

Supplementary Material

Supplemental Table 1: ICD-9-CM and ICD-10-CM CHD Code Inclusion Criteria.

Click 126	ICD-9-CM	ICD-10-CM
Severe (15 ICD-9-CM codes and 14 ICD-10-CM codes)		
Hypoplastic Left Heart Syndrome (HLHS)	746.7	Q23.4
Tricuspid Atresia, stenosis or absence	746.1	Q22.4
Hypoplastic right heart syndrome		Q22.6
Single ventricle, cor triloculare, double inlet left ventricle	745.3	Q20.4
Cor biloculare	745.7	
Pulmonary valve atresia or absence	746.01	Q22.0
Truncus Arteriosus, Common Truncus	745.0	Q20.0
Double outlet Right ventricle (DORV)	745.11	Q20.1
Double outlet Left ventricle (DOLV)		Q20.2
Tetralogy of Fallot	745.2	Q21.3
Transposition of the Great arteries (TGA), Complete TGA, dextro-TGA, TGA not otherwise specified, classical TGA ¹	745.1	Q20.3
	745.10	
	745.19	
Congenital Corrected transposition of great arteries (CCTGA), levo-TGA	745.12	Q20.5
Endocardial cushion defect; Atrioventricular septal defect; Complete atrioventricular canal defect (CAVCD) Endocardial cushion defect unspecified Endocardial cushion defect, other ¹	745.6	Q21.2
	745.60	
	745.69	
Interrupted aortic arch	747.11	Q25.21
Total anomalous pulmonary venous return (TAPVR)	747.41	Q26.2
SHUNT AND VALVE²		
SHUNT (7 ICD-9-CM codes and 8 ICD-10-CM codes)³		
Ventricular septal defect (VSD)	745.4	Q21.0
Secundum atrial septal defect (ASD)	745.5	Q21.1
Primum atrial septal defect	745.61	
Other specified defects of septal closure, sinus venosus ASD, inferior sinus venosus ASD, superior sinus venosus ASD	745.8	Q21.8
Congenital malformation of cardiac septum, unspecified		Q21.9
Unspecified defect of septal closure	745.9	
Patent ductus arteriosus (PDA)	747.0	Q25.0
Aortopulmonary septal defect (AP window)		Q21.4
Partial anomalous pulmonary venous return (PAPVR)	747.42	Q26.3

Anomalous pulmonary venous connection, unspecified		Q26.4
VALVE (14 ICD-9-CM codes and 22 ICD-10-CM codes)⁴		
Anomalies of the pulmonary valve; Pulmonary valve anomaly unspecified ¹	746.0	Q22.3
	746.00	
Pulmonary valve stenosis (PS)	746.02	Q22.1
Pulmonary valve anomaly, other, pulmonary valve regurgitation	746.09	Q22.2
Ebstein anomaly of the tricuspid valve	746.2	Q22.5
Congenital malformations of tricuspid valve		Q22.8
Congenital malformation of tricuspid valve, unspecified		Q22.9
Aortic valve stenosis (AS)	746.3	Q23.0
Aortic insufficiency or bicuspid or unicuspid aortic valve	746.4	Q23.1
Other congenital malformations of aortic and mitral valves		Q23.8
Congenital malformation of aortic and mitral valves, and specified		Q23.9
Mitral stenosis or mitral valve abnormalities	746.5	Q23.2
Mitral insufficiency, cleft mitral valve	746.6	Q23.3
Subaortic stenosis, subaortic membrane	746.81	Q24.4
Infundibular or subvalvular pulmonary stenosis	746.83	Q24.3
Coarctation of the aorta ¹	747.1	Q25.1
	747.10	
Supravalvular aortic stenosis		Q25.3
Hypoplasia of the aorta		Q25.42
Atresia or stenosis of aorta	747.22	Q25.29
Absence and aplasia of aorta		Q25.41
Atresia of pulmonary artery		Q25.5
Pulmonary artery atresia, coarctation, or hypoplasia of the branch pulmonary arteries	747.31	Q25.71
Anomalies of the pulmonary artery, other	747.39	Q25.79
OTHER CHD (2 ICD-9-CM codes and 2 ICD-10-CM codes)⁵		
Cor triatriatum	746.82	Q24.2
Coronary artery anomaly, anomalous coronary artery, anomalous left coronary artery off the pulmonary artery (ALCAPA), anomalous right coronary artery off the pulmonary artery (ARCAPA)	746.85	Q24.5
OTHER VASCULAR (3 ICD-10-CM codes)⁶		
Double aortic arch		Q25.45
Right aortic arch component of Vascular ring		Q25.47
Anomalous origin of the subclavian artery component of vascular ring		Q25.48

¹ Some ICD-9-CM codes were adjusted over time to include an additional decimal place, but are considered the same code

² Cases with no Severe codes and has both Shunt AND Valve codes.

³ Cases with Shunt codes with or without any other group codes, but no Severe or Valve codes.

⁴ Case with Valve codes with or without any other group codes, but no Severe or Shunt codes.

⁵ Cases with only 'Other CHD' type group codes, AND no Severe, Shunt or Valve codes.

⁶Cases with 'Other Vascular' codes required either code Q25.45 or the combination of Q25.47 and Q25.48 to be included.

Notes. The following 25 ICD-9-CM codes were excluded from the case definition: 746.84 obstructive heart anomalies NEC, 746.86 congenital heart block, 746.87 malposition of heart, 746.89 congenital heart anomaly NEC, 746.9 congenital heart anomaly NOS, 747.20 congenital anomaly of aorta NOS, 747.21 anomalies of aortic arch, 747.29 congenital anomalies of aorta NEC, 747.3 pulmonary artery anomaly, 747.32 pulmonary AV malformation, 747.39 other anomalies of the pulmonary artery and circulation, 747.40 Great vein anomaly NOS, 747.49 great vein anomaly NEC, 747.5 and umbilical artery absence, 747.6 (end 1993) peripheral vascular anomaly NEC, 747.60 (begin 1993) unspecified peripheral vascular anomaly, 747.61 GI vessel anomaly, 747.62 renal vessel anomaly, 747.63 upper limb vessel anomaly, 747.64 lower limb vessel anomaly, 747.69 other specified peripheral vascular anomaly, 747.81 cerebrovascular anomaly, 747.82 spinal vessel anomaly, 747.83 persistent fetal circulation, 747.89 circulatory anomaly NEC, 747.9 circulatory anomaly NOS.

