AIIC2023
FORTEZZA DA BASSO
Firenze 10-13 maggio 2023

Convegno Nazionale
Associazione Italiana Ingegneri Clinici

Innovazione e accessibilità:
il governo delle tecnologie sanitarie come sfida sociale

AIIC 1993 - 2023

Convegno «L'Intelligenza Artificiale al servizio della Salute: sfide e opportunità»

11 Maggio 2023

«Un caso pratico di utilizzo d'I.A. in Sanità: l'esperienza dell'Ospedale di Vimercate»

Sistema Socio Sanitario
Regione Lombardia
ASST Brianza

Hernan POLO FRIZ M.D.

ASST BRIANZA – Ospedale di Vimercate

Università degli studi di Milano-Bicocca

UNIVERSITÀ DEGLI STUDI DI MILANO BICOCCA

DISCLOSURE

Il sottoscritto Hernan Polo Friz *ai sensi dell'art. 3.3 sul Conflitto di Interessi, pag. 17 del Reg. Applicativo dell'Accordo Stato-Regione del 5 novembre 2009,*

Dichiara

che negli ultimi anni ha avuto rapporti diretti di finanziamento con i seguenti soggetti portatori di interessi commerciali in campo sanitario:

Bayer, Boehringer Ingelheim, Daiichi-Sankyo, Novartis, Pfizer, Sanofi, Servier, Clinical Forum Srl, Health and Life, IMS Health, Maccann Medical Complete Srl, Medi K Srl, Springer Healthcare Italia Srl.

Alcuni spunti per migliorare il SERVIZIO ai nostri pazienti mediante le nuove opportunità offerte dall'utilizzo AVANZATO del DATO in ambito clinico e di ricerca.

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ALCUNI ESEMPI DALLA PRATICA CLINICA

"CASO CLINICO" 1:

SVILUPPO APPLICATIVO, VALUTAZIONE DELL'EFFICACIA E DELL'ACCETTABILITÀ DI UN SISTEMA DI SUPPORTO DECISIONALE COMPUTERIZZATO (SSDC) PRESO UN OSPEDALE GENERALE

"CASO CLINICO" 2:

SVILUPPO, VALUTAZIONE DELL'EFFICACIA E VALIDAZIONE CLINICA DI MODELLI DI *MACHINE LEARNING* A SUPPORTO DELL'ATTIVITÀ' CLINICA IN UN OSPEDALE GENERALE

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Sito sperimentale

Diffusione della Cartella Clinica Elettronica in Europa secondo l'HIMSS European EMR Adoption Model

Livello	0	1	2	3	4	5	6	7
Italia	17,1 %	39,3 %	30,2 %	3,6 %	1,8 %	7,6 %	0,5 %	0,0 %
Europa	29,3 %	17,3 %	28,3 %	3,3 %	3,1 %	16,5 %	2,0 %	0,1 %

HIMSS EMRAM STAGE 6&7 COMMUNITY

Facility Name	State	Country	Facility Type	Model	Score
ISMETT **(Hospital)**	Sicilia	Italy	Hospital	EMRAM	6
AUSL IRCCS - Reggio Emilia **(Hospital)**	Emilia-Romagna	Italy	Hospital	EMRAM	6
Ospedale di Vimercate **(Hospital)**	Lombardia	Italy	Hospital	EMRAM	6
IRCCS - Istituto Clinico Humanitas **(Hospital)**	Lombardia	Italy	Hospital	EMRAM	6

Showing 1 to 4 of 4 entries

Previous 1 Next

Ospedali categoria 6 (4 istituzioni in Italia) o 7 (nessuna) secondo la classificazione HIMSS Emram, ad Aprile 2023

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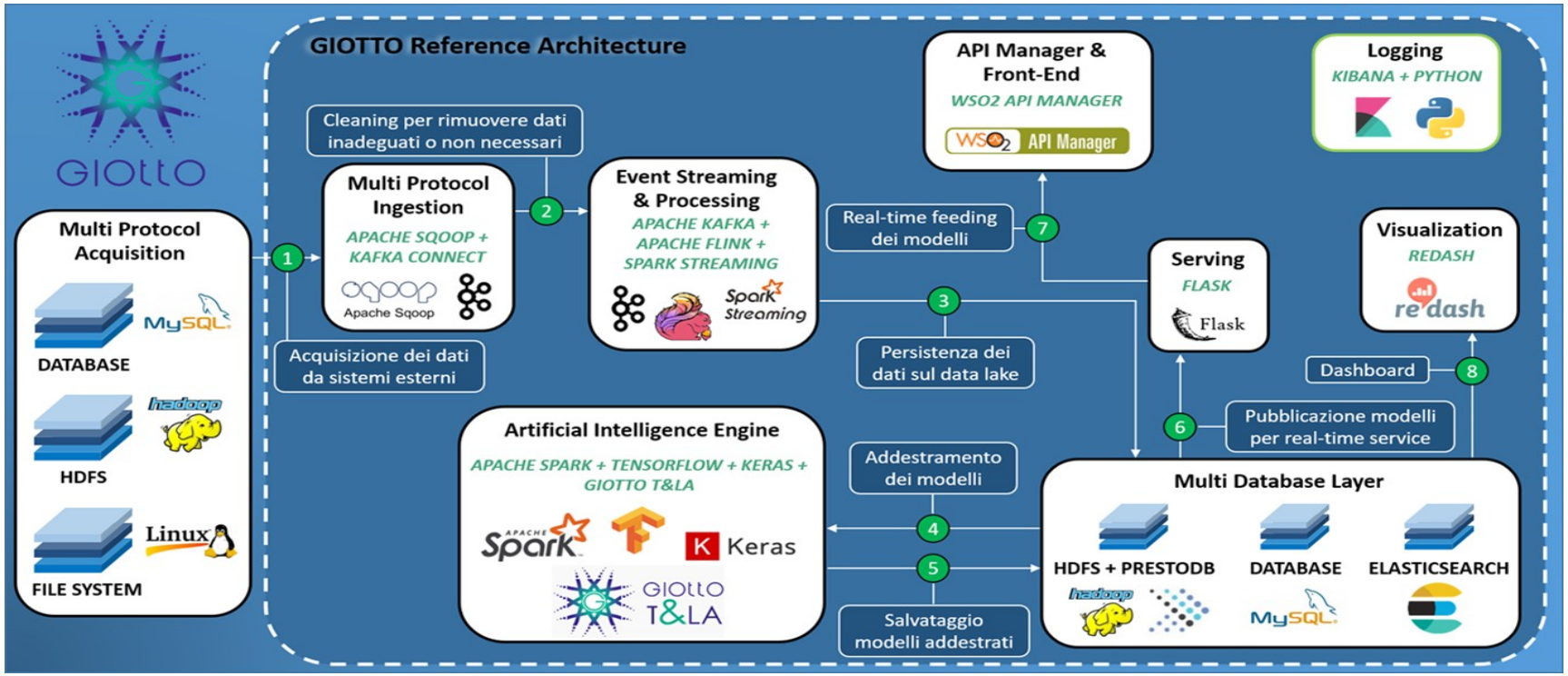
Infrastruttura Big Data

L'ASST di Vimercate si è dotata di una piattaforma Big Data & AI per sviluppare e implementare le soluzioni di intelligenza artificiale.

