-139	<0.001*	20.6
Heart Failure	Patient had heart failure (% reported)	2%	1%	3%	0.157	2.3
Hypertension	Patient had high blood pressure (% reported)	46%	38%	54%	<0.001†	1.4
INR	International Normalized Ratio	1.13; 1.07-1.25	1.11; 1.06-1.20	1.15; 1.08-1.28	0.004*	28.8
Ischemic Heart Disease	Patient had ischemic heart disease (% reported)	15%	11%	18%	<0.01†	18.3
LDH	Lactate dehydrogenase concentration in blood (U/L)	320; 249-431	271; 214-323	405; 310-527	<0.001*	24.6
O_2 (%)	Oxygen percentage in blood (%)	95; 90-97	96; 94-98	92; 87-96	<0.001*	16.5
Obesity	Patient had obesity (% reported)	9%	6%	11%	0.058	36.1
$PaCO_2$	Partial pressure of carbon dioxide in arterial blood (mmHg)	33; 30-36	34; 30-37	33; 30-35	0.116	15.4
PaO_2	Partial pressure of oxygen in arterial blood (mmHg)	69; 59-80	73; 67-81	64; 54-76	<0.001*	15.3
PCT	Platelet count (ng/mL)	0.19; 0.09-0.56	0.09; 0.05-0.26	0.28; 0.13-0.72	<0.001*	71.8
pH	Blood pH	7; 7-7	7; 7-7	7; 7-7	<0.001*	17.3
Position+	Patient position during chest x-ray (%supine)	78%	68%	87%	<0.001†	0
Positivity at admission	Positivity to the SARS-CoV-2 swab at the admission time (% positive)	95%	94%	96%	0.142	4.7
Prognosis	Patient outcome, see section 2 (% cases)	-	46.8%	53.2%	0.468†	0.0
RBC	Red blood cells count ($10^6$9/L)	4.65; 4.26-5.07	4.70; 4.34-5.11	4.59; 4.13-5.03	<0.001*	3.0
Respiratory Failure	Patient had respiratory failure (% reported)	1%	100%	2%	0.131	19.0
SaO_2	Arterial oxygen saturation (%)	95; 91-97	96; 94-98	92; 87-96	<0.001*	39.2
Sex	Patient's sex (%males)	68%	59%	75%	<0.001†	0
Stroke	Patient had stroke (% reported)	4%	3%	4%	0.447	2.3
Therapy Anakinra+	Patient was treated with Anakinra (%yes)	100%	0%	0%	-	10.8
Therapy anti-inflammatory+	Patient was treated with anti-inflammatory drugs therapy (%yes)	55%	53%	57%	0.243	13.5
Therapy antiviral+	Patient was treated with antiviral drugs (%yes)	47%	44%	50%	0.129	10.7
Therapy Eparine+	Patient was treated with eparine (no; yes; prophylactic treatment; therapeutic treatment)	56.6%; 11.5%; 28%; 3.9%	73.3%; 8.3%; 17.2%; 1.1%	39.9%; 14.7%; 38.8%; 6.6%	<0.001†	13.4
Therapy hydroxychloroquine+	Patient was treated with hydroxychloroquine (%yes)	59%	56%	62%	0.118	11.6
Therapy Tocilizumab+	Patient was treated with Tocilizumab (%yes)	9%	2%	15%	<0.001†	12.4
WBC	White blood cells count ($10^6$9/L)	6.30; 4.73-8.42	5.58; 4.32-7.17	7.10; 5.25-9.80	0.012*	0.7

- Women were both less and older than man, suggesting that they become less ill and suffer from more serious conditions at an older age;
- Women mortality was lower, as **72% were male** confirming results reported in literature by Chen et.al. *Clinical characteristics of 113 deceased patients with coronavirus disease 2019: retrospective study*. BMJ, 2020.

