

Rethinking COPD Exacerbation Prediction: What Data Can (and Can't Yet) Tell Us



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The European Union

Meuse-Rhine (NL-BE-DE)



RM@H

Remote Monitoring (at Home) for better health in the Meuse-Rhine region

To develop multi-stakeholder generic **Hybrid Care Paths** of remote monitoring using wearable technology to optimize, personalize and improve patient's care in a cross-border setting.

PARTNERS



COMARCH



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Alexianer
ZENTRUM FÜR SEELISCHE GESUNDHEIT
AACHEN / GANGET



KU LEUVEN



Maastricht University



NALLA GAMES FOR HEALTH



Subobjectives

1

2

3

Anim

4

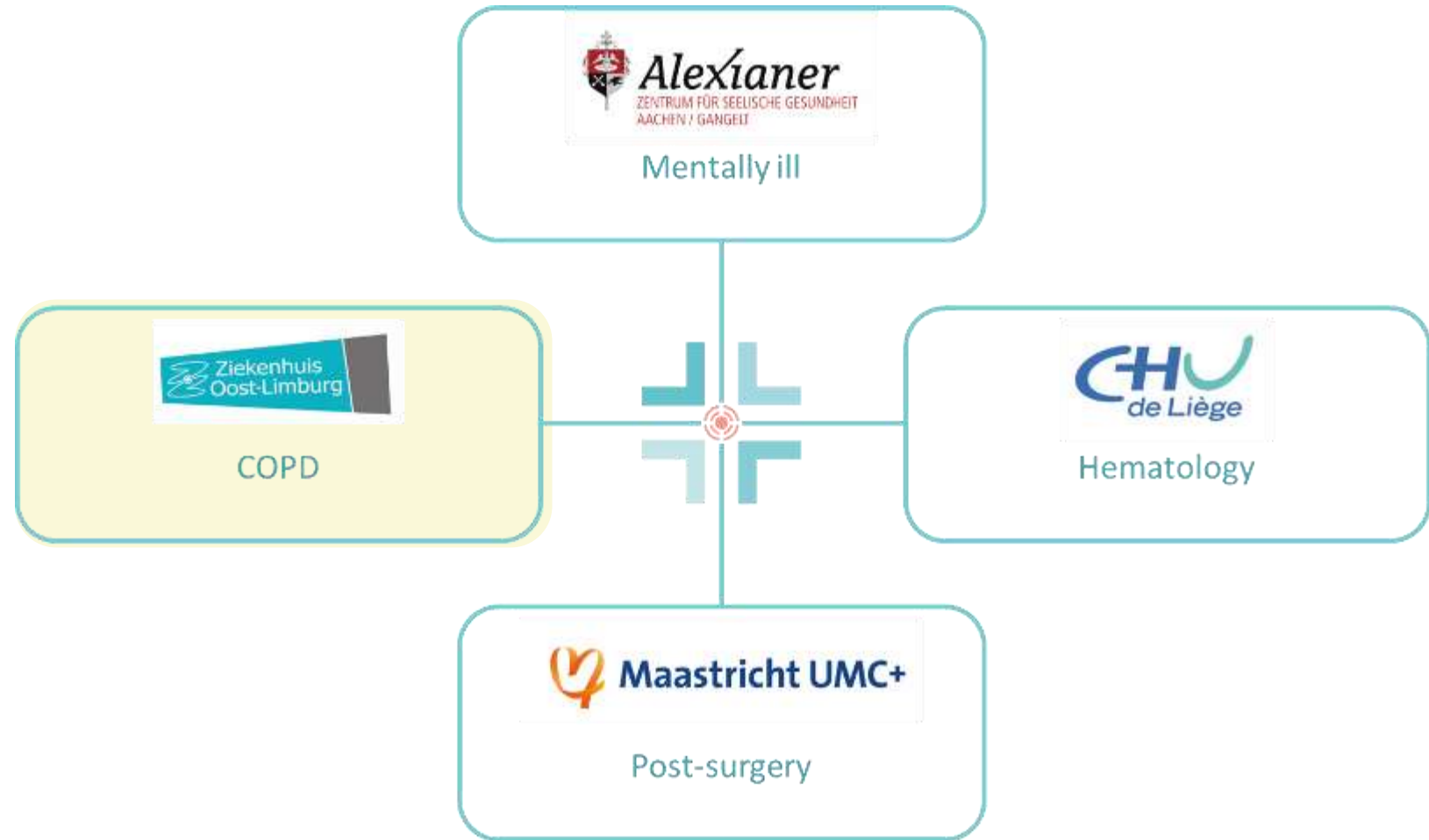
rtme

5

Subobjectives

3

To develop predictive AI models on vital parameters and study the impact of housing conditions (WP2)





COPD/ECOPD



COPD



Chronic Obstructive Pulmonary Disease (COPD) is a heterogeneous lung condition characterized by chronic respiratory problems such as dyspnea, cough, sputum production, and exacerbations [1].

COPD



Chronic Obstructive Pulmonary Disease (COPD) is a heterogeneous lung condition characterized by chronic respiratory problems such as dyspnea, cough, sputum production, and exacerbations [1].



Exacerbations of COPD (ECOPD): *"an event characterized by increased dyspnea and/or cough and sputum that worsens in less than 14 days, which may be accompanied by tachypnea and/or tachycardia and is often associated with increased local and systemic inflammation caused by infection, pollution, or other insult to the airways [1]"*.



However, there is still no gold standard for the definition of COPD exacerbations, leading to misclassification, improper use of healthcare resources, and inefficient treatment and prevention.

COPD



Chronic Obstructive Pulmonary Disease (COPD) is a heterogeneous lung condition characterized by chronic respiratory problems such as dyspnea, cough, sputum production, and **exacerbations** [1].



global estimated prevalence - 10.3% [2]



3rd leading cause of death by 2030 [2]



COPD related costs \approx 38.6 billion euros [3]



Early recognition and prompt treatment by a physician can improve the outcomes of ECOPD, thus improving patients QoL and relieving healthcare systems from the economic burden.