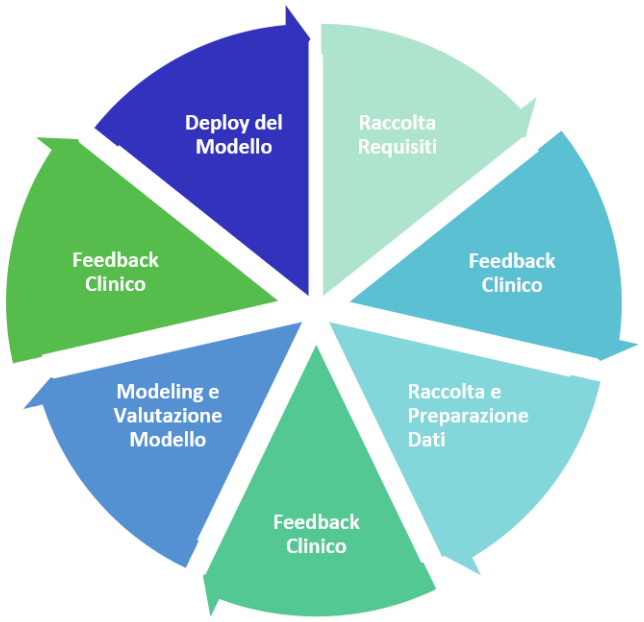
L'Intelligenza Artificiale è in grado di valorizzare il patrimonio informativo della sanità mediante algoritmi e modelli predittivi a supporto di sistemi decisionali.



Partecipazione attiva del clinico nel processo di sviluppo

Lo sviluppo di soluzioni tecnologiche in generale e IA in particolare avviene in un processo MULTIDISCIPLINARE, dalla raccolta dei requisiti fino all'implementazione e validazione della soluzione sviluppata.

Chi e come usufruirà del modello?
Integrazione con i sistemi informativi delle strutture ospedaliere e accessibilità al personale autorizzato.



Come scegliere le ipotesi?
Vengono concordate le tipologie di predizioni valide per il task.
Come scegliere le features?
È più importante la glicemia o i trigliceridi? Solo il medico conosce il dominio.

Come verrà utilizzato il modello?
Supporto alle decisioni, prevalutazioni diagnostiche, ottimizzazione della logistica.
Che significato avrà il risultato?
In base all'applicazione, il risultato dovrà soddisfare determinati criteri.

"CASO CLINICO" 1:

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DOI 10.1186/s13012-017-0644-2

Implementation Science

RESEARCH Open Access

What hinders the uptake of computerized decision support systems in hospitals? A qualitative study and framework for implementation

Elisa G. Liberati[1*], Francesca Ruggiero[2,3], Laura Galuppo[4], Mara Gorli[4], Marien González-Lorenzo[5], Marco Maraldi[6], Pietro Ruggieri[6], Hernan Polo Friz[7], Giuseppe Scaratti[4], Koren H. Kwag[8], Roberto Vespignani[9] and Lorenzo Moja[2,3]

JAMA Network Open

Original Investigation | Health Informatics

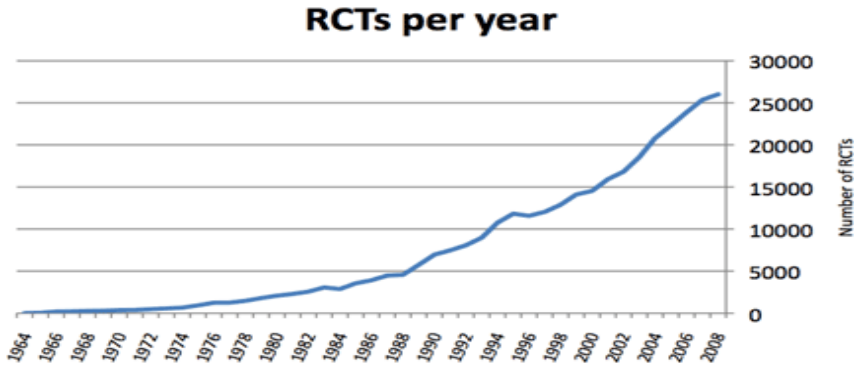
Effectiveness of a Hospital-Based Computerized Decision Support System on Clinician Recommendations and Patient Outcomes

A Randomized Clinical Trial

Lorenzo Moja, MD, PhD; Hernan Polo Friz, MD; Matteo Capobussi, MD; Koren Kwag, MSc; Rita Banzi, PhD; Francesca Ruggiero, MS; Marien González-Lorenzo, PhD; Elisa G. Liberati, PhD; Massimo Mangia, BE; Peter Nyberg, MD; Ilkka Kunnamo, MD; Claudio Cimminiello, MD; Giuseppe Vighi, MD; Jeremy M. Grimshaw, MD; Giovanni Delgrossi, BE; Stefanos Bonovas, MD

RCTs constant increase

"Approximately every 10 years there is a doubling of the number of RCTs."

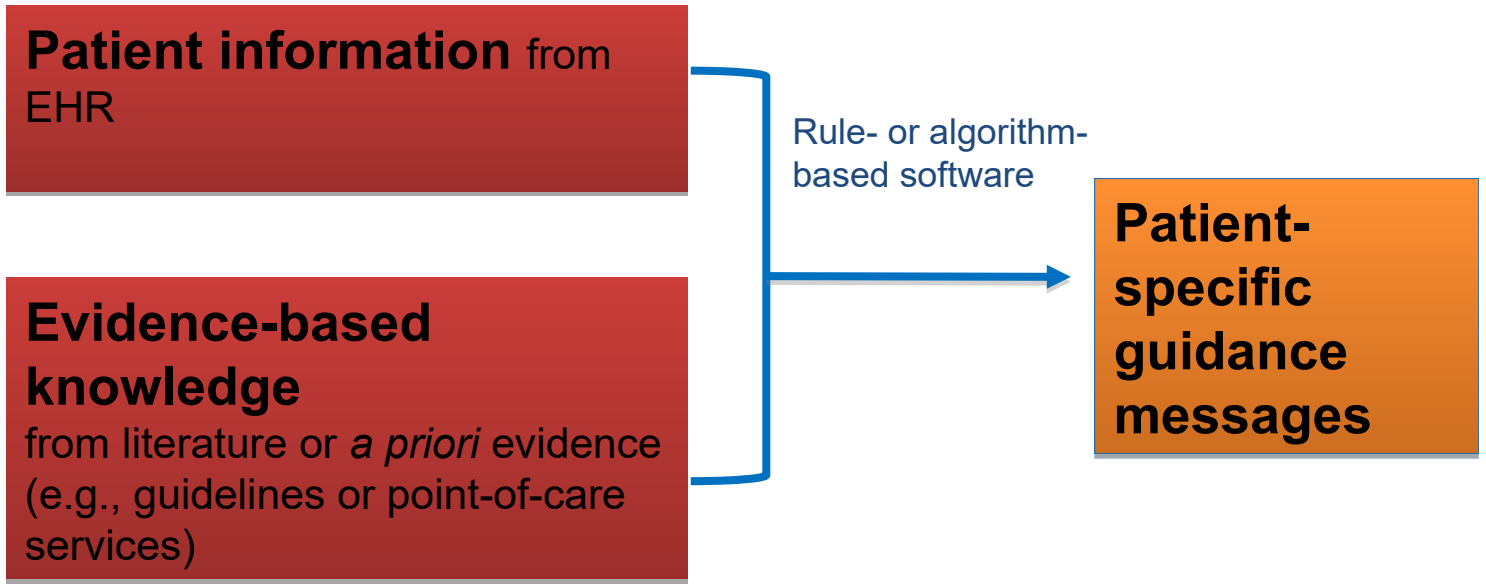


"At current rates we can expect to see 50,000 RCTs per year published by 2018-9."
30.000 2012 … 100.000 by 2030.

