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LOCAL ADAPTATION OF MRA-FW FOR CARDIOVASCULAR RISK ASSESSMENT IN ARAL SEA REGION INPATIENTS

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Abstract: This study examines the adaptation of the Medical Risk-Aware Feature Weighting (MRA-FW) algorithm to the clinical profile of cardiology inpatients from the Aral Sea region. A total of 2,039 inpatient medical records from Nukus (2024–2026) were retrospectively digitized and analyzed. High proportions of cardiovascular, cerebrovascular, and renal comorbid conditions were observed; these values describe the selected inpatient cohort and are not interpreted as population prevalence. The original MRA-FW formulation combines model-based feature importance, statistical relevance, and a medical prior. For regional adaptation, a regularized combination of local and global medical priors is proposed to incorporate regional clinical information without excessively shifting the prior coefficients. In the previous reproducible MRA-FW experiment using 68,597 cleaned Cardiovascular Disease records and five classifiers, Recall ranged from 0.9432 to 0.9803 and F2-score from 0.8215 to 0.8401. The principal effect of the method is interpreted as a sensitivity-oriented shift of the screening operating point rather than a universal improvement in all metrics.

Keywords: Aral Sea region, cardiovascular risk, inpatient cohort, comorbidity, artificial intelligence, MRA-FW, adaptive feature weighting, medical prior, Recall, F2-score, CardioAI-DSS.

Annotatsiya: Ushbu tadqiqotda Orolbo'yi mintaqasidagi kardiologiya yo'nalishida davolanayotgan statsionar bemorlarning klinik profiliga Medical Risk-Aware Feature Weighting (MRA-FW) algoritmini moslashtirish masalasi o'rganilgan. Nukus shahrida 2024–2026-yillar davomida statsionarda davolangan bemorlarning jami 2 039 ta tibbiy kartasi retrospektiv tarzda raqamlashtirilib, tahlil qilindi. Yurak-qon tomir, serebrovaskulyar va buyrak bilan bog'liq hamroh kasalliklarning yuqori ulushi aniqlandi; mazkur ko'rsatkichlar tanlangan statsionar bemorlar kohortasini tavsiflaydi va aholi orasidagi kasalliklar tarqalish darajasi sifatida talqin qilinmaydi. MRA-FW algoritmining dastlabki formulasi model tomonidan aniqlangan belgilar muhimligi, statistik ahamiyat va tibbiy aprior koeffitsiyentni birlashtiradi. Mintaqaviy moslashtirish uchun mahalliy va global tibbiy aprior koeffitsiyentlarni regularizatsiyalangan tarzda birlashtirish taklif etiladi. Bu yondashuv aprior koeffitsiyentlarni haddan tashqari o'zgartirmagan holda hududiy klinik ma'lumotlarni hisobga olish imkonini beradi. Avvalgi reproduktiv MRA-FW tajribasida yurak-qon tomir kasalliklariga oid tozalangan 68 597 ta yozuv va beshta klassifikator qo'llanilgan bo'lib, Recall ko'rsatkichi 0,9432 dan 0,9803 gacha, F2-score esa 0,8215 dan 0,8401 gacha bo'lgan. Usulning asosiy samarasi barcha metrikalarni universal tarzda yaxshilash emas, balki skringning ishchi nuqtasini yuqori sezgirlik tomon siljitish sifatida talqin qilinadi.

Kalit so'zlar: Orolbo'yi mintaqasi, yurak-qon tomir xavfi, statsionar bemorlar kohortasi, komorbidlik, sun'iy intellekt, MRA-FW, belgilarni adaptiv vaznlash, tibbiy aprior koeffitsiyent, Recall, F2-score, CardioAI-DSS.