The following 24 ICD-10-CM codes were excluded from the case definition: Q20.6 isomerism of atrial appendages, Q20.8 other congenitally malformations of cardiac chambers and connections, Q20.9 congenital malformation of cardiac chambers and connections unspecified, Q24.0 malposition of heart or Apex, dextrocardia, Q24.1 levocardia, Q24.8 other specified congenital malformations of the heart, Q24.9 unspecified defect of the heart, Q25.40 anomalies of aorta, unspecified, Q25.43 congenital aneurysm of aorta, Q25.4 for congenital dilation of aorta, Q25.46 torturous aortic arch, Q25.47 right aortic arch, Q25.49 other congenital malformations of aorta, Q25.6 branch pulmonary artery stenosis, Q25.72 congenital pulmonary arteriovenous malformation, Q25.79 other congenital malformations of the pulmonary artery, Q25.8 other congenital malformations of other great arteries, Q25.9 congenital malformation of great arteries unspecified, Q26.0 congenital stenosis vena cava, Q26.1 left superior vena cava, Q26.5 anomalous portal venous connection, Q26.6 portal vein – hepatic artery fistula, Q26.8 other congenital malformations of great veins, Q26.9 anomalies of great veins unspecified.

Abbreviations: CHD = congenital heart defect; ICD-9-CM = International Classification of Diseases 9th revision, Clinical Modification; ICD-10-CM = International Classification of Diseases 10th revision, Clinical Modification.

Supplemental Table 2: ICD codes in Clinical Classification Software Categories

CCS/CCSR Category ICD9/10 Codes	ICD-9-CM	ICD-10-CM
Cardiac Anomalies - CCS_DX_Single_213.0		
COMMON TRUNCUS	'7450 '	
COMPL TRANSPOS GREAT VES	'74510'	
DOUBLE OUTLET RT VENTRIC	'74511'	
CORRECT TRANSPOS GRT VES	'74512'	
TRANSPOS GREAT VESS NEC	'74519'	
TETRALOGY OF FALLOT	'7452 '	
COMMON VENTRICLE	'7453 '	
VENTRICULAR SEPT DEFECT	'7454 '	
SECUNDUM ATRIAL SEPT DEF	'7455 '	
ENDOCARD CUSHION DEF NOS	'74560'	
OSTIUM PRIMUM DEFECT	'74561'	
ENDOCARD CUSHION DEF NEC	'74569'	
COR BILOCULARE	'7457 '	
SEPTAL CLOSURE ANOM NEC	'7458 '	
SEPTAL CLOSURE ANOM NOS	'7459 '	
PULMONARY VALVE ANOM NOS	'74600'	
CONG PULMON VALV ATRESIA	'74601'	
CONG PULMON VALVE STENOS	'74602'	
PULMONARY VALVE ANOM NEC	'74609'	
CONG TRICUSP ATRES/STEN	'7461 '	
EBSTEIN-s ANOMALY	'7462 '	
CONG AORTA VALV STENOSIS	'7463 '	
CONG AORTA VALV INSUFFIC	'7464 '	
CONGEN MITRAL STENOSIS	'7465 '	
CONG MITRAL INSUFFICIENC	'7466 '	
HYPOPLAS LEFT HEART SYND	'7467 '	
CONG SUBAORTIC STENOSIS	'74681'	
COR TRIATRIATUM	'74682'	
INFUNDIB PULMON STENOSIS	'74683'	
OBSTRUCT HEART ANOM NEC	'74684'	
CORONARY ARTERY ANOMALY	'74685'	
CONGENITAL HEART BLOCK	'74686'	
MALPOSITION OF HEART	'74687'	
CONG HEART ANOMALY NEC	'74689'	
CONG HEART ANOMALY NOS	'7469 '	
PATENT DUCTUS ARTERIOSUS	'7470 '	
COARCTATION OF AORTA	'74710'	
INTERRUPT OF AORTIC ARCH	'74711'	

CONG ANOM OF AORTA NOS	'74720'	
ANOMALIES OF AORTIC ARCH	'74721'	
AORTIC ATRESIA/STENOSIS	'74722'	
CONG ANOM OF AORTA NEC	'74729'	
PULMONARY ARTERY ANOM (end 2011)	'7473 '	
Pulmon art coarct/atres (Begin 2011)	'74731'	
Pulmonary AV malformatn (Begin 2011)	'74732'	
Oth anom pul artery/circ (Begin 2011)	'74739'	
GREAT VEIN ANOMALY NOS	'74740'	
TOT ANOM PULM VEN CONNEC	'74741'	
PART ANOM PULM VEN CONN	'74742'	
GREAT VEIN ANOMALY NEC	'74749'	
UMBILICAL ARTERY ABSENCE	'7475 '	
PERIPH VASCULAR ANOM NEC (End 1993)	'7476 '	
UNSPEC PERIPH VASCULAR ANOM (Begin 1993)	'74760'	
GI VESSEL ANOMALY (Begin 1993)	'74761'	
RENAL VESSEL ANOMALY (Begin 1993)	'74762'	
UP LIMB VESSEL ANOMALY (Begin 1993)	'74763'	
LOWER LIMB VESSEL ANOMALY (Begin 1993)	'74764'	
OTH SPEC PERIPH VASCULAR ANOM (Begin 1993)	'74769'	
CEREBROVASCULAR ANOMALY	'74781'	
SPINAL VESSEL ANOMALY (Begin 1993)	'74782'	
PERSISTENT FETAL CIRCULATION (Begin 2002)	'74783'	
CIRCULATORY ANOMALY NEC	'74789'	
CIRCULATORY ANOMALY NOS	'7479 '	
Hx-cong malform-heart (Begin 2010)	'V1365'	
Other Congenital Anomalies of the Heart - CCS_DX_3_14.1.20		
Tetralogy of Fallot	'7452 '	
Cardiac And Circulatory Congenital Anomalies - CCSR_MAL001		
Abnormal findings on neonatal screening for critical congenital heart disease		P095
Common arterial trunk		Q200
Double outlet right ventricle		Q201
Double outlet left ventricle		Q202
Discordant ventriculoarterial connection		Q203
Double inlet ventricle		Q204
Discordant atrioventricular connection		Q205
Isomerism of atrial appendages		Q206
Other congenital malformations of cardiac chambers and connections		Q208
Congenital malformation of cardiac chambers and connections, unspecified		Q209
Ventricular septal defect		Q210
Atrial septal defect		Q211
Atrioventricular septal defect		Q212