Una delle finalità della medicina basata sulle prove di efficacia consiste nell'incrementare la qualità e l'appropriatezza delle cure tramite il "knowledge transfer", cioè il trasferimento delle nuove conoscenze dalla ricerca al letto del paziente.

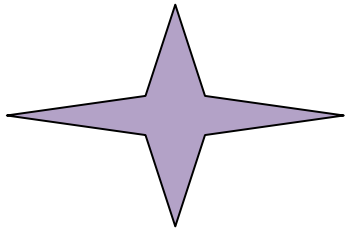
Che cos'è un SSDC/CDSS

- **E' un algoritmo che lavora in maniera integrata con la cartella elettronica, incrociando i dati del paziente con i risultati dell'evidenza scientifica disponibile, offrendo al clinico informazioni paziente-specifiche, basate sulle migliori evidenze disponibili.**

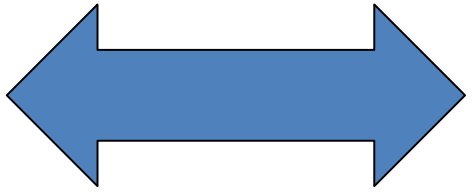


Progetto CODES: risultati e prospettive future

PROBLEMA

SSDC  **CONTESTO**

???

APPLICAZIONE  **RICERCA**

Azienda Ospedaliera San Gerardo

COMITATO ETICO
DELLA PROVINCIA MONZA BRIANZA
Via Pergolesi, 33 - 20090 Monza (MB)
Tel: +39 0 39 2333693
Fax: +39 0 39 2339035
e-mail: comitato.etico@hsgerardo.org

SPERIMENTAZIONI CLINICHE
PARERE DEL COMITATO ETICO

Codice protocollo	CODES
Acronimo	CODES RCT
Titolo dello studio	STUDIO CLINICO RANDOMIZZATO E CONTROLLATO PER VALUTARE L'EFFICACIA DI UN SISTEMA DI SUPPORTO DECISIONALE BASATO SULLE MIGLIORI EVIDENZE SCENTIFICHE ED INTEGRATO CON LA CARTELLA CLINICA ELETTRONICA
Promotore	ISTITUTO ORTOPEDICO GALEAZZI IRCCS
Sperimentatore Responsabile	HERNAN POLO FRIZ
Struttura sanitaria/Unità Operativa	A.O. DI DESIO E VIMERCATE

Esempi di reminder/allert

scr00500	Glucose tests for patients with hypertension, dyslipidaemia or cardiovascular disease
scr00581	ACE inhibitors or angiotensin-receptor blockers for patients with diabetes and hypertension but no microalbuminuria
scr00050	Checking for hyperthyroidism in recent onset atrial fibrillation
scr00278	Initial doses of ACE inhibitors in patients with congestive heart failure
scr00281	Harmful effects of NSAIDs (including COX-2 inhibitors) in patients with congestive heart failure
scr00553	Diagnosing esophageal varices and starting beta-blockers in patients with cirrhosis

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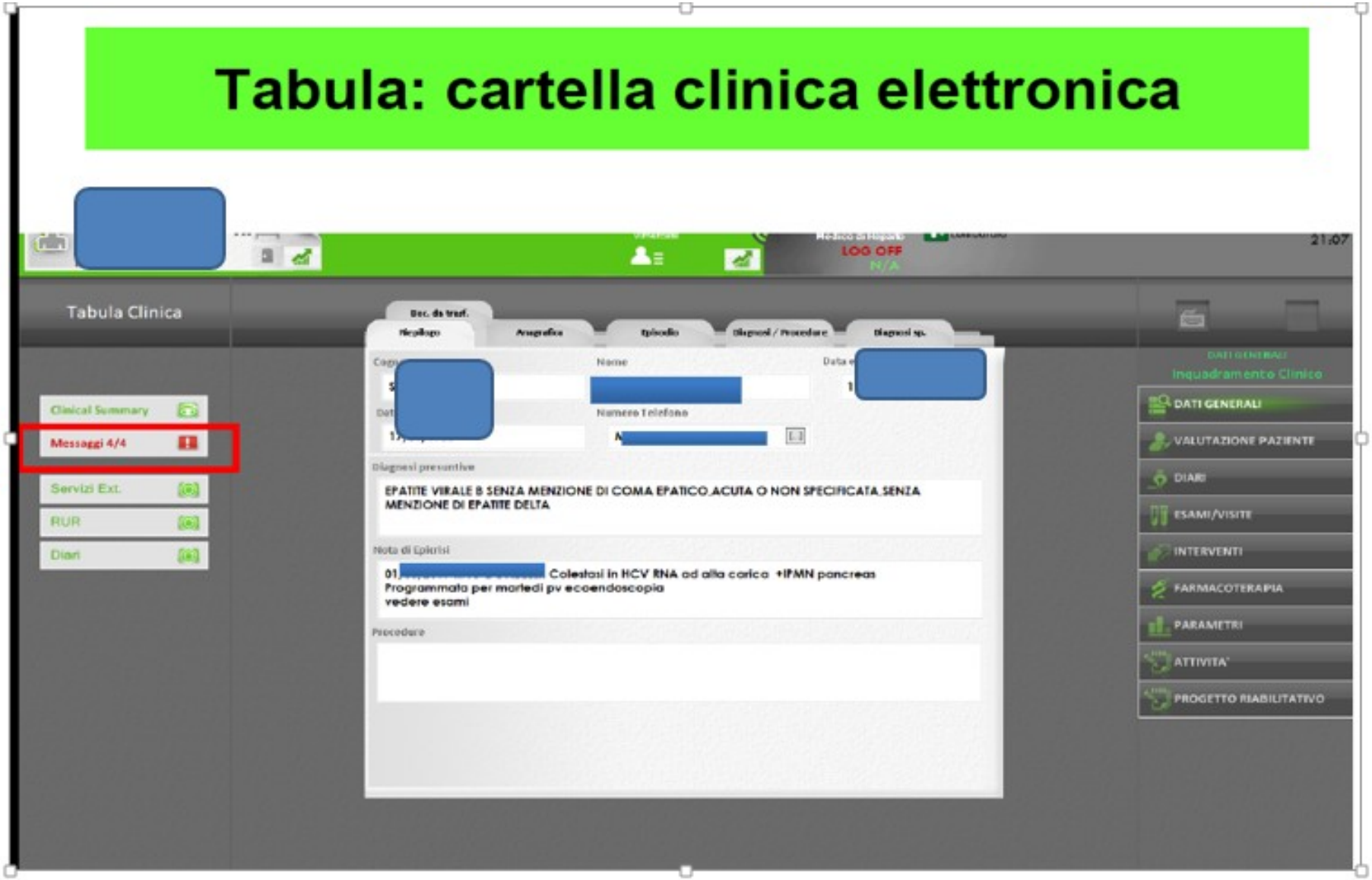
Tabula: cartella clinica elettronica