Аннотация: В данном исследовании рассматривается адаптация алгоритма Medical Risk-Aware Feature Weighting (MRA-FW) к клиническому профилю стационарных пациентов кардиологического профиля из Приаральского региона. Ретроспективно были оцифрованы и проанализированы 2039 медицинских карт стационарных пациентов из Нукуса за период 2024–2026 годов. Были выявлены высокие доли сердечно-сосудистых, цереброваскулярных и почечных сопутствующих заболеваний; данные показатели характеризуют исследуемую стационарную когорту и не интерпретируются как распространённость заболеваний среди населения. Исходная формулировка MRA-FW объединяет значимость признаков, определённую моделью, их статистическую значимость и медицинский априорный вес. Для региональной адаптации предлагается регуляризованное сочетание

локального и глобального медицинских априорных весов, позволяющее учитывать региональную клиническую информацию без чрезмерного смещения коэффициентов априорных весов. В предыдущем воспроизводимом эксперименте MRA-FW с использованием 68 597 очищенных записей о сердечно-сосудистых заболеваниях и пяти классификаторов показатель Recall находился в диапазоне от 0,9432 до 0,9803, а показатель F2-score — от 0,8215 до 0,8401. Основной эффект метода интерпретируется как смещение рабочей точки скрининга в сторону повышения чувствительности, а не как универсальное улучшение всех метрик.

Ключевые слова: Приаральский регион, сердечно-сосудистый риск, стационарная когорта, коморбидность, искусственный интеллект, MRA-FW, адаптивное взвешивание признаков, медицинский априорный вес, Recall, F2-score, CardioAI-DSS.

INTRODUCTION

Cardiovascular diseases remain among the leading causes of death and disability worldwide [1]. Machine-learning methods can identify nonlinear relationships among numerous variables in clinical risk assessment; however, transparent validation, appropriate reporting, and clinically meaningful performance metrics remain essential for clinical prediction models [2,3]. Research on the application of artificial intelligence to cardiology and medical information systems is also developing in Uzbekistan [4,5].

The Aral Sea region represents a distinctive environmental and clinical context for cardiovascular risk assessment. The population of this region has experienced substantial environmental and socioeconomic changes over several decades, while healthcare facilities frequently manage patients with complex combinations of cardiovascular, cerebrovascular, renal, and other chronic comorbidities. However, clinical characteristics observed in hospital-based cohorts should be distinguished from population-level prevalence estimates. Inpatient data primarily reflect the characteristics of patients who require hospital-based medical care and therefore provide an important, but clinically selected, representation of disease burden.

The increasing availability of electronic medical records creates new opportunities for applying artificial intelligence (AI) and machine learning (ML) to cardiovascular risk assessment. Machine-learning models can process heterogeneous clinical variables and identify nonlinear relationships that may not be fully captured by conventional statistical approaches. Nevertheless, the predictive performance of such models depends not only on the choice of algorithm but also on the quality, distribution, and clinical relevance of the input features. A model developed using data from one population may therefore demonstrate different behavior when applied to patients from another geographical or clinical setting.

One important challenge in clinical AI is the incorporation of medical knowledge into data-driven predictive models. Purely data-driven feature selection may assign high importance to variables that are statistically informative but have limited clinical interpretability, while clinically predefined weighting schemes may fail to reflect patterns specific to a particular patient population. The Medical Risk-Aware Feature Weighting (MRA-FW) framework addresses this issue by combining model-based feature importance, statistical relevance, and medical prior information. Such an approach provides an opportunity to incorporate clinical knowledge into the feature-weighting process while retaining the predictive capacity of machine-learning models.

REVIEW OF LITERATURE ON THE SUBJECT

Recent literature shows that cardiovascular prediction with machine learning should be considered together with transparent model development and validation. Collins et al. [2] formulated TRIPOD+AI reporting guidance for prediction models based on regression or machine-learning methods, while Liu et al. [3] reviewed machine-learning models for cardiovascular risk prediction using electronic health-record data. These studies provide the methodological context for the present work: improvements in a screening metric should be interpreted together with the validation design, the selected operating threshold, and the clinical purpose of the model. Saito and Rehmsmeier [6] further showed the importance of precision-recall analysis for imbalanced binary classification, supporting the use of Recall- and F2-oriented assessment when reducing missed positive cases is a priority.

