

SUPPLEMENTARY APPENDIX

We identified relevant codes (for stenosis and regurgitation of mitral, aortic, tricuspid and pulmonary valves as well as associated repairs and replacements) for diagnosis, procedure and prescription by sourcing code lists from prior studies (1-3), running updated valve code searches (enabling contemporary codes lists to allow comparison with more recent data) and by matching synonymous codes between the Read, ICD 10 and OPCS4 controlled clinical terminologies. Diagnosis terms were available to describe stenosis, regurgitation and other and unspecified disorders of the mitral, aortic, tricuspid, pulmonary, and unspecified heart valves with a limited number of codes specifying if the disorder was of rheumatic or non-rheumatic origin. Procedure codes were available to describe mechanical heart valve replacements (i.e. codes referring to mechanical or artificial valves, Starr prosthesis, and Bjork-Shiley prosthesis), bioprosthetic heart valve replacements (i.e. codes relating to allografts, xenografts, Carpentier and Edwards prosthesis) and unspecified heart valve replacements, and valvuloplasty (valvotomy), annuloplasty and other and unspecified valve repairs and operations specific to each of the four, and unspecified, heart valves. All identified terms were independently reviewed for inclusion by two authors (VA and AB).

We implemented EHR phenotype algorithms identifying individuals with AF and VHD both prevalent at baseline (i.e. first VHD code recorded at any time point in an individual's medical record before study entry) and incident over follow up (i.e. first VHD code recorded after AF diagnosis). For every individual, the earliest date for a VHD code was recorded. A hierarchy was created for classification of individuals into one VHD category at baseline based on perceived clinical importance (**figure 1**), considering in order: valve replacements, valve repairs, followed by valve diseases: mitral stenosis, AS, mitral regurgitation and aortic regurgitation (diseases of tricuspid and pulmonary valves were excluded due to limited numbers of events), supported by the ROCKET-AF subgroup analysis(4). For unspecified valve replacement codes, we investigated whether combining information on age at valve replacement and subsequent OAC prescription (i.e. key criteria influencing choice of valve replacement)(5) could be used to infer type of valve replacement (mechanical or bioprosthetic).

Among 676 individuals with incident heart valve replacements, 570 (84.3%) were mechanical or bioprosthetic replacements; 106 (15.7%) were unspecified. (**figure S2**). Among 4,128 individuals with incident VHD, 316 (7.7%) had rheumatic valve disease, 359 (8.7%) had non-rheumatic disease, but for the majority (3637, 88.1%), the rheumatic basis of VHD was unspecified (**figure S3**). For individuals with incident heart valve replacements, there were differences in age distributions at heart valve replacement (**figure S4**) and in the proportion with warfarin prescriptions at 6 months post-valve surgery. The median (IQR) ages for mechanical, bioprosthetic and unspecified heart valve replacements were 70.1 (62.2-75.8), 75.8 (72.2-80.8), and 75.1 (65.7-81.1) years respectively. The proportions with warfarin prescriptions for mechanical, bioprosthetic and unspecified heart valve replacements were 74.3%, 52.1% and 57.6% respectively. Based on these insights it could be inferred that individuals <70 years were likely to have a mechanical valve replacement and individuals >75 years were likely to have

a bioprosthetic valve replacement. For individuals 70-75 years, where the age distribution for mechanical and bioprosthetic replacements overlap, warfarin prescriptions (36 codes) were used to infer a mechanical valve replacement and no warfarin prescription to infer a bioprosthetic valve replacement.