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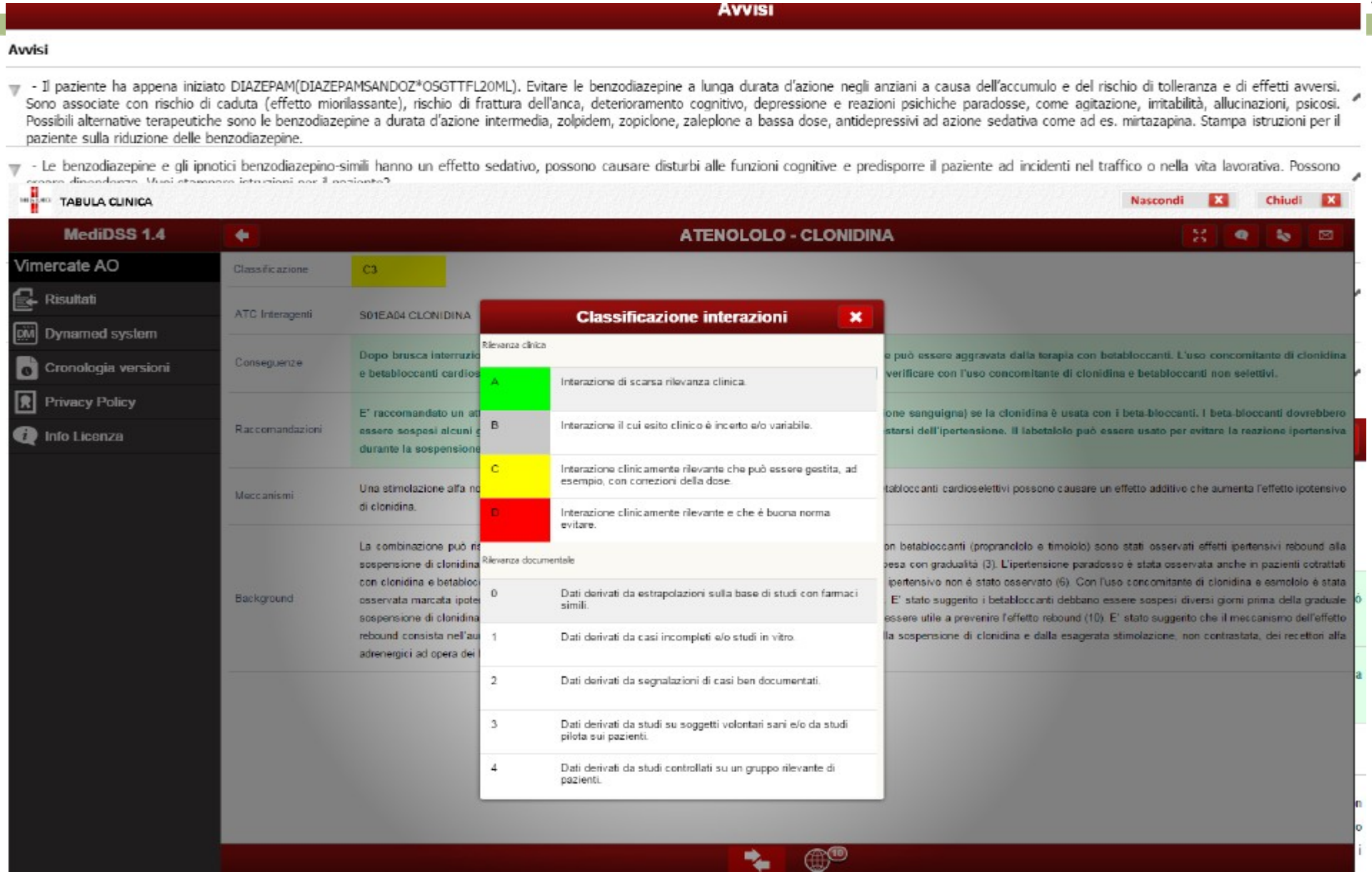

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Effetti avversi potenzialmente causati da farmaci (PHARAO®)

	Effetto anticolinergico	Rischio sanguinamento	Costipazione	Ortostatismo	Prolungamento QT	Tossicità renale	Sedazione	Rischio convulsioni	Effetto serotoninergico
Livello di rischio	A	A	C	B	A	A	C	A	A
acido ursodesossicolico	0	0	0	0	0	0	0	0	0
atenololo	0	0	0	0	0	0	0	0	0
clonidina	0	0	1	2	0	0	2	0	0
colestiramina	0	0	1	0	0	0	0	0	0
diazepam	0	0	0	0	0	0	3	0	0
insulina	0	0	0	0	0	0	0	0	0
pantoprazolo	0	0	1	0	0	0	0	0	0

Reminder internazionali

Circa 270 reminder sviluppati a livello internazionale, attraverso un processo editoriale strutturato – DUODECIM, Finnish Medical Association

Database per interazioni farmacologiche e eventi indesiderati 16.000+ - SFINX

Disegno dello studio

Reminder generati e tassi di risoluzione

	Intervention group (n=3242)	Control group (n=3238)	p-value
Reminders generated	14403	13991	
Reminders generated per patient	4.44 ± 4.94; 3 (1–6)	4.32 ± 4.70; 3 (1–6)	0.65
Reminders resolved	5475	4708	
Reminders resolved per patient	1.69 ± 2.99; 0 (0–2)	1.45 ± 2.66; 0 (0–2)	0.007
Resolution rate (95% CI)	38.0% (37.2% to 38.8%)	33.7% (32.9% to 34.4%)	<0.001
Time to resolution (days)	5.2 ± 13.4; 2.2 (0.9–6.0)	5.6 ± 14.0; 2.9 (1.0–6.1)	<0.001

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Abstract

IMPORTANCE Sophisticated evidence-based information resources can filter medical evidence from the literature, integrate it into electronic health records, and generate recommendations tailored to individual patients.

Key Points

Question Can a multispecialty computerized clinical decision support system (CDSS) reduce inappropriate prescribing in a general hospital?