Research relevant to cardiovascular artificial intelligence is also developing in Uzbekistan. Azimova et al. [5] described early steps in medical artificial intelligence, and Uzokov et al. [4] discussed the application of artificial intelligence to ischaemic heart disease. More recently, Dehkordi et al. [10] reported an electro-mechanical risk score for coronary artery disease using seismocardiography in a study involving centers in Uzbekistan. In parallel, the clinical concept of cardiorenal syndrome emphasizes the bidirectional relationship between cardiac and renal dysfunction [9]. Taken together, these works support the use of clinically informed cardiovascular models, but the present study addresses a more specific methodological problem: how regional inpatient information can modify the medical-prior component of a feature-weighting algorithm without directly

converting local disease frequencies into fixed prior coefficients. This gap motivates the regularized local adaptation of MRA-FW evaluated here.

Accounting for the local clinical profile is important when developing clinical decision-support systems for the Aral Sea region. However, disease proportions observed in a single center or inpatient cohort should not be equated with population prevalence. Therefore, the indicators obtained from the 2,039 patients in this study are interpreted as the clinical and comorbidity profile of the selected cardiology inpatient cohort.

The MRA-FW algorithm integrates model-based feature importance, statistical relevance, medical prior information, adaptive feature weighting, Top-K selection, risk-aware sample weighting, and F2-score-based threshold selection within a single pipeline for cardiovascular risk screening. In previous experiments, the method increased Recall and F2-score across five classifier types, while Accuracy and Precision decreased in some configurations and ROC-AUC changed only minimally. Thus, MRA-FW should be interpreted not as a model that universally improves accuracy, but as a screening strategy designed to miss fewer positive cases [6].

The aim of this study was to characterize the clinical and comorbidity profile of 2,039 patients in the Nukus cardiology inpatient setting, adapt the medical-prior component of the MRA-FW algorithm to local clinical information in a regularized manner, and establish a methodological basis for subsequent clinical evaluation within the CardioAI-DSS system.

RESEARCH METHODOLOGY

Local retrospective clinical data. In the clinical part of the study, a total of 2,039 patient records from the Nukus cardiology inpatient service for 2024–2026 were digitized and structured. The source document reports a mean patient age of 61.1 years. To reduce direct personal identification, the records were coded using conditional identifiers such as P0001–P2039. The main clinical conditions recorded in the cohort are presented in Table 1 (Table 1).

Table 1. Main clinical and comorbid conditions in the selected cardiology inpatient cohort (N=2,039)¹

№	Clinical / comorbid condition	Patients	Proportion, %
1	History of myocardial infarction / acute coronary syndrome	2 037	99.9
2	History of stroke (CVA / TIA)	1 966	96.4
3	Nephropathy / chronic kidney disease	1 951	95.7
4	Arterial hypertension	1 945	95.4
5	Chronic heart failure	1 896	93.0
6	Ischaemic heart disease	1 818	89.2
7	Cardiac rhythm disorders	1 481	72.6
8	Anemia	963	47.2
9	Type 2 diabetes mellitus	436	21.4

These indicators reflect the inpatient clinical profile associated with the patient-selection and coding protocol. The exceptionally high proportions recorded for myocardial infarction/acute coronary syndrome and stroke particularly highlight the importance of coding “medical history,” “primary diagnosis,” and “reason for current hospitalization” as separate categories in subsequent clinical audits (Figure 1).

¹ Source: Author's own work.

