I. Supplementary Material

A. Acute Kidney Injury (AKI)

1) Overall Performance: SHAP Filter vs. SHAP Weight: Table I summarizes the overall 5-fold cross-validation performance for the baseline SHAP-based filtering and weighting strategies. Results show that SHAP weighting consistently achieves higher AUC, F1, and recall across all models compared to SHAP filtering.

2) SHAP Filter Variants: Table II reports the 5-fold cross-validation performance for each SHAP Filter variant, including combinations with Isolation Forest (IF), Odds Ratio (OR), or both. These variants illustrate the limitations of unweighted filtering, particularly in models' precision–recall trade-offs.

3) SHAP Weight Variants: Table III presents the 5-fold cross-validation performance for each SHAP Weight variant. Weighting schemes consistently improve model robustness, with the IF + OR combination yielding the best overall scores across most metrics.

TABLE I
5-fold CV Results for SHAP Filter vs. SHAP Weight Baselines (Mean ± Std).

Strategy	Model	AUC	Accuracy	F1 Score	Precision	Recall
SHAP Filter (Baseline)	Logistic	0.8637 ± 0.0250	0.7850 ± 0.0174	0.6279 ± 0.0572	0.7347 ± 0.1208	0.5834 ± 0.1512
	MLP	0.8401 ± 0.0311	0.7632 ± 0.0312	0.5819 ± 0.0921	0.7023 ± 0.1286	0.5430 ± 0.1987
	RF	0.8521 ± 0.0443	0.7759 ± 0.0329	0.5941 ± 0.1191	0.7395 ± 0.1423	0.5469 ± 0.1940
	XGB	0.7967 ± 0.0728	0.7385 ± 0.0621	0.5304 ± 0.0831	0.6927 ± 0.1810	0.4696 ± 0.1355
SHAP Weight	Logistic	0.9154 ± 0.0006	0.8265 ± 0.0073	0.7579 ± 0.0038	0.6871 ± 0.0184	0.8459 ± 0.0195
	MLP	0.9210 ± 0.0006	0.8344 ± 0.0117	0.7643 ± 0.0057	0.7058 ± 0.0326	0.8360 ± 0.0332
	RF	0.9225 ± 0.0009	0.8527 ± 0.0008	0.7520 ± 0.0016	0.8181 ± 0.0029	0.6958 ± 0.0037
	XGB	0.9359 ± 0.0006	0.8516 ± 0.0051	0.7881 ± 0.0027	0.7278 ± 0.0161	0.8599 ± 0.0180

TABLE II
5-fold CV Results for SHAP Filter Variants (Mean ± Std).

Strategy	Model	AUC	Accuracy	F1 Score	Precision	Recall
Baseline - SHAP Filter	Logistic	0.8637 ± 0.0250	0.7850 ± 0.0174	0.6279 ± 0.0572	0.7347 ± 0.1208	0.5834 ± 0.1512
	MLP	0.8401 ± 0.0311	0.7632 ± 0.0312	0.5819 ± 0.0921	0.7023 ± 0.1286	0.5430 ± 0.1987
	RF	0.8521 ± 0.0443	0.7759 ± 0.0329	0.5941 ± 0.1191	0.7395 ± 0.1423	0.5469 ± 0.1940
	XGB	0.7967 ± 0.0728	0.7385 ± 0.0621	0.5304 ± 0.0831	0.6927 ± 0.1810	0.4696 ± 0.1355
IF only - SHAP Filter	Logistic	0.8792 ± 0.0069	0.7880 ± 0.0276	0.5615 ± 0.1165	0.8227 ± 0.0508	0.4460 ± 0.1526
	MLP	0.8558 ± 0.0298	0.7836 ± 0.0336	0.5498 ± 0.1555	0.8143 ± 0.0832	0.4514 ± 0.1963
	RF	0.8514 ± 0.0113	0.7533 ± 0.0341	0.4114 ± 0.1596	0.8529 ± 0.0573	0.2935 ± 0.1684
	XGB	0.7791 ± 0.0236	0.7317 ± 0.0226	0.3984 ± 0.1375	0.7310 ± 0.1093	0.2981 ± 0.1448
OR only - SHAP Filter	Logistic	0.8741 ± 0.0129	0.8025 ± 0.0070	0.6628 ± 0.0586	0.7450 ± 0.0823	0.6259 ± 0.1579
	MLP	0.8636 ± 0.0163	0.7922 ± 0.0206	0.6599 ± 0.0336	0.7138 ± 0.0864	0.6384 ± 0.1356
	RF	0.8545 ± 0.0182	0.7868 ± 0.0305	0.5741 ± 0.1484	0.7902 ± 0.0787	0.4905 ± 0.2048
	XGB	0.7867 ± 0.0545	0.7412 ± 0.0378	0.5261 ± 0.1047	0.6262 ± 0.0680	0.4591 ± 0.1242
IF + Odds - SHAP Filter	Logistic	0.8626 ± 0.0332	0.7719 ± 0.0542	0.5338 ± 0.2978	0.7521 ± 0.1148	0.5282 ± 0.3350
	MLP	0.8316 ± 0.0557	0.7606 ± 0.0518	0.4929 ± 0.2998	0.5840 ± 0.3446	0.4851 ± 0.3540
	RF	0.8408 ± 0.0476	0.7575 ± 0.0456	0.5105 ± 0.2681	0.7372 ± 0.1419	0.5165 ± 0.3532
	XGB	0.7651 ± 0.0587	0.7148 ± 0.0474	0.4583 ± 0.2480	0.6339 ± 0.1247	0.4771 ± 0.3165

