

# Prevalence and Predictors of Statin Treatment Among Patients With Chronic Heart Failure at a Tertiary-Care Center in Thailand

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## ABSTRACT

**BACKGROUND:** Statins play important roles in the prevention of atherosclerotic vascular diseases; however, their beneficial effects in patients with chronic heart failure (CHF) are uncertain. This study aimed to investigate the prevalence and predictors of treatment with statins to better understand their prescribing patterns in CHF patients.

**METHODS:** We conducted a cross-sectional study in patients with first-time diagnoses of CHF receiving care in the outpatient clinics affiliated with a tertiary-care teaching hospital in Thailand. Data were retrieved from electronic claims database. Multivariable logistic regression was used to identify independent predictors of treatment with statins.

**RESULTS:** A total of 3445 patients were included in this study. Among them, 1908 (55.4%) were prescribed statins, with most of them (89.7%) receiving simvastatin 20mg daily. Factors independently associated with the statin treatment include the following: being male (odds ratio [OR] = 1.21, 95% confidence interval [CI] = 1.02-1.44,  $P = .03$ ); diagnoses of dyslipidemia (OR = 4.88, 95% CI = 3.88-6.14,  $P < .001$ ), ischemic heart disease (OR = 2.71, 95% CI = 2.18-3.36,  $P < .001$ ), diabetes (OR = 1.95, 95% CI = 1.55-2.46,  $P < .001$ ), or cerebrovascular disease (OR = 1.64, 95% CI = 1.12-2.40,  $P = .01$ ); and receipt of angiotensin-converting enzyme inhibitors (OR = 3.44, 95% CI = 2.87-4.13,  $P < .001$ ), aspirin (OR = 2.79, 95% CI = 2.30-3.40,  $P < .001$ ), non-dihydropyridine calcium channel blockers (OR = 2.35, 95% CI = 1.30-4.24,  $P = .004$ ), organic nitrates (OR = 2.04, 95% CI = 1.16-3.58,  $P = .01$ ), beta-blockers (OR = 1.51, 95% CI = 1.23-1.84,  $P < .001$ ), and digoxin (OR = 0.65, 95% CI = 0.50-0.86,  $P = .002$ ).

**CONCLUSIONS:** Statins were prescribed to more than half of the newly diagnosed CHF patients. Independent predictors of statin treatments include hypercholesterolemia and comorbidities indicative of high atherosclerotic vascular risk as well as drugs recommended as cardiovascular protective therapy for CHF patients.

**KEYWORDS:** dyslipidemia, heart failure, hydroxymethylglutaryl-coenzyme A reductase inhibitors, predictor, prevalence, statins

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## Introduction

The prevalence of chronic heart failure (CHF) is estimated to be 1% to 2% among adult population.<sup>1</sup> The prevalence of CHF rises to 5%-9% among people >65 years of age, suggesting that CHF affects mainly older people and the prevalence will likely increase as a result of aging population.<sup>1-5</sup> In addition, CHF is the leading cause of disease-related morbidity and mortality. Overall, 40% to 50% of heart failure patients die within 5 years of their initial diagnosis.<sup>3,4,6,7</sup> Thus, CHF increases health care costs and causes a substantial economic burden on individual patients and the society.<sup>5,8</sup> Prevention of the disease-related morbidity and mortality becomes an important goal in management of patients with CHF.

Statins (3-hydroxy-3-methylglutaryl-coenzyme A reductase inhibitors) play a significant role in the primary and secondary prevention of atherosclerotic cardiovascular diseases (ASCVD). This benefit has been demonstrated in high-risk patients diagnosed with ASCVD and other conditions leading

to high atherosclerotic vascular risk.<sup>9</sup> Among patients with CHF, however, the beneficial effects of statins appear uncertain. Two large randomized controlled trials found that rosuvastatin did not reduce the primary endpoint of mortality and morbidity in CHF patients with or without ischemic heart disease (IHD), although the use of rosuvastatin was associated with a reduced risk of hospitalization.<sup>10,11</sup> Furthermore, relevant guidelines from professional organizations have recommended against a routine initiation of statin treatment in CHF patients unless they have ASCVD or other indications for statin use due to the conflict of available evidence.<sup>1,3,9,12</sup> Therefore, it is of relevance to investigate the prevalence and predictors of treatment with statins in CHF patients to better understand their prescribing patterns in actual clinical practice. This information could help explain the possible reasons for the initiation of statin treatment and the extent to which statins are prescribed despite the controversies on their beneficial effects in patients with CHF. The results will provide information on



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the quality of care and may be used for health policy development for the CHF population.

