SUPPLEMENTAL MATERIAL

Dataset Statistics

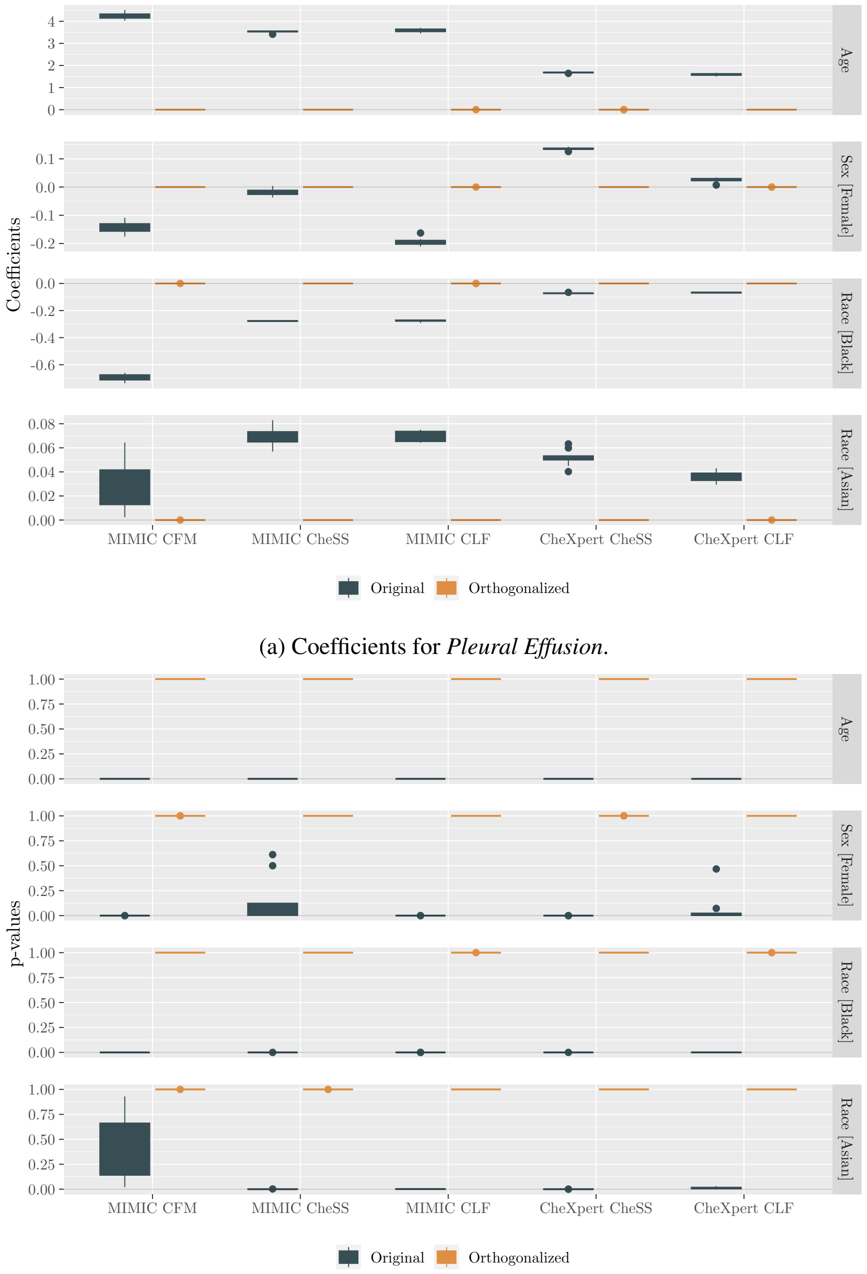
MIMIC						
Training set						
	All	White	Black	Asian	Male	Female
Patients	42,148	31,936 (75.77%)	8,398 (19.93%)	1,814 (4.30%)	20,123 (47.74%)	22,025 (52.26%)
Scans	181,342	140,445 (77.45%)	33,906 (18,70%)	6,991 (3.86%)	97,361 (53.69%)	83961 (46.21%)
Age	62.6 ± 16.6	63.9 ± 16.3	57.7 ± 16.7	62.1 ± 17.8	62.32 ± 15.8	63.0 ± 17.5
Test set						
	All	White	Black	Asian	Male	Female
Patients	257	205 (79.77%)	45 (17.51%)	7 (2.72%)	141 (54.86%)	116 (45.14%)
Scans	3,041	2,235 (73.50%)	676 (22.22%)	130 (4.27%)	1,658 (54.52%)	1,383 (45.48%)
Age	65.8 ± 12.1	66.2 ± 12.3	64.1 ± 11.9	67.4 ± 9.5	66.0 ± 11.6	65.4 ± 12.8
CheXpert						
Training set						
	All	White	Black	Asian	Male	Female
Patients	25,730	20,034 (77.86%)	1,751 (6.81%))	3,945 (15.33%)	14,165 (55.05%)	11,565 (44.95%)
Scans	76,205	59,238 (77.73%)	5,596 (7.34%)	11,371 (14.92%)	44,774 (58.75%)	31,431 (41.25%)
Age	63.1 ± 17.4	64.3 ± 17.2	55.7 ± 17.4	61.6 ± 17.4	62.5 ± 17.0	63.8 ± 17.9
Test set						
	All	White	Black	Asian	Male	Female
Patients	12,866	9,956 (77.38%)	879 (6.83%)	2,031 (15.79%)	7,091 (55.11%)	5,775 (44.89%)
Scans	38,240	29,844 (78.04%)	2746 (7.18%)	5,650 (14.278%)	22,265 (58.22%)	15,975 (41.78%)
Age	63.3 ± 17.2	64.2 ± 17.1	57.4 ± 16.3	61.1 ± 17.6	62.8 ± 16.4	63.9 ± 18.3