References

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3. Lane DA, Skjoth F, Lip GYH, Larsen TB, Kotecha D. Temporal Trends in Incidence, Prevalence, and Mortality of Atrial Fibrillation in Primary Care. *J Am Heart Assoc*. 2017;6(5).
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Table S1 Code lists for atrial fibrillation with concomitant VHD: 235 Read, 49 ICD10 and 86 OPCS-4 and 36 BNF codes

Valvular atrial fibrillation										
Valvular heart disease										
Read:	G540.16	G541100	G541212	G541200	G11..00	G540.15	G542000	G110.00	G541300	9
G543300	G542.00	G540.00	G541.00	G540000	G54z500	G543215	G121.12	G130.00	G140413	19
G120.00	G540.14	G541500	G13..00	G54z100	G541012	G541400	G133.12	G543.00	G543100	29
G541000	G543012	G543011	G140.00	G11..11	G131.14	G12..00	G544200	G541z00	G544100	39
G543z00	G111.11	G140111	G54z013	G111.12	G543000	G540z00	G113.00	G54..11	G13z.00	49
G11z.00	G541600	G140000	G133.00	G132.12	G540200	G121.00	G110.11	G132.00	G132.13	59
G540100	G140412	G543400	G542012	G542100	G141z00	G543213	G54z000	G540300	G544.00	69
G544000	G540.12	G140400	G140112	G121.11	G542z00	G141.00	G112.13	G112.00	G543200	79
G541011	Gyu5600	G131.00	G140514	G12z.00	G112.12	G111.00	G542200	Gyu1000	Gyu5800	89
G141100	G140300	G544X00	G114.00	G541211	G140100	G131.13	G543311	G14021Y	G141000	99
G122.00	A932.11	G13y.00	Gyu5A00	G140500	G140z00	G54z014	G14021X	G140200	Gyu1100	109
G133.11	G542011	G542X00	Gyu5500	Gyu1200	Gyu5D00	Gyu5B00				116
ICD10:	I05	I050	I051	I052	I058	I059	I06	I060	I061	125
I062	I068	I069	I07	I070	I071	I072	I078	I079	I08	135
I080	I081	I082	I083	I088	I089	I34	I340	I341	I342	145
I348	I349	I35	I350	I351	I352	I358	I359	I36	I360	155
I361	I362	I368	I369	I37	I370	I371	I372	I378	I379	165
Mechanical valve replacements										
Read:	7914200	14T3.00	7910200	ZV43300	7910211	7911200	7914212	ZV45H00	7910212	174
7913200	7912200									176
OPCS4	K253	K263	K273	K283	K293					181
Bioprosthetic valve replacements										
Read:	7911100	7911000	7913000	7914211	7910213	7910100	7914100	7914000	7910214	190
7913100	7910000	7912000	7912100							194
OPCS4:	K251	K252	K261	K262	K271	K272	K281	K282	K291	203
K292										204
Unspecified valve replacements										
Read:	7911.12	7910300	7910.12	7914300	14S4.00	7911300	ZV42200	7914.11	7912300	213
7913.12	7912.11	7913300	7911500							217
OPCS4:	K254	K264	K274	K284	K294	K357				223
Valve repairs										
Read:	791z.00	7918.00	7N40000	7910.00	7N40.00	7N40100	7918000	7911.00	7N40300	232
7N40200	7914z00	7916z11	7916.11	7916100	7915000	7916000	7917000	7917z00	7910400	242
7918100	7912.00	7917.11	7916300	7913.11	791..00	7918200	7911.11	7910.11	7919300	252
7917300	7919100	7915300	7919.11	7911y00	7910z00	7915.00	7917100	7918y00	7915100	262
7913.00	791y.00	7918z00	7916.00	7914400	7913400	7917311	7911400	7918111	7919000	272
7911z00	7919400	7910y00	7914.00	7915200	7918300	7916z00	7916y00	7915y00	7917.00	282
7916200	7912z00	7912y00	7913y00	7910411	791D100	7911411	791D000	7912.12	791D.00	292
7913z00	7918500	7913411	7914y00	7912511	7918400	7912500	7917200	7917y00	7915z00	302
7914411	7919200	791Dy00								305
OPCS4:	K25	K255	K258	K259	K26	K265	K268	K269	K27	314
K275	K276	K278	K279	K28	K285	K288	K289	K29	K295	324
K298	K299	K30	K301	K302	K303	K304	K308	K309	K31	334
K311	K312	K313	K314	K318	K319	K32	K321	K322	K323	344
K324	K328	K329	K34	K341	K342	K343	K344	K345	K346	354
K348	K349	K35	K351	K352	K353	K354	K355	K356	K358	364
K359	K36	K361	K362	K368	K369					370