TABLE III
5-FOLD CV RESULTS FOR SHAP WEIGHT VARIANTS (MEAN ± STD).

Strategy	Model	AUC	Accuracy	F1 Score	Precision	Recall
Shapley Weight	Logistic	0.9154 ± 0.0006	0.8265 ± 0.0073	0.7579 ± 0.0038	0.6871 ± 0.0184	0.8459 ± 0.0195
	MLP	0.9210 ± 0.0006	0.8344 ± 0.0117	0.7643 ± 0.0057	0.7058 ± 0.0326	0.8360 ± 0.0332
	RF	0.9225 ± 0.0009	0.8527 ± 0.0008	0.7520 ± 0.0016	0.8181 ± 0.0029	0.6958 ± 0.0037
	XGB	0.9359 ± 0.0006	0.8516 ± 0.0051	0.7881 ± 0.0027	0.7278 ± 0.0161	0.8599 ± 0.0180
IF only - SHAP Weight	Logistic	0.9154 ± 0.0006	0.8313 ± 0.0051	0.7600 ± 0.0021	0.6998 ± 0.0144	0.8321 ± 0.0164
	MLP	0.9211 ± 0.0009	0.8360 ± 0.0086	0.7649 ± 0.0029	0.7102 ± 0.0291	0.8308 ± 0.0321
	RF	0.9225 ± 0.0008	0.8535 ± 0.0004	0.7541 ± 0.0013	0.8175 ± 0.0019	0.6997 ± 0.0032
	XGB	0.9360 ± 0.0005	0.8541 ± 0.0047	0.7886 ± 0.0028	0.7373 ± 0.0144	0.8480 ± 0.0130
OR only - SHAP Weight	Logistic	0.9154 ± 0.0006	0.8313 ± 0.0030	0.7606 ± 0.0011	0.6985 ± 0.0092	0.8351 ± 0.0109
	MLP	0.9212 ± 0.0006	0.8380 ± 0.0072	0.7664 ± 0.0025	0.7146 ± 0.0248	0.8279 ± 0.0277
	RF	0.9225 ± 0.0010	0.8531 ± 0.0009	0.7534 ± 0.0021	0.8163 ± 0.0017	0.6996 ± 0.0042
	XGB	0.9362 ± 0.0006	0.8545 ± 0.0026	0.7897 ± 0.0016	0.7364 ± 0.0086	0.8515 ± 0.0087
IF + Odds - SHAP Weight	Logistic	0.9154 ± 0.0006	0.8314 ± 0.0024	0.7607 ± 0.0013	0.6985 ± 0.0067	0.8352 ± 0.0071
	MLP	0.9211 ± 0.0007	0.8353 ± 0.0087	0.7655 ± 0.0045	0.7059 ± 0.0228	0.8375 ± 0.0236
	RF	0.9223 ± 0.0009	0.8534 ± 0.0007	0.7537 ± 0.0013	0.8177 ± 0.0026	0.6989 ± 0.0027
	XGB	0.9361 ± 0.0006	0.8543 ± 0.0029	0.7894 ± 0.0021	0.7362 ± 0.0084	0.8510 ± 0.0071

B. Full Performance Overview: Diabetes Mellitus (ICD - 250)

Table IV presents the 5-fold CV results for the SHAP Filter and SHAP Weight strategies applied to diabetes mellitus prediction. The observed performance gains further support the generalizability of our refinement framework.