Table T.1: Statistics of the utilized MIMIC and CheXpert subsets per split and subgroups.

Influence of Protected Features on Model Prediction

The following figures are an extension of the results presented in Section and visualize Table 1. This includes the distribution of coefficients and p-values over ten randomly initialized runs obtained from the *evaluation model*. The results are shown for the three exemplary labels *Pleural Effusion*, *Cardiomegaly*, and *No Finding*.

Pathology: Pleural Effusion

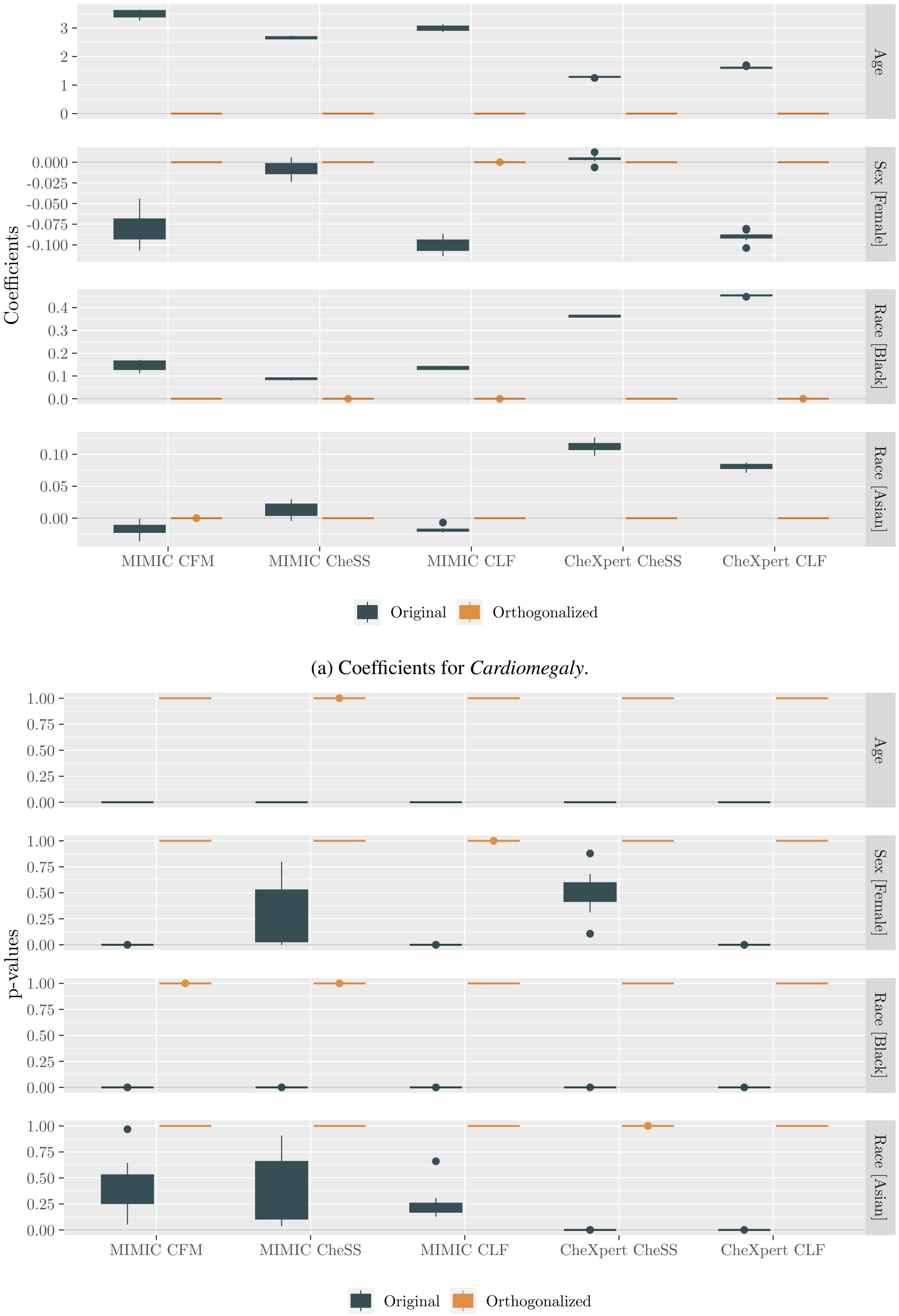


(a) Coefficients for *Pleural Effusion*.

(b) p-values associated with the respective coefficients.

Figure F.1: Distribution of derived coefficients and p-values for 10 downstream models per embedding and protected feature category on the label *Pleural Effusion*.