Tetralogy of Fallot	Q213
Aortopulmonary septal defect	Q214
Other congenital malformations of cardiac septa	Q218
Congenital malformation of cardiac septum, unspecified	Q219
Pulmonary valve atresia	Q220
Congenital pulmonary valve stenosis	Q221
Congenital pulmonary valve insufficiency	Q222
Other congenital malformations of pulmonary valve	Q223
Congenital tricuspid stenosis	Q224
Ebsteins anomaly	Q225
Hypoplastic right heart syndrome	Q226
Other congenital malformations of tricuspid valve	Q228
Congenital malformation of tricuspid valve, unspecified	Q229
Congenital stenosis of aortic valve	Q230
Congenital insufficiency of aortic valve	Q231
Congenital mitral stenosis	Q232
Congenital mitral insufficiency	Q233
Hypoplastic left heart syndrome	Q234
Other congenital malformations of aortic and mitral valves	Q238
Congenital malformation of aortic and mitral valves, unspecified	Q239
Dextrocardia	Q240
Levocardia	Q241
Cor triatriatum	Q242
Pulmonary infundibular stenosis	Q243
Congenital subaortic stenosis	Q244
Malformation of coronary vessels	Q245
Congenital heart block	Q246
Other specified congenital malformations of heart	Q248
Congenital malformation of heart, unspecified	Q249
Patent ductus arteriosus	Q250
Coarctation of aorta	Q251
Atresia of aorta	Q252
Interruption of aortic arch	Q2521
Other atresia of aorta	Q2529
Supravalvular aortic stenosis	Q253
Other congenital malformations of aorta	Q254
Congenital malformation of aorta unspecified	Q2540
Absence and aplasia of aorta	Q2541
Hypoplasia of aorta	Q2542
Congenital aneurysm of aorta	Q2543
Congenital dilation of aorta	Q2544
Double aortic arch	Q2545
Tortuous aortic arch	Q2546

Right aortic arch		Q2547
Anomalous origin of subclavian artery		Q2548
Other congenital malformations of aorta		Q2549
Atresia of pulmonary artery		Q255
Stenosis of pulmonary artery		Q256
Coarctation of pulmonary artery		Q2571
Congenital pulmonary arteriovenous malformation		Q2572
Other congenital malformations of pulmonary artery		Q2579
Other congenital malformations of other great arteries		Q258
Congenital malformation of great arteries, unspecified		Q259
Congenital stenosis of vena cava		Q260
Persistent left superior vena cava		Q261
Total anomalous pulmonary venous connection		Q262
Partial anomalous pulmonary venous connection		Q263
Anomalous pulmonary venous connection, unspecified		Q264
Anomalous portal venous connection		Q265
Portal vein-hepatic artery fistula		Q266
Other congenital malformations of great veins		Q268
Congenital malformation of great vein, unspecified		Q269
Congenital absence and hypoplasia of umbilical artery		Q270
Congenital renal artery stenosis		Q271
Other congenital malformations of renal artery		Q272
Arteriovenous malformation, site unspecified		Q2730
Arteriovenous malformation of vessel of upper limb		Q2731
Arteriovenous malformation of vessel of lower limb		Q2732
Arteriovenous malformation of digestive system vessel		Q2733
Arteriovenous malformation of renal vessel		Q2734
Arteriovenous malformation, other site		Q2739
Congenital phlebectasia		Q274
Other specified congenital malformations of peripheral vascular system		Q278
Congenital malformation of peripheral vascular system, unspecified		Q279
Arteriovenous malformation of precerebral vessels		Q280
Other malformations of precerebral vessels		Q281
Arteriovenous malformation of cerebral vessels		Q282
Other malformations of cerebral vessels		Q283
Other specified congenital malformations of circulatory system		Q288
Congenital malformation of circulatory system, unspecified		Q289
Atrial Septal Defect - CCS_DX_3_14.1.4		
Atrial septal defect	'7455 '	
Congenital Insufficiency of Aortic Valve - CCS_DX_3_14.1.14		
Congenital insufficiency of aortic valve	'7464 '	
Hypertension - CCS_DX_2_7.1		
Essential hypertension [98.]	'4011 '	

Essential hypertension [98.]	'4019 '	
Hypertensive heart and/or renal disease	'40200'	
Hypertensive heart and/or renal disease	'40201'	
Hypertensive heart and/or renal disease	'40210'	
Hypertensive heart and/or renal disease	'40211'	
Hypertensive heart and/or renal disease	'40290'	
Hypertensive heart and/or renal disease	'40291'	
Hypertensive heart and/or renal disease	'4030 '	
Hypertensive heart and/or renal disease	'40300'	
Hypertensive heart and/or renal disease	'40301'	
Hypertensive heart and/or renal disease	'4031 '	
Hypertensive heart and/or renal disease	'40310'	
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Hypertensive heart and/or renal disease	'40493'	
Other hypertensive complications	'4010 '	
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Other hypertensive complications	'40519'	
Other hypertensive complications	'40591'	
Other hypertensive complications	'40599'	
Other hypertensive complications	'4372 '	
Factors Influencing Healthcare - CCS_DX_2_17.2		
Rehabilitation care; fitting of prostheses; and adjustment of devices [254.]	'V520 '	
Rehabilitation care; fitting of prostheses; and adjustment of devices [254.]	'V521 '	

Rehabilitation care; fitting of prostheses; and adjustment of devices [254.]	'V524 '	
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Rehabilitation care; fitting of prostheses; and adjustment of devices [254.]	'V5882'	
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Other aftercare [257.]	'V5843'	