Risultati



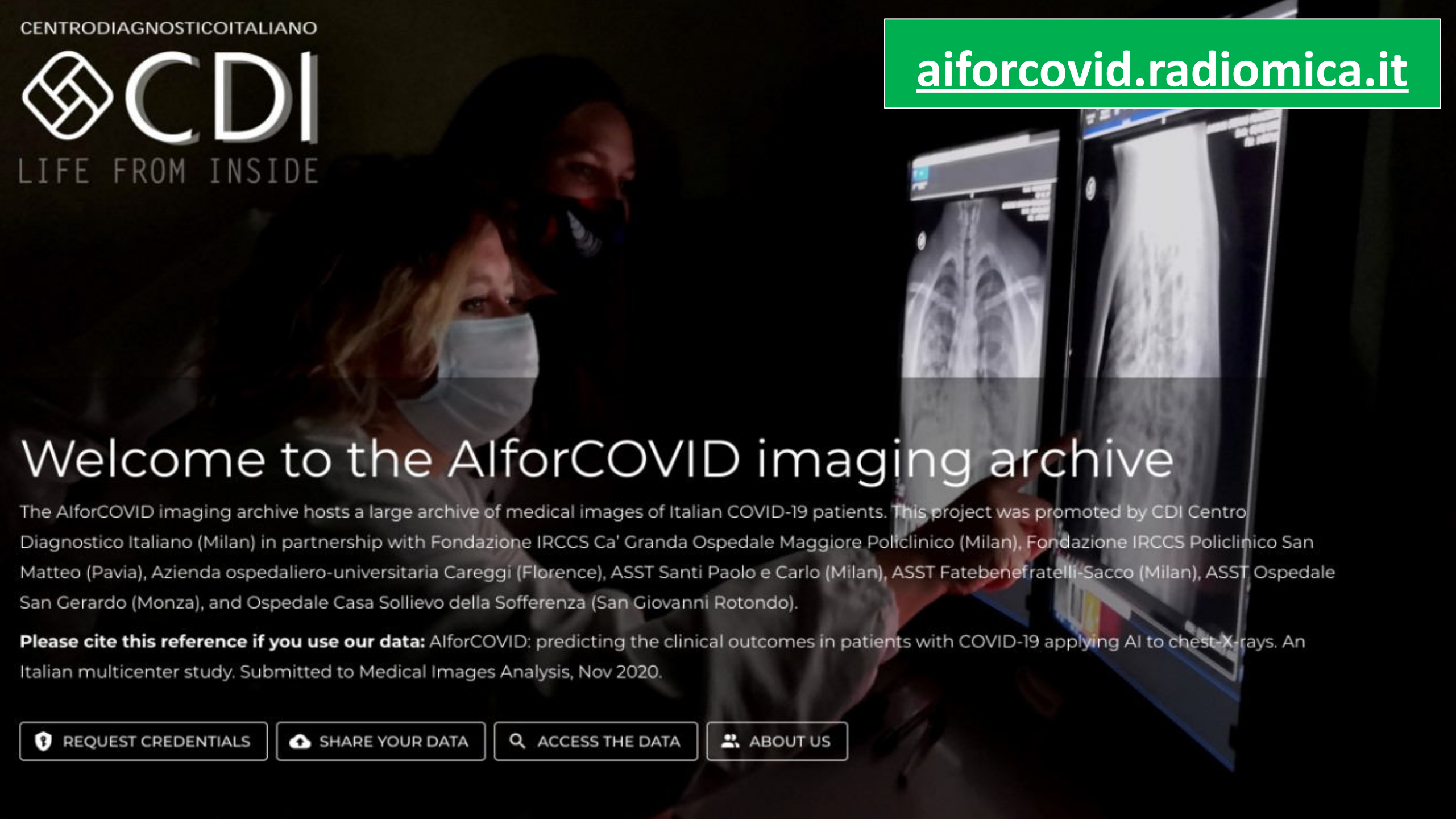
Clinical feature importance: age, LDH and O_2, were chosen in every fold for all the classifiers.