Pathology: Cardiomegaly

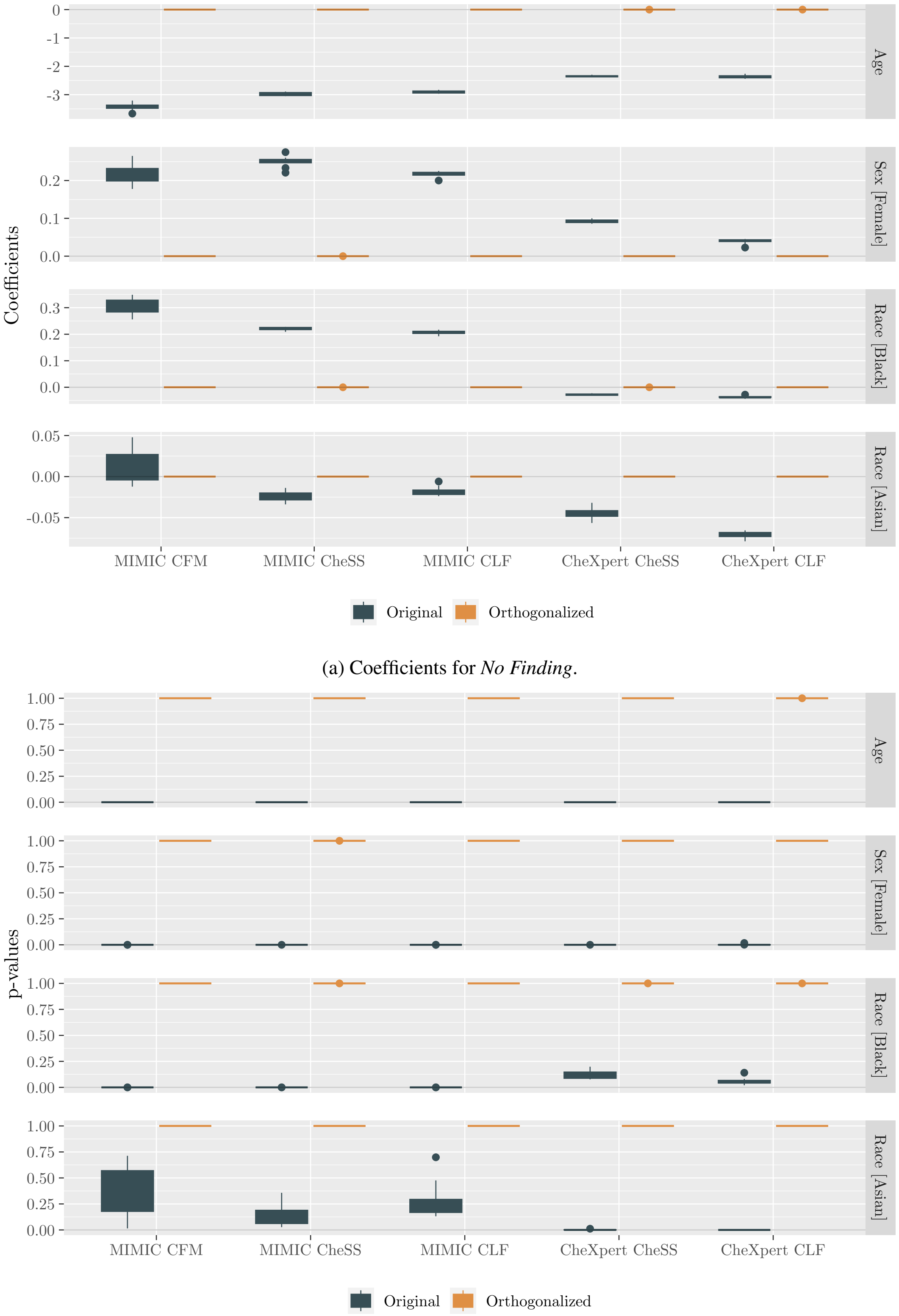


(a) Coefficients for *Cardiomegaly*.

(b) p-values associated with the respective coefficients.

Figure F.2: Distribution of derived coefficients and p-values for 10 downstream models per embedding and protected feature category on the label *Cardiomegaly*.

Pathology: No Finding



(a) Coefficients for *No Finding*.

(b) p-values associated with the respective coefficients.

Figure F.3: Distribution of derived coefficients and p-values for 10 downstream models per embedding and protected feature category on the label *No Finding*.