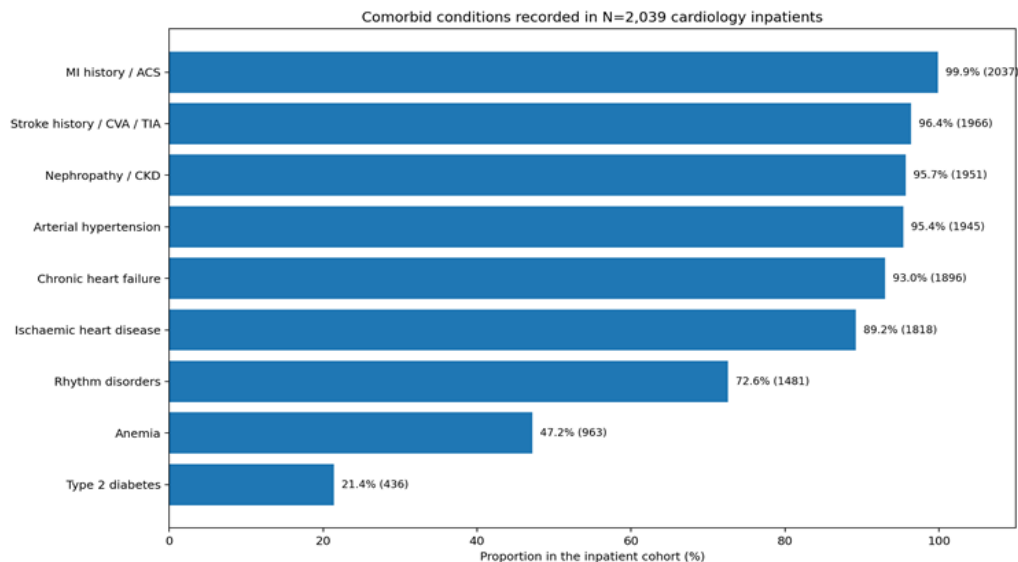


Figure 1. Main comorbid conditions recorded in N=2,039 cardiology inpatients²

Figure 1 shows that cardiovascular, cerebrovascular, and renal conditions were recorded at high proportions within the selected inpatient cohort. The percentages in the figure should not be interpreted as epidemiological prevalence for the general population of the Aral Sea region; they describe the clinical composition of patients treated in a specialized cardiology inpatient setting.

Baseline mathematical model of the MRA-FW algorithm. In MRA-FW, the overall importance score of each feature i combines three components:

$$G_i = \alpha I_i + \beta S_i + \gamma R_i, \quad \alpha + \beta + \gamma = 1$$

Here, I_i denotes model-based feature importance; S_i denotes statistical relevance to the target; R_i denotes the medical prior; and α , β , and γ control the contribution of the three components. In the baseline implementation, $\alpha=0.4$, $\beta=0.3$, and $\gamma=0.3$ are used.

The combined score is converted into an adaptive feature weight through Softmax normalization:

$$w_i = m \cdot \exp(G_i/\tau) / \sum_{j=1}^m \exp(G_j/\tau)$$

Here, m is the number of features, τ is the Softmax temperature, and w_i is the final adaptive weight of feature i and no data-quality coefficient is used in this formulation; this clearly separates the mathematical structure of MRA-FW from later algorithms that explicitly model data reliability or noise.

Regularized adaptation of the local medical prior. The high comorbidity observed in the local cohort indicates that the prior importance assigned to some clinical feature groups may need to be reconsidered. However, the frequency of a condition in an inpatient cohort is not directly equated with a medical-prior coefficient. For example, observing nephropathy in 95.7% of the cohort does not automatically imply $R_i=0.957$. Therefore, the local clinical prior is regularized against the global prior using shrinkage:

$$\begin{aligned} \rho_i &= n_i / (n_i + \kappa) \\ R_{i,\text{reg}} &= \rho_i R_{i,\text{local}} + (1 - \rho_i) R_{i,\text{global}} \end{aligned}$$

Here, n_i is the number of reliable local observations for feature i , and κ is a regularization hyperparameter controlling the balance between local and global priors. For the local configuration, the combined score is:

$$G_{i,\text{local}} = \alpha I_i + \beta S_i + \gamma R_{i,\text{reg}}$$

This approach allows local or single-center signals to be incorporated without abruptly changing the prior. Local clinical information is therefore used not to assign a ready-made coefficient, but as a signal indicating which clinical groups warrant recalibration of prior importance (Table 2).

Table 2. Clinical directions for adapting the local medical prior³

Clinical feature group	Signal in the local cohort	Adaptation principle
Arterial blood pressure	Hypertension recorded at a high proportion	Maintain a high baseline prior and refine it through local validation

² Source: Author's own work.

³ Source: Author's own work.