Warfarin prescription codes										
BNF:	45	61	833	1781	6262	8466	8467	13348	17965	379
23078	30202	30203	31511	31937	33711	34019	34086	34087	34088	389
34095	34299	34416	34417	34418	34517	34526	34576	34691	34758	399
34864	34918	36099	38041	38044	39866	40143				406

Note: final table column gives the cumulative total number of identified codes.

Table S2 AF subtype and absolute risk of stroke, systemic embolism, and all-cause mortality(per 100 person-years).

Sub-types of patients with AF	Absolute risk				Risk difference vs no VHD
	unadjusted	Model 1: age adjusted	Model 2: age- and sex- adjusted	Model 3: fully adjusted	
no valvular heart disease	13.3 [13.2, 13.5]	16.8 [16.6, 17.0]	16.8 [16.6, 17.1]	18.2 [18.0, 18.4]	
Any heart valve disease	15.0 [14.5, 15.5]	20.2 [19.6, 20.9]	20.4 [19.7, 21.0]	20.1 [19.5, 20.8]	1.9 [1.0, 2.9]
mechanical replacement	9.9 [9.0, 10.8]	19.6 [17.8, 21.4]	19.7 [17.9, 21.5]	20.2 [18.4, 22.1]	2.0 [-0.3, 4.4]
bioprosthetic replacement	12.4 [10.8, 13.9]	13.9 [12.1, 15.7]	13.8 [12.1, 15.6]	13.9 [12.1, 15.7]	-4.3 [-6.8, -1.7]
valve repair	8.1 [6.7, 9.5]	14.6 [12.0, 17.2]	14.9 [12.3, 17.6]	15.3 [12.5, 18.0]	-2.9 [-6.3, 0.4]
mitral stenosis	13.5 [11.9, 15.2]	21.3 [18.7, 24.0]	22.4 [19.6, 25.2]	22.4 [19.6, 25.2]	4.2 [0.5, 7.9]
mitral regurgitation	15.0 [14.1, 15.9]	19.3 [18.1, 20.4]	19.5 [18.3, 20.7]	19.1 [18.0, 20.3]	0.9 [-0.7, 2.6]
mitral disorder nos	16.4 [14.9, 18.0]	21.0 [19.0, 23.0]	21.2 [19.2, 23.3]	20.7 [18.7, 22.7]	2.5 [-0.1, 5.1]
aortic stenosis	25.9 [24.1, 27.7]	25.5 [23.7, 27.3]	25.5 [23.7, 27.2]	24.6 [22.9, 26.3]	6.4 [4.1, 8.7]
aortic regurgitation	16.8 [14.5, 19.0]	21.4 [18.5, 24.2]	21.4 [18.5, 24.3]	20.9 [18.1, 23.7]	2.7 [-1.1, 6.6]
aortic disorder nos	17.7 [14.1, 21.2]	20.0 [15.9, 24.0]	19.9 [15.9, 24.0]	20.9 [16.7, 25.1]	2.7 [-3.1, 8.5]

Table S3. Recorded echocardiography rates by age group(1998-2010).

Year	Rate of recorded echocardiogram (%)			
	Age group(years)			
	<65	65-74	74-84	≥85
1998	5.5	7.0	4.3	1.8
1999	9.1	10.1	5.8	2.9
2000	12.0	13.0	9.2	4.5
2001	15.5	17.7	12.6	6.5
2002	20.7	21.5	17.4	9.9
2003	27.5	29.0	23.6	14.4
2004	37.4	37.7	32.8	21.9
2005	45.8	45.9	40.0	26.9
2006	51.4	53.8	47.3	32.4
2007	57.1	60.4	54.6	37.5
2008	61.5	64.4	62.7	44.3
2009	65.4	69.0	67.7	48.3