Predicting Protected Information

			Age		Sex			Race [White]			Race [Black]			Race [Asian]		
	Emb.	**Orthogonalized?**	**MAE**	**R^2**	**AUC**	**Sens.**	**Spec.**	**AUC**	**Sens.**	**Spec.**	**AUC**	**Sens.**	**Spec.**	**AUC**	**Sens.**	**Spec.**
MIMIC	CFM	✗	8.040 ±1.456	0.314 ±0.241	0.979 ±0.000	0.933 ±0.025	0.902 ±0.039	0.848 ±0.004	0.940 ±0.016	0.497 ±0.049	0.871 ±0.004	0.521 ±0.055	0.944 ±0.015	0.870 ±0.005	0.179 ±0.028	0.991 ±0.005
		✓	10.969 ±0.433	-0.294 ±0.087	0.507 ±0.031	0.775 ±0.077	0.224 ±0.100	0.501 ±0.045	1.000 ±0.000	0.000 ±0.000	0.509 ±0.042	0.000 ±0.000	1.000 ±0.000	0.464 ±0.076	0.000 ±0.000	1.000 ±0.000
	CheSS	✗	7.893 ± 0.066	0.331 ± 0.010	0.945 ± 0.001	0.907 ± 0.011	0.820 ± 0.016	0.761 ± 0.004	0.975 ± 0.008	0.158 ± 0.039	0.768 ± 0.003	0.143 ± 0.039	0.968 ± 0.010	0.733 ± 0.004	0.013 ± 0.008	0.997 ± 0.002
		✓	9.908 ± 0.082	-0.083 ± 0.016	0.482 ± 0.037	0.982 ± 0.024	0.013 ± 0.025	0.489 ± 0.060	1.000 ± 0.000	0.000 ± 0.000	0.478 ± 0.068	0.000 ± 0.000	1.000 ± 0.000	0.514 ± 0.048	0.000 ± 0.000	1.000 ± 0.000
	CLF	✗	8.816 ± 0.063	0.161 ± 0.011	0.832 ± 0.000	0.804 ± 0.015	0.702 ± 0.016	0.631 ± 0.005	0.988 ± 0.004	0.048 ± 0.012	0.652 ± 0.005	0.050 ± 0.012	0.987 ± 0.005	0.663 ± 0.007	0.000 ± 0.000	1.000 ± 0.000
		✓	9.941 ± 0.095	-0.093 ± 0.025	0.456 ± 0.039	0.994 ± 0.007	0.007 ± 0.006	0.500 ± 0.048	1.000 ± 0.000	0.000 ± 0.000	0.498 ± 0.056	0.000 ± 0.000	1.000 ± 0.000	0.493 ± 0.084	0.000 ± 0.000	1.000 ± 0.000
CheXpert	CheSS	✗	9.333 ± 0.103	0.529 ± 0.009	0.946 ± 0.000	0.912 ± 0.008	0.821 ± 0.018	0.780 ± 0.001	0.984 ± 0.007	0.136 ± 0.038	0.762 ± 0.001	0.018 ± 0.006	0.999 ± 0.001	0.816 ± 0.001	0.173 ± 0.047	0.983 ± 0.007
		✓	13.875 ± 0.035	-0.009 ± 0.005	0.499 ± 0.010	1.000 ± 0.000	0.000 ± 0.000	0.501 ± 0.007	1.000 ± 0.000	0.000 ± 0.000	0.498 ± 0.015	0.000 ± 0.000	1.000 ± 0.000	0.500 ± 0.007	0.000 ± 0.000	1.000 ± 0.000
	CLF	✗	10.693 ± 0.047	0.385 ± 0.005	0.868 ± 0.000	0.854 ± 0.008	0.696 ± 0.014	0.721 ± 0.001	0.993 ± 0.003	0.040 ± 0.012	0.688 ± 0.002	0.003 ± 0.002	1.000 ± 0.000	0.764 ± 0.000	0.049 ± 0.016	0.993 ± 0.003
		✓	13.866 ± 0.035	-0.009 ± 0.005	0.496 ± 0.010	1.000 ± 0.000	0.000 ± 0.000	0.501 ± 0.008	1.000 ± 0.000	0.000 ± 0.000	0.497 ± 0.021	0.000 ± 0.000	1.000 ± 0.000	0.503 ± 0.009	0.000 ± 0.000	1.000 ± 0.000

Table T.2: Regression/Classification performance for deriving protected features from an embedding vector with mean and standard deviation over 10 randomly initialized runs. The displayed metrics include mean absolute error (MAE), R^2 for age regression as well as AUC, sensitivity (sens.), and specificity (spec.) for classification.

