

Supplemental Material

TABLE I: Average accuracy on MC-CRC dataset with different proportions of the training data under one-round training. We report the results of five-fold cross-validation with their 95% confidence intervals. Centralized methods are used for baselines, **bold** is the highest among federated algorithms and **red** represents the highest among all methods including centralized learning. Prefix *R*- and *E*- indicate ResNet-50 and EfficientViT backbones pre-trained on ImageNet, respectively. Prefix *C*- indicates CTransPath backbone pre-trained on pathology images.

Models	Accuracy under One-round Training on MC-CRC						
	1%	5%	10%	30%	50%	70%	100%
<i>R-Centralized</i>	0.7185 (0.713, 0.720)	0.7913 (0.791, 0.799)	0.8819 (0.881, 0.884)	0.9033 (0.903, 0.905)	0.9306 (0.93, 0.931)	0.9414 (0.941, 0.942)	0.9450 (0.943, 0.945)
<i>R-Centralized-FC</i>	0.8334 (0.833, 0.835)	0.8970 (0.897, 0.897)	0.9129 (0.912, 0.913)	0.9260 (0.925, 0.926)	0.9378 (0.937, 0.938)	0.9412 (0.941, 0.942)	0.9458 (0.945, 0.946)
<i>R-FedAvg</i>	0.1465 (0.145, 0.148)	0.3095 (0.303, 0.315)	0.4025 (0.400, 0.408)	0.4145 (0.409, 0.417)	0.4461 (0.444, 0.448)	0.4823 (0.482, 0.486)	0.4345 (0.431, 0.435)
<i>R-FedProx</i>	0.1900 (0.189, 0.197)	0.2976 (0.294, 0.301)	0.4332 (0.432, 0.437)	0.4621 (0.462, 0.466)	0.4663 (0.463, 0.468)	0.4448 (0.444, 0.446)	0.4818 (0.480, 0.486)
<i>R-FedPAQ</i>	0.1984 (0.195, 0.200)	0.3373 (0.336, 0.341)	0.3798 (0.377, 0.382)	0.5208 (0.519, 0.523)	0.4778 (0.475, 0.479)	0.4919 (0.491, 0.495)	0.4994 (0.498, 0.504)
<i>R-FedAvg-FC</i>	0.7942 (0.794, 0.795)	0.8552 (0.855, 0.856)	0.8628 (0.862, 0.863)	0.8817 (0.881, 0.882)	0.8900 (0.890, 0.891)	0.8857 (0.885, 0.886)	0.8977 (0.897, 0.898)
<i>R-FedDBL(ours)</i>	0.8832 (0.883, 0.884)	0.8456 (0.845, 0.846)	0.9229 (0.922, 0.923)	0.9411 (0.941, 0.941)	0.9410 (0.941, 0.941)	0.9413 (0.941, 0.942)	0.9399 (0.939, 0.940)
<i>E-Centralized</i>	0.8001	0.8996	0.9190	0.9468	0.9490	0.9587	0.9614
<i>E-Centralized-FC</i>	0.8077 (0.807, 0.808)	0.8795 (0.879, 0.880)	0.9003 (0.899, 0.901)	0.9243 (0.924, 0.925)	0.9318 (0.931, 0.932)	0.9345 (0.934, 0.935)	0.9370 (0.936, 0.937)
<i>E-FedAvg</i>	0.6820 (0.678, 0.687)	0.7876 (0.786, 0.789)	0.7906 (0.790, 0.793)	0.8178 (0.817, 0.821)	0.8099 (0.808, 0.811)	0.8183 (0.818, 0.819)	0.8227 (0.822, 0.823)
<i>E-FedProx</i>	0.7166 (0.714, 0.719)	0.7879 (0.783, 0.789)	0.7683 (0.766, 0.769)	0.7939 (0.792, 0.796)	0.8181 (0.817, 0.818)	0.8108 (0.810, 0.813)	0.8211 (0.820, 0.823)
<i>E-FedPAQ</i>	0.6759 (0.672, 0.678)	0.7878 (0.786, 0.790)	0.7801 (0.778, 0.785)	0.8081 (0.806, 0.808)	0.8348 (0.833, 0.836)	0.8259 (0.826, 0.829)	0.8175 (0.816, 0.819)
<i>E-FedAvg-FC</i>	0.7190 (0.718, 0.720)	0.8298 (0.829, 0.830)	0.8535 (0.853, 0.854)	0.8821 (0.882, 0.883)	0.8916 (0.891, 0.892)	0.8977 (0.897, 0.898)	0.9013 (0.901, 0.901)
<i>E-FedDBL(ours)</i>	0.8515 (0.851, 0.852)	0.9132 (0.913, 0.914)	0.9275 (0.927, 0.928)	0.9331 (0.932, 0.933)	0.9329 (0.932, 0.933)	0.9328 (0.932, 0.933)	0.9330 (0.932, 0.933)
<i>C-Centralized-FC</i>	0.9390	0.9594	0.9670	0.9756	0.9788	0.9801	0.9817
<i>C-FedAvg-FC</i>	0.9074 (0.907, 0.908)	0.9382 (0.938, 0.939)	0.9455 (0.945, 0.946)	0.9536 (0.953, 0.954)	0.9563 (0.956, 0.956)	0.9577 (0.957, 0.958)	0.9595 (0.959, 0.960)
<i>C-FedDBL(ours)</i>	0.9213 (0.921, 0.922)	0.9640 (0.964, 0.964)	0.9654 (0.965, 0.966)	0.9663 (0.966, 0.967)	0.9668 (0.966, 0.967)	0.9669 (0.966, 0.967)	0.9669 (0.966, 0.967)

TABLE II: Average accuracy on BCSS dataset with different proportions of the training data under one-round training. For simplification, the detail settings can be found in Table I.