ECOPD as (Re)hospitalization

30-50%

Patients
experience

≥ 1 ECOPD / year

20%

Patients presenting to
the Emergency Room
for ECOPD require
hospitalization

18%

Patients are readmitted
for ECOPD

within 30 days

[4,5]



30-DAY HOSPITAL READMISSION PREDICTION



Objective

GOAL

Predict 30-day
unplanned
hospital
readmission, due
to ECOPD

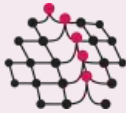
WHY

RQ1. Which are the features more relevant to predict 30-day readmission in the COPD cohort?

RQ2. Are single-time-point hospital measurements sufficient to predict COPD deterioration (with rehospitalization as a proxy)?

Methods - Cohort

PhysioNet



MIMIC-IV
Database [6]

admissions.csv.gz
unique subject_id : 223,452
unique (subject_id, hadm_id) : 546,028

sort by subject_id, admittance

calculate Label:

- shift admittance column up → next_admittime
- Label = 1 IFF (next_admittime - dischtime) <=30

calculate next admission type:

- shift admission_type column up → next_adm_type
- keep only rows where next_adm_type is not next_adm_type is not NaN, not ELECTIVE, not AMBULATORY OBSERVATION, not SURGICAL SAME DAY ADMISSION

admissions with next_adm, that is not elective;
unique subject_id : 43,589
unique (subject_id, hadm_id) : 103,813

diagnoses_icd.csv.gz: select (subject_id, hadm_id), i.e. admissions, with COPD diagnosis:

- first diagnosis (seq_num == 1) && (
- ICD_9: '496', '49120', '49121', '49122' OR
- ICD_10: 'J440', 'J441', 'J449')

unique subject_id : 16,055
unique (subject_id, hadm_id) : 34,501

keep only admissions with Length of Stay >= 1 day
unique subject_id : 15,001
unique (subject_id, hadm_id) : 30,592






merge

unique subject_id : 4,218
unique (subject_id, hadm_id) : 7,667

40%

LABEL = 1
(readmitted within
30 days)

Methods - Features

Type of data	Features
Admissions	 Gender, age, month_of_adm (month of admission), admission_type (= 1 if emergency), discharge_location, insurance, los (length of stay), time_from_last_adm (time from last admission), n_adm_last_1y (number of admission in previous year)
Indexes	 Charlson Comorbidity Index and LACE Score
Lab	 Mean, standard deviation and % of abnormal values of different lab results
Procedures	 First 10 procedures (768-d vector)
Discharge Notes	 Discharge Summary (768-d vector)

Methods – Features

First 10 procedures concatenated of 1 admission

Tokenization

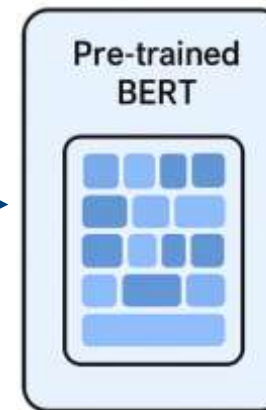
Bio_ClinicalBERT [7]

Last Hidden Layer

[CLS] token extraction

injection or infusion of antibiotics
insertion of endotracheal tube
replacement of tracheostomy tube

[injection, of, antibiotics,
insertion, of, endotracheal,
tube,
replacement, ...]