Dataset:	MIMIC									CheXpert					
Embedding:	CFM			CheSS			CLF			CheSS			CLF		
Orthogonalized?	✗	✓	Δ	✗	✓	Δ	✗	✓	Δ	✗	✓	Δ	✗	✓	Δ
Enl. Cardiomed.	0.728 ± 0.009	0.721 ± 0.018	-0.97 %	0.636 ± 0.003	0.643 ± 0.007	+1.09 %	0.601 ± 0.002	0.593 ± 0.004	-1.35 %	0.621 ± 0.001	0.636 ± 0.003	+2.36 %	0.634 ± 0.000	0.639 ± 0.001	+0.78 %
Cardiomegaly	0.780 ± 0.002	0.775 ± 0.003	-0.65 %	0.750 ± 0.001	0.751 ± 0.001	+0.13 %	0.737 ± 0.000	0.736 ± 0.001	-0.14 %	0.789 ± 0.000	0.791 ± 0.001	+0.25 %	0.799 ± 0.000	0.793 ± 0.000	-0.76 %
Lung Opacity	0.696 ± 0.003	0.684 ± 0.005	-1.75 %	0.626 ± 0.002	0.627 ± 0.004	+0.16 %	0.623 ± 0.001	0.612 ± 0.002	-1.80 %	0.685 ± 0.000	0.684 ± 0.000	-0.15 %	0.695 ± 0.000	0.690 ± 0.000	-0.72 %
Lung Lesion	0.731 ± 0.006	0.718 ± 0.007	-1.81 %	0.623 ± 0.003	0.630 ± 0.004	+1.11 %	0.576 ± 0.009	0.591 ± 0.014	+2.54 %	0.672 ± 0.002	0.700 ± 0.002	+4.00 %	0.701 ± 0.001	0.707 ± 0.002	+0.85 %
Edema	0.843 ± 0.001	0.837 ± 0.002	-0.72 %	0.804 ± 0.000	0.798 ± 0.000	-0.75 %	0.791 ± 0.000	0.783 ± 0.001	-1.02 %	0.791 ± 0.000	0.789 ± 0.000	-0.25 %	0.788 ± 0.000	0.783 ± 0.000	-0.64 %
Consolidation	0.748 ± 0.008	0.742 ± 0.009	-0.81 %	0.648 ± 0.001	0.650 ± 0.005	+0.31 %	0.638 ± 0.003	0.640 ± 0.002	+0.31 %	0.669 ± 0.001	0.683 ± 0.001	+2.05 %	0.689 ± 0.001	0.692 ± 0.002	+0.43 %
Pneumonia	0.703 ± 0.005	0.704 ± 0.004	+0.14 %	0.586 ± 0.005	0.597 ± 0.009	+1.84 %	0.589 ± 0.003	0.607 ± 0.002	+2.97 %	0.610 ± 0.002	0.652 ± 0.003	+6.44 %	0.652 ± 0.001	0.659 ± 0.004	+1.06 %
