

Supplementary Materials

Temporal trends of emergency department visits of patients with atrial fibrillation: a nationwide population-based study

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Table S1. Definitions of covariates and AF-related complications

Diagnosis	ICD-10-CM codes
AF	I48.0-I48.4, I48.9
Valvular atrial fibrillation (EHRA type 1 VHD)	I05.0, I05.2, I05.9, Z95.2-Z95.4 with AF diagnosis
Hypertension	I10-I13, I15; and minimum 1 prescription of anti-hypertensive drug (thiazide, loop diuretics, aldosterone antagonist, alpha-/beta-blocker, calcium-channel blocker, angiotensin-converting enzyme inhibitor, angiotensin II receptor blocker).
Diabetes mellitus	E11-E14; and minimum 1 prescription of anti-diabetic drugs (sulfonylureas, metformin, meglitinides, thiazolidinediones, dipeptidyl peptidase-4 inhibitors, α -glucosidase inhibitors, and insulin).
Dyslipidemia	E78
Heart Failure	I50
Stroke/TIA/TE	I63, I64, G458, G459, I74
Myocardial infarction	I21, I22
Peripheral artery disease	I70, I73
VHD (EHRA type 2)	I34.0-I34.2 (mitral valve disease), I35.0-I35.2, I06.0-I06.2 (aortic valve disease), I36.0-I36.2, I07.0-I07.2 (tricuspid valve disease) and I37.0-I37.2 (pulmonic valve disease)
Cancer	C00-97 and RID code (V193)
Chronic obstructive pulmonary disease	J41-J44
Chronic kidney disease	N18, N19
Hemodialysis	Procedure code: O7011-O7020
Peritoneal dialysis	Procedure code: O7017, O7075
Percutaneous coronary intervention	Procedure code: M6561, M6562, M6563, M6564
CHA ₂ DS ₂ -VASc score	Heart failure (1 point), hypertension (1 point), age \geq 75 years (2 points), diabetes mellitus (1 point), previous stroke/TIA/TE (2 points), vascular disease (prior myocardial infarction or peripheral artery disease, 1 point), age \geq 65 years (1 point) and female sex (1 point)
AF-related complications (as a primary diagnosis of ED visit)	
Ischemic stroke	I63, I64
Atrial fibrillation	I48.0-I48.4, I48.9
Heart failure	I50
Myocardial infarction	I21, I22
Intracranial hemorrhage	I60-62

Gastrointestinal bleeding

I85, K22.1, K22.8, K25.0, K25.2, K25.4, K25.6, K26.0, K26.2, K26.4, K26.6, K27.0, K27.2, K27.4, K27.6, K28.0, K28.2, K28.4, K28.6, K29.0, K31.8, K55.2, K57.0, K57.1, K57.2, K57.3, K57.4, K57.5, K57.8, K57.9, K62.5, K66.1, K92.0, K92.1, K92.2

Other major bleeding

D62 (posthemorrhagic anemia), H05.2 (hemorrhage of orbit), H35.6 (retinal hemorrhage), H43.1 (vitreous hemorrhage), J94.2 (hemothorax), M25.0 (hemarthrosis), R04 (hemorrhage from respiratory passages; epistaxis, hemorrhage from throat, hemoptysis, or other sites/unspecified sites from respiratory passages)

Abbreviation: AF, atrial fibrillation; ED, emergency department; EHRA, European Heart Rhythm Association; RID, Rare Intractable Disease program; VHD, valvular heart disease.