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Other aftercare [257.]	'V5861'	
Other aftercare [257.]	'V5862'	
Other aftercare [257.]	'V5863'	
Other aftercare [257.]	'V5864'	
Other aftercare [257.]	'V5865'	
Other aftercare [257.]	'V5866'	
Other aftercare [257.]	'V5867'	
Other aftercare [257.]	'V5868'	
Other aftercare [257.]	'V5869'	
Other aftercare [257.]	'V5871'	
Other aftercare [257.]	'V5872'	
Other aftercare [257.]	'V5873'	
Other aftercare [257.]	'V5874'	
Other aftercare [257.]	'V5875'	
Other aftercare [257.]	'V5876'	
Other aftercare [257.]	'V5877'	
Other aftercare [257.]	'V5878'	
Other aftercare [257.]	'V588 '	
Other aftercare [257.]	'V5881'	
Other aftercare [257.]	'V5883'	
Other aftercare [257.]	'V5889'	
Other aftercare [257.]	'V589 '	
Other aftercare [257.]	'V660 '	
Other aftercare [257.]	'V665 '	
Other aftercare [257.]	'V666 '	
Other aftercare [257.]	'V667 '	
Other aftercare [257.]	'V669 '	
Other aftercare [257.]	'V670 '	
Other aftercare [257.]	'V6700'	
Other aftercare [257.]	'V6701'	
Other aftercare [257.]	'V6709'	
Other aftercare [257.]	'V6751'	
Other aftercare [257.]	'V6759'	
Other aftercare [257.]	'V676 '	
Other aftercare [257.]	'V679 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'7929 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'79500'	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'79507'	
Other screening for suspected conditions (not mental disorders or	'79508'	

infectious disease) [258.]		
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'79518'	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'7954 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'79677'	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'79678'	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V280 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V281 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V282 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V283 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V284 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V285 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V288 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V2881'	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V2882'	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V2889'	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V289 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V715 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V7181'	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V7189'	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V7240'	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V7241'	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V760 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V761 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V7610'	

Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V813 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V814 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V815 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V816 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V820 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V821 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V822 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V823 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V824 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V825 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V826 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V8271'	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V8279'	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V828 '	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V8281'	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V8289'	
Other screening for suspected conditions (not mental disorders or infectious disease) [258.]	'V829 '	
Cardiac Dysrhythmias - CCS_DX_3_7.2.9		
Paroxysmal supraventricular tachycardia	'4270 '	
Paroxysmal ventricular tachycardia	'4271 '	
Atrial fibrillation	'42731'	
Atrial flutter	'42732'	
Premature beats	'42760'	
Premature beats	'42761'	
Premature beats	'42769'	
Sinoatrial node dysfunction	'42781'	
Other cardiac dysrhythmias	'4272 '	
Other cardiac dysrhythmias	'42789'	
Other cardiac dysrhythmias	'4279 '	

Other cardiac dysrhythmias	'7850 '	
Other cardiac dysrhythmias	'7851 '	
Ventricular Septal Defect - CCS_DX_3_14.1.3		
Ventricular septal defect	'7454 '	
Congenital Anomalies - CCS_DX_1_14.0		
	'V1365'	
Transposition of great vessels	'74510'	
Tetralogy of Fallot	'7452 '	
Ventricular septal defect	'7454 '	
Atrial septal defect	'7455 '	
Endocardial cushion defects	'74560'	
Endocardial cushion defects	'74561'	
Endocardial cushion defects	'74569'	
Pulmonary valve atresia and stenosis	'74600'	
Pulmonary valve atresia and stenosis	'74601'	
Pulmonary valve atresia and stenosis	'74602'	
Pulmonary valve atresia and stenosis	'74609'	
Aortic valve stenosis	'7463 '	
Patent ductus arteriosus	'7470 '	
Coarctation of aorta	'74710'	
Pulmonary artery anomalies	'7473 '	
Pulmonary artery anomalies	'74731'	
Pulmonary artery anomalies	'74732'	
Pulmonary artery anomalies	'74739'	
Cerebrovascular anomalies	'74781'	
Double outlet right ventricle	'74511'	
Common ventricle	'7453 '	
Congenital insufficiency of aortic valve	'7464 '	
Hypoplastic left heart syndrome	'7467 '	
Gastrointestinal vessel congenital anomaly	'74761'	
Persistent fetal circulation	'74783'	
Other anomalies of bulbus cordis and cardiac septal closure	'7450 '	
Other anomalies of bulbus cordis and cardiac septal closure	'74512'	
Other anomalies of bulbus cordis and cardiac septal closure	'74519'	
Other anomalies of bulbus cordis and cardiac septal closure	'7457 '	
Other anomalies of bulbus cordis and cardiac septal closure	'7458 '	
Other anomalies of bulbus cordis and cardiac septal closure	'7459 '	
Other heart valve congenital anomalies	'7461 '	
Other heart valve congenital anomalies	'7462 '	
Other heart valve congenital anomalies	'7465 '	
Other heart valve congenital anomalies	'7466 '	
Other congenital anomalies of the heart	'74681'	
Other congenital anomalies of the heart	'74682'	