Atelectasis	0.746 ± 0.002	0.734 ± 0.004	-1.63 %	0.702 ± 0.000	0.696 ± 0.001	-0.86 %	0.685 ± 0.001	0.671 ± 0.001	-2.09 %	0.631 ± 0.000	0.636 ± 0.001	+0.79 %	0.632 ± 0.000	0.633 ± 0.001	+0.16 %
Pneumothorax	0.843 ± 0.005	0.830 ± 0.007	-1.57 %	0.649 ± 0.002	0.645 ± 0.005	-0.62 %	0.634 ± 0.003	0.638 ± 0.004	+0.63 %	0.732 ± 0.001	0.749 ± 0.001	+2.27 %	0.730 ± 0.001	0.740 ± 0.001	+1.35 %
Pleural Effusion	0.870 ± 0.001	0.859 ± 0.002	-1.28 %	0.802 ± 0.000	0.792 ± 0.001	-1.26 %	0.797 ± 0.000	0.781 ± 0.000	-2.05 %	0.792 ± 0.000	0.798 ± 0.000	+0.75 %	0.804 ± 0.000	0.801 ± 0.000	-0.37 %
Pleural Other	0.894 ± 0.009	0.874 ± 0.021	-2.29 %	0.711 ± 0.005	0.746 ± 0.011	+4.69 %	0.684 ± 0.006	0.693 ± 0.009	+1.30 %	0.723 ± 0.001	0.756 ± 0.004	+4.37 %	0.718 ± 0.001	0.718 ± 0.004	+0.00 %
Fracture	0.752 ± 0.007	0.739 ± 0.013	-1.76 %	0.643 ± 0.005	0.648 ± 0.009	+0.77 %	0.642 ± 0.004	0.652 ± 0.012	+1.53 %	0.668 ± 0.001	0.682 ± 0.003	+2.05 %	0.667 ± 0.001	0.673 ± 0.003	+0.89 %
Support Devices	0.909 ± 0.001	0.905 ± 0.001	-0.44 %	0.801 ± 0.000	0.801 ± 0.001	+0.00 %	0.767 ± 0.001	0.763 ± 0.001	-0.52 %	0.731 ± 0.000	0.748 ± 0.000	+2.27 %	0.711 ± 0.000	0.721 ± 0.000	+1.39 %
No Finding	0.801 ± 0.003	0.770 ± 0.005	-4.03 %	0.746 ± 0.001	0.725 ± 0.002	-2.90 %	0.747 ± 0.000	0.728 ± 0.001	-2.61 %	0.833 ± 0.000	0.824 ± 0.001	-1.09 %	0.854 ± 0.000	0.844 ± 0.000	-1.18 %
Total	0.789 ± 0.005	0.778 ± 0.009	-1.39 %	0.695 ± 0.003	0.696 ± 0.005	-0.14 %	0.679 ± 0.003	0.678 ± 0.006	-0.14 %	0.710 ± 0.001	0.723 ± 0.002	+1.83 %	0.720 ± 0.001	0.721 ± 0.002	+0.13 %