TABLE IV
5-FOLD CV RESULTS ON ICD-250 FOR ALL SHAP-BASED REFINEMENT STRATEGIES (MEAN ± STD).

Strategy	Model	AUC	Accuracy	F1 Score	Precision	Recall
Baseline - SHAP Filter	Logistic	0.6487 ± 0.0720	0.7600 ± 0.0369	0.2795 ± 0.1028	0.3973 ± 0.1211	0.2328 ± 0.1125
	MLP	0.5952 ± 0.0941	0.7644 ± 0.0355	0.1799 ± 0.0779	0.3769 ± 0.1291	0.1306 ± 0.0735
	RF	0.7448 ± 0.0921	0.7982 ± 0.0226	0.1282 ± 0.1589	0.7910 ± 0.2604	0.0803 ± 0.1043
	XGB	0.6009 ± 0.1228	0.7662 ± 0.0560	0.0427 ± 0.0795	0.3989 ± 0.4666	0.0390 ± 0.0790
Baseline - SHAP Weight	Logistic	0.9010 ± 0.0008	0.8764 ± 0.0084	0.7036 ± 0.0053	0.7099 ± 0.0370	0.7000 ± 0.0320
	MLP	0.9195 ± 0.0023	0.8827 ± 0.0171	0.7286 ± 0.0183	0.7197 ± 0.0783	0.7496 ± 0.0672
	RF	0.9203 ± 0.0024	0.9014 ± 0.0020	0.7276 ± 0.0076	0.8627 ± 0.0032	0.6291 ± 0.0118
	XGB	0.9264 ± 0.0015	0.8967 ± 0.0039	0.7524 ± 0.0044	0.7560 ± 0.0197	0.7494 ± 0.0147
IF + Odds - SHAP Filter	Logistic	0.6494 ± 0.0705	0.6802 ± 0.1287	0.3691 ± 0.0215	0.3709 ± 0.1343	0.4440 ± 0.1616
	MLP	0.6436 ± 0.0425	0.7073 ± 0.0896	0.3137 ± 0.0584	0.3835 ± 0.1503	0.3411 ± 0.1782
	RF	0.6948 ± 0.0550	0.7811 ± 0.0256	0.1602 ± 0.1778	0.6387 ± 0.3111	0.1328 ± 0.1774
	XGB	0.5747 ± 0.0670	0.7753 ± 0.0226	0.1565 ± 0.2249	0.2568 ± 0.2233	0.1510 ± 0.2361
IF + Odds - SHAP Weight	Logistic	0.9032 ± 0.0007	0.8811 ± 0.0033	0.7115 ± 0.0022	0.7240 ± 0.0176	0.6999 ± 0.0144
	MLP	0.9202 ± 0.0011	0.8913 ± 0.0041	0.7429 ± 0.0048	0.7364 ± 0.0195	0.7499 ± 0.0114
	RF	0.9218 ± 0.0012	0.9025 ± 0.0003	0.7312 ± 0.0020	0.8649 ± 0.0053	0.6334 ± 0.0056
	XGB	0.9274 ± 0.0011	0.8980 ± 0.0016	0.7539 ± 0.0019	0.7624 ± 0.0086	0.7456 ± 0.0054
IF only - SHAP Filter	Logistic	0.6486 ± 0.0747	0.7067 ± 0.0582	0.3715 ± 0.0647	0.3528 ± 0.0891	0.4161 ± 0.1186
	MLP	0.6148 ± 0.0997	0.7483 ± 0.0377	0.2523 ± 0.2015	0.3313 ± 0.0905	0.2714 ± 0.2596
	RF	0.6935 ± 0.0824	0.7920 ± 0.0122	0.1919 ± 0.1219	0.5611 ± 0.2046	0.1291 ± 0.0956
	XGB	0.6673 ± 0.1333	0.7807 ± 0.0125	0.1874 ± 0.2260	0.3305 ± 0.2248	0.1718 ± 0.2273
IF only - SHAP Weight	Logistic	0.9019 ± 0.0015	0.8811 ± 0.0027	0.7088 ± 0.0031	0.7278 ± 0.0154	0.6911 ± 0.0128
	MLP	0.9180 ± 0.0045	0.8909 ± 0.0102	0.7364 ± 0.0114	0.7502 ± 0.0495	0.7266 ± 0.0370
	RF	0.9196 ± 0.0019	0.9014 ± 0.0019	0.7275 ± 0.0070	0.8636 ± 0.0007	0.6286 ± 0.0103
	XGB	0.9260 ± 0.0028	0.8985 ± 0.0026	0.7534 ± 0.0052	0.7671 ± 0.0103	0.7403 ± 0.0069
OR only - SHAP Filter	Logistic	0.5853 ± 0.1075	0.7421 ± 0.0289	0.2134 ± 0.1399	0.3000 ± 0.0639	0.1968 ± 0.1711
	MLP	0.5576 ± 0.1402	0.7629 ± 0.0201	0.1644 ± 0.1436	0.2884 ± 0.0748	0.1340 ± 0.1305
	RF	0.7180 ± 0.0590	0.7928 ± 0.0026	0.1884 ± 0.2200	0.3846 ± 0.2566	0.1497 ± 0.1782
	XGB	0.6000 ± 0.1290	0.8009 ± 0.0475	0.2360 ± 0.3111	0.2715 ± 0.3447	0.2100 ± 0.2850
OR only - SHAP Weight	Logistic	0.9010 ± 0.0009	0.8791 ± 0.0061	0.7048 ± 0.0044	0.7228 ± 0.0305	0.6891 ± 0.0212
	MLP	0.9192 ± 0.0006	0.8905 ± 0.0026	0.7409 ± 0.0053	0.7349 ± 0.0136	0.7475 ± 0.0170
	RF	0.9201 ± 0.0018	0.9016 ± 0.0020	0.7272 ± 0.0081	0.8664 ± 0.0029	0.6267 ± 0.0130
	XGB	0.9258 ± 0.0021	0.8981 ± 0.0034	0.7539 ± 0.0045	0.7632 ± 0.0159	0.7451 ± 0.0066