Table S2. Baseline characteristics of the total AF population in Korea

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	P for trend
Number	132,548	144,842	157,368	170,953	186,147	193,346	214,900	229,947	256,790	285,713	317,017	347,709	
Age													
Mean ± SD	66±13	66±13	67±13	67±13	68±13	68±13	69±13	69±13	70±13	70±13	70±12	71±12	<0.001
20-29	1.5	1.4	1.2	1.0	0.9	0.8	0.7	0.6	0.6	0.6	0.6	0.5	<0.001
30-39	3.1	2.9	2.6	2.4	2.2	2.0	1.8	1.6	1.5	1.5	1.3	1.2	<0.001
40-49	8.0	7.7	7.0	6.5	6.0	5.5	5.1	4.7	4.5	4.4	4.2	3.9	<0.001
50-59	15.6	15.2	15.0	14.7	14.7	14.9	14.6	14.2	13.7	13.1	12.6	12.1	<0.001
60-69	28.1	27.4	26.9	26.3	25.4	24.4	23.5	23.0	22.9	23.2	23.3	22.9	<0.001
70-79	30.3	31.2	32.1	32.8	33.3	34.1	35.0	35.6	35.1	34.2	33.7	33.6	<0.001
80-	13.5	14.4	15.3	16.4	17.6	18.2	19.3	20.4	21.7	23.0	24.4	25.9	<0.001
Sex (male)	54.5	54.9	55.2	55.3	55.9	56.2	56.6	57.1	57.4	57.4	57.3	57.5	<0.001
Comorbidities													
Hypertension	76.2	75.9	76.4	77.1	77.6	74.5	78.7	80.7	80.3	79.8	79.7	79.6	<0.001
Diabetes mellitus	21.6	22.0	22.6	23.3	23.8	24.0	24.6	25.2	25.5	25.7	26.2	26.8	<0.001
Heart failure	24.1	23.5	22.6	22.0	21.9	22.8	23.3	25.0	26.1	28.9	31.0	33.9	<0.001
Stroke/TIA/TE	17.2	17.7	18.3	19.2	19.8	19.6	20.2	21.1	20.9	21.0	21.2	21.1	<0.001
Myocardial infarction	5.5	5.2	5.1	5.0	4.7	4.2	3.6	3.6	3.6	3.8	4.0	4.2	<0.001
Peripheral artery disease	10.5	12.3	15.1	17.9	18.5	18.1	17.2	17.5	17.6	18.6	19.5	19.9	<0.001
VHD (EHRA type 2)	5.6	5.0	4.9	4.7	4.6	4.7	4.8	4.8	4.6	4.5	4.3	4.1	<0.001
Cancer	5.7	6.4	6.6	7.0	7.2	7.4	7.0	6.7	6.8	6.8	6.9	7.0	<0.001
COPD	19.5	20.2	20.2	20.0	19.9	19.8	19.8	19.7	18.5	19.0	18.7	18.8	<0.001
Chronic kidney disease	2.9	3.1	3.3	3.6	3.8	4.0	4.6	5.1	5.5	5.8	6.3	6.9	<0.001
Hemodialysis	0.9	0.9	1.0	1.0	1.1	1.1	1.3	1.3	1.4	1.4	1.5	1.6	<0.001
Peritoneal dialysis	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.1	<0.001
Previous PCI	1.5	1.7	1.9	2.1	2.0	2.0	2.1	2.2	2.2	2.2	2.1	2.1	<0.001
CHA₂DS₂-VASc score													
Mean ± SD	2.9±1.6	2.9±1.6	3±1.6	3±1.6	3.1±1.6	3.1±1.7	3.1±1.6	3.2±1.6	3.3±1.6	3.3±1.6	3.4±1.7	3.4±1.7	<0.001
0, 1	22.2	21.7	20.6	19.8	19.3	20.1	18.4	16.7	16.2	15.6	14.8	13.7	<0.001
≥2	77.8	78.3	79.4	80.2	80.7	79.9	81.6	83.3	83.8	84.4	85.2	86.3	<0.001
Medication													
Antithrombotic therapy													
No therapy	24.1	22.8	21.0	20.2	19.2	18.3	17.0	15.5	15.6	16.0	15.3	14.9	<0.001
Antiplatelet agent	46.8	47.4	49.0	49.3	49.6	48.7	48.6	47.2	46.3	40.6	35.0	30.1	<0.001
Oral Anticoagulants	29.1	29.8	30.0	30.5	31.2	33.0	34.4	37.3	38.1	43.4	49.7	55.0	<0.001