Multicenter Study > Med Image Anal. 2021 Dec;74:102216. doi: 10.1016/j.media.2021.102216. Epub 2021 Aug 28.

(a) Mild class, all neurons (b) Mild class, 40 most selected neurons (c) Severe class, all neurons (d) Severe class, 40 most selected neurons

Figure 9: Two examples of the activation maps provided by the Grad-CAM approach, using all the neurons in the dense layer of the CNN dense layer or all the 40 neurons selected by the RFECV wrapper.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Welcome to the AIforCOVID imaging archive
The AIforCOVID imaging archive hosts a large archive of medical images of Italian COVID-19 patients. This project was promoted by CDI Centro Diagnostico Italiano (Milan) in partnership with Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico (Milan), Fondazione IRCCS Policlinico San Matteo (Pavia), Azienda ospedaliero-universitaria Careggi (Florence), ASST Santi Paolo e Carlo (Milan), ASST Fatebenefratelli-Sacco (Milan), ASST Ospedale San Gerardo (Monza), and Ospedale Casa Sollievo della Sofferenza (San Giovanni Rotondo).
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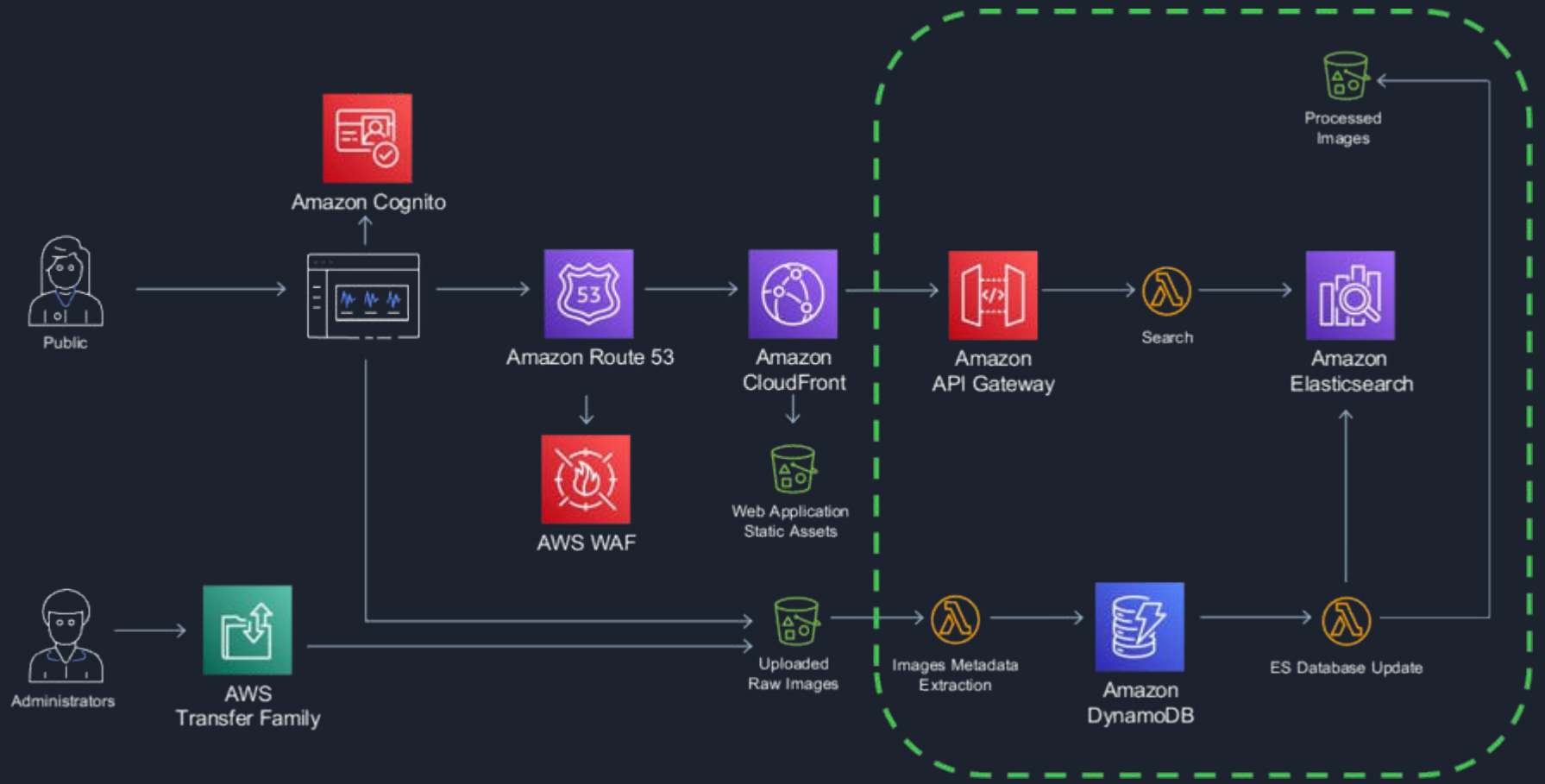
CDI – Centro Diagnostico Italiano