512x768

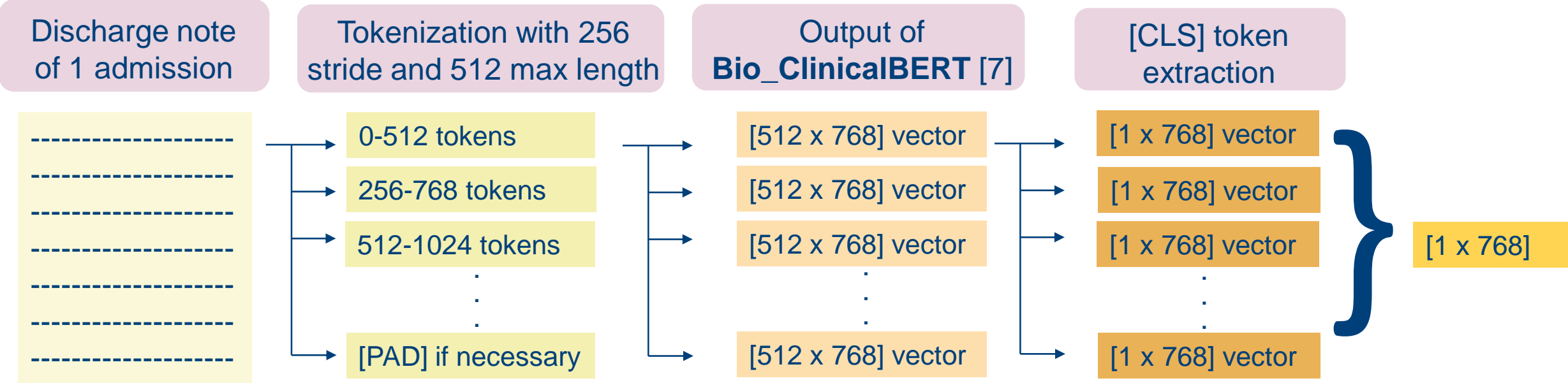


1x768

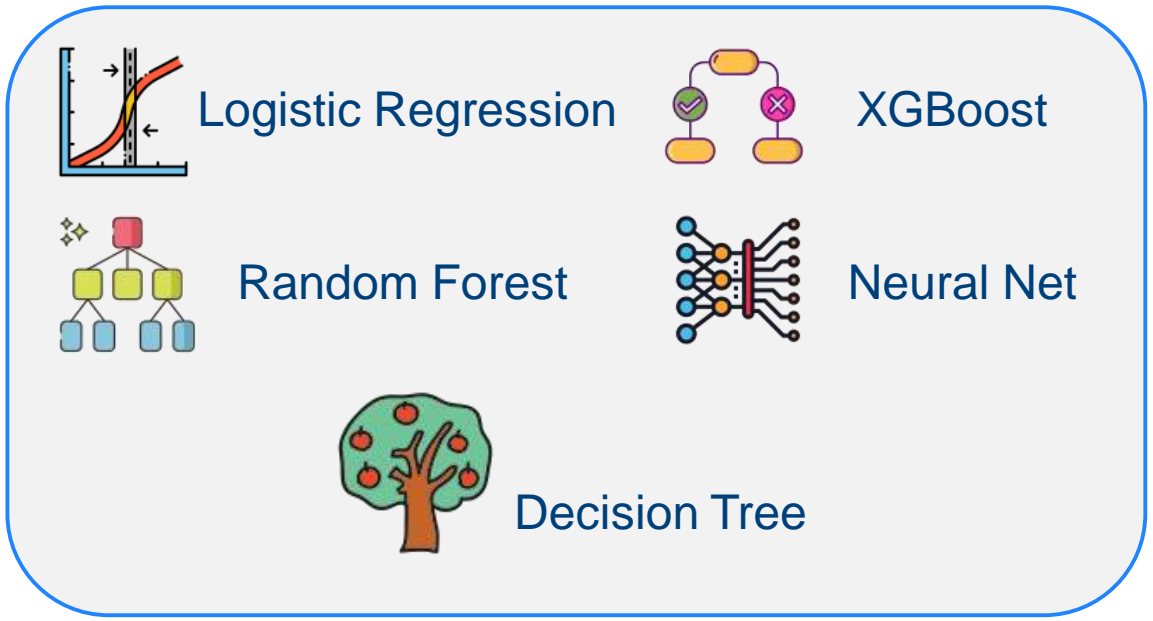


* Bio_ClinicalBERT [7] represents a domain-specialized adaptation of the BERT architecture, trained on all clinical notes from the MIMIC-III database (~880M words).