Renal function	Nephropathy/CKD recorded at a high proportion	Consider a cautious increase in the clinical prior assigned to renal features
Anemia / hemoglobin	Anemia recorded in nearly half of the cohort	Evaluate the hematological component as a separate prior
Age	Mean age 61.1 years	Retain age as a baseline risk factor
Cholesterol	No separate predictive analysis reported in the local cohort	Avoid sharply reducing the baseline prior without sufficient local evidence

Experimental MRA-FW protocol. The baseline experimental evaluation of MRA-FW was conducted using the open cardiovascular disease dataset containing 70,000 records; after medical filtering, 68,597 records remained. The dataset includes age, sex, height, weight, systolic and diastolic blood pressure, cholesterol, glucose, smoking, alcohol use, physical activity, and the binary cardio target [7].

Five classifiers were evaluated: Logistic Regression, Hist Gradient Boosting, XGBoost, Random Forest, and Extra Trees. The experiment used stratified 5-fold cross-validation. In each outer fold, MRA-FW components were learned only from the training portion. The decision threshold was selected on a 20% validation subset within the training fold. Candidate thresholds from 0.10 to 0.90 were evaluated in 0.01 increments, and the threshold yielding the highest validation F2-score was selected. The test fold was not used for threshold selection.

The optimal threshold is defined as:

$$\theta^* = \arg \max_{\theta \in \Theta} F_2(\theta)$$

The F2-score is calculated as:

$$F_2 = 5PR / (4P + R)$$

where P denotes Precision and R denotes Recall. F2-score gives greater weight to Recall than Precision and is useful in screening tasks where reducing missed-positive cases is a priority [8].

ANALYSIS AND RESULTS

Local clinical profile. In the data from 2,039 inpatients, cardiovascular, cerebrovascular, and renal conditions were frequently recorded together. This finding provides a practical basis for reassessing the medical-prior component of MRA-FW under local conditions. At the same time, these figures refer to the selected inpatient cohort and are not used to draw epidemiological conclusions about the general population.

The principal outcome of the local adaptation is not a new set of rigid, manually assigned R_i values, but the use of the combined framework global prior + local clinical signal + regularization. This approach allows prior coefficients to be selected more objectively during subsequent local validation.

Reproducible experimental results of MRA-FW. In the previous experimental evaluation of MRA-FW on the 68,597-record cardiovascular disease dataset, Recall and F2-score increased across all five classifiers. The highest Recall was obtained with Logistic Regression + MRA-FW (0.9803), while the highest F2-score was obtained with Hist Gradient Boosting + MRA-FW (0.8401). ROC-AUC values changed very little, indicating that the main effect of MRA-FW is a sensitivity-oriented shift in the decision operating point rather than a fundamental change in class-ranking performance.

Abbreviations: LR – Logistic Regression; HGB – Hist Gradient Boosting; XGB – XGBoost; RF – Random Forest; ET – Extra Trees (Table 3; Figure 2).

Table 3. Comparison of baseline and MRA-FW results⁴

Model	Base Recall	MRA Recall	Base F2	MRA F2	Base Accuracy	MRA Accuracy	Base AUC	MRA AUC
LR	0.6668	0.9803	0.6825	0.8362	0.7273	0.5541	0.7912	0.7901
HGB	0.6921	0.9794	0.7035	0.8401	0.7355	0.5695	0.8013	0.7999
XGB	0.6879	0.9776	0.7002	0.8399	0.7349	0.5724	0.8014	0.8000
RF	0.7018	0.9685	0.7039	0.8305	0.7123	0.5577	0.7739	0.7679
ET	0.6997	0.9432	0.6990	0.8215	0.7004	0.5776	0.7566	0.7493

Figure 2. Screening trade-off of MRA-FW illustrated with Hist Gradient Boosting⁵

⁴ Source: Author's own work.

⁵ Source: Author's own work.

Figure 2 shows that, with MRA-FW, Recall increased from 0.6921 to 0.9794, an increase of 28.73 percentage points, while F2-score increased from 0.7035 to 0.8401. At the same time, Accuracy decreased from 0.7355 to 0.5695, whereas ROC-AUC changed only slightly from 0.8013 to 0.7999. Therefore, the result is more appropriately interpreted as a sensitivity-oriented screening strategy designed to miss fewer positive cases rather than as an improvement across all performance metrics.