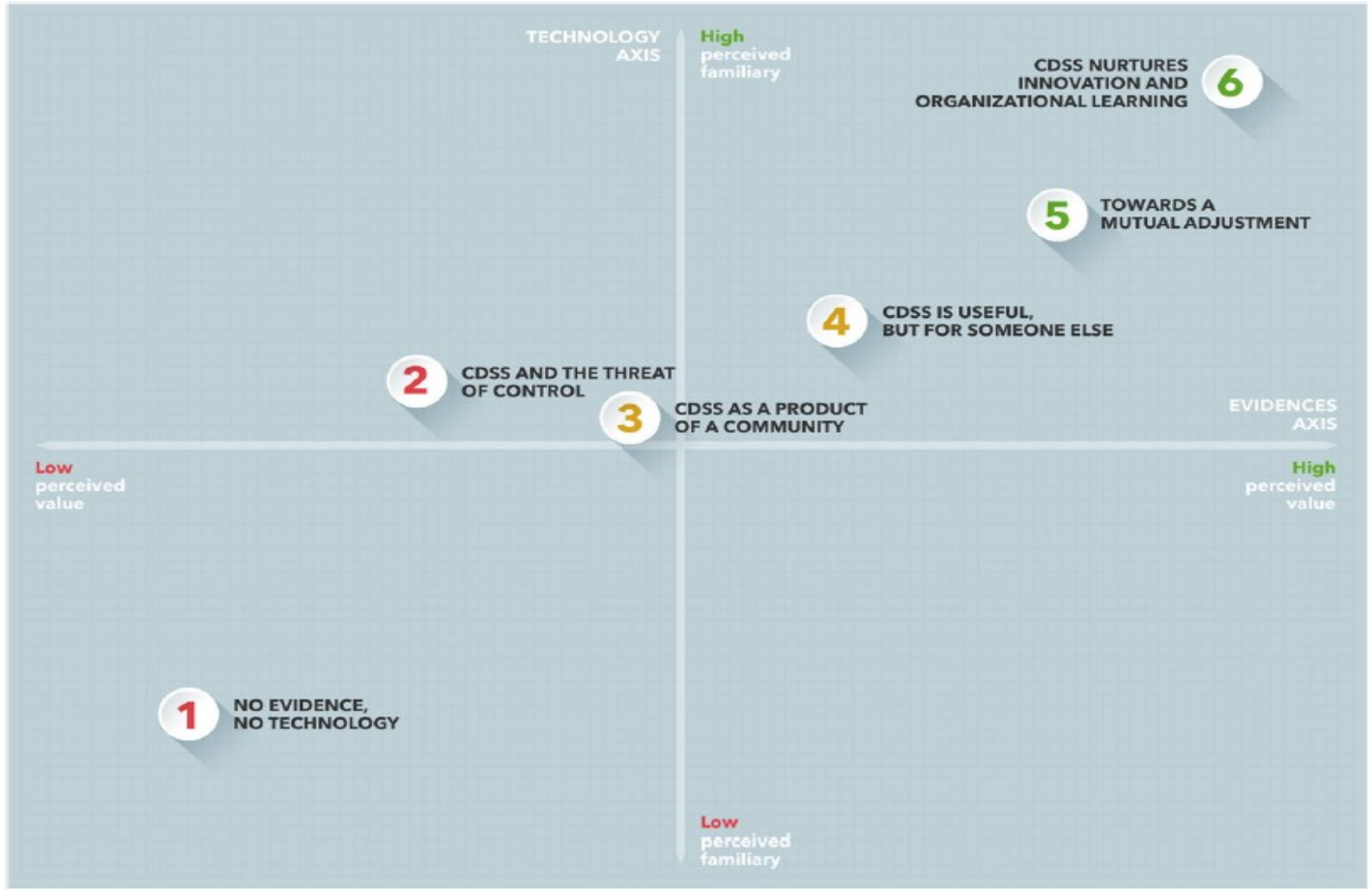

Fig. 1 The six positions represent different degree of perceived control over CDSSs. Each position is characterized by a degree of perceived control over, and mastery of, information technologies and scientific evidence. Since progression through the position is not necessarily linear, the figure should be interpreted as an indicative, rather than definitive, representation of the process of CDSSs' uptake

DOI 10.1186/s13012-017-0644-2

Implementation Science

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RESEARCH Open Access

What hinders the uptake of computerized decision support systems in hospitals? A qualitative study and framework for implementation

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"CASO CLINICO" 2:

SVILUPPO, VALUTAZIONE DELL'EFFICACIA E VALIDAZIONE CLINICA DI MODELLI DI *MACHINE LEARNING* A SUPPORTO DELL'ATTIVITA' CLINICA IN UN OSPEDALE GENERALE

ASL Roma 3, ASL di Verbano Cusio Ossola, ASST di Vimercate, APSS di Trento, ASL di Latina e Fondazione Poliambulanza di Brescia sono i vincitori dell'edizione 2020 del Premio innovazione Digitale in Sanità.

Sistema Socio Sanitario
Regione Lombardia
ASST Brianza

Case Study

Predicting 30-day hospital readmissions in patients with heart failure using machine learning.

Hernan Polo Friz, MD
Internal Medicine Department
ASST della Brianza

Predicting hospital admissions in patients with Heart Failure using Machine Learning

Rationale

- Heart failure (HF) is a common, serious condition, with a prevalence of 1–2% of adult population which rises to 10% in the elderly.
- Acute HF represents a leading cause of mortality and 1% - 2% of all hospitalizations, especially in older subjects. Moreover, hospital care accounts for about two-thirds of HF direct cost.
- Numerous studies have addressed the efficacy of different programs for reducing readmissions and death in HF patients, but those programs may be prohibitively expensive when applied to an entire patient cohort.
- Therefore, different predictive models have been developed to identify patients at high risk for hospital readmissions, mainly based on conventional statistical approaches and with a simple model structure. Among them, the LACE index was clinically validated as a predictor of readmission and/or death within 30 days from discharge.
- Anyway, the prognostic performance of the LACE index and the other conventional statistics-based predictive tools is still unsatisfactory.

Predicting hospital admissions in patients with Heart Failure using Machine Learning

Aims

- The aim of this study was to assess the ability of ML algorithms to predict unplanned readmissions within 30 days after hospitalizations for acute decompensated HF, in elderly patients.

- We also compared the prognostic performance of these algorithms with a conventional predictive tool, the clinically validated LACE index.

Predicting hospital admissions in patients with Heart Failure using Machine Learning

Methods

Inclusion and exclusion criteria, endpoints and cases selection process

- Vimercate EHR is active since 2010.Thus, in this study, we included all patients who were discharged alive between 1st January 2010 and 31st July 2019, after an hospitalization with a discharge diagnosis of acute HF, identified using the International Classification of Diseases (ICD)-9 Codes: 428.xx or DRG (diagnosis-related group): 127.
- Hospitalizations with a length of stay less than one day, readmission within 24 hours and admissions with in-hospital death were excluded.
- We also excluded patients under the age of 65 and those who died within 30 days after the index event.
- If the patient faced multiple readmissions within the 30-day only the first readmission episode was considered in order to obtain a sample statistically independent and mutually exclusive across the two classes of admission: non-readmitted and readmitted patients.