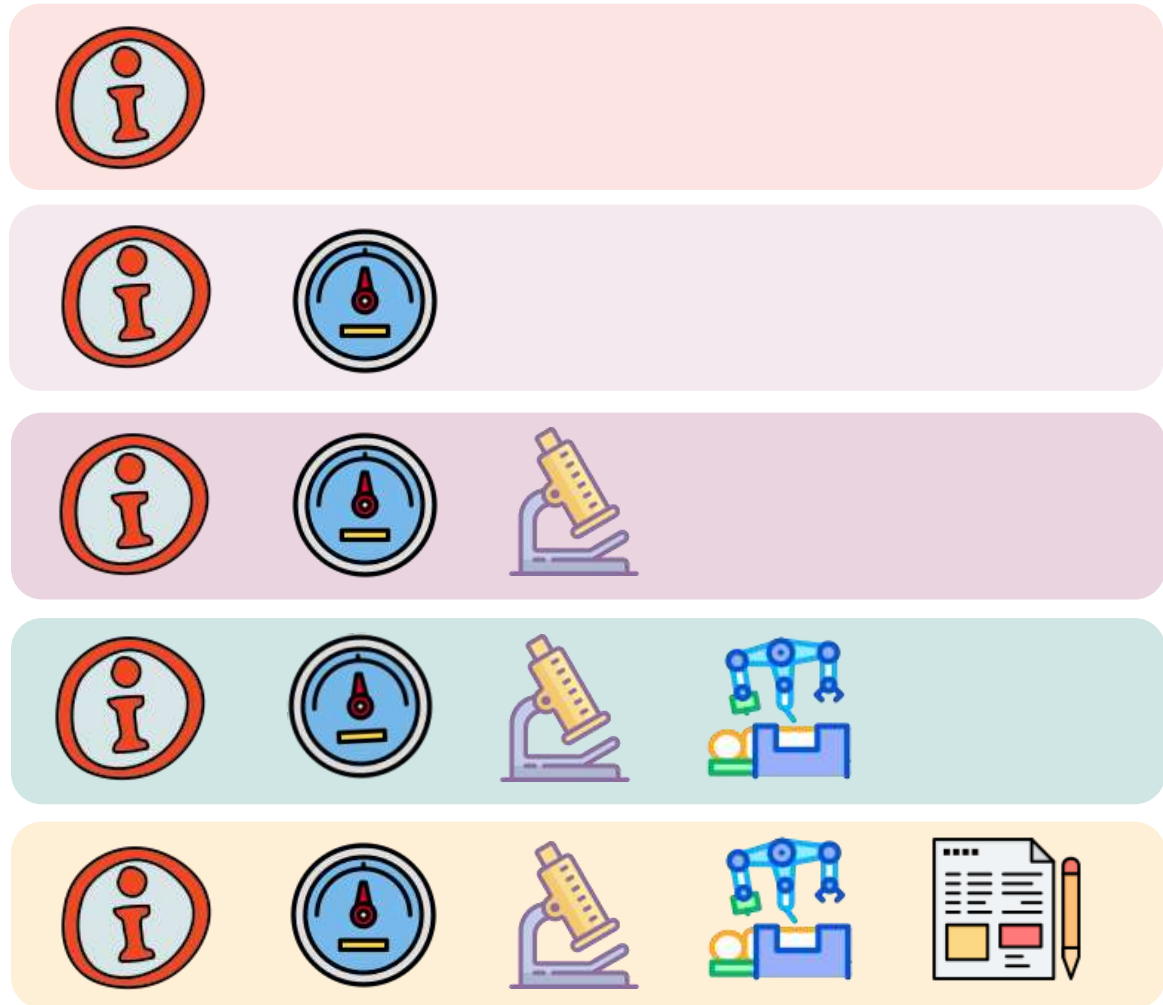
Methods – Features



Methods - Framework



Results



XGBoost

AUC

F1-score

0.5910

0.4849

0.6185

0.5149

0.6332

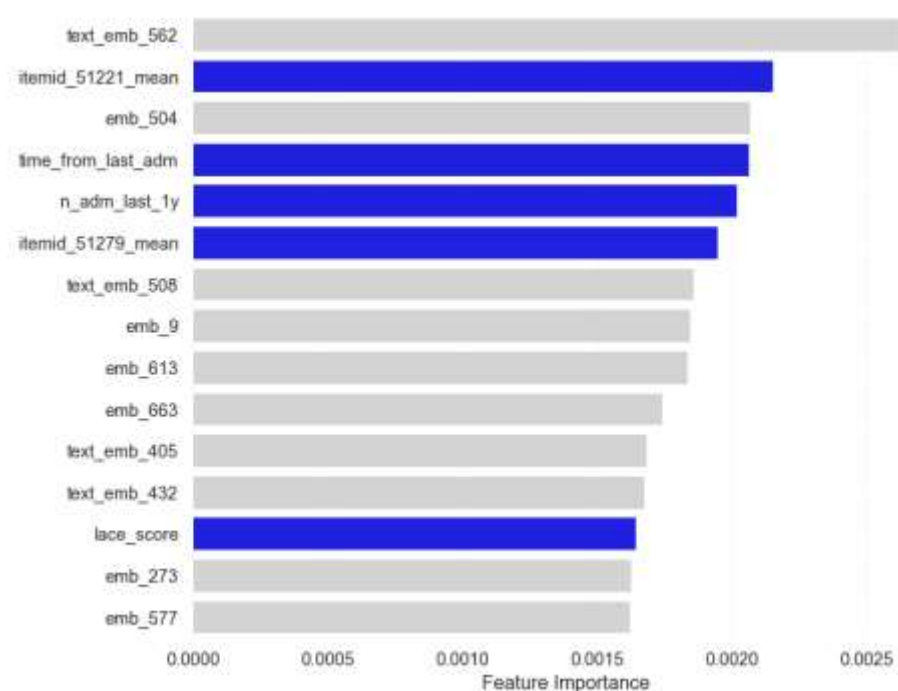