Table T.3: Prediction performance original versus orthogonalized data on the MIMIC and CheXpert datasets. The table shows the mean and standard deviation of the AUC over 10 randomly initialized runs. Additionally, Δ depicts the percentual change from the original to the corrected embedding AUC.

Downstream Prediction Performance

The following table provides additional metrics for the the labels *Pleural Effusion*, *Cardiomegaly* and *No Finding* and supplements and Table T.3.

Pathology:		**Pleural Effusion**		**Cardiomegaly**		**No Finding**	
	Ortho.:	✗	✓	✗	✓	✗	✓
MIMIC CFM	AUC	0.870 ± 0.001	0.856 ± 0.002	0.780 ± 0.001	0.767 ± 0.003	0.801 ± 0.003	0.786 ± 0.005
	Acc.	0.804 ± 0.003	0.784 ± 0.003	0.753 ± 0.004	0.751 ± 0.002	0.839 ± 0.005	0.821 ± 0.004
	Sens.	0.612 ± 0.037	0.485 ± 0.011	0.351 ± 0.083	0.169 ± 0.015	0.318 ± 0.063	0.474 ± 0.018
	Spec.	0.897 ± 0.016	0.929 ± 0.003	0.897 ± 0.034	0.961 ± 0.005	0.953 ± 0.018	0.896 ± 0.008
	Prec.	0.744 ± 0.020	0.768 ± 0.007	0.559 ± 0.029	0.608 ± 0.017	0.613 ± 0.057	0.500 ± 0.011
	F1	0.670 ± 0.016	0.594 ± 0.008	0.423 ± 0.059	0.264 ± 0.019	0.411 ± 0.047	0.486 ± 0.008
MIMIC CheSS	AUC	0.802 ± 0.000	0.792 ± 0.001	0.750 ± 0.000	0.742 ± 0.001	0.747 ± 0.001	0.737 ± 0.001
	Acc.	0.755 ± 0.002	0.737 ± 0.001	0.742 ± 0.002	0.740 ± 0.001	0.816 ± 0.004	0.797 ± 0.001
	Sens.	0.506 ± 0.046	0.320 ± 0.007	0.139 ± 0.048	0.054 ± 0.009	0.245 ± 0.023	0.372 ± 0.007
	Spec.	0.876 ± 0.022	0.939 ± 0.002	0.960 ± 0.015	0.987 ± 0.002	0.941 ± 0.010	0.889 ± 0.002
	Prec.	0.666 ± 0.019	0.716 ± 0.005	0.556 ± 0.011	0.597 ± 0.012	0.476 ± 0.019	0.423 ± 0.003
	F1	0.573 ± 0.023	0.442 ± 0.006	0.218 ± 0.061	0.099 ± 0.015	0.322 ± 0.016	0.396 ± 0.005
MIMIC CLF	AUC	0.797 ± 0.001	0.780 ± 0.000	0.737 ± 0.000	0.727 ± 0.001	0.747 ± 0.000	0.736 ± 0.001
	Acc.	0.748 ± 0.001	0.724 ± 0.002	0.739 ± 0.001	0.737 ± 0.000	0.819 ± 0.004	0.801 ± 0.003