2nd April 2020



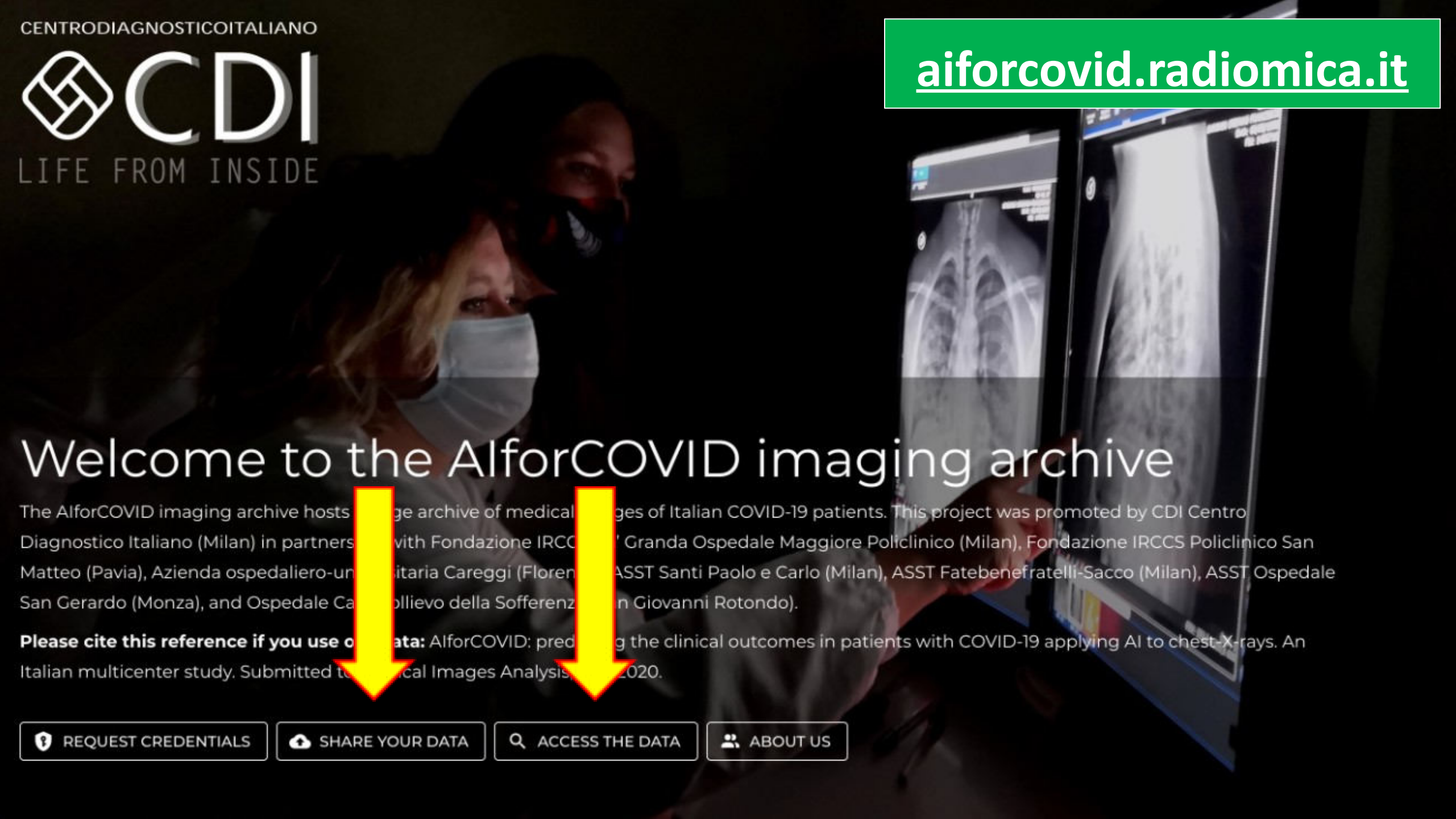

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Image File	Hospital	Age	Sex	Positivity at admission	Temp °C	Days Fever	Cough	Difficulty in Breathing	Therapy Anti-Inflammatory	WBC (10^9/L)	CRP (mg/dL)	Fibrinogen	LDH
P_102.dcm	A	72	Female	Positive	37.3	6-9	Yes	No	Yes	5.37	3.96	–	
P_131.dcm	D	36	Male	Positive	39.3	6-9	Yes	No	Yes	5.76	43.40	651	
P_132.dcm	D	57	Male	Positive	37.0	6-9	No	No	No	11.48	64.00	700	
P_117.dcm	A	39	Female	Positive	37.2	3-5	Yes	No	Yes	10.17	0.75	–	
P_16.dcm	A	44	Male	Positive	38.0	6-9	Yes	No	Yes	6.64	5.20	–	
P_118.dcm	A	76	Male	Positive	38.6	0-2	Yes	No	Yes	17.72	13.72	–	
P_195.dcm	D	79	Male	Positive	37.8	6-9	Yes	No	No	6.21	115.30	698	
P_193.dcm	D	82	Male	Positive	38.0	6-9	Yes	No	Yes	7.28	149.30	513	
P_140.dcm	D	61	Female	Positive	37.0	3-5	Yes	No	No	6.37	20.70	–	