Other congenital anomalies of the heart	'74683'	
Other congenital anomalies of the heart	'74684'	
Other congenital anomalies of the heart	'74685'	
Other congenital anomalies of the heart	'74686'	
Other congenital anomalies of the heart	'74687'	
Other congenital anomalies of the heart	'74689'	
Other congenital anomalies of the heart	'7469 '	
Other congenital anomalies of aorta	'74711'	
Other congenital anomalies of aorta	'74720'	
Other congenital anomalies of aorta	'74721'	
Other congenital anomalies of aorta	'74722'	
Other congenital anomalies of aorta	'74729'	
Other circulatory congenital anomalies	'74740'	
Other circulatory congenital anomalies	'74741'	
Other circulatory congenital anomalies	'74742'	
Other circulatory congenital anomalies	'74749'	
Other circulatory congenital anomalies	'7475 '	
Other circulatory congenital anomalies	'7476 '	
Other circulatory congenital anomalies	'74760'	
Other circulatory congenital anomalies	'74762'	
Other circulatory congenital anomalies	'74763'	
Other circulatory congenital anomalies	'74764'	
Other circulatory congenital anomalies	'74769'	
Other circulatory congenital anomalies	'74782'	
Other circulatory congenital anomalies	'74789'	
Other circulatory congenital anomalies	'7479 '	
	'V1367'	
Esophageal atresia/tracheoesophageal fistula	'7503 '	
Pyloric stenosis	'7505 '	
Rectal and large intestine atresia/stenosis	'7512 '	
Hirschsprungs disease	'7513 '	
'Meckel's diverticulum'	'7510 '	
Atresia and stenosis of small intestine	'7511 '	
Anomalies of intestinal fixation	'7514 '	
Other upper gastrointestinal congenital anomalies	'7500 '	
Other upper gastrointestinal congenital anomalies	'75010'	
Other upper gastrointestinal congenital anomalies	'75011'	
Other upper gastrointestinal congenital anomalies	'75012'	
Other upper gastrointestinal congenital anomalies	'75013'	
Other upper gastrointestinal congenital anomalies	'75015'	
Other upper gastrointestinal congenital anomalies	'75016'	
Other upper gastrointestinal congenital anomalies	'75019'	
Other upper gastrointestinal congenital anomalies	'75021'	

Other upper gastrointestinal congenital anomalies	'75022'	
Other upper gastrointestinal congenital anomalies	'75023'	
Other upper gastrointestinal congenital anomalies	'75024'	
Other upper gastrointestinal congenital anomalies	'75025'	
Other upper gastrointestinal congenital anomalies	'75026'	
Other upper gastrointestinal congenital anomalies	'75027'	
Other upper gastrointestinal congenital anomalies	'75029'	
Other upper gastrointestinal congenital anomalies	'7504 '	
Other upper gastrointestinal congenital anomalies	'7506 '	
Other upper gastrointestinal congenital anomalies	'7507 '	
Other upper gastrointestinal congenital anomalies	'7508 '	
Other upper gastrointestinal congenital anomalies	'7509 '	
Other lower gastrointestinal congenital anomalies	'7515 '	
Other lower gastrointestinal congenital anomalies	'75160'	
Other lower gastrointestinal congenital anomalies	'75161'	
Other lower gastrointestinal congenital anomalies	'75162'	
Other lower gastrointestinal congenital anomalies	'75169'	
Other lower gastrointestinal congenital anomalies	'7517 '	
Other lower gastrointestinal congenital anomalies	'7518 '	
Other lower gastrointestinal congenital anomalies	'7519 '	
	'V1362'	
Undescended testicle	'7525 '	
Undescended testicle	'75251'	
Undescended testicle	'75252'	
Hypospadias and epispadias	'7526 '	
Hypospadias and epispadias	'75261'	
Hypospadias and epispadias	'75262'	
Hypospadias and epispadias	'V1361'	
Obstructive genitourinary defect	'7532 '	
Obstructive genitourinary defect	'75320'	
Obstructive genitourinary defect	'75321'	
Obstructive genitourinary defect	'75322'	
Obstructive genitourinary defect	'75323'	
Obstructive genitourinary defect	'75329'	
Polycystic kidney	'75312'	
Polycystic kidney	'75313'	
Polycystic kidney	'75314'	
Other cystic kidney disease	'7531 '	
Other cystic kidney disease	'75310'	
Other cystic kidney disease	'75311'	
Other cystic kidney disease	'75315'	
Other cystic kidney disease	'75316'	
Other cystic kidney disease	'75317'	

Other cystic kidney disease	'75319'	
Embryonic cyst of fallopian tubes and broad ligaments	'75211'	
Other congenital anomalies of genitalia	'7520 '	
Other congenital anomalies of genitalia	'75210'	
Other congenital anomalies of genitalia	'75219'	
Other congenital anomalies of genitalia	'7522 '	
Other congenital anomalies of genitalia	'7523 '	
Other congenital anomalies of genitalia	'75231'	
Other congenital anomalies of genitalia	'75232'	
Other congenital anomalies of genitalia	'75233'	
Other congenital anomalies of genitalia	'75234'	
Other congenital anomalies of genitalia	'75235'	
Other congenital anomalies of genitalia	'75236'	
Other congenital anomalies of genitalia	'75239'	
Other congenital anomalies of genitalia	'75240'	
Other congenital anomalies of genitalia	'75241'	
Other congenital anomalies of genitalia	'75242'	
Other congenital anomalies of genitalia	'75243'	
Other congenital anomalies of genitalia	'75244'	
Other congenital anomalies of genitalia	'75245'	
Other congenital anomalies of genitalia	'75246'	
Other congenital anomalies of genitalia	'75247'	
Other congenital anomalies of genitalia	'75249'	
Other congenital anomalies of genitalia	'75263'	
Other congenital anomalies of genitalia	'75264'	
Other congenital anomalies of genitalia	'75265'	
Other congenital anomalies of genitalia	'75269'	
Other congenital anomalies of genitalia	'7527 '	
Other congenital anomalies of genitalia	'7528 '	
Other congenital anomalies of genitalia	'75281'	
Other congenital anomalies of genitalia	'75289'	
Other congenital anomalies of genitalia	'7529 '	
Other congenital anomalies of urinary system	'7530 '	
Other congenital anomalies of urinary system	'7533 '	
Other congenital anomalies of urinary system	'7534 '	
Other congenital anomalies of urinary system	'7535 '	
Other congenital anomalies of urinary system	'7536 '	
Other congenital anomalies of urinary system	'7537 '	
Other congenital anomalies of urinary system	'7538 '	
Other congenital anomalies of urinary system	'7539 '	
	'V1363'	
Spina bifida	'74100'	
Spina bifida	'74101'	