Warfarin	29.1	29.8	30.0	30.5	31.1	32.8	34.1	33.5	34.9	22.7	15.4	11.4	<0.001
NOAC	0	0	0	0	0.1	0.2	0.3	3.8	3.2	20.7	34.3	43.6	<0.001
Antiarrhythmic drugs													
Class Ic	7.2	7.6	8.3	8.9	9.9	11.3	12.0	12.9	13.5	13.7	14.4	15.2	<0.001
Class III	10.1	10.3	10.5	10.7	10.8	11.1	11.2	11.6	12.3	12.4	12.5	13.1	<0.001
Digoxin	41.2	38.6	36.5	34.6	32.4	31.2	29.5	27.5	25.8	23.8	21.7	20.0	<0.001
Beta-blocker	36.0	36.2	36.7	37.0	38.2	39.9	40.7	40.7	40.8	41.3	42.5	43.1	<0.001
Non-DHP CCB	19.2	19.2	19.6	19.8	20.1	20.2	19.7	19.4	18.7	18.2	17.9	17.2	<0.001
DHP CCB	26.4	24.2	21.9	18.7	16.4	14.1	12.6	11.5	10.5	9.5	8.7	7.9	<0.001
ACE inhibitor	38.7	41.0	43.5	46.5	48.1	49.0	49.8	50.7	49.9	49.4	49.8	49.9	<0.001
ARB	34.6	35.3	35.0	33.8	32.8	31.5	30.3	29.1	27.8	26.8	26.5	26.3	<0.001
Diuretics	58.5	56.4	54.8	53.4	52.2	50.5	49.3	48.5	47.1	46.3	46.2	45.9	<0.001
Statin	23.8	26.5	28.3	31.6	34.3	36.1	39.0	42.0	45.1	47.0	49.1	50.7	<0.001

Abbreviation: ACE, angiotensin-converting enzyme; ARB, angiotensin II receptor blocker; CCB, calcium-channel blocker; COPD, chronic obstructive pulmonary disease; DAPT, dual antiplatelet therapy; DHP, dihydropyridine; EHRA, European Heart Rhythm Association; NOAC, non-vitamin K antagonist oral anticoagulant; PCI, percutaneous coronary intervention; SD, standard deviation; TE, thromboembolism; TIA, transient ischemic attack; VHD, valvular heart disease.

Table S3. The annual number of patients visited ED, number of total ED visits, and clinical outcome including subsequent hospitalization, 30-day, and 90-day mortality after ED visit

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total AF patients	132,548	144,842	157,368	170,953	186,147	193,346	214,900	229,947	256,790	285,713	317,017	347,709
Number of patients who visited ED \geq1 in index year	40,425	44,576	47,975	52,648	57,754	59,914	67,011	70,376	79,188	87,077	99,306	99,763
% of patients with \geq1 ED visit in index year	30.5%	30.8%	30.5%	30.8%	31.0%	31.0%	31.2%	30.6%	30.8%	30.5%	31.3%	28.7%
Number of total ED visits of NVAF patients	62,781	69,781	75,806	83,721	93,102	97,903	111,101	116,102	130,441	144,724	169,678	159,004
Subsequent hospitalization after ED visit	46,024	49,907	53,376	57,724	63,882	65,667	73,283	75,779	84,798	95,917	126,727	119,432
% of subsequent hospitalization after ED visit in total ED visits	73.3%	71.5%	70.4%	68.9%	68.6%	67.1%	66.0%	65.3%	65.0%	66.3%	74.7%	75.1%
30-day mortality after ED visit	10.4%	10.3%	10.0%	9.6%	9.8%	9.6%	9.6%	8.9%	8.8%	8.6%	8.2%	7.6%
90-day mortality after ED visit	16.3%	15.9%	15.5%	15.1%	15.6%	15.3%	15.1%	14.3%	14.0%	13.8%	13.2%	12.0%

Abbreviation: NVAF, non-valvular atrial fibrillation; ED, emergency department.

Table S4. Comparison of baseline characteristics between patients who visited or did not visit ED in 2017

	Total	Patients who did not visit ED	Patients who visited ED	p-value
Number	347,709	247,946	99,763	
Age				
Mean ± SD	71±12	70±12	73±13	<0.001
20-29	0.5	0.5	0.5	<0.001
30-39	1.2	1.2	1.3	
40-49	3.9	4.1	3.5	
50-59	12.1	13.0	9.6	
60-69	22.9	24.9	18.0	
70-79	33.6	34.0	32.6	
80-	25.9	22.4	34.6	
Sex (male)	57.5	58.6	54.8	<0.001
Comorbidities				
Hypertension	79.6	78.1	83.4	<0.001
Diabetes mellitus	26.8	24.6	32.2	<0.001
Heart failure	33.9	33.5	35.1	<0.001
Stroke/TIA/TE	21.1	20.3	23.0	<0.001
Myocardial infarction	4.2	3.7	5.5	<0.001
Peripheral artery disease	19.9	18.9	22.3	<0.001
COPD	18.8	17.0	23.3	<0.001
Chronic kidney disease	6.9	5.5	10.1	<0.001
Hemodialysis	1.6	1.1	2.8	<0.001
Peritoneal dialysis	0.1	0.1	0.3	<0.001
Previous PCI	2.1	1.8	2.7	<0.001
CHA₂DS₂-VASc score				
Mean ± SD	3.4±1.7	3.3±1.6	3.8±1.7	<0.001
0, 1	13.7	14.8	10.8	<0.001
≥2	86.3	85.2	89.2	
Medication				
Antithrombotic therapy				<0.001
No therapy	14.9	15.5	13.7	
Antiplatelet agent	30.1	31.3	26.9	
Oral Anticoagulants	55.0	53.2	59.5	
Warfarin	11.4	12.0	9.9	
NOAC	43.6	41.2	49.6	