Figure S1 Quality of recording valvular heart diseases in electronic health records in 1998 to 2010: specified heart valves

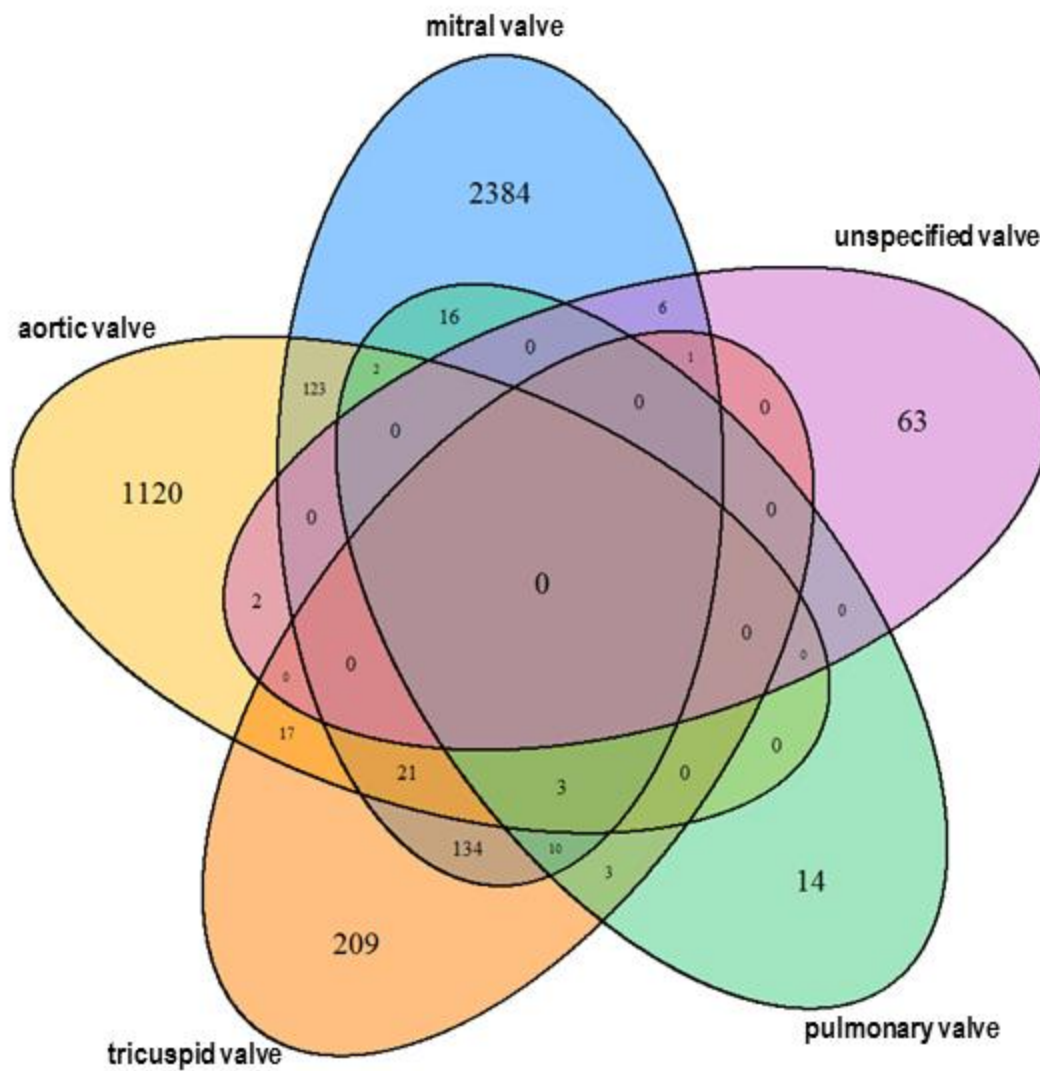


Figure S2 Quality of recording valvular heart diseases in electronic health records in 1998 to 2010: mechanical vs. bioprosthetic valve replacements