The aim of this study was to investigate the prevalence of treatment with statins among patients with their first-time diagnoses of CHF in an outpatient setting. The study also aimed to identify patient characteristics, comorbidities, and co-prescribed drugs associated with statin treatment in CHF patients.

## Methods

### *Study design and data collection*

This research was a retrospective, cross-sectional study in newly diagnosed CHF patients receiving care at the outpatient clinics affiliated with a 1000-bed, public, tertiary-care, teaching hospital in Phitsanulok province in Thailand. Patient data were retrieved from the administrative database of medical and pharmacy claims provided by the Department of Medical Record and Statistics at the study hospital. We recruited all patients who were at least 18 years of age and had their first-time diagnoses of CHF identified with the 10th revision of the International Classification of Diseases (ICD-10) code I50 during January 2007 to December 2013. The date of first-time diagnosis of CHF was defined as the index date. The first-time diagnosis was confirmed by retrospectively reviewing for any records of previous diagnosis of CHF at least 1 year prior to the index date. Patients were excluded if they did not have their prescriptions filled by the outpatient pharmacy at the study hospital because we were unable to obtain their prescription data. Patients were also excluded if they were referred to the clinics for one-time consultation or for an investigative study (eg, echocardiography) and therefore would not receive further treatment at the study hospital.

The electronic claims database provided information on patient demographics including age and sex, comorbidities, and prescription data. The comorbidities were identified with ICD-10 including hypertension (I10-I15), IHD (I20-I25), atrial fibrillation (I48), cardiomyopathy (I42), cerebrovascular disease (I60-I69), mitral valve disease (I05, I34), aortic valve disease (I06, I35), hypercholesterolemia (E78.0), diabetes mellitus (E10-E14), and chronic kidney disease (N18, N19).

Drugs prescribed to patients on the index date were available as drug codes together with doses and the amounts prescribed. We categorized co-prescribed drugs into pharmacologic groups including angiotensin-converting enzyme inhibitors (ACEIs)/angiotensin receptor blockers (ARBs), aldosterone antagonists, beta-blockers, dihydropyridine calcium channel blockers (DHP-CCBs), non-dihydropyridine calcium channel blockers (NDHP-CCBs), loop diuretics, organic nitrates, statins, and thiazide diuretics. Aspirin and digoxin were not categorized into pharmacologic groups and were coded as a single drug entity.

The outcome variable of interest was treatment with statins. We dichotomized treatment with statins as the presence or

absence on the index date based on pharmacy claims data. Each statin was coded as a single drug entity to enable determination of the prevalence of individual statins prescribed in the study.

### *Data analysis*

Baseline characteristics of patients in the entire study were summarized and presented as means and standard deviations for numeric variables and as proportions (percentage) for categorical variables.

We calculated the overall prevalence of treatment with statins as the proportion of patients treated with any statins to the total number of patients in the study. The prevalence of treatment with individual statins was calculated by dividing the number of patients treated with each statin by the total number of patients prescribed statins. The prevalence of treatment with statins according to the year patients recruited into the study was also calculated. A linear trend analysis was performed to determine changes over time in the statin treatments with unadjusted logistic regression.<sup>13</sup>

We stratified patient demographics, comorbidities, and co-prescribed drugs to examine frequency distribution between patients who were and were not treated with statins. We used univariable logistic regression to calculate odds ratio (OR; crude ORs) to identify potential factors associated with statin treatment. Those variables with a  $P$ -value  $\leq .2$  were all entered in the multivariable logistic regression to identify factors independently associated with statin treatment in patients with CHF.

All data analysis was conducted with Stata software (StataCorp, College Station, TX, USA). Statistical tests were performed two-sided, and the results were considered statistically significant when the  $P$ -value was  $<.05$ .

### *Ethical approval*

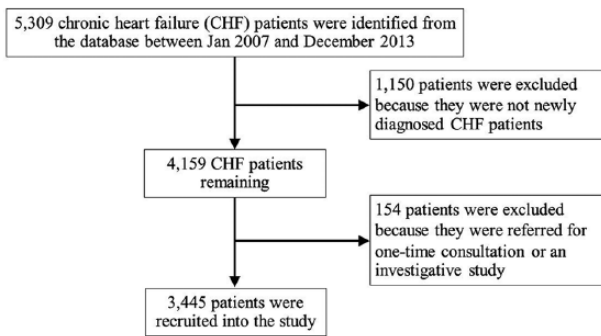
The study protocol was approved by the Institutional Review Board on human research at Naresuan University and the Human Research Committee at the study hospital prior to data collection. Informed consent from patients was not required.