CONCLUSIONS AND SUGGESTIONS

The local clinical data indicate that the medical-prior component of MRA-FW can be enriched with regional clinical signals. In particular, the high proportions of arterial hypertension, renal dysfunction, and anemia in the selected inpatient cohort provide a basis for separate analysis of these feature groups during local validation. The clinical literature also describes cardiorenal interaction as an important concept reflecting the bidirectional relationship between cardiac and renal dysfunction [9].

An important methodological aspect of local adaptation is that inpatient prevalence is not transferred directly into R_i . Instead, the global prior is retained and the local prior is integrated progressively through regularization. This preserves useful local information while reducing the risk of overfitting to a single-center clinical sample.

The experimental results of MRA-FW demonstrate that an operating point oriented toward reducing false-negative cases can be established for screening. At the same time, higher Recall may be accompanied by additional false-positive alerts. Therefore, within CardioAI-DSS, the MRA-FW output is considered a clinical decision-support component that helps identify patients requiring further examination rather than a module that replaces the final diagnosis.

In Uzbekistan, research on the application of artificial intelligence to cardiovascular disease is developing in the areas of ECG analysis, clinical risk assessment, and multimodal signals [4,10]. In particular, a multicenter 2026 EMR Score study involving centers in Uzbekistan combined seismocardiographic signals with clinical risk factors using a 1D-CNN and also performed external-center validation [10]. Such studies highlight the importance of independent clinical evaluation alongside adaptation to local data.

In the next stage, this MRA-FW adaptation approach can be evaluated in independent clinical cohorts from Nukus and other regions, while prior coefficients and thresholds can be further refined on the basis of validation. This can progressively strengthen the adaptability of CardioAI-DSS to regional clinical settings.

REFERENCES:

1. World Health Organization. Cardiovascular diseases (CVDs). Fact sheet. Geneva: WHO, 2025.
2. Collins G.S., Moons K.G.M., Dhiman P. et al. TRIPOD+AI statement: updated guidance for reporting clinical prediction models that use regression or machine learning methods. *BMJ*. 2024;385:e078378.
3. Liu T. et al. Machine learning based prediction models for cardiovascular disease risk using electronic health records data: systematic review and meta-analysis. *European Heart Journal - Digital Health*. 2025;6(1):7–22.
4. Uzokov J., Alyavi A., Alyavi B., Abdullaev A. How artificial intelligence can assist with ischaemic heart disease. *European Heart Journal*. 2024;45(21):1866–1868. DOI: 10.1093/eurheartj/ehae030.
5. Azimova N.D., Ashirbaev S.P., Vikhrov I.P. The first steps in artificial intelligence development in medicine in Uzbekistan. *Health Problems of Civilization*. 2020;14(4):314–319. DOI: 10.5114/hpc.2020.98086.
6. Saito T., Rehmsmeier M. The precision-recall plot is more informative than the ROC plot when evaluating binary classifiers on imbalanced datasets. *PLoS ONE*. 2015;10(3):e0118432.
7. Ulianova S. Cardiovascular Disease Dataset. Kaggle. 70,000 patient records, 11 features and binary target. Accessed 2026.
8. Pedregosa F., Varoquaux G., Gramfort A. et al. Scikit-learn: Machine Learning in Python. *Journal of Machine Learning Research*. 2011;12:2825–2830.
9. Ronco C., Haapio M., House A.A. et al. Cardiorenal syndrome. *Journal of the American College of Cardiology*. 2008;52(19):1527–1539.
10. Dehkordi P., Tavakolian K., Rocco T., Fozilov K., Yuldashov A., Yuldashov B., Atamuratov B. et al. Electro-mechanical risk score for coronary artery disease risk estimation using seismocardiography. *European Heart Journal - Digital Health*. 2026;7(8):ztag139. DOI: 10.1093/ehjdh/ztag139.
11. Chen T., Guestrin C. XGBoost: A Scalable Tree Boosting System. *Proceedings of the 22nd ACM SIGKDD International Conference*. 2016:785–794.
12. Lundberg S.M., Lee S.I. A Unified Approach to Interpreting Model Predictions. *Advances in Neural Information Processing Systems*. 2017;30:4765–4774.

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