Methods

Inclusion and exclusion criteria, endpoints and cases selection process

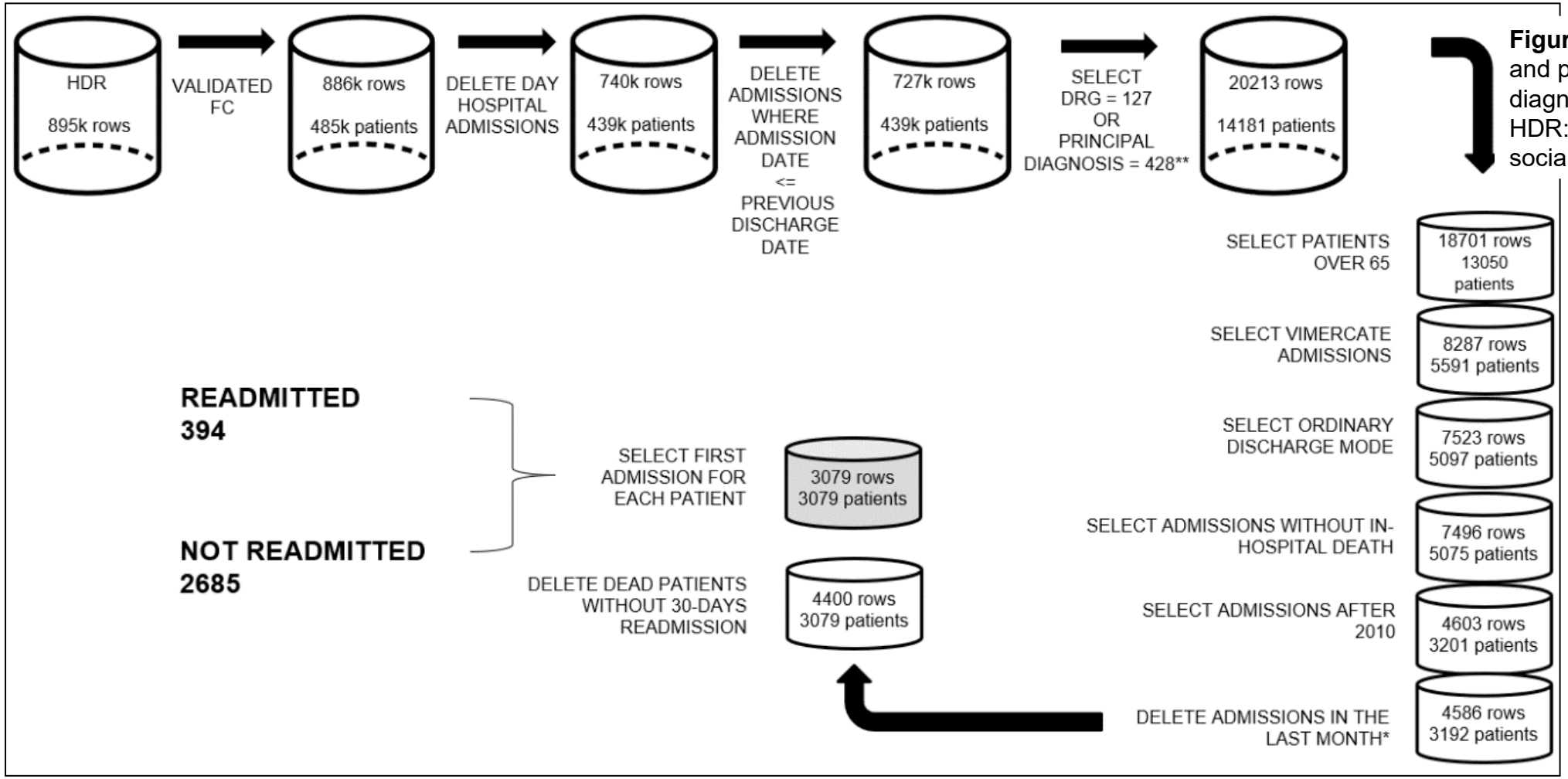


Figure 1. Selection of study sample (A) and preprocessing workflow (B). DRG: diagnosis-related group.
HDR: Hospital Discharge Register. FC: social security number

Predicting hospital admissions in patients with Heart Failure using Machine Learning

Heart Failure - Methods

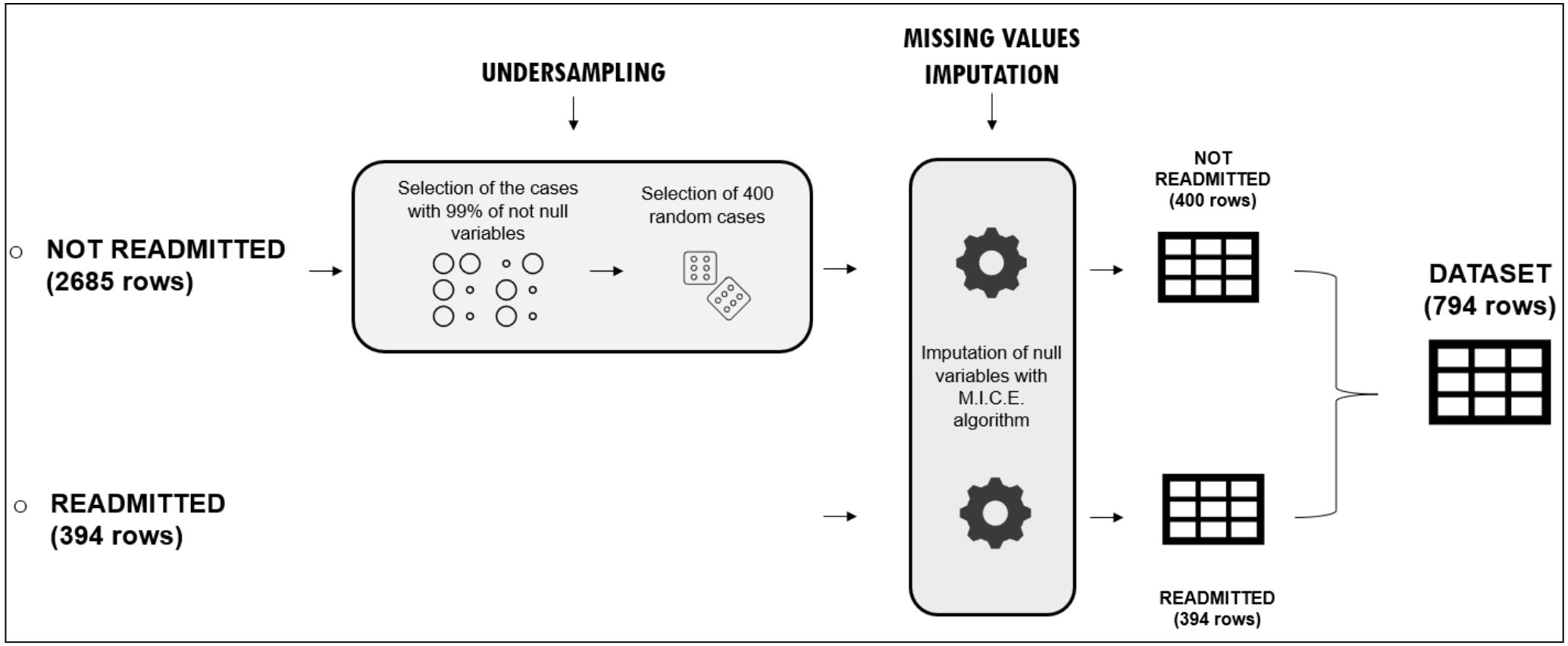
Process of feature engineering, data preprocessing and feature selection

- The features considered are demographics, medical history, physical examinations, diagnoses, procedures, labs, and medications.
- As a first step, features with more than 20% of missing values were eliminated.
- Since the dataset was very unbalanced, it was performed an undersampling of the more populated class. The samples with at least 99% of non-missing values were selected and of these we randomly extracted 400 records. In order to address the residual missing values, on each class we applied the MICE method to impute them.
- Finally, we applied the LASSO algorithm to get the most significant features.

Predicting hospital admissions in patients with Heart Failure using Machine Learning

Methods

Process of feature engineering, data preprocessing and feature selection



Predicting hospital admissions in patients with Heart Failure using Machine Learning