Models	Accuracy under One-round Training on BCSS						
	1%	5%	10%	30%	50%	70%	100%
<i>R-Centralized</i>	0.7654 (0.760, 0.769)	0.4843 (0.471, 0.488)	0.5879 (0.581, 0.601)	0.8757 (0.875, 0.887)	0.8888 (0.888, 0.891)	0.9033 (0.900, 0.905)	0.9392 (0.938, 0.939)
<i>R-Centralized-FC</i>	0.5806 (0.580, 0.582)	0.8106 (0.810, 0.812)	0.8640 (0.863, 0.865)	0.9345 (0.934, 0.935)	0.9490 (0.948, 0.949)	0.9543 (0.954, 0.955)	0.9600 (0.959, 0.960)
<i>R-FedAvg</i>	0.5972 (0.594, 0.598)	0.7495 (0.749, 0.752)	0.7062 (0.706, 0.712)	0.6959 (0.689, 0.698)	0.6611 (0.658, 0.669)	0.5889 (0.587, 0.591)	0.6420 (0.638, 0.649)
<i>R-FedProx</i>	0.5951 (0.592, 0.596)	0.7277 (0.725, 0.730)	0.7158 (0.709, 0.720)	0.7155 (0.709, 0.718)	0.6654 (0.663, 0.673)	0.6631 (0.655, 0.664)	0.6308 (0.622, 0.632)
<i>R-FedPAQ</i>	0.5929 (0.589, 0.593)	0.6679 (0.660, 0.670)	0.6592 (0.653, 0.663)	0.6776 (0.677, 0.681)	0.6025 (0.601, 0.604)	0.6812 (0.673, 0.684)	0.5374 (0.530, 0.546)
<i>R-FedAvg-FC</i>	0.5740 (0.573, 0.575)	0.6234 (0.619, 0.624)	0.7714 (0.770, 0.773)	0.8754 (0.875, 0.876)	0.9014 (0.901, 0.902)	0.9259 (0.926, 0.926)	0.9365 (0.936, 0.937)
<i>R-FedDBL(ours)</i>	0.9012 (0.900, 0.902)	0.9511 (0.951, 0.951)	0.9603 (0.960, 0.961)	0.9711 (0.971, 0.971)	0.9745 (0.974, 0.975)	0.9731 (0.973, 0.973)	0.9652 (0.965, 0.965)
<i>E-Centralized</i>	0.5384 (0.536, 0.544)	0.8444 (0.839, 0.847)	0.9098 (0.908, 0.911)	0.8791 (0.876, 0.882)	0.9298 (0.927, 0.930)	0.9350 (0.932, 0.936)	0.9448 (0.943, 0.946)
<i>E-Centralized-FC</i>	0.6241 (0.621, 0.624)	0.6188 (0.617, 0.619)	0.7845 (0.784, 0.786)	0.8777 (0.877, 0.878)	0.9127 (0.912, 0.913)	0.9344 (0.934, 0.935)	0.9458 (0.945, 0.946)
<i>E-FedAvg</i>	0.2230 (0.217, 0.230)	0.5790 (0.571, 0.587)	0.7258 (0.721, 0.737)	0.9364 (0.935, 0.937)	0.9327 (0.931, 0.933)	0.9449 (0.945, 0.946)	0.9384 (0.938, 0.940)
<i>E-FedProx</i>	0.2266 (0.221, 0.233)	0.6121 (0.603, 0.616)	0.7879 (0.787, 0.795)	0.9354 (0.934, 0.936)	0.9324 (0.931, 0.934)	0.9447 (0.943, 0.945)	0.9350 (0.935, 0.936)
<i>E-FedPAQ</i>	0.3283 (0.318, 0.336)	0.5841 (0.581, 0.591)	0.7843 (0.775, 0.787)	0.9406 (0.940, 0.941)	0.9397 (0.939, 0.940)	0.9444 (0.943, 0.945)	0.9368 (0.936, 0.938)