C. Full Performance Overview: Heart Failure (ICD - 428)

Table V summarizes the 5-fold CV results for the SHAP Filter and SHAP Weight strategies on heart failure prediction. Similar trends to AKI are observed, with SHAP Weight consistently improving both ROC-AUC and recall across all models.

TABLE V
5-FOLD CV RESULTS ON ICD-428 (HEART FAILURE) FOR ALL SHAP-BASED REFINEMENT STRATEGIES (MEAN ± STD).

Strategy	Model	AUC	Accuracy	F1 Score	Precision	Recall
Baseline - SHAP Filter	Logistic	0.7558 ± 0.1115	0.8335 ± 0.0396	0.4208 ± 0.1413	0.4181 ± 0.1446	0.4264 ± 0.1477
	MLP	0.7486 ± 0.0932	0.8446 ± 0.0242	0.3524 ± 0.1828	0.4116 ± 0.1451	0.3287 ± 0.2113
	RF	0.7924 ± 0.0899	0.8641 ± 0.0078	0.2695 ± 0.1481	0.5522 ± 0.1024	0.1937 ± 0.1389
	XGB	0.6629 ± 0.1094	0.8566 ± 0.0028	0.0455 ± 0.0399	0.4250 ± 0.2012	0.0248 ± 0.0223
IF - SHAP Filter	Logistic	0.5997 ± 0.2342	0.8325 ± 0.0652	0.2127 ± 0.2664	0.3269 ± 0.3305	0.1667 ± 0.2149
	MLP	0.5559 ± 0.2403	0.8545 ± 0.0222	0.1286 ± 0.1935	0.3218 ± 0.3470	0.0842 ± 0.1298
	RF	0.7435 ± 0.0679	0.8578 ± 0.0002	0.1150 ± 0.1918	0.3343 ± 0.2896	0.0857 ± 0.1447
	XGB	0.5858 ± 0.1485	0.8551 ± 0.0044	0.0401 ± 0.0695	0.1216 ± 0.2105	0.0240 ± 0.0416
IF - SHAP Weight	Logistic	0.9178 ± 0.0024	0.8945 ± 0.0015	0.6453 ± 0.0049	0.6194 ± 0.0107	0.6741 ± 0.0223
	MLP	0.9243 ± 0.0011	0.8997 ± 0.0065	0.6606 ± 0.0084	0.6405 ± 0.0390	0.6864 ± 0.0524
	RF	0.9244 ± 0.0012	0.9105 ± 0.0007	0.6099 ± 0.0034	0.8033 ± 0.0036	0.4916 ± 0.0031
	XGB	0.9293 ± 0.0015	0.9036 ± 0.0011	0.6711 ± 0.0045	0.6525 ± 0.0087	0.6910 ± 0.0169
IF + Odds - SHAP Filter	Logistic	0.7964 ± 0.0324	0.8397 ± 0.0368	0.3895 ± 0.0949	0.4749 ± 0.1405	0.3770 ± 0.1650