Antiarrhythmic drugs

Class Ic	15.2	15.7	13.8	<0.001
Class III	13.1	9.9	21.0	<0.001
Digoxin	20.0	17.6	25.8	<0.001
Beta-blocker	43.1	40.8	48.8	<0.001
Non-DHP CCB	17.2	13.8	25.7	<0.001
DHP CCB	7.9	6.8	10.5	<0.001
ACE inhibitor	49.9	49.2	51.6	<0.001
ARB	26.3	22.1	36.7	<0.001
Diuretics	45.9	39.2	62.7	<0.001
Statin	50.7	49.3	54.2	<0.001

Abbreviation: ACE, angiotensin-converting enzyme; ARB, angiotensin II receptor blocker; CCB, calcium-channel blocker; COPD, chronic obstructive pulmonary disease; DAPT, dual antiplatelet therapy; DHP, dihydropyridine; NOAC, non-vitamin K antagonist oral anticoagulant; PCI, percutaneous coronary intervention; SD, standard deviation; TE, thromboembolism; TIA, transient ischemic attack.

Table S5. Number and incidence of patients who visited the ED from AF-related complications from 2006 to 2017

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Ischemic stroke	5,393 (4.07)	5,829 (4.02)	6,440 (4.09)	6,667 (3.90)	7,513 (4.04)	7,812 (4.04)	8,661 (4.03)	9,006 (3.92)	9,746 (3.80)	10,167 (3.56)	11,395 (3.59)	10,911 (3.14)
AF	3,948 (2.98)	4,542 (3.14)	5,008 (3.18)	5,539 (3.24)	6,162 (3.31)	7,202 (3.72)	7,895 (3.67)	8,065 (3.51)	9,283 (3.62)	9,675 (3.39)	11,058 (3.49)	11,256 (3.24)
HF	2,412 (1.82)	2,693 (1.86)	2,960 (1.88)	3,224 (1.89)	3,671 (1.97)	3,734 (1.93)	4,063 (1.89)	4,315 (1.88)	4,804 (1.87)	5,340 (1.87)	6,310 (1.99)	6,216 (1.79)
MI	1,967 (1.48)	1,898 (1.31)	1,634 (1.04)	1,510 (0.88)	1,491 (0.80)	1,428 (0.74)	1,401 (0.65)	1,470 (0.64)	1,701 (0.66)	1,796 (0.63)	2,061 (0.65)	2,018 (0.58)
ICH	1,195 (0.90)	1,154 (0.80)	1,128 (0.72)	1,102 (0.64)	1,202 (0.65)	1,139 (0.59)	1,167 (0.54)	1,139 (0.50)	1,261 (0.49)	1,331 (0.47)	1,320 (0.42)	1,243 (0.36)
GI bleeding	1,056 (0.80)	1,164 (0.80)	1,235 (0.78)	1,362 (0.80)	1,530 (0.82)	1,529 (0.79)	1,750 (0.81)	1,853 (0.81)	2,109 (0.82)	2,296 (0.80)	2,670 (0.84)	2,438 (0.70)
Other major bleeding	399 (0.30)	516 (0.36)	527 (0.33)	612 (0.36)	623 (0.33)	687 (0.36)	861 (0.40)	859 (0.37)	1,032 (0.40)	1,130 (0.40)	1,263 (0.40)	1,197 (0.34)

Number (%)

The incidence was defined as ED visits from AF-related complications per 100 patients with AF (%).

Abbreviation: AF, atrial fibrillation; GI, gastrointestinal; HF, heart failure; ICH, intracranial hemorrhage; MI, myocardial infarction.