<i>E-FedAvg-FC</i>	0.4879 (0.477, 0.494)	0.5966 (0.595, 0.599)	0.5738 (0.573, 0.574)	0.7883 (0.787, 0.789)	0.8232 (0.823, 0.823)	0.8601 (0.860, 0.861)	0.8867 (0.886, 0.887)
<i>E-FedDBL(ours)</i>	0.8971 (0.897, 0.898)	0.9368 (0.936, 0.937)	0.9324 (0.932, 0.933)	0.9485 (0.948, 0.949)	0.9607 (0.960, 0.961)	0.9640 (0.964, 0.964)	0.9656 (0.965, 0.966)
<i>C-Centralized-FC</i>	0.6159 (0.614, 0.618)	0.5904 (0.589, 0.592)	0.6692 (0.668, 0.670)	0.8886 (0.886, 0.887)	0.9435 (0.943, 0.944)	0.9609 (0.960, 0.961)	0.9726 (0.972, 0.973)
<i>C-FedAvg-FC</i>	0.5858 (0.585, 0.587)	0.5772 (0.577, 0.578)	0.5676 (0.567, 0.568)	0.6689 (0.668, 0.669)	0.8072 (0.807, 0.807)	0.8537 (0.853, 0.854)	0.9072 (0.907, 0.908)
<i>C-FedDBL(ours)</i>	0.9593 (0.959, 0.960)	0.9754 (0.975, 0.976)	0.9777 (0.977, 0.978)	0.9770 (0.977, 0.978)	0.9834 (0.983, 0.983)	0.9883 (0.988, 0.988)	0.9910 (0.991, 0.991)

TABLE III: Average F1-score on MC-CRC dataset with different proportions of the training data under one-round training. For simplification, the detail settings can be found in Table I.

Models	F1-score under One-round Training on MC-CRC						
	1%	5%	10%	30%	50%	70%	100%
<i>R-Centralized</i>	0.7191 (0.714, 0.721)	0.7863 (0.786, 0.794)	0.8801 (0.879, 0.883)	0.9027 (0.902, 0.905)	0.9300 (0.929, 0.930)	0.9415 (0.941, 0.942)	0.9451 (0.943, 0.946)
<i>R-Centralized-FC</i>	0.8301 (0.829, 0.831)	0.8977 (0.898, 0.898)	0.9137 (0.914, 0.914)	0.9265 (0.926, 0.927)	0.9383 (0.938, 0.938)	0.9417 (0.942, 0.942)	0.9463 (0.946, 0.946)
<i>R-FedAvg</i>	0.0669 (0.065, 0.068)	0.2203 (0.214, 0.225)	0.3214 (0.320, 0.328)	0.3250 (0.320, 0.327)	0.3240 (0.322, 0.325)	0.3829 (0.383, 0.388)	0.3366 (0.332, 0.337)
<i>R-FedProx</i>	0.1086 (0.107, 0.115)	0.2110 (0.208, 0.214)	0.3468 (0.345, 0.350)	0.3576 (0.357, 0.361)	0.3627 (0.360, 0.366)	0.3468 (0.346, 0.350)	0.3981 (0.397, 0.402)
<i>R-FedPAQ</i>	0.1146 (0.111, 0.116)	0.2527 (0.252, 0.257)	0.2789 (0.277, 0.282)	0.4285 (0.426, 0.430)	0.3773 (0.374, 0.378)	0.3930 (0.392, 0.394)	0.4032 (0.402, 0.409)
<i>R-FedAvg-FC</i>	0.7912 (0.791, 0.792)	0.8527 (0.852, 0.853)	0.8610 (0.860, 0.861)	0.8805 (0.880, 0.881)	0.8896 (0.889, 0.890)	0.8841 (0.884, 0.884)	0.8971 (0.897, 0.898)