Spina bifida	'74102'	
Spina bifida	'74103'	
Spina bifida	'74190'	
Spina bifida	'74191'	
Spina bifida	'74192'	
Spina bifida	'74193'	
Congenital hydrocephalus	'7423 '	
Other spinal cord congenital anomalies	'74251'	
Other spinal cord congenital anomalies	'74253'	
Other spinal cord congenital anomalies	'74259'	
Microcephalus	'7421 '	
Other nervous system congenital anomalies	'7400 '	
Other nervous system congenital anomalies	'7401 '	
Other nervous system congenital anomalies	'7402 '	
Other nervous system congenital anomalies	'7420 '	
Other nervous system congenital anomalies	'7422 '	
Other nervous system congenital anomalies	'7424 '	
Other nervous system congenital anomalies	'7428 '	
Other nervous system congenital anomalies	'7429 '	
Cleft palate without cleft lip	'74900'	
Cleft palate without cleft lip	'74901'	
Cleft palate without cleft lip	'74902'	
Cleft palate without cleft lip	'74903'	
Cleft palate without cleft lip	'74904'	
Cleft lip with or without cleft palate	'74910'	
Cleft lip with or without cleft palate	'74911'	
Cleft lip with or without cleft palate	'74912'	
Cleft lip with or without cleft palate	'74913'	
Cleft lip with or without cleft palate	'74914'	
Cleft lip with or without cleft palate	'74920'	
Cleft lip with or without cleft palate	'74921'	
Cleft lip with or without cleft palate	'74922'	
Cleft lip with or without cleft palate	'74923'	
Cleft lip with or without cleft palate	'74924'	
Cleft lip with or without cleft palate	'74925'	
Congenital anomalies of the eye	'74300'	
Congenital anomalies of the eye	'74303'	
Congenital anomalies of the eye	'74306'	
Congenital anomalies of the eye	'74310'	
Congenital anomalies of the eye	'74311'	
Congenital anomalies of the eye	'74312'	
Congenital anomalies of the eye	'74320'	
Congenital anomalies of the eye	'74321'	

Congenital anomalies of the eye	'74322'	
Congenital anomalies of the eye	'74330'	
Congenital anomalies of the eye	'74331'	
Congenital anomalies of the eye	'74332'	
Congenital anomalies of the eye	'74333'	
Congenital anomalies of the eye	'74334'	
Congenital anomalies of the eye	'74335'	
Congenital anomalies of the eye	'74336'	
Congenital anomalies of the eye	'74337'	
Congenital anomalies of the eye	'74339'	
Congenital anomalies of the eye	'74341'	
Congenital anomalies of the eye	'74342'	
Congenital anomalies of the eye	'74343'	
Congenital anomalies of the eye	'74344'	
Congenital anomalies of the eye	'74345'	
Congenital anomalies of the eye	'74346'	
Congenital anomalies of the eye	'74347'	
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Congenital anomalies of the eye	'74349'	
Congenital anomalies of the eye	'74351'	
Congenital anomalies of the eye	'74352'	
Congenital anomalies of the eye	'74353'	
Congenital anomalies of the eye	'74354'	
Congenital anomalies of the eye	'74355'	
Congenital anomalies of the eye	'74356'	
Congenital anomalies of the eye	'74357'	
Congenital anomalies of the eye	'74358'	
Congenital anomalies of the eye	'74359'	
Congenital anomalies of the eye	'74361'	
Congenital anomalies of the eye	'74362'	
Congenital anomalies of the eye	'74363'	
Congenital anomalies of the eye	'74364'	
Congenital anomalies of the eye	'74365'	
Congenital anomalies of the eye	'74366'	
Congenital anomalies of the eye	'74369'	
Congenital anomalies of the eye	'7438 '	
Congenital anomalies of the eye	'7439 '	
Microtia (incomplete development of external ear)	'74423'	
Branchial cleft cyst or fistula	'74441'	
Branchial cleft cyst or fistula	'74442'	
Other face and neck congenital anomalies	'74400'	
Other face and neck congenital anomalies	'74401'	
Other face and neck congenital anomalies	'74402'	

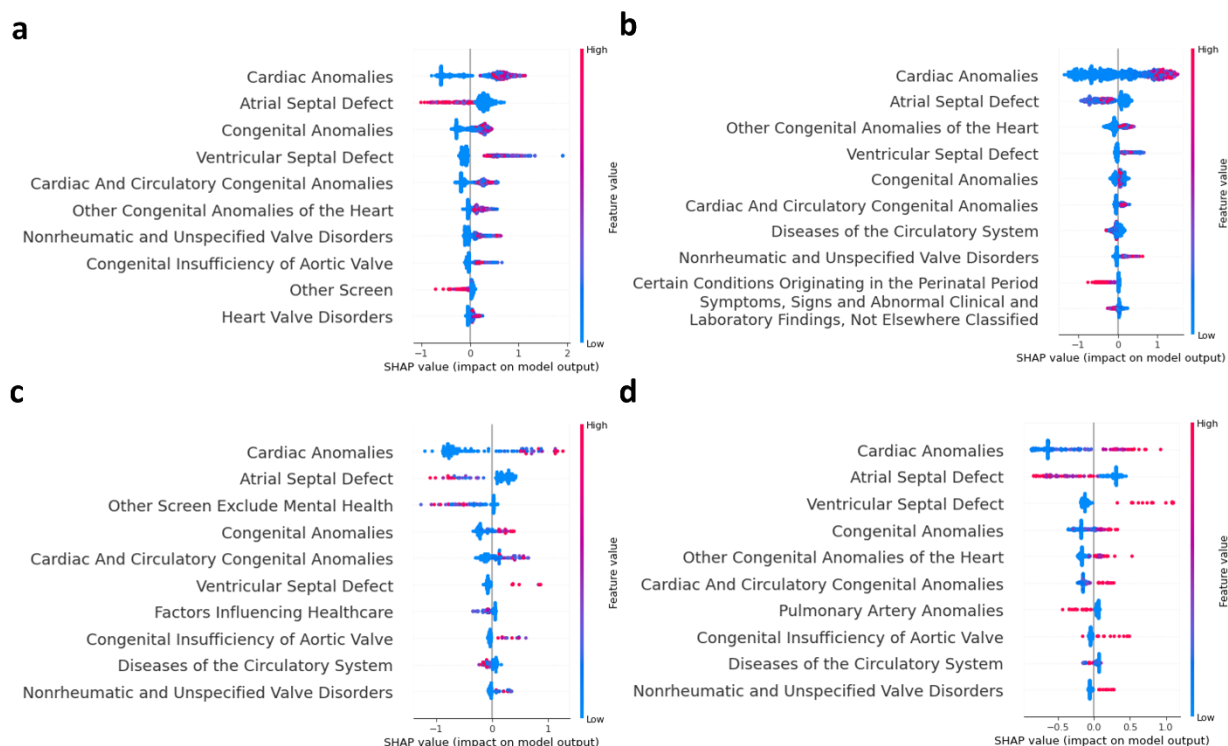
Other face and neck congenital anomalies	'74403'	
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Other face and neck congenital anomalies	'7441 '	
Other face and neck congenital anomalies	'74421'	
Other face and neck congenital anomalies	'74422'	
Other face and neck congenital anomalies	'74424'	
Other face and neck congenital anomalies	'74429'	
Other face and neck congenital anomalies	'7443 '	
Other face and neck congenital anomalies	'74443'	
Other face and neck congenital anomalies	'74446'	
Other face and neck congenital anomalies	'74447'	
Other face and neck congenital anomalies	'74449'	
Other face and neck congenital anomalies	'7445 '	
Other face and neck congenital anomalies	'74481'	
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Other face and neck congenital anomalies	'74483'	
Other face and neck congenital anomalies	'74484'	
Other face and neck congenital anomalies	'74489'	
Other face and neck congenital anomalies	'7449 '	
Congenital anomalies of larynx trachea and bronchus	'7482 '	
Congenital anomalies of larynx trachea and bronchus	'7483 '	
Other respiratory congenital anomalies	'7480 '	
Other respiratory congenital anomalies	'7481 '	
Other respiratory congenital anomalies	'7484 '	
Other respiratory congenital anomalies	'7485 '	
Other respiratory congenital anomalies	'74860'	
Other respiratory congenital anomalies	'74861'	
Other respiratory congenital anomalies	'74869'	
Other respiratory congenital anomalies	'7488 '	
Other respiratory congenital anomalies	'7489 '	
Foot deformities	'75450'	
Foot deformities	'75451'	
Foot deformities	'75452'	
Foot deformities	'75453'	
Foot deformities	'75459'	
Foot deformities	'75460'	
Foot deformities	'75461'	
Foot deformities	'75462'	
Foot deformities	'75469'	
Foot deformities	'75470'	
Foot deformities	'75471'	