P_136.dcm	D	76	Male	Positive	–	3-5	Yes	Yes	Yes	5.81	167.00	689	
P_151.dcm	D	45	Female	Positive	38.0	6-9	No	Yes	Yes	–	–	–	
P_127.dcm	D	38	Male	Positive	37.6	3-5	Yes	No	Yes	5.64	24.70	–	
P_123.dcm	D	59	Male	Positive	37.9	3-5	Yes	No	Yes	3.36	13.70	513	
P_143.dcm	D	77	Male	Negative	–	6-9	Yes	No	–	6.79	79.50	528	
P_187.dcm	D	90	Male	Positive	37.5	>9	Yes	Yes	No	5.98	187.80	700	
P_157.dcm	D	52	Male	Positive	38.5	>9	Yes	No	Yes	12.13	86.70	700	
P_156.dcm	D	71	Male	Positive	39.7	3-5	No	No	Yes	2.87	143.40	700	
P_152.dcm	D	59	Female	Positive	–	>9	Yes	No	No	8.08	62.30	700	
P_126.dcm	D	55	Male	Positive	37.0	3-5	Yes	No	Yes	19.74	570.50	–	
P_164.dcm	D	54	Male	Positive	37.0	>9	Yes	Yes	–	9.54	84.90	561	
P_185.dcm	D	88	Male	Positive	37.0	6-9	Yes	Yes	–	4.13	130.30	657	
P_159.dcm	D	89	Female	Negative	38.5	0-2	No	Yes	Yes	26.63	344.50	700	

Share your Data

Thank you for deciding to share your data!