<i>R-FedDBL(ours)</i>	0.8833 (0.883, 0.884)	0.8502 (0.850, 0.851)	0.9268 (0.926, 0.927)	0.9443 (0.944, 0.945)	0.9443 (0.944, 0.945)	0.9445 (0.944, 0.945)	0.9432 (0.943, 0.944)
<i>E-Centralized</i>	0.7956 (0.794, 0.798)	0.8999 (0.899, 0.901)	0.9189 (0.917, 0.919)	0.9465 (0.946, 0.947)	0.9464 (0.944, 0.948)	0.9589 (0.959, 0.959)	0.9614 (0.961, 0.962)
<i>E-Centralized-FC</i>	0.8079 (0.807, 0.808)	0.8793 (0.879, 0.880)	0.9008 (0.900, 0.901)	0.9249 (0.924, 0.925)	0.9323 (0.932, 0.933)	0.9349 (0.934, 0.935)	0.9376 (0.937, 0.938)
<i>E-FedAvg</i>	0.6790 (0.675, 0.684)	0.7902 (0.789, 0.791)	0.7914 (0.791, 0.794)	0.8199 (0.820, 0.823)	0.8122 (0.810, 0.814)	0.8155 (0.815, 0.816)	0.8222 (0.821, 0.823)
<i>E-FedProx</i>	0.7112 (0.709, 0.714)	0.7852 (0.780, 0.787)	0.7667 (0.764, 0.767)	0.7973 (0.795, 0.799)	0.8207 (0.819, 0.821)	0.8088 (0.808, 0.812)	0.8209 (0.820, 0.822)
<i>E-FedPAQ</i>	0.6623 (0.658, 0.665)	0.7848 (0.782, 0.787)	0.7821 (0.780, 0.787)	0.8090 (0.807, 0.809)	0.8384 (0.837, 0.840)	0.8275 (0.827, 0.831)	0.8200 (0.819, 0.821)
<i>E-FedAvg-FC</i>	0.7045 (0.703, 0.706)	0.8288 (0.828, 0.829)	0.8522 (0.852, 0.853)	0.8814 (0.881, 0.881)	0.8907 (0.890, 0.891)	0.8973 (0.897, 0.898)	0.9008 (0.900, 0.901)
<i>E-FedDBL(ours)</i>	0.8525 (0.852, 0.853)	0.9159 (0.915, 0.916)	0.9298 (0.929, 0.930)	0.9348 (0.934, 0.935)	0.9345 (0.934, 0.935)	0.9345 (0.934, 0.935)	0.9347 (0.934, 0.935)
<i>C-Centralized-FC</i>	0.9396 (0.939, 0.940)	0.9599 (0.959, 0.96)	0.9673 (0.967, 0.968)	0.9757 (0.975, 0.976)	0.9789 (0.978, 0.979)	0.9802 (0.979, 0.980)	0.9817 (0.981, 0.982)
<i>C-FedAvg-FC</i>	0.9031 (0.903, 0.904)	0.9385 (0.938, 0.939)	0.9459 (0.945, 0.946)	0.9541 (0.954, 0.954)	0.9568 (0.956, 0.957)	0.9582 (0.958, 0.959)	0.9600 (0.959, 0.960)
<i>C-FedDBL(ours)</i>	0.9217 (0.921, 0.922)	0.9643 (0.964, 0.964)	0.9657 (0.965, 0.966)	0.9666 (0.966, 0.967)	0.9671 (0.967, 0.967)	0.9672 (0.967, 0.967)	0.9672 (0.967, 0.967)

TABLE IV: Average F1-score on BCSS dataset with different proportions of the training data under one-round training. For simplification, the detail settings can be found in Table I.