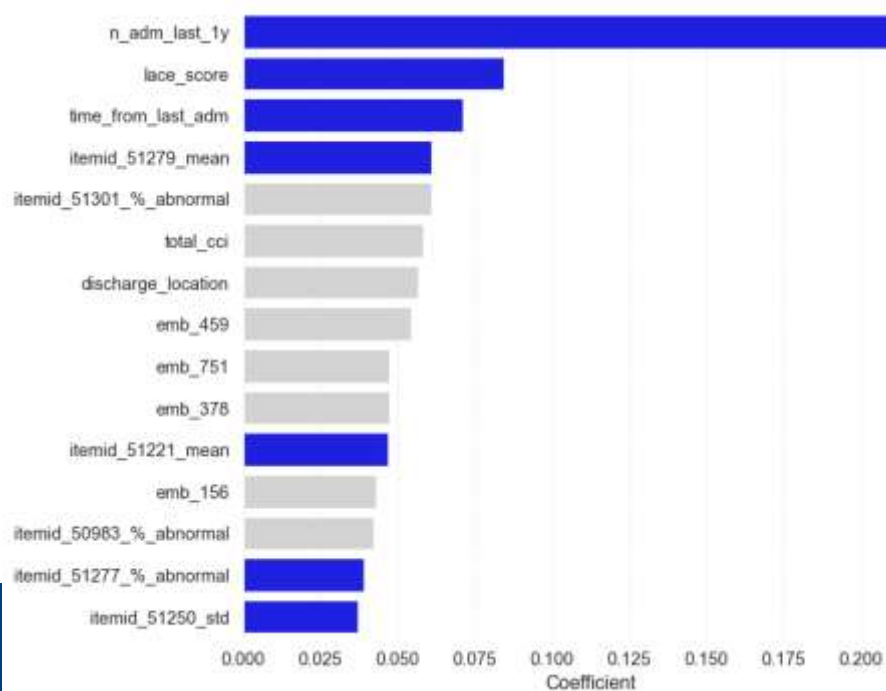
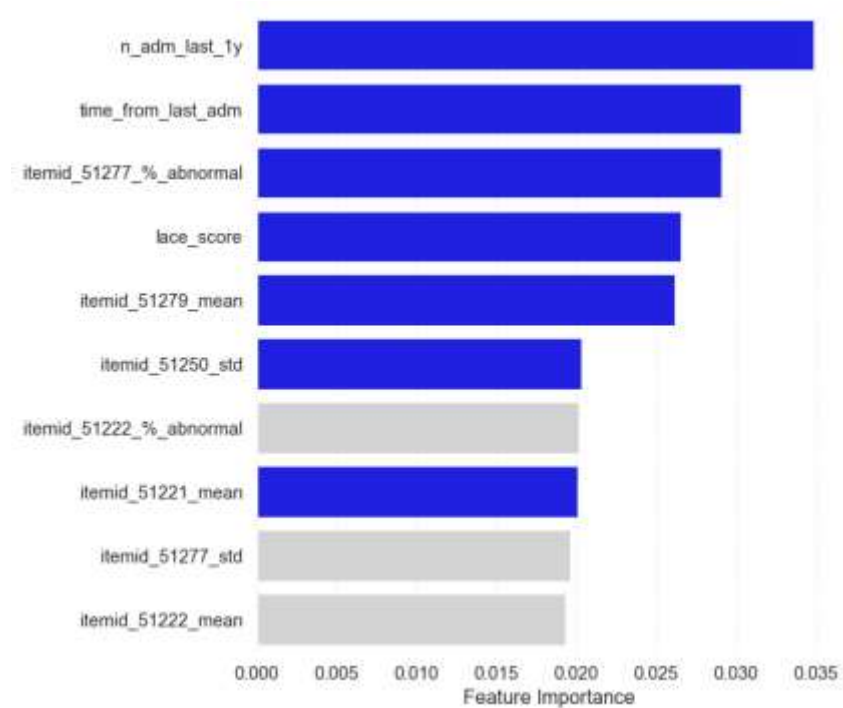
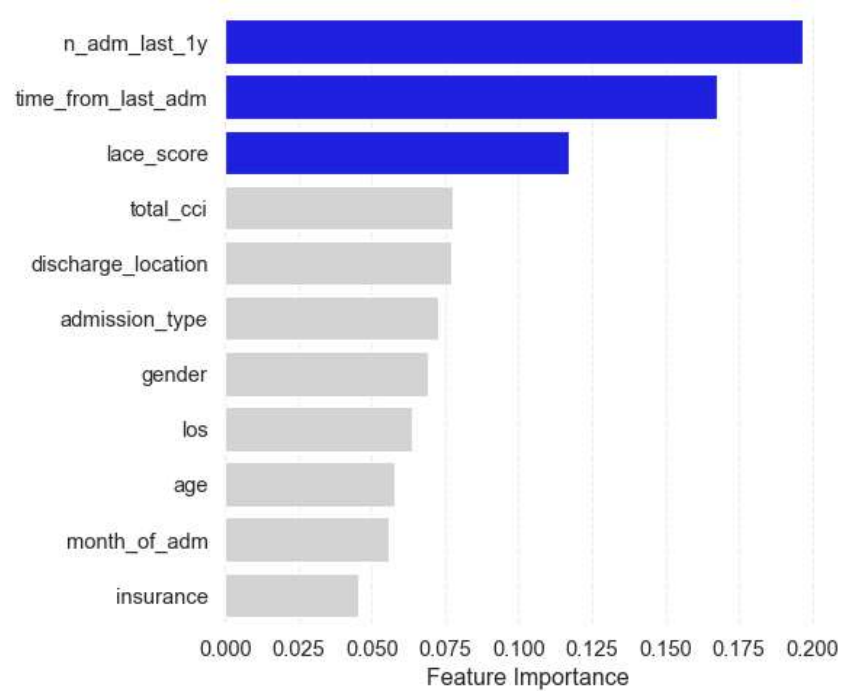
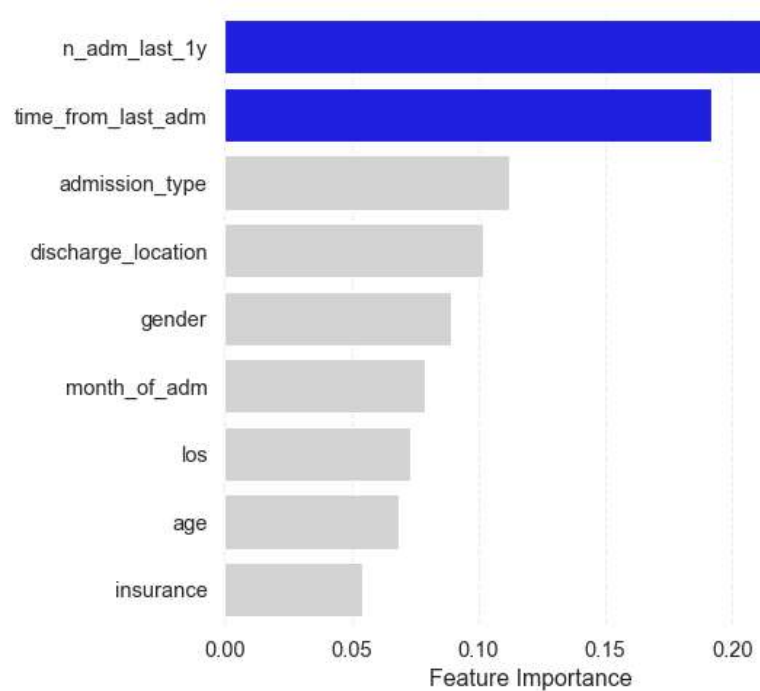
0.5432