To receive all the upload instructions, please contact the AIforCOVID staff at aiforcovid@cdi.it

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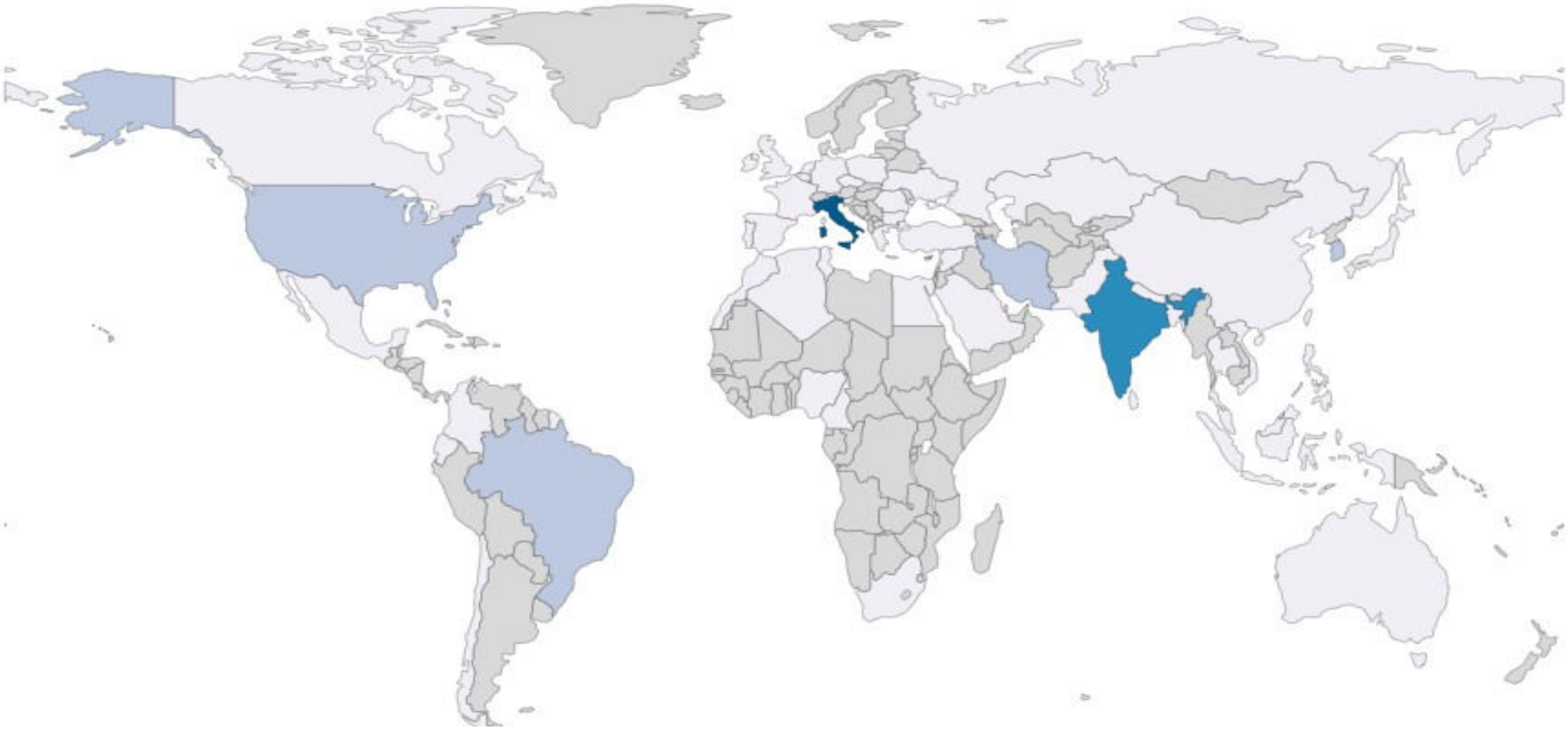