Models	F1-score under One-round Training on BCSS						
	1%	5%	10%	30%	50%	70%	100%
<i>R-Centralized</i>	0.5851 (0.569, 0.587)	0.2486 (0.244, 0.253)	0.4529 (0.448, 0.466)	0.8262 (0.826, 0.840)	0.8255 (0.824, 0.829)	0.8335 (0.825, 0.837)	0.8955 (0.893, 0.897)
<i>R-Centralized-FC</i>	0.2056 (0.204, 0.208)	0.4846 (0.483, 0.486)	0.7297 (0.726, 0.732)	0.8979 (0.896, 0.898)	0.9231 (0.922, 0.923)	0.9304 (0.930, 0.931)	0.9404 (0.939, 0.941)
<i>R-FedAvg</i>	0.2300 (0.225, 0.231)	0.4059 (0.405, 0.408)	0.3689 (0.368, 0.375)	0.3433 (0.336, 0.346)	0.2962 (0.293, 0.305)	0.2176 (0.215, 0.229)	0.2798 (0.276, 0.287)
<i>R-FedProx</i>	0.2276 (0.223, 0.229)	0.3968 (0.393, 0.398)	0.3578 (0.350, 0.362)	0.3600 (0.354, 0.363)	0.3024 (0.299, 0.311)	0.3052 (0.298, 0.307)	0.2633 (0.254, 0.265)
<i>R-FedPAQ</i>	0.2207 (0.215, 0.221)	0.3096 (0.301, 0.313)	0.2979 (0.289, 0.302)	0.3351 (0.334, 0.339)	0.2420 (0.239, 0.244)	0.3305 (0.323, 0.333)	0.2419 (0.241, 0.247)
<i>R-FedAvg-FC</i>	0.2004 (0.199, 0.202)	0.2650 (0.258, 0.266)	0.4161 (0.415, 0.417)	0.7445 (0.742, 0.747)	0.8192 (0.819, 0.820)	0.8764 (0.876, 0.877)	0.8959 (0.895, 0.896)
<i>R-FedDBL(ours)</i>	0.8471 (0.845, 0.848)	0.9227 (0.921, 0.923)	0.9413 (0.941, 0.941)	0.9578 (0.957, 0.958)	0.9638 (0.964, 0.964)	0.9621 (0.962, 0.962)	0.9550 (0.954, 0.955)
<i>E-Centralized</i>	0.4008 (0.395, 0.403)	0.7595 (0.753, 0.762)	0.8533 (0.851, 0.855)	0.8273 (0.824, 0.832)	0.8922 (0.888, 0.894)	0.8996 (0.895, 0.900)	0.9230 (0.921, 0.924)
<i>E-Centralized-FC</i>	0.2985 (0.293, 0.300)	0.2632 (0.260, 0.264)	0.4275 (0.427, 0.429)	0.7120 (0.709, 0.713)	0.8190 (0.818, 0.819)	0.8830 (0.882, 0.883)	0.9062 (0.905, 0.906)
<i>E-FedAvg</i>	0.1760 (0.173, 0.181)	0.4872 (0.479, 0.492)	0.6311 (0.627, 0.640)	0.8992 (0.897, 0.900)	0.8834 (0.880, 0.884)	0.9083 (0.907, 0.910)	0.8920 (0.891, 0.895)
<i>E-FedProx</i>	0.1816 (0.179, 0.186)	0.5028 (0.494, 0.506)	0.6901 (0.689, 0.697)	0.8936 (0.892, 0.894)	0.8950 (0.894, 0.897)	0.9087 (0.907, 0.909)	0.9038 (0.903, 0.906)
<i>E-FedPAQ</i>	0.2117 (0.205, 0.213)	0.4940 (0.492, 0.499)	0.7115 (0.704, 0.713)	0.8951 (0.893, 0.897)	0.9017 (0.901, 0.903)	0.9122 (0.911, 0.913)	0.8970 (0.896, 0.898)
<i>E-FedAvg-FC</i>	0.2560 (0.249, 0.258)	0.2284 (0.226, 0.232)	0.1932 (0.193, 0.193)	0.4306 (0.430, 0.431)	0.4989 (0.498, 0.501)	0.6515 (0.651, 0.652)	0.7428 (0.741, 0.743)
<i>E-FedDBL(ours)</i>	0.8141 (0.814, 0.815)	0.8890 (0.888, 0.890)	0.8949 (0.894, 0.895)	0.9187 (0.918, 0.919)	0.9359 (0.935, 0.936)	0.9395 (0.939, 0.940)	0.9430 (0.942, 0.943)
<i>C-Centralized-FC</i>	0.2572 (0.255, 0.261)	0.2191 (0.217, 0.222)	0.3272 (0.326, 0.328)	0.7578 (0.748, 0.750)	0.9035 (0.903, 0.904)	0.9392 (0.938, 0.939)	0.9614 (0.961, 0.961)
<i>C-FedAvg-FC</i>	0.2148 (0.214, 0.216)	0.1981 (0.197, 0.200)	0.1816 (0.181, 0.182)	0.3272 (0.326, 0.328)	0.4571 (0.457, 0.458)	0.6165 (0.616, 0.617)	0.8061 (0.805, 0.807)
<i>C-FedDBL(ours)</i>	0.9416 (0.941, 0.942)	0.9644 (0.964, 0.965)	0.9685 (0.968, 0.969)	0.9676 (0.967, 0.968)	0.9758 (0.975, 0.976)	0.9818 (0.981, 0.982)	0.9859 (0.985, 0.986)

TABLE V: Comparisons with different methods on 50-round training (Accuracy). For simplification, the detail settings can be found in Table I. † means models trained for 50 rounds.