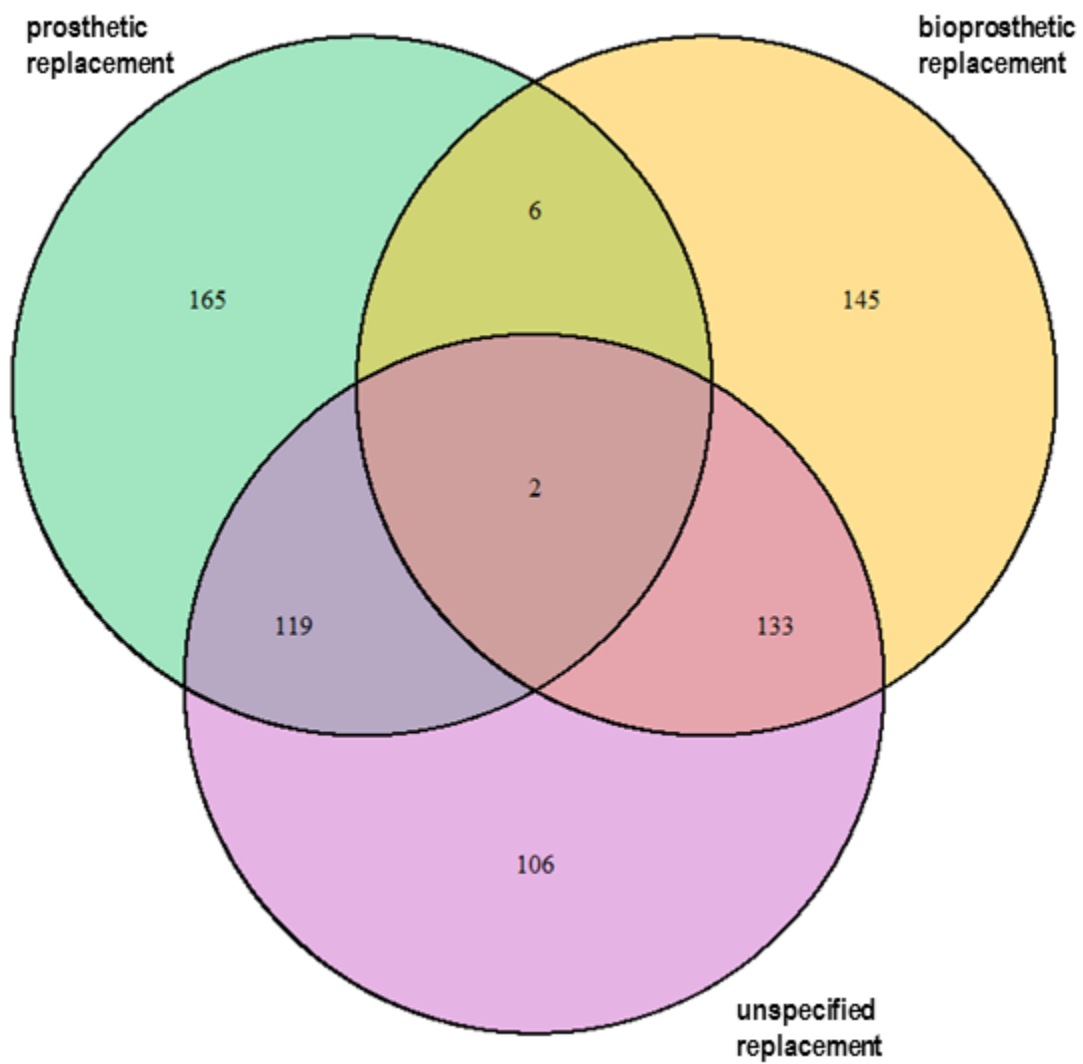


Figure S3 Quality of recording valvular heart diseases in electronic health records in 1998 to 2010: rheumatic vs. non-rheumatic valve disorders