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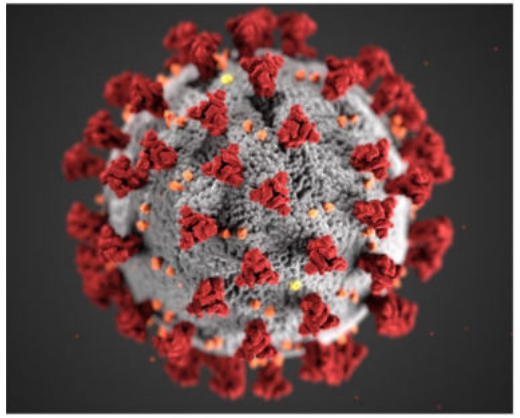


HIDA Event

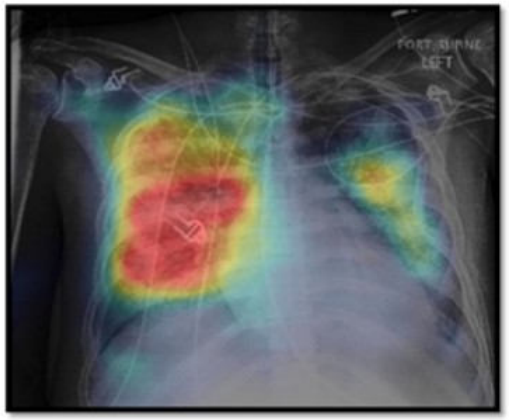
INTERNATIONAL VIRTUAL COVID-DATA CHALLENGE

Join data scientists from Germany, Israel and Italy in this international COVID-virtual challenge in April 2021!

ai4covid - Hackathon

Covid CXR Hackathon

Artificial Intelligence for Covid-19 prognosis: aiming at accuracy and explainability



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AIforCOVID Risk Score

Report generated on: September 16, 2021

How is this report generated?

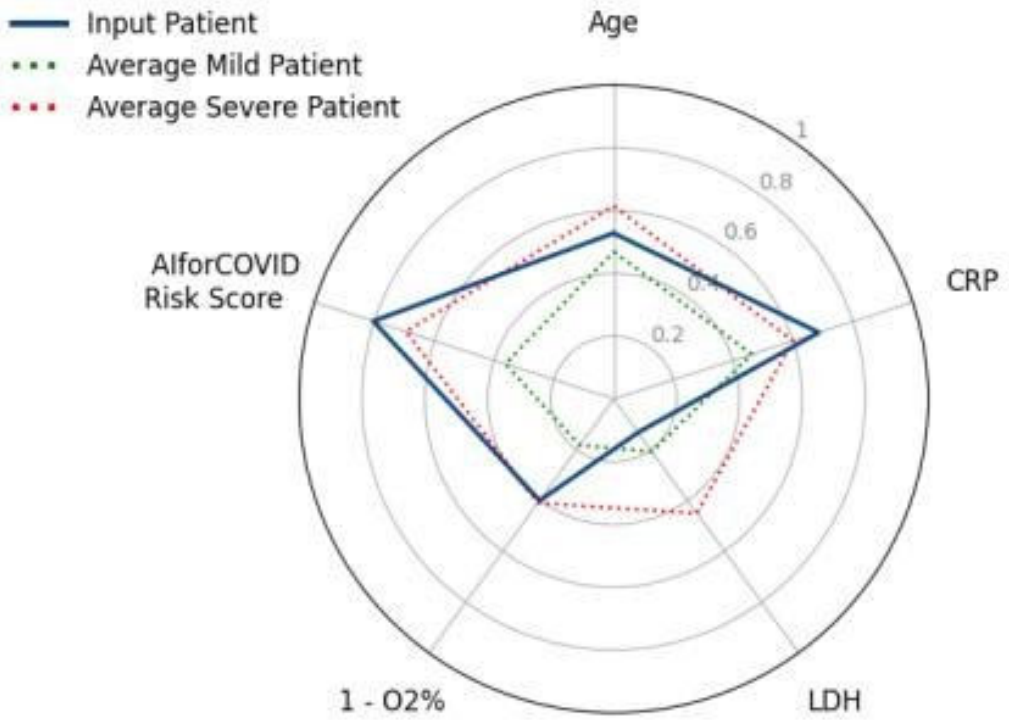
This report results from an automatic analysis based on AIforCOVID imaging archive, which comprehends more than 1000 images and clinical data of COVID-19 patients collected in several Italian hospitals at the time of hospitalization.
Uploaded patients data will be compared to 2 groups identified in the archive: a Mild group, which comprehends patients that did not need ventilatory support, and a Severe group, which includes patients that required non-invasive ventilation support or admission to an Intensive Care Unit. For further details about our Artificial Intelligence algorithms, refer to our publication.