0.6398

0.5287

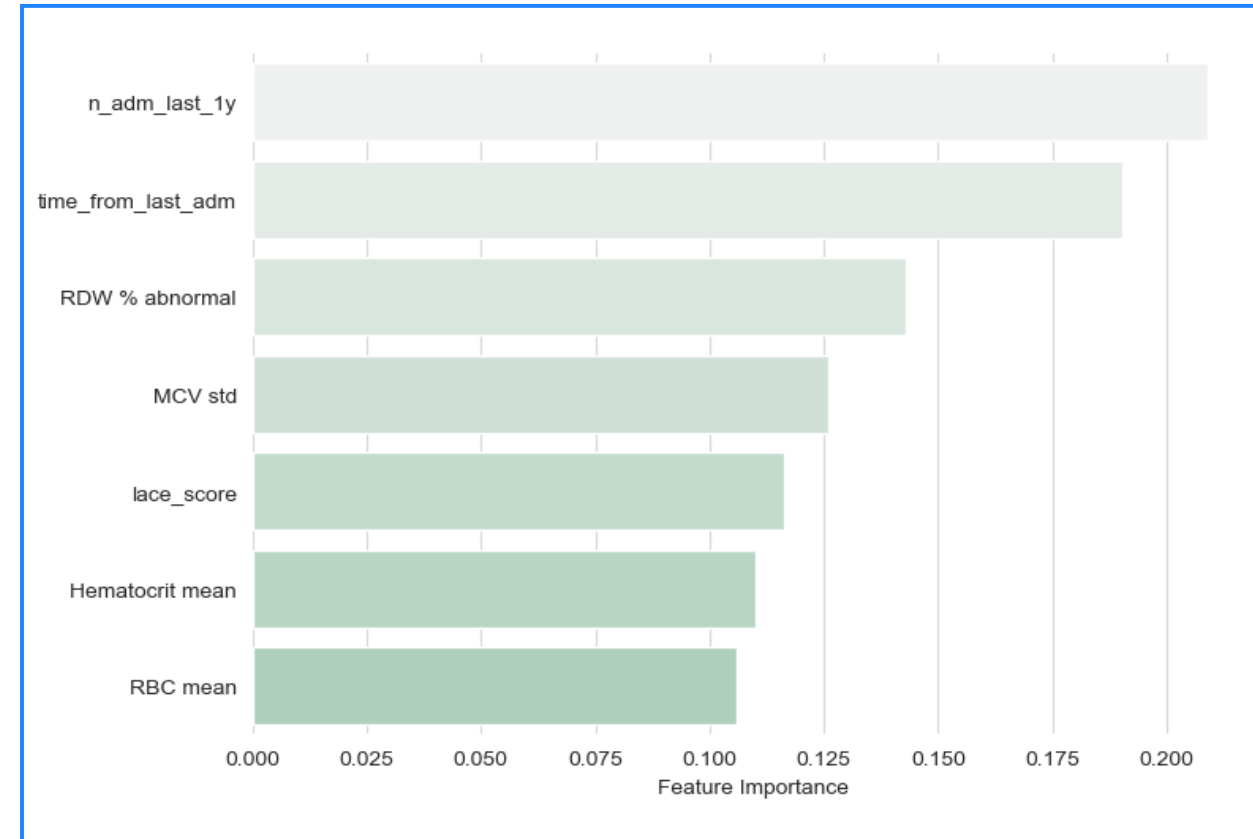
0.6472

0.5468



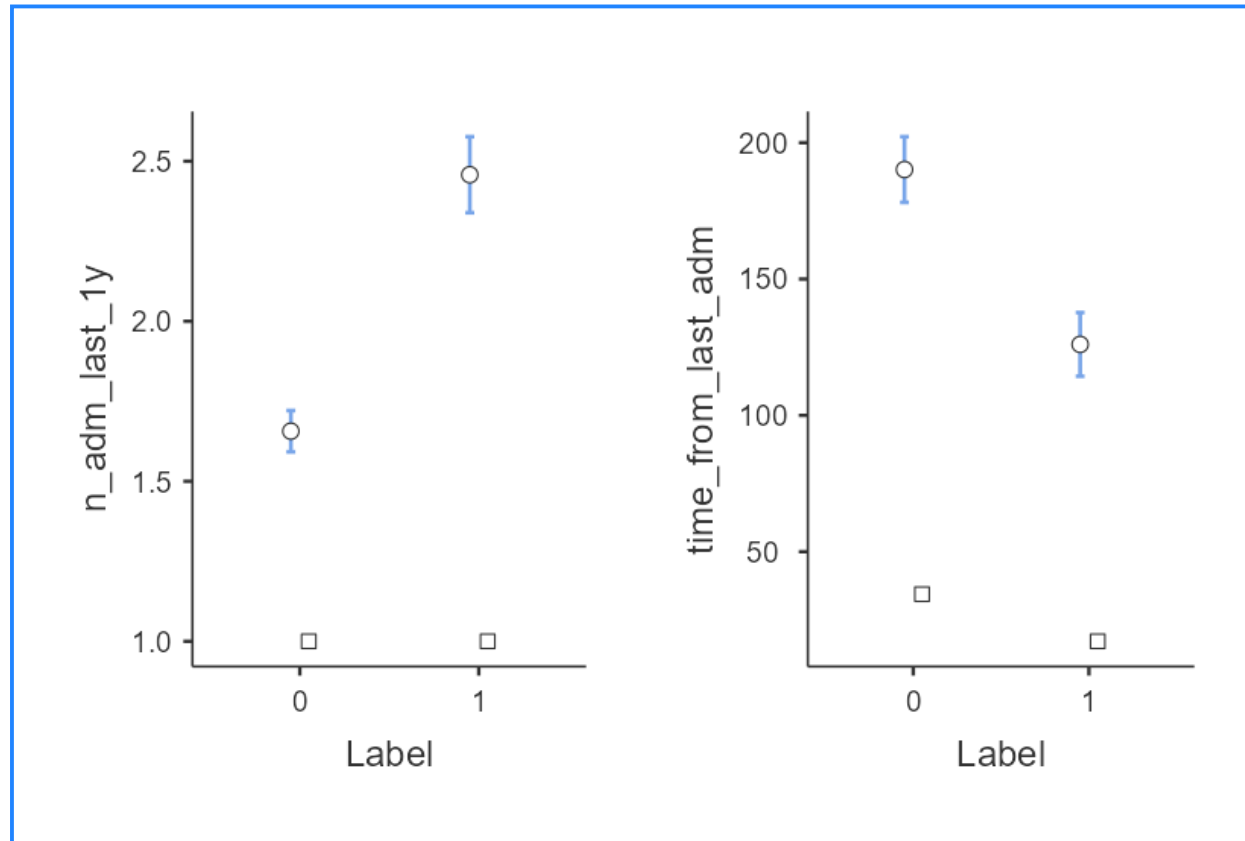
Results – Reduced Feature Set

Data - XGB	AUC	F1-score
Admissions (Adm)	0.591	0.4849
Adm + Indexes	0.6185	0.5149
Adm + Indexes + Lab	0.6332	0.5432
Adm + Indexes + Lab + Procedures	0.6398	0.5287
Adm + Indexes + Lab + Procedures + Text	0.6472	0.5468
Reduced Feature Set (Most Important Features)	0.6515	0.5464



Results – Reduced Feature Set

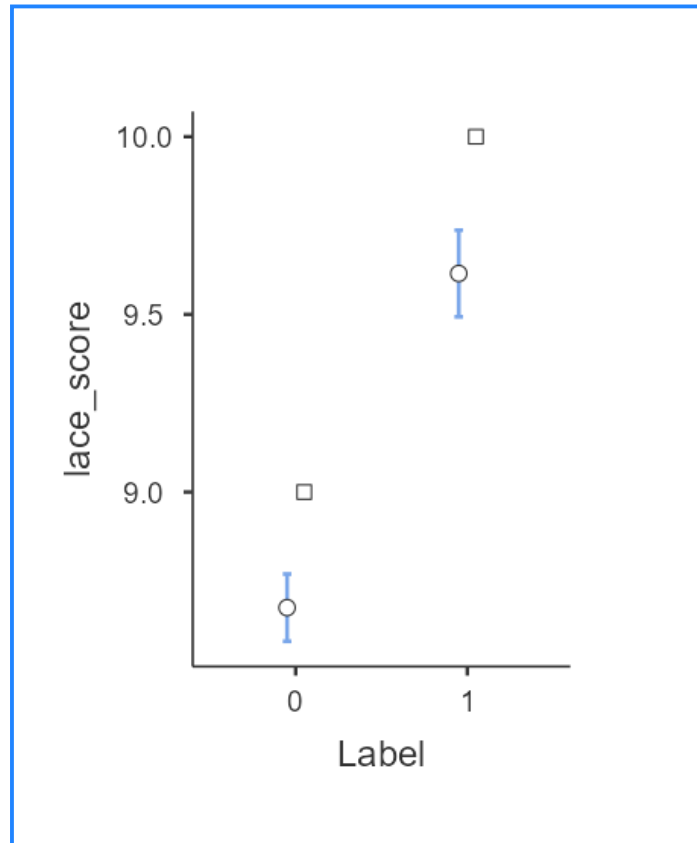
○ Mean (95% CI)
□ Median



- $p < 0.001$ (Mann-Whitney U test)
- **n_adm_last_1y**
- **time_from_last_adm**
- Hospitalisation in the previous year prior to index admission was the key predictor of COPD-related readmission [8].