Datasets	Models	Accuracy under Multiple-round Training						
		1%	5%	10%	30%	50%	70%	100%
MC-CRC	<i>R-Centralized</i> †	0.8830 (0.882, 0.883)	0.9308 (0.930, 0.932)	0.9508 (0.951, 0.952)	0.9713 (0.971, 0.971)	0.9789 (0.978, 0.979)	0.9817 (0.981, 0.982)	0.9846 (0.984, 0.985)
	<i>E-Centralized</i> †	0.8745 (0.873, 0.878)	0.9422 (0.941, 0.943)	0.9581 (0.958, 0.958)	0.9733 (0.973, 0.974)	0.9795 (0.979, 0.980)	0.9838 (0.983, 0.984)	0.9860 (0.986, 0.986)
	<i>R-FedAvg</i> †	0.8747 (0.874, 0.875)	0.9289 (0.928, 0.929)	0.9385 (0.938, 0.939)	0.9542 (0.954, 0.955)	0.9590 (0.959, 0.959)	0.9604 (0.960, 0.961)	0.9629 (0.962, 0.963)
	<i>R-FedProx</i> †	0.8786 (0.878, 0.879)	0.9289 (0.928, 0.929)	0.9409 (0.940, 0.941)	0.9549 (0.954, 0.955)	0.9586 (0.958, 0.959)	0.9615 (0.961, 0.962)	0.9622 (0.962, 0.962)
	<i>E-FedAvg</i> †	0.9175 (0.917, 0.918)	0.9433 (0.943, 0.943)	0.9493 (0.949, 0.950)	0.9621 (0.962, 0.962)	0.9655 (0.965, 0.966)	0.9282 (0.923, 0.932)	0.9701 (0.970, 0.970)
	<i>E-FedProx</i> †	0.9147 (0.914, 0.915)	0.9434 (0.943, 0.944)	0.9500 (0.950, 0.950)	0.9616 (0.961, 0.962)	0.9666 (0.966, 0.967)	0.9692 (0.969, 0.969)	0.9710 (0.971, 0.971)
	<i>R-FedDBL(ours)</i>	0.8832 (0.883, 0.884)	0.8456 (0.845, 0.846)	0.9229 (0.922, 0.923)	0.9411 (0.941, 0.941)	0.9410 (0.941, 0.941)	0.9413 (0.941, 0.942)	0.9399 (0.939, 0.940)
	<i>E-FedDBL(ours)</i>	0.8515 (0.851, 0.852)	0.9132 (0.913, 0.914)	0.9275 (0.927, 0.928)	0.9331 (0.932, 0.933)	0.9329 (0.932, 0.933)	0.9328 (0.932, 0.933)	0.9330 (0.932, 0.933)
	<i>C-FedDBL(ours)</i>	0.9213 (0.921, 0.922)	0.9640 (0.964, 0.964)	0.9654 (0.965, 0.966)	0.9663 (0.966, 0.967)	0.9668 (0.966, 0.967)	0.9669 (0.966, 0.967)	0.9669 (0.966, 0.967)
	<i>R-Centralized</i> †	0.8291 (0.822, 0.833)	0.9171 (0.915, 0.918)	0.9458 (0.945, 0.947)	0.9650 (0.965, 0.966)	0.9810 (0.981, 0.981)	0.9818 (0.982, 0.982)	0.9838 (0.983, 0.984)
	<i>E-Centralized</i> †	0.8603 (0.856, 0.861)	0.9525 (0.952, 0.953)	0.9542 (0.953, 0.955)	0.9634 (0.962, 0.964)	0.9802 (0.980, 0.981)	0.9830 (0.983, 0.983)	0.9828 (0.983, 0.984)
	<i>R-FedAvg</i> †	0.8657 (0.862, 0.868)	0.9334 (0.932, 0.934)	0.9393 (0.938, 0.940)	0.9634 (0.963, 0.964)	0.9730 (0.973, 0.973)	0.9804 (0.980, 0.980)	0.9834 (0.983, 0.983)
	<i>R-FedProx</i> †	0.8700 (0.868, 0.873)	0.9201 (0.918, 0.921)	0.9502 (0.948, 0.951)	0.9671 (0.967, 0.967)	0.9737 (0.973, 0.974)	0.9776 (0.977, 0.978)	0.9830 (0.983, 0.983)
	<i>E-FedAvg</i> †	0.8608 (0.859, 0.862)	0.9412 (0.941, 0.942)	0.9451 (0.943, 0.945)	0.9782 (0.978, 0.978)	0.9815 (0.981, 0.982)	0.9847 (0.984, 0.985)	0.9840 (0.984, 0.984)