Methods

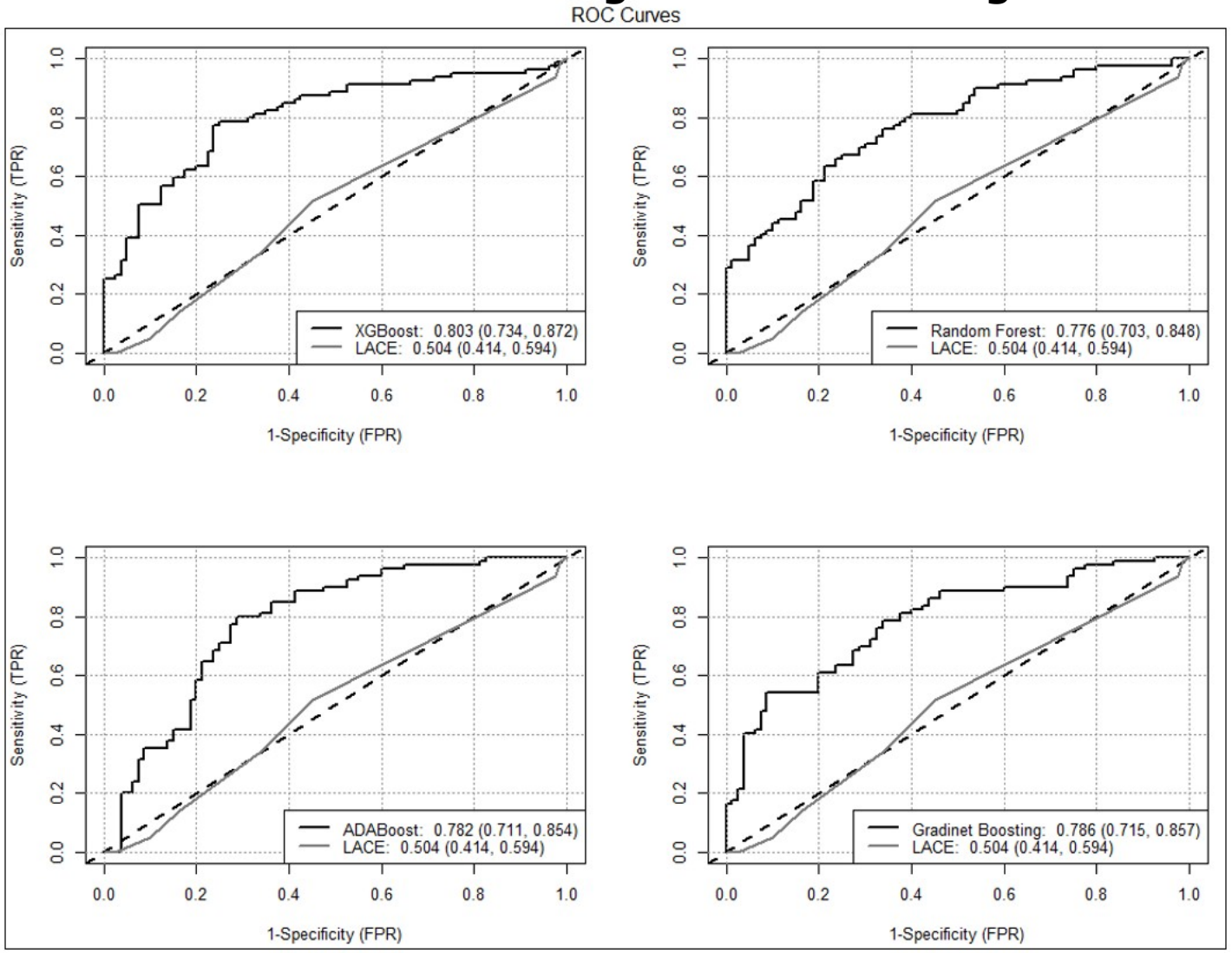
Development of ML prediction models

- The data aforementioned were used to create train datasets for developing prediction models, by using the following workflow:
    a) creation of a row dataset
    b) dataset pre-processing: aimed to obtain a dataset free of missing values and redundant information.
    c) feature selection
    d) model creation and validation: the prepared dataset was split in two portions: training set or cohort and test set or cohort. The selected algorithms were trained on the training set, and the resulting models were tested on the test set
- The training set has been created through a random selection of 80% (635 records) of the rows while the test set is composed of the remaining part (159 records).
- The following algorithms were trained and tested: Ada Boost (Adaptive Boosting), Gradient Boost (Gradient Boosting) , XG Boost (eXtreme Gradient Boosting), Random Forest.

Predicting hospital admissions in patients with Heart Failure using Machine Learning

Results

Recever Operating Curves for LACE Index and four ML approaches in the prediction of 30-day all-cause readmission after decompensated heart failure hospitalization in elderly patiens.



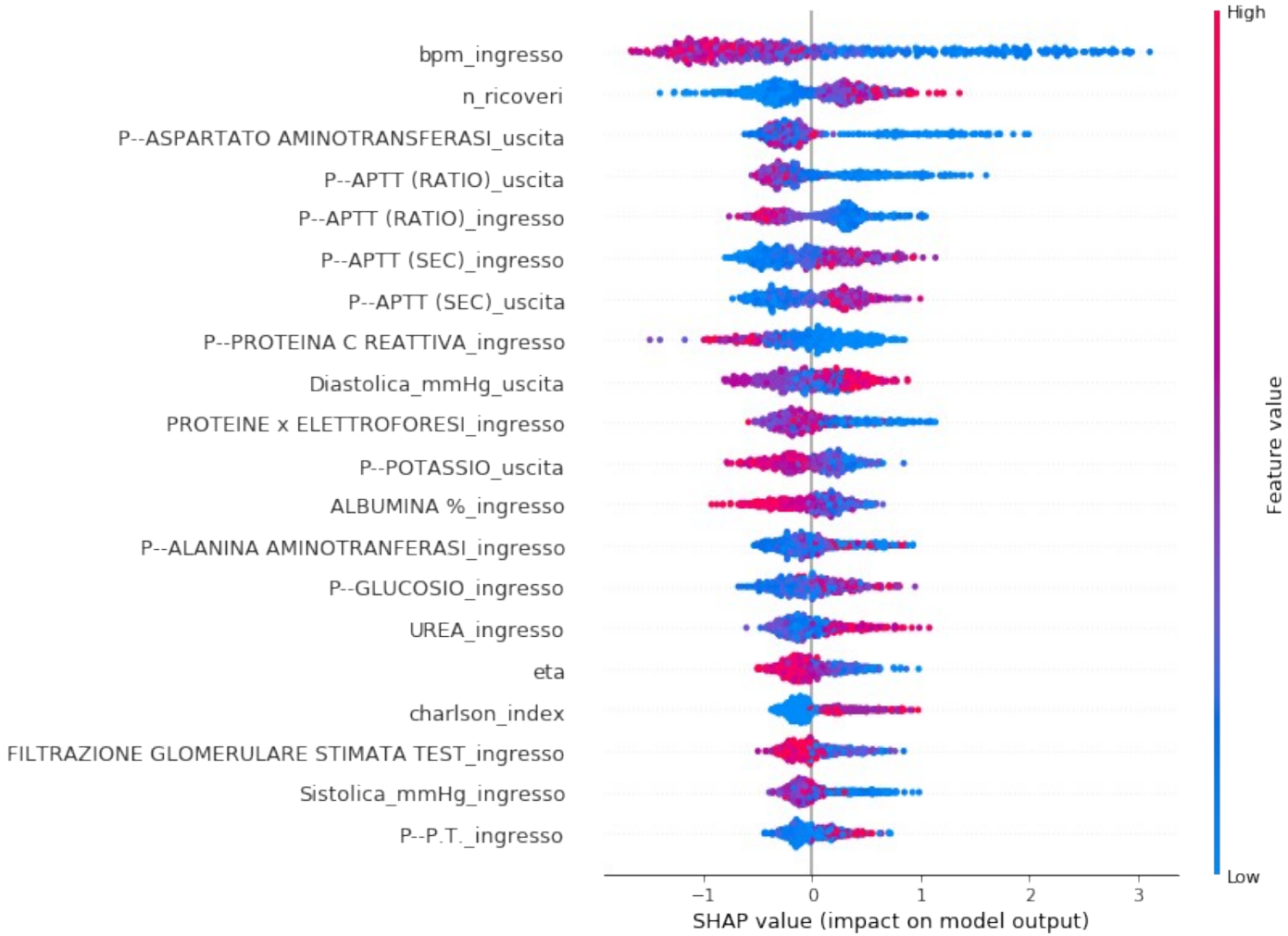
Predicting hospital admissions in patients with Heart Failure using Machine Learning

Results

SHAP (SHapley Additive exPlanations)

A game theoretic approach to explain the output of any machine learning model.

- Variables are ranked in descending order according to their effect on the output (readmission).
- Every variable is depicted in red for higher values and blue for lower values.
- On the horizontal axis are represented the SHAP values, with positive numbers representing a positive prediction effect on the target, and negative values representing a negative effect.



Predicting hospital admissions in patients with Heart Failure using Machine Learning

Conclusions

- Among elderly patients discharged alive after hospitalization due to an acute HF exacerbation event, the rate of all-cause unplanned readmissions within 30 days was high, nearly 13 %.