Results – Reduced Feature Set

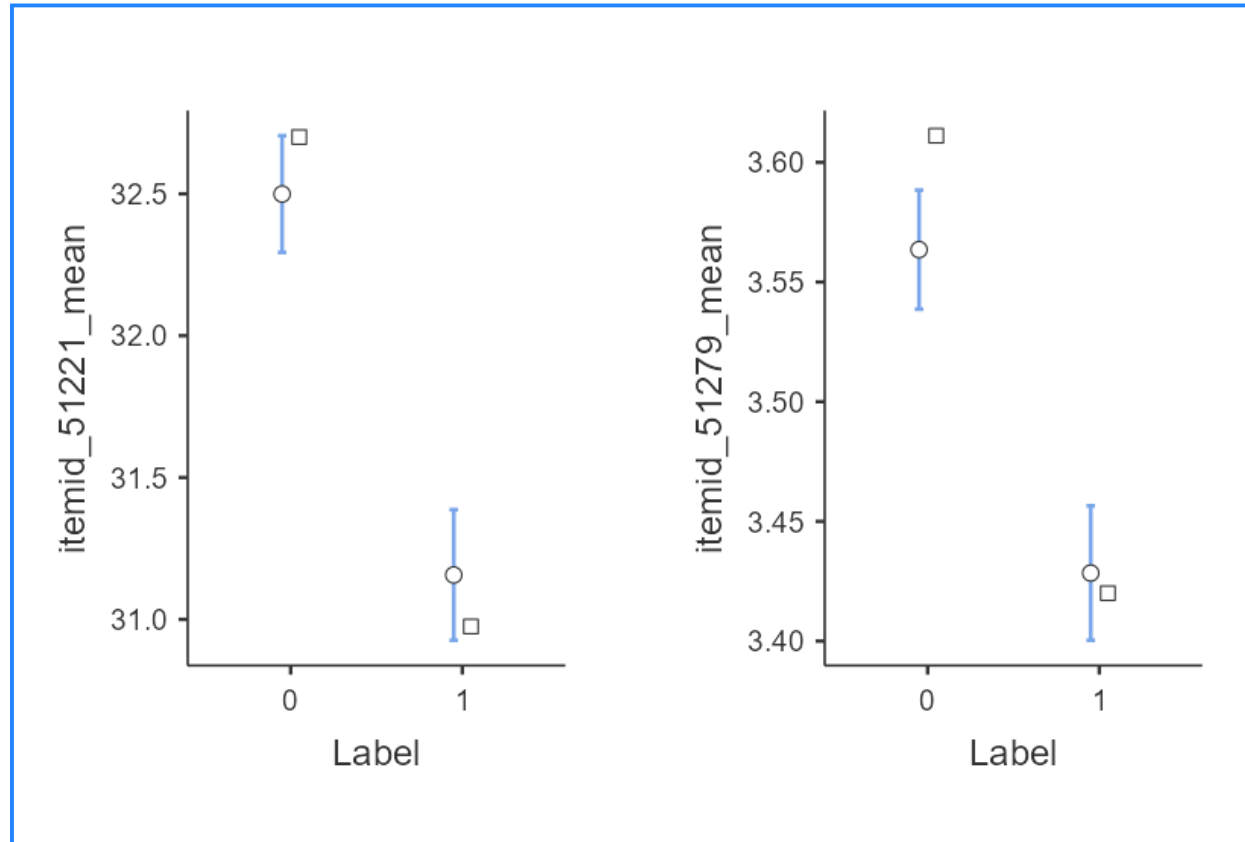
- Mean (95% CI)
- Median



- $p < 0.001$ (Mann-Whitney U test)
- The **LACE Score** was first developed by van Walraven et al. [9] in 2010 to predict the risk of unplanned readmission or death within 30 days after hospital discharge.