	MLP	0.6988 ± 0.1635	0.8343 ± 0.0319	0.3039 ± 0.1791	0.3769 ± 0.2065	0.2963 ± 0.2118
	RF	0.7899 ± 0.0718	0.8472 ± 0.0241	0.1407 ± 0.1283	0.5359 ± 0.2091	0.1071 ± 0.1126
	XGB	0.5595 ± 0.0818	0.8049 ± 0.0839	0.1202 ± 0.1650	0.0989 ± 0.1365	0.1687 ± 0.2472
IF + Odds - SHAP Weight	Logistic	0.9200 ± 0.0025	0.8990 ± 0.0031	0.6471 ± 0.0080	0.6458 ± 0.0266	0.6509 ± 0.0371
	MLP	0.9258 ± 0.0021	0.9015 ± 0.0053	0.6636 ± 0.0062	0.6483 ± 0.0329	0.6827 ± 0.0365
	RF	0.9252 ± 0.0020	0.9111 ± 0.0009	0.6139 ± 0.0048	0.8038 ± 0.0050	0.4965 ± 0.0051
	XGB	0.9300 ± 0.0019	0.9058 ± 0.0023	0.6701 ± 0.0065	0.6697 ± 0.0222	0.6723 ± 0.0313
Odds - SHAP Filter	Logistic	0.8236 ± 0.0187	0.8457 ± 0.0477	0.5156 ± 0.0469	0.5035 ± 0.1159	0.5650 ± 0.1059
	MLP	0.7865 ± 0.0396	0.8440 ± 0.0504	0.4641 ± 0.0800	0.4997 ± 0.1238	0.4774 ± 0.1552
	RF	0.8228 ± 0.0277	0.8387 ± 0.0601	0.2924 ± 0.1693	0.5699 ± 0.1694	0.2943 ± 0.2707
	XGB	0.6507 ± 0.1055	0.7808 ± 0.1213	0.1785 ± 0.1302	0.2732 ± 0.1923	0.2382 ± 0.2725
Odds - SHAP Weight	Logistic	0.9202 ± 0.0023	0.8987 ± 0.0017	0.6503 ± 0.0058	0.6399 ± 0.0136	0.6620 ± 0.0263
	MLP	0.9253 ± 0.0020	0.8951 ± 0.0115	0.6586 ± 0.0087	0.6202 ± 0.0465	0.7089 ± 0.0546
	RF	0.9254 ± 0.0021	0.9111 ± 0.0007	0.6135 ± 0.0043	0.8050 ± 0.0049	0.4956 ± 0.0058
	XGB	0.9299 ± 0.0016	0.9048 ± 0.0021	0.6717 ± 0.0054	0.6601 ± 0.0132	0.6844 ± 0.0200
Shapley - SHAP Weight	Logistic	0.9204 ± 0.0025	0.9020 ± 0.0025	0.6480 ± 0.0073	0.6636 ± 0.0169	0.6337 ± 0.0201
	MLP	0.9249 ± 0.0021	0.9017 ± 0.0071	0.6582 ± 0.0060	0.6584 ± 0.0558	0.6650 ± 0.0562
	RF	0.9251 ± 0.0015	0.9112 ± 0.0011	0.6159 ± 0.0096	0.8014 ± 0.0042	0.5003 ± 0.0141
	XGB	0.9299 ± 0.0028	0.9078 ± 0.0023	0.6711 ± 0.0045	0.6822 ± 0.0160	0.6608 ± 0.0153