- ML models performed moderately well for predicting risk of readmission, with XGBoost method showing the higher achieved AUC for sensitivity 0.803
- The traditional prognostic tool LACE index presented a lower prognostic ability (0.54, 0.59 and 0.53 respectively).

- By performing SHAP analysis we provided a breakdown of the main variables from the training dataset which were associated with all-cause hospitalizations within 30 days, when applying XGBoost ML model, in an attempt to open the so-called black box.

- In conclusion, ML models can be proposed for the identification of HF elderly patients at high risk of hospitalization, enabling care teams to target interventions to improve overall clinical outcomes.

Internal and Emergency Medicine
https://doi.org/10.1007/s11739-022-02996-w

IM - ORIGINAL

Check for updates

Machine learning and LACE index for predicting 30-day readmissions after heart failure hospitalization in elderly patients

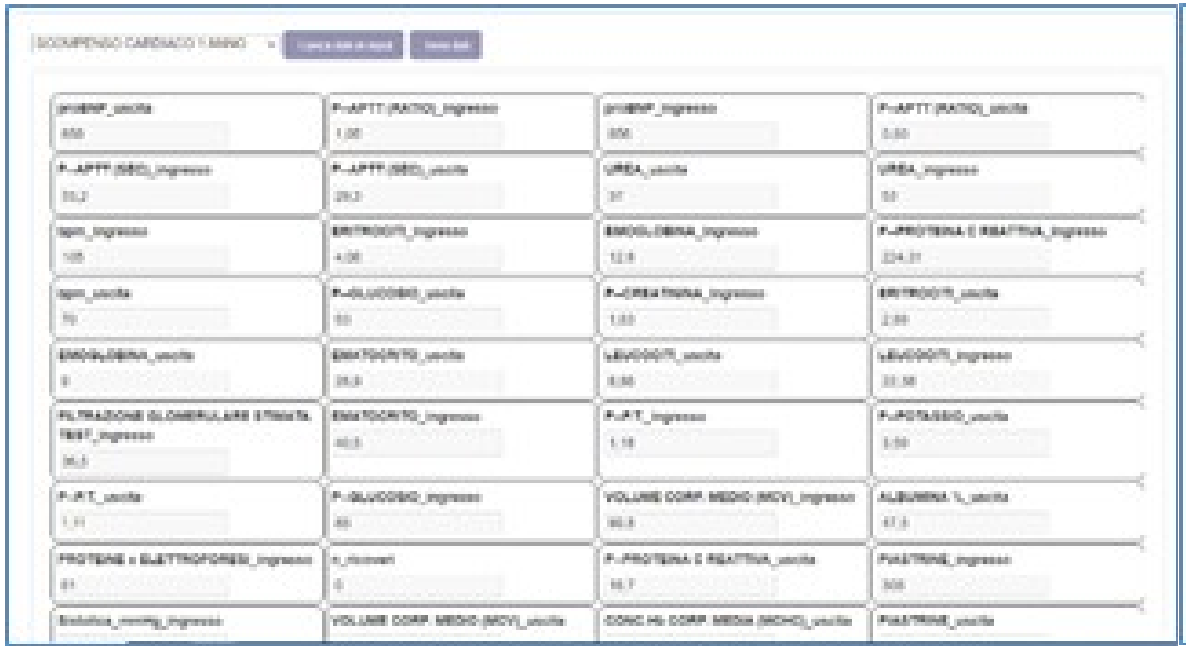
Hernan Polo Friz[1] · Valentina Esposito[2] · Giuseppe Marano[3] · Laura Primitz[1] · Alice Bovio[4] · Giovanni Delgrossi[5] · Michele Bombelli[6] · Guido Grignaffini[7] · Giovanni Monza[8] · Patrizia Boracchi[3]

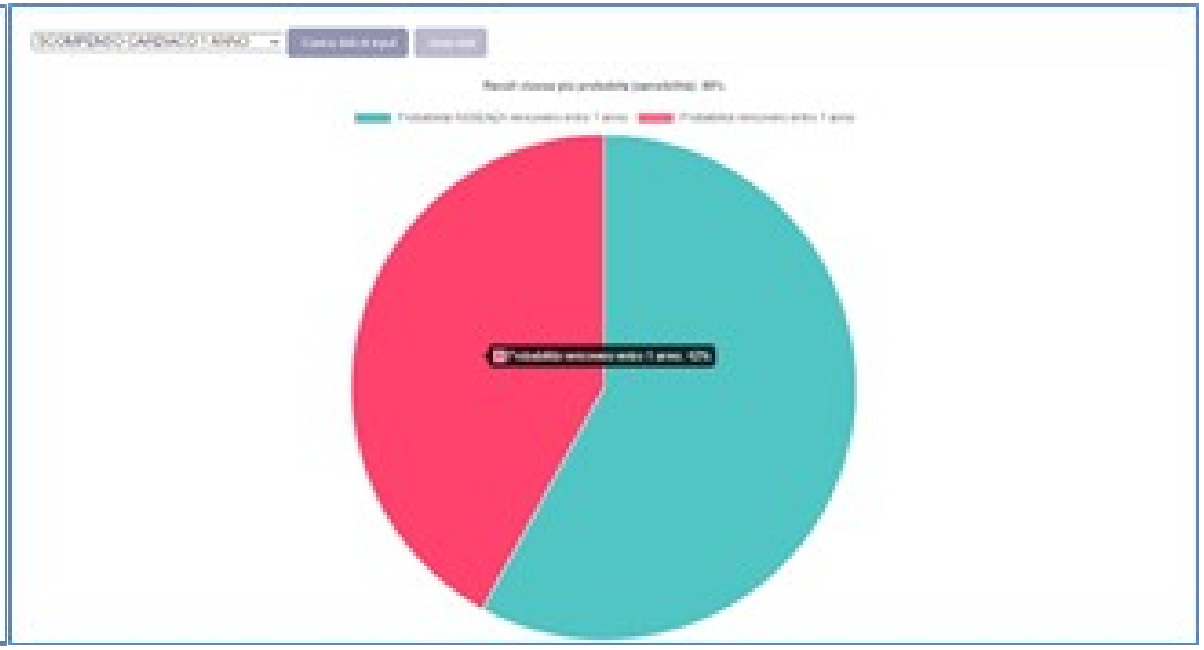
Received: 4 December 2021 / Accepted: 20 April 2022

Predicting hospital admissions in patients with Heart Failure using Machine Learning

Conclusions

- The integration of the predictive model with the Electronic Medical Record makes it possible to concretely apply the new features to the hospitalized patients and start an observational period that will provide significant indications for the hearth failure chronic disease.





Take-home messages

Some concepts and thoughts on the use of AI in clinical medicine and research

Some application fields of AI in medicine:

- Artificial intelligence for improving imaging reading/interpretation
- **Artificial intelligence for advancing medical workflows (e.g. CDSS)**
- Artificial intelligence for improved insight into disease pathogenesis and therapies
- **Artificial intelligence for predicting clinical outcomes**

Some concepts and thoughts on the use of AI in clinical medicine and research

Some considerations on AI for predicting clinical outcomes :

- **Comparison with already used predictive tools, know to clinicians** (to gain trust in the ML predictions and confidence in applying them to clinical care by clinicians)
- **Use of variables (features) commonly used and easily available** (rather than adding new variables which may be difficult /time consuming to capture)
- **Open the black box** (to allow clinicians to peek inside the black box getting a deeper understanding of the most important features from ML models, thus favoring the clinical translation of ML)
- **Improve the knowledge of AI methodology by clinicians and researchers** (to empower clinicians and researchers to participate to and to critically appraise studies on clinical applications of machine learning)

Take-home messages

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