	Sens.	0.508 ± 0.026	0.299 ± 0.012	0.065 ± 0.019	0.011 ± 0.002	0.322 ± 0.014	0.421 ± 0.013
	Spec.	0.864 ± 0.014	0.930 ± 0.005	0.982 ± 0.006	0.998 ± 0.000	0.928 ± 0.007	0.884 ± 0.007
	Prec.	0.644 ± 0.012	0.674 ± 0.008	0.573 ± 0.022	0.647 ± 0.063	0.496 ± 0.016	0.443 ± 0.008
	F1	0.567 ± 0.012	0.414 ± 0.011	0.115 ± 0.031	0.021 ± 0.003	0.390 ± 0.006	0.431 ± 0.006
CheXpert CheSS	AUC	0.793 ± 0.000	0.798 ± 0.000	0.789 ± 0.000	0.794 ± 0.001	0.833 ± 0.000	0.825 ± 0.001
	Acc.	0.726 ± 0.001	0.730 ± 0.000	0.875 ± 0.000	0.876 ± 0.000	0.915 ± 0.000	0.915 ± 0.000
	Sens.	0.616 ± 0.028	0.606 ± 0.004	0.053 ± 0.012	0.077 ± 0.006	0.099 ± 0.014	0.064 ± 0.010
	Spec.	0.800 ± 0.018	0.814 ± 0.003	0.996 ± 0.001	0.994 ± 0.001	0.992 ± 0.001	0.995 ± 0.001
	Prec.	0.679 ± 0.010	0.690 ± 0.002	0.642 ± 0.027	0.640 ± 0.019	0.546 ± 0.012	0.564 ± 0.016
	F1	0.645 ± 0.011	0.645 ± 0.002	0.097 ± 0.020	0.138 ± 0.009	0.167 ± 0.020	0.115 ± 0.015
CheXpert CLF	AUC	0.804 ± 0.000	0.801 ± 0.000	0.799 ± 0.000	0.794 ± 0.001	0.854 ± 0.000	0.844 ± 0.000
	Acc.	0.732 ± 0.001	0.731 ± 0.001	0.878 ± 0.000	0.878 ± 0.000	0.916 ± 0.000	0.915 ± 0.000
	Sens.	0.686 ± 0.021	0.670 ± 0.006	0.102 ± 0.014	0.122 ± 0.007	0.144 ± 0.029	0.161 ± 0.017
	Spec.	0.764 ± 0.014	0.772 ± 0.003	0.991 ± 0.002	0.989 ± 0.001	0.989 ± 0.003	0.987 ± 0.002
	Prec.	0.665 ± 0.006	0.668 ± 0.001	0.634 ± 0.021	0.619 ± 0.007	0.563 ± 0.013	0.541 ± 0.010
	F1	0.675 ± 0.007	0.669 ± 0.003	0.175 ± 0.020	0.204 ± 0.009	0.228 ± 0.034	0.248 ± 0.018

Table T.4: Prediction performance original versus orthogonalized data on the MIMIC and CheXpert datasets. The table shows the mean and standard deviation over 10 randomly initialized runs for the labels *Pleural Effusion*, *Cardiomegaly* and *No Finding* and the metrics AUC, accuracy, sensitivity, specificity, precision, and F1-score.