Please note that this is not a medical device: it is not CE marked nor FDA cleared. Any use of this software and the associated information is intended for research and statistical analysis only.

Patient's Chest X-Ray and clinical data:

Age	64 y
Oxygen Saturation (O_2 %)	91 %
Lactate Dehydrogenase Concentration (LDH)	242 U/L
C-Reactive Protein Concentration (CRP)	25.86 mg/dL

AIforCOVID Risk Score of severe prognosis: 80 %



In this graph, each variable has been scaled in a 0-1 range and plotted on its radius.
For each considered variable, the centre of the graph represents the condition of lower risk of severe prognosis. For example, Oxygen Saturation has been plotted in the inverse direction, so that higher values of O_2 % will be plotted towards the centre.

"Average Mild Patient" and "Average Severe Patient" represent average values for the respective group distributions and have been plotted to allow visual comparison of patient's risk.

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Piattaforma basata sull'intelligenza artificiale per diagnosi e terapie personalizzate

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Così da Nord a Sud si testano le strategie per mettere all'a

SALUTE *Nuova modalità di diagnos*

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Oltre 800 radiografie Covid, Cdi condivide piattaforma Ai

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Sanità e Politica

Covid-19, la diagnostica predittiva per personalizzare la terapia per i pazienti

Un'innovativa piattaforma, basata sull'intelligenza artificiale applicata all'imaging

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CISION

AI-for-COVID19: Predictive Diagnostics Platform Available to Global Scientific Community

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m around the globe share
w they use technology to fix
me of the world's most
essing issues.

MinnieEurope

talian hospitals on COVID

aff writers

ing and partners in Italy have released a
from COVID-19 patients to facilitate the
development of artificial intelligence (AI) algorithms.

Available with open access to the global scientific community, the AIforCOVID Imaging Archive contains more than 1,000 chest radiographs from COVID-19 patients along with clinical information

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study

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Studio retrospettivo
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CARATTERIZZAZIONE E PREDIZIONE DELLE SEQUELE POLMONARI NEI PAZIENTI AFFETTI DA SINDROME POST-COVID

Cod.: **AIpostCOVID**

Versione 02 del 24/9/2021

Altri centri partecipanti:

1. ASST Santi Paolo e Carlo
2. Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico
3. Fondazione IRCCS Policlinico San Matteo
4. ASST Fatebenefratelli Sacco
5. Azienda ospedaliero-universitaria Careggi
6. Azienda Ospedaliero Universitaria Pisana
7. DeepTrace Technologies s.r.l.
8. Policlinico Universitario Campus Bio-Medico
9. IRCCS Casa Sollievo della Sofferenza
10. IRCCS Policlinico San Donato
11. Fondazione Bruno Kessler

One more thing. . .


Even if technologies changed
our lives, don't forget ourself to
stay human

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Grazie per l'attenzione

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