	<i>E-FedProx</i> †	0.8873 (0.884, 0.888)	0.9395 (0.938, 0.940)	0.9575 (0.956, 0.958)	0.9763 (0.976, 0.976)	0.9784 (0.978, 0.979)	0.9849 (0.984, 0.985)	0.9852 (0.985, 0.985)
BCSS	<i>R-FedDBL(ours)</i>	0.9012 (0.900, 0.902)	0.9511 (0.951, 0.951)	0.9603 (0.960, 0.961)	0.9711 (0.971, 0.971)	0.9745 (0.974, 0.975)	0.9731 (0.973, 0.973)	0.9652 (0.965, 0.965)
	<i>E-FedDBL(ours)</i>	0.8971 (0.897, 0.898)	0.9368 (0.936, 0.937)	0.9324 (0.932, 0.933)	0.9485 (0.948, 0.949)	0.9607 (0.960, 0.961)	0.9640 (0.964, 0.964)	0.9656 (0.965, 0.966)
	<i>C-FedDBL(ours)</i>	0.9593 (0.959, 0.960)	0.9754 (0.975, 0.976)	0.9777 (0.977, 0.978)	0.9770 (0.977, 0.978)	0.9834 (0.983, 0.983)	0.9883 (0.988, 0.988)	0.9910 (0.991, 0.991)
	<i>R-Centralized</i> †	0.8291 (0.822, 0.833)	0.9171 (0.915, 0.918)	0.9458 (0.945, 0.947)	0.9650 (0.965, 0.966)	0.9810 (0.981, 0.981)	0.9818 (0.982, 0.982)	0.9838 (0.983, 0.984)
	<i>E-Centralized</i> †	0.8603 (0.856, 0.861)	0.9525 (0.952, 0.953)	0.9542 (0.953, 0.955)	0.9634 (0.962, 0.964)	0.9802 (0.980, 0.981)	0.9830 (0.983, 0.983)	0.9828 (0.983, 0.984)
	<i>R-FedAvg</i> †	0.8657 (0.862, 0.868)	0.9334 (0.932, 0.934)	0.9393 (0.938, 0.940)	0.9634 (0.963, 0.964)	0.9730 (0.973, 0.973)	0.9804 (0.980, 0.980)	0.9834 (0.983, 0.983)

TABLE VI: Comparisons with different methods on 50-round training (F1-score). For simplification, the detail settings can be found in Table I. † means models trained for 50 rounds.

Datasets	Models	F1-score under Multiple-round Training						
		1%	5%	10%	30%	50%	70%	100%
MC-CRC	<i>R-Centralized</i> †	0.8813 (0.881, 0.882)	0.9307 (0.930, 0.932)	0.9512 (0.951, 0.952)	0.9714 (0.971, 0.972)	0.9789 (0.978, 0.979)	0.9816 (0.981, 0.982)	0.9845 (0.984, 0.985)
	<i>E-Centralized</i> †	0.8741 (0.872, 0.877)	0.9427 (0.942, 0.943)	0.9581 (0.958, 0.958)	0.9732 (0.973, 0.973)	0.9794 (0.979, 0.980)	0.9837 (0.983, 0.984)	0.9859 (0.985, 0.986)
	<i>R-FedAvg</i> †	0.8720 (0.872, 0.873)	0.9283 (0.928, 0.928)	0.9386 (0.938, 0.939)	0.9545 (0.954, 0.955)	0.9592 (0.959, 0.959)	0.9607 (0.960, 0.961)	0.9632 (0.963, 0.963)
	<i>R-FedProx</i> †	0.8751 (0.875, 0.876)	0.9288 (0.928, 0.929)	0.9409 (0.940, 0.941)	0.9550 (0.955, 0.955)	0.9591 (0.959, 0.959)	0.9618 (0.961, 0.962)	0.9625 (0.962, 0.963)
	<i>E-FedAvg</i> †	0.9172 (0.917, 0.918)	0.9434 (0.943, 0.943)	0.9494 (0.949, 0.950)	0.9623 (0.962, 0.962)	0.9655 (0.965, 0.966)	0.9206 (0.914, 0.926)	0.9701 (0.970, 0.971)
	<i>E-FedProx</i> †	0.9147 (0.914, 0.915)	0.9437 (0.943, 0.944)	0.9502 (0.950, 0.950)	0.9617 (0.962, 0.962)	0.9669 (0.966, 0.967)	0.9693 (0.969, 0.969)	0.9712 (0.971, 0.972)