Foot deformities	'75479'	
Congenital hip dislocation	'75430'	
Congenital hip dislocation	'75431'	
Congenital hip dislocation	'75432'	
Congenital hip dislocation	'75433'	
Congenital hip dislocation	'75435'	
Polydactyly (extra digits) and syndactyly (webbing between digits)	'75500'	
Polydactyly (extra digits) and syndactyly (webbing between digits)	'75501'	
Polydactyly (extra digits) and syndactyly (webbing between digits)	'75502'	
Polydactyly (extra digits) and syndactyly (webbing between digits)	'75510'	
Polydactyly (extra digits) and syndactyly (webbing between digits)	'75511'	
Polydactyly (extra digits) and syndactyly (webbing between digits)	'75512'	
Polydactyly (extra digits) and syndactyly (webbing between digits)	'75513'	
Polydactyly (extra digits) and syndactyly (webbing between digits)	'75514'	
Congenital absence of lower limb	'75530'	
Congenital absence of lower limb	'75531'	
Congenital absence of lower limb	'75532'	
Congenital absence of lower limb	'75533'	
Congenital absence of lower limb	'75534'	
Congenital absence of lower limb	'75535'	
Congenital absence of lower limb	'75536'	
Congenital absence of lower limb	'75537'	
Congenital absence of lower limb	'75538'	
Congenital absence of lower limb	'75539'	
Congenital hip deformity	'75561'	
Congenital hip deformity	'75562'	
Congenital hip deformity	'75563'	
Other congenital anomalies of limbs	'75442'	
Other congenital anomalies of limbs	'75520'	
Other congenital anomalies of limbs	'75521'	
Other congenital anomalies of limbs	'75522'	
Other congenital anomalies of limbs	'75523'	
Other congenital anomalies of limbs	'75524'	
Other congenital anomalies of limbs	'75525'	
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Other congenital anomalies of limbs	'75527'	
Other congenital anomalies of limbs	'75528'	
Other congenital anomalies of limbs	'75529'	
Other congenital anomalies of limbs	'7554 '	
Other congenital anomalies of limbs	'75550'	
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Other congenital anomalies of limbs	'75567'	
Other congenital anomalies of limbs	'75569'	
Other congenital anomalies of limbs	'7558 '	
Other congenital anomalies of limbs	'7559 '	
Congenital anomalies of skull and facial bones	'7560 '	
Lumbosacral spondylolysis	'75611'	
Spondylolisthesis	'75612'	
Other spinal congenital anomalies	'75610'	
Other spinal congenital anomalies	'75613'	
Other spinal congenital anomalies	'75614'	
Other spinal congenital anomalies	'75615'	
Other spinal congenital anomalies	'75616'	
Other spinal congenital anomalies	'75617'	
Other spinal congenital anomalies	'75619'	
Osteogenesis imperfecta	'75651'	
Congenital anomalies of the diaphragm	'7566 '	
Congenital anomalies of abdominal wall	'7567 '	
Congenital anomalies of abdominal wall	'75670'	
Congenital anomalies of abdominal wall	'75671'	
Congenital anomalies of abdominal wall	'75672'	
Congenital anomalies of abdominal wall	'75673'	
Congenital anomalies of abdominal wall	'75679'	
Congenital pigmentary anomalies of skin	'75733'	
Other congenital anomalies of integument	'7570 '	
Other congenital anomalies of integument	'7571 '	
Other congenital anomalies of integument	'7572 '	
Other congenital anomalies of integument	'75731'	
Other congenital anomalies of integument	'75732'	
Other congenital anomalies of integument	'75739'	
Other congenital anomalies of integument	'7574 '	
Other congenital anomalies of integument	'7575 '	
Other congenital anomalies of integument	'7576 '	
Other congenital anomalies of integument	'7578 '	