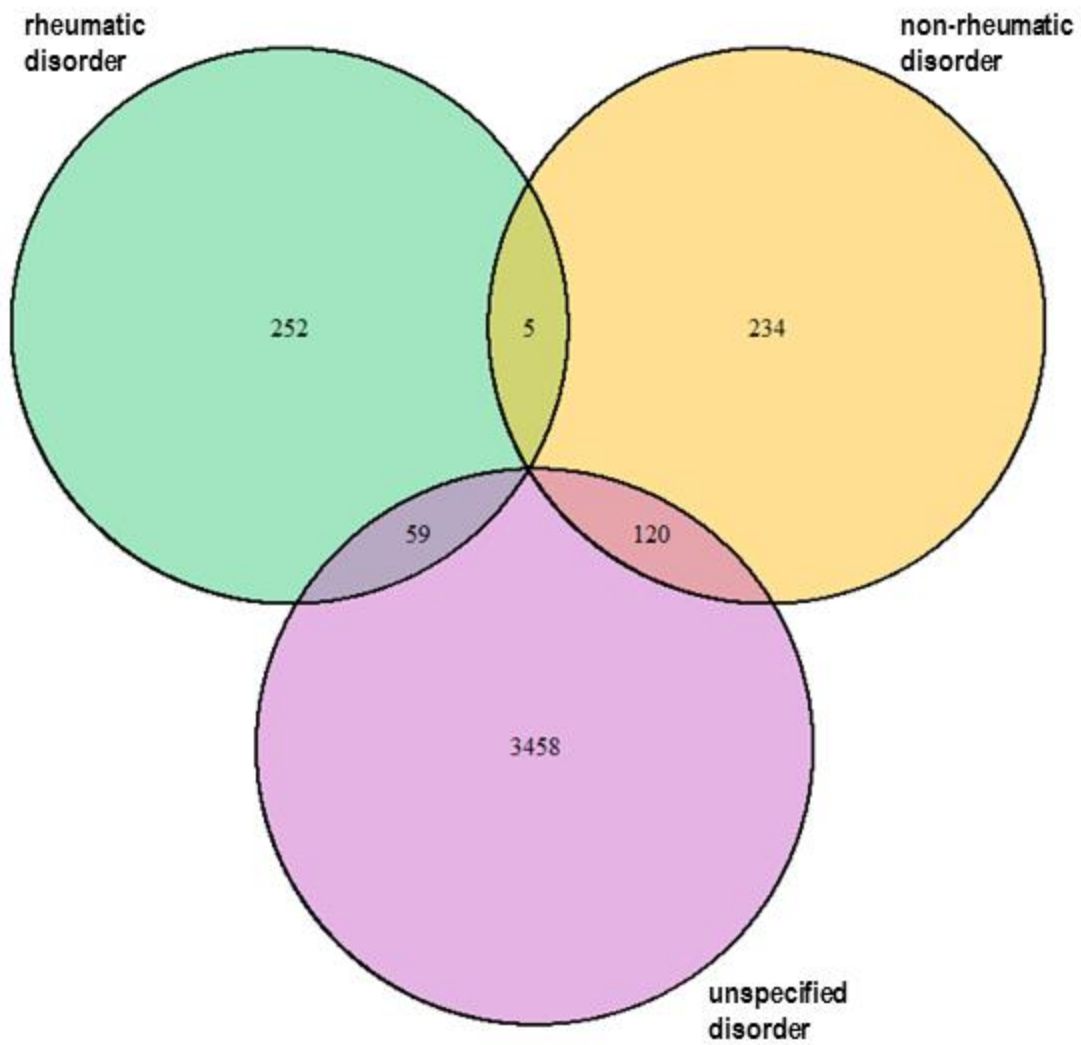
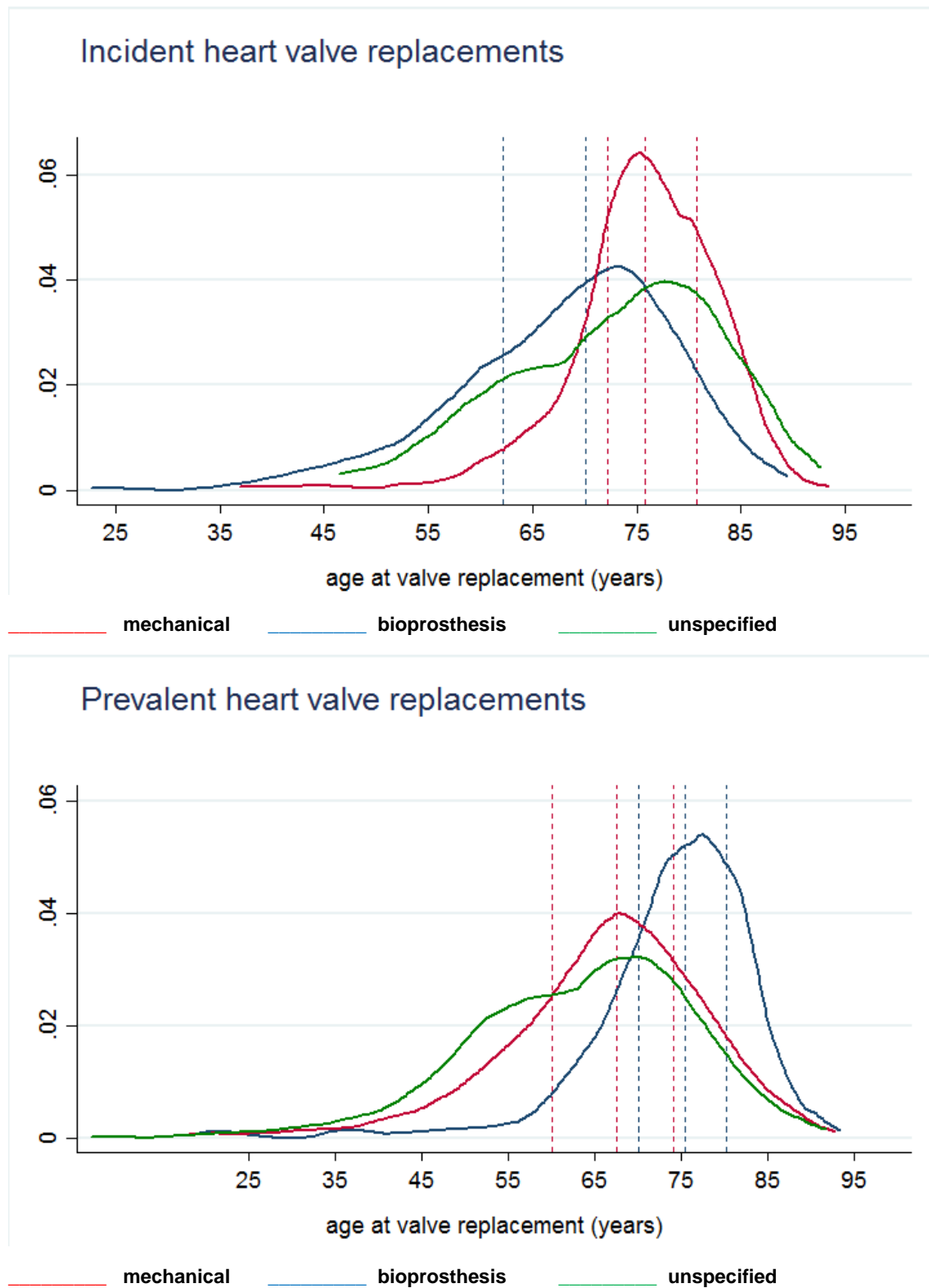


Figure S4 Differences in age distributions in individuals with mechanical, bioprosthetic and unspecified valve codes



Notes: vertical dashed lines represent median and interquartile interval values showing overlap in the age distributions for individuals with mechanical and bioprosthetic valve replacements between the ages 70 to 75 years.