	<i>R-FedDBL(ours)</i>	0.8833 (0.883, 0.884)	0.8502 (0.850, 0.851)	0.9268 (0.926, 0.927)	0.9443 (0.944, 0.945)	0.9443 (0.944, 0.945)	0.9445 (0.944, 0.945)	0.9432 (0.943, 0.944)
	<i>E-FedDBL(ours)</i>	0.8525 (0.852, 0.853)	0.9159 (0.915, 0.916)	0.9298 (0.929, 0.930)	0.9348 (0.934, 0.935)	0.9345 (0.934, 0.935)	0.9345 (0.934, 0.935)	0.9347 (0.934, 0.935)
	<i>C-FedDBL(ours)</i>	0.9217 (0.921, 0.922)	0.9643 (0.964, 0.964)	0.9657 (0.965, 0.966)	0.9666 (0.966, 0.967)	0.9671 (0.967, 0.967)	0.9672 (0.967, 0.967)	0.9672 (0.967, 0.967)
	<i>R-Centralized</i> †	0.7671 (0.760, 0.771)	0.8798 (0.877, 0.881)	0.9182 (0.918, 0.920)	0.9554 (0.955, 0.957)	0.9722 (0.972, 0.972)	0.9756 (0.975, 0.976)	0.9761 (0.975, 0.977)
	<i>E-Centralized</i> †	0.7782 (0.772, 0.779)	0.9280 (0.927, 0.929)	0.9370 (0.935, 0.938)	0.9527 (0.951, 0.954)	0.9717 (0.971, 0.972)	0.9775 (0.977, 0.978)	0.9766 (0.976, 0.978)
	<i>R-FedAvg</i> †	0.8088 (0.804, 0.814)	0.9003 (0.898, 0.901)	0.8999 (0.897, 0.902)	0.9448 (0.944, 0.946)	0.9598 (0.959, 0.960)	0.9721 (0.972, 0.972)	0.9741 (0.974, 0.974)
	<i>R-FedProx</i> †	0.8095 (0.807, 0.813)	0.8851 (0.883, 0.886)	0.9293 (0.926, 0.930)	0.9522 (0.952, 0.953)	0.9599 (0.959, 0.961)	0.9669 (0.966, 0.967)	0.9769 (0.976, 0.977)
	<i>E-FedAvg</i> †	0.7724 (0.768, 0.773)	0.9051 (0.904, 0.906)	0.9014 (0.897, 0.903)	0.9686 (0.968, 0.969)	0.9750 (0.975, 0.975)	0.9791 (0.979, 0.979)	0.9780 (0.978, 0.978)
	<i>E-FedProx</i> †	0.8270 (0.822, 0.828)	0.9036 (0.901, 0.904)	0.9382 (0.937, 0.939)	0.9653 (0.965, 0.966)	0.9696 (0.969, 0.970)	0.9776 (0.977, 0.978)	0.9778 (0.977, 0.978)
BCSS	<i>R-FedDBL(ours)</i>	0.8471 (0.845, 0.848)	0.9227 (0.921, 0.923)	0.9413 (0.941, 0.941)	0.9578 (0.957, 0.958)	0.9638 (0.964, 0.964)	0.9621 (0.962, 0.962)	0.9550 (0.954, 0.955)
	<i>E-FedDBL(ours)</i>	0.8141 (0.814, 0.815)	0.8890 (0.888, 0.890)	0.8949 (0.894, 0.895)	0.9187 (0.918, 0.919)	0.9359 (0.935, 0.936)	0.9395 (0.939, 0.940)	0.9430 (0.942, 0.943)
	<i>C-FedDBL(ours)</i>	0.9416 (0.941, 0.942)	0.9644 (0.964, 0.965)	0.9685 (0.968, 0.969)	0.9676 (0.967, 0.968)	0.9758 (0.975, 0.976)	0.9818 (0.981, 0.982)	0.9859 (0.985, 0.986)
	<i>R-Centralized</i> †	0.7671 (0.760, 0.771)	0.8798 (0.877, 0.881)	0.9182 (0.918, 0.920)	0.9554 (0.955, 0.957)	0.9722 (0.972, 0.972)	0.9756 (0.975, 0.976)	0.9761 (0.975, 0.977)
	<i>E-Centralized</i> †	0.7782 (0.772, 0.779)	0.9280 (0.927, 0.929)	0.9370 (0.935, 0.938)	0.9527 (0.951, 0.954)	0.9717 (0.971, 0.972)	0.9775 (0.977, 0.978)	0.9766 (0.976, 0.978)
	<i>R-FedAvg</i> †	0.8088 (0.804, 0.814)	0.9003 (0.898, 0.901)	0.8999 (0.897, 0.902)	0.9448 (0.944, 0.946)	0.9598 (0.959, 0.960)	0.9721 (0.972, 0.972)	0.9741 (0.974, 0.974)