Other congenital anomalies of integument	'7579 '	
Pectus excavatum	'75481'	
'Down's Syndrome'	'7580 '	
All other congenital anomalies	'7540 '	
All other congenital anomalies	'7541 '	
All other congenital anomalies	'7542 '	
All other congenital anomalies	'75440'	
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All other congenital anomalies	'75689'	
All other congenital anomalies	'7569 '	
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All other congenital anomalies	'7582 '	
All other congenital anomalies	'7583 '	
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All other congenital anomalies	'75982'	
All other congenital anomalies	'75983'	
All other congenital anomalies	'75989'	
All other congenital anomalies	'7599 '	
All other congenital anomalies	'7952 '	
All other congenital anomalies	'V136 '	
All other congenital anomalies	'V1364'	
All other congenital anomalies	'V1366'	
All other congenital anomalies	'V1368'	
All other congenital anomalies	'V1369'	

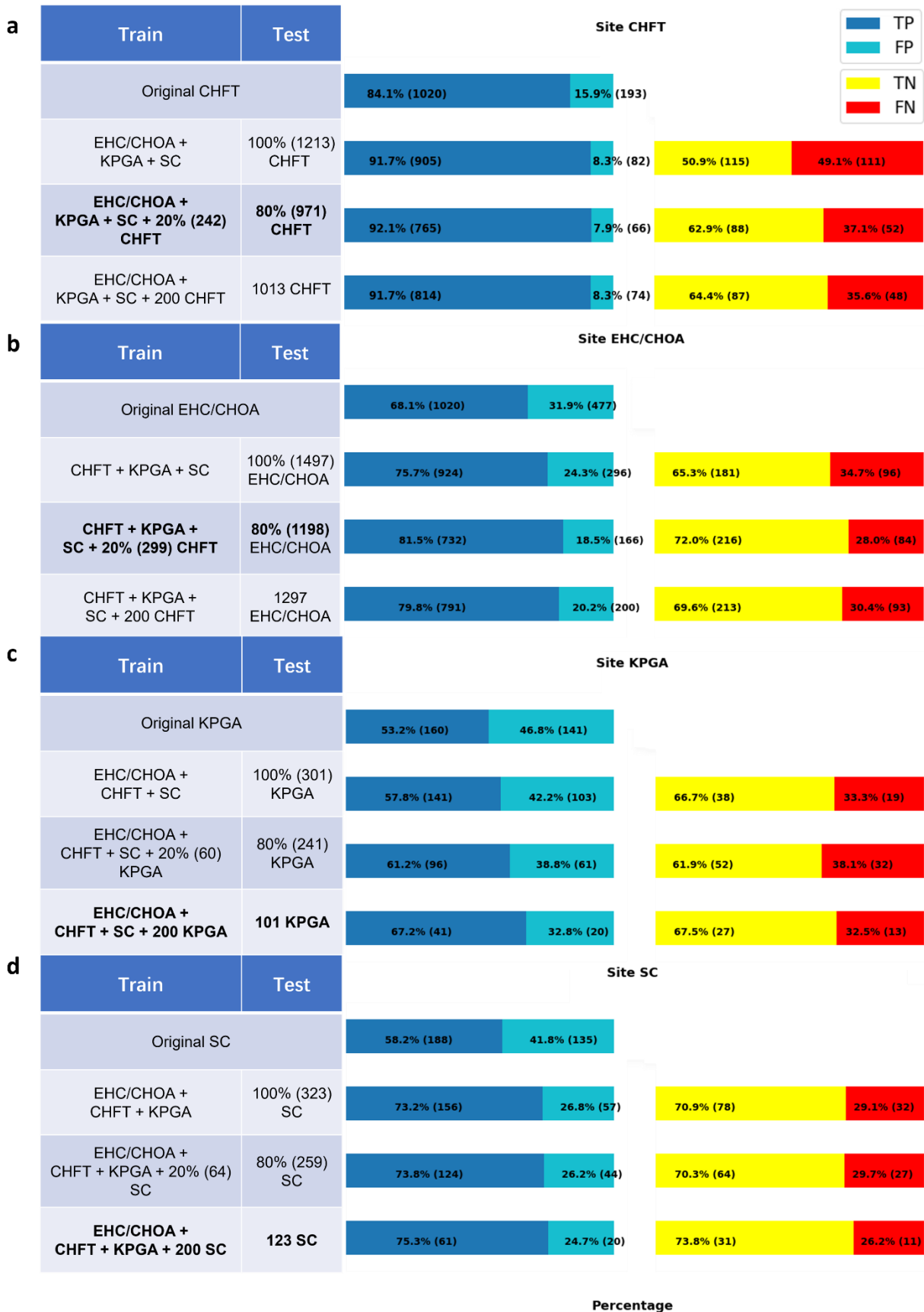


Supplemental Figure 1. SHAP Summary Plot of Top 10 Common Relevant Features for Congenital Heart Defect (CHD) Prediction Using the XGBoost Model at Four Individual Sites

Notes. Each dot on the plots represents the SHAP value of that feature for one of the individuals in the dataset.

a. SHAP summary plot of the ten common relevant features across CHFT data using the XGBoost model for CHD prediction. **b.** SHAP summary plot of the ten common relevant features across EHC/CHOA data using the XGBoost model for CHD prediction. **c.** SHAP summary plot of the ten common relevant features across KPGA data using the XGBoost model for CHD prediction. **d.** SHAP summary plot of the ten common relevant features across SC data using the XGBoost model for CHD prediction.

Acronyms: *CHD*=Congenital Heart Defects; *SHAP*= *SH*apley *AD*ditive *ex*Planation values; *SC*=South Carolina.



(Supplemental Figure 2). Percentage Stacked Bar Graph for PPVs and NPVs for Congenital Heart Defect (CHD) Identification Using the XGBoost Model at Four Sites with Different Train/Test Methods

Abbreviations: CHD= Congenital Heart Disease, PPV= Positive Predictive Value, NPV = Negative Predictive Value, CHFT=Center for Heart Failure Therapies, EHC=Emory Healthcare, CHOA= Children's Healthcare of Atlanta, SC=South Carolina, KPGA= Kaiser Permanente of Georgia,