Results – Reduced Feature Set

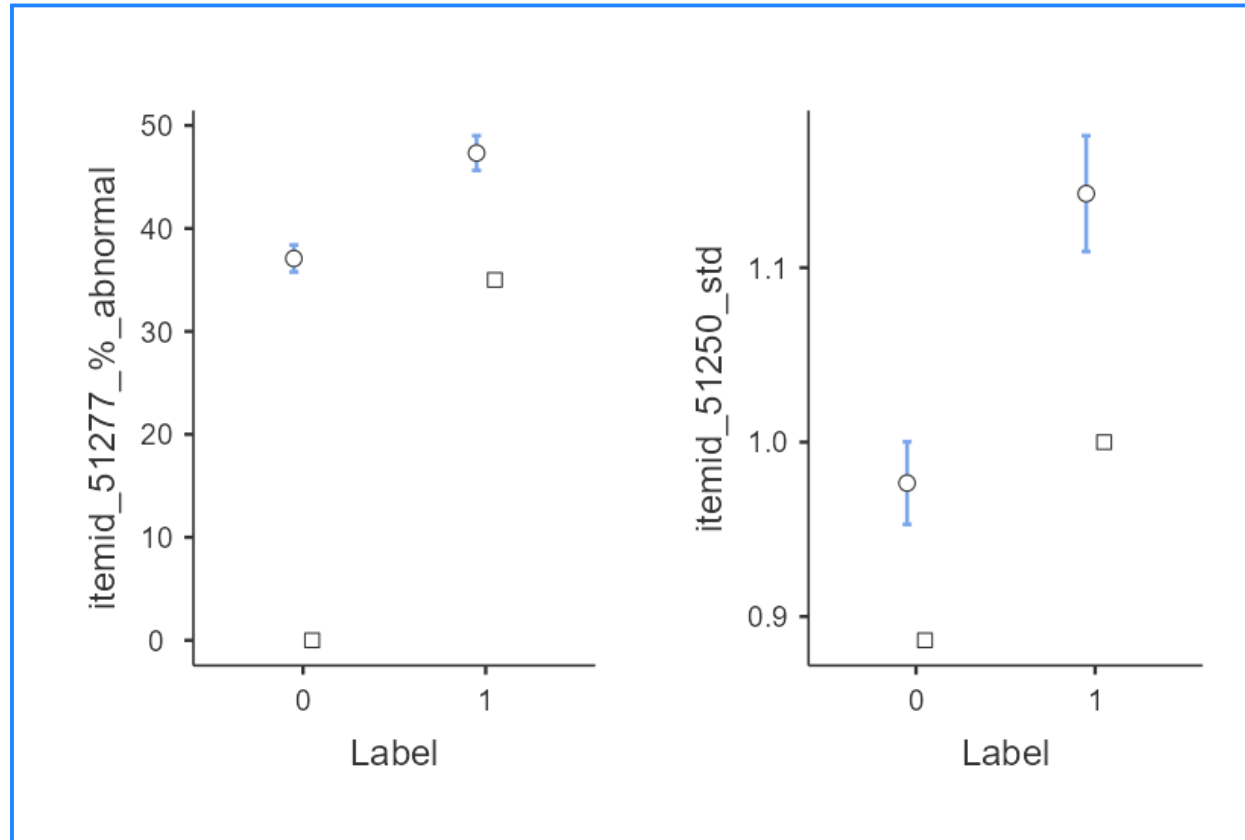
- Mean (95% CI)
- Median



- $p < 0.001$ (Mann-Whitney U test)
- **RBC**: Red Blood Cells Count
- **Haematocrit**: percentage of RBC with respect to the total blood volume
- Lower haematocrit levels are associated with greater COPD severity and adverse outcomes [10].

Results – Reduced Feature Set

○ Mean (95% CI)
□ Median



- $p < 0.001$ (Mann-Whitney U test)
- **RDW** measures the variation in RBC size
- **MCV** measures the average size of RBC
- Associated with increased mortality in stable COPD and AECOPD cohorts [11].



CONCLUSIONS / NEXT STEPS



Conclusions

RQ1.

Which are the features more relevant to predict 30-day readmission in the COPD cohort?

This study identified a set of clinically meaningful predictors of COPD readmission, demonstrating strong alignment between data-driven feature importance and established medical evidence.

Conclusions

RQ2.

Are single-time-point hospital measurements sufficient to predict COPD deterioration (rehospitalization as proxy)?

Studies using continuous in-home data for predicting COPD exacerbations demonstrate a notable increase in predictive performance.

Conclusions

Rethinking COPD Exacerbation Prediction:

Exacerbation Prediction as Hospital Admission

What Data Can Tell Us

Identified Features, to be internally validated

(and Can't Yet) Tell Us

Remote Monitoring to improve readmission risk score



Questions?

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Bibliography

- [1] GOLD-2025-Report-v1.0-15Nov2024_WMV. 2025. Accessed January 15, 2026. https://goldcopd.org/wp-content/uploads/2024/11/GOLD-2025-Report-v1.0-15Nov2024_WMV.pdf
- [2] Naeem S, Wang F, Mubarak R, et al. Mapping the Global distribution, risk factors, and temporal trends of COPD incidence and mortality (1990–2021): ecological analysis. *BMC Med.* 2025;23(1). doi:10.1186/s12916-025-04014-0
- [3] Levine SM, Marciniuk DD. Global Impact of Respiratory Disease: What Can We Do, Together, to Make a Difference? *Chest.Elsevier Inc.* 2022;161(5):1153-1154. doi:10.1016/j.chest.2022.01.014
- [4] Hurst JR, Vestbo J, Anzueto A, et al. *Susceptibility to Exacerbation in Chronic Obstructive Pulmonary Disease A Bs Tr Ac t.* 2010.
- [5] Ruan H, Zhao H, Wang J, Zhang H, Li J. All-cause readmission rate and risk factors of 30- and 90-day after discharge in patients with chronic obstructive pulmonary disease: a systematic review and meta-analysis. *Ther Adv Respir Dis.* 2023;17. doi:10.1177/17534666231202742
- [6] Johnson AEW, Bulgarelli L, Shen L, et al. Author Correction: MIMIC-IV, a freely accessible electronic health record dataset (Scientific Data, (2023), 10, 1, (1), 10.1038/s41597-022-01899-x). *Sci Data. Nature Research.* 2023;10(1). doi:10.1038/s41597-023-02136-9
- [7] Alsentzer E, Murphy JR, Boag W, et al. Publicly Available Clinical BERT Embeddings. Published online June 20, 2019. <http://arxiv.org/abs/1904.03323>
- [8] Njoku CM, Alqahtani JS, Wimmer BC, et al. Risk factors and associated outcomes of hospital readmission in COPD: A systematic review. *Respir Med. W.B. Saunders Ltd.* 2020;173. doi:10.1016/j.rmed.2020.105988
- [9] Van Walraven C, Dhalla IA, Bell C, et al. Derivation and validation of an index to predict early death or unplanned readmission after discharge from hospital to the community. *CMAJ Canadian Medical Association Journal.* 2010;182(6):551-557. doi:10.1503/cmaj.091117
- [10] Long Z, Zeng Q, Ou Y, et al. Red Blood Cell Distribution Width/Hematocrit Ratio: A New Predictor of 28 Days All-Cause Mortality of AECOPD Patients in ICU. *International Journal of COPD.* 2024;19:2497-2516. doi:10.2147/COPD.S492049
- [11] Yu K, Gao A, He Y, Huang Z, Liu W. Red blood cell distribution width and mortality in chronic obstructive pulmonary disease patients with acute respiratory failure: a retrospective study. *Sci Rep.* 2025;15(1). doi:10.1038/s41598-025-18480-2