## Results

### *Patient characteristics*

A total of 5309 CHF patients were identified during the study period. Among them, 1150 patients were excluded because they were not newly diagnosed CHF patients, and 154 patients were excluded because they were referred to the clinics for one-time consultation or an investigative study. Thus, a total of 3445 patients were recruited into the study. The flow diagram of patient recruitment is shown in Figure 1.

The mean age was  $65.2 \pm 16.4$  years and 60.1% of the cohort were female (Table 1). Hypertension was the most prevalent



**Figure 1.** The flowchart of patient recruitment into the study.

(52.7%) comorbid condition. Hypercholesterolemia was diagnosed in 33.0% of the cohort. ACEIs/ARBs and loop diuretics were the two most frequently prescribed drugs (59.7% and 57.9%, respectively) to CHF patients in this study.

#### *Prevalence of statin treatment in patients with CHF*

Overall, 1908 (55.4%) patients were prescribed statins at their first-time diagnoses of CHF (Table 1). Most of the patients (89.7%) were prescribed simvastatin 20 mg daily, whereas the rest received atorvastatin 40 mg daily and pravastatin 40 mg daily (Table 2). We did not find any prescriptions for atorvastatin at dosage higher than 40 mg daily in this study.

We stratified the prevalence of statin prescription in newly diagnosed CHF by years and found a significant linear trend of statin treatment ( $P < .001$ ; Table 3). The prevalence of statin treatment in 2013 approached 65%. The prevalence of statin treatment was the highest in patients with the diagnosis of hypercholesterolemia, followed by IHD and diabetes mellitus (Table 4).

#### *Predictors of statin treatment in patients with CHF*

In univariable logistic regression analyses, several factors were found predictive of the statin treatment (Table 5). Strong associations were found for the diagnosis of IHD, hypercholesterolemia, and treatment with aspirin, organic nitrates, and NDHP-CCBs.

All independent variables with the  $P$ -value  $< .2$  in univariable logistic regression analyses were further entered in the multivariable logistic regression model. Factors that were independently associated with statin treatment ( $P < .05$ ) included being male, IHD, cerebrovascular disease, and receipt of ACEIs/ARBs, beta-blockers, aspirin, digoxin, organic nitrates, and NDHP-CCBs (Table 6).

## Discussion

This study aimed to investigate the prevalence and associated factors of statin treatment in CHF patients in actual practice. We found that more than half (55.4%) of the patients were

**Table 1.** Patient characteristics in the entire study (N=3445).

BASELINE CHARACTERISTICS	N (%)
Female	2071 (60.1)
Age (years)	
Mean (SD)	65.2 (16.4)
$\geq 65$ years	1993 (57.9)
$\geq 75$ years	1070 (31.1)
Comorbidities	
Hypertension	1815 (52.7)
Hypercholesterolemia	1137 (33.0)
Ischemic heart disease	1037 (30.1)
Diabetes mellitus	919 (26.7)
Atrial fibrillation	499 (14.5)
Chronic kidney disease	419 (12.2)
Mitral valve disease	377 (10.9)
Cerebrovascular disease	218 (6.3)
Aortic valve disease	193 (5.6)
Cardiomyopathy	142 (4.1)
Drugs	
ACEIs or ARBs	2056 (59.7)
Loop diuretics	1994 (57.9)
Statins	1908 (55.4)
Aspirin	1432 (41.6)
Beta-blockers	1257 (37.0)
Calcium channel blockers	720 (20.9)
Thiazide diuretics	577 (16.8)
Aldosterone antagonists	559 (16.2)
Digoxin	468 (13.6)
Organic nitrates	169 (4.9)
Amiodarone	81 (2.4)

Abbreviations: ACEIs, angiotensin-converting enzyme inhibitors; ARBs, angiotensin receptor blockers.

**Table 2.** The prevalence of statin treatment in newly diagnosed CHF stratified by agents.

STATINS	PREVALENCE, N (%)
Atorvastatin 40 mg/day	121 (6.4)
Pravastatin 40 mg/day	75 (3.9)
Simvastatin 20 mg/day	1712 (89.7)
Total	1908 (100.0)

Abbreviation: CHF, chronic heart failure.

**Table 3.** The prevalence of statin treatment in newly diagnosed CHF patients stratified by years.

YEARS	NUMBER OF NEWLY DIAGNOSED HEART FAILURE PATIENTS	NUMBER OF PATIENTS RECEIVING STATINS, N (%)	P-VALUE FOR LINEAR TREND
2007	420	184 (43.8)	<.001
2008	473	234 (49.5)	
2009	499	265 (53.1)	
2010	527	293 (55.6)	
2011	549	322 (58.7)	
2012	538	323 (60.0)	
2013	439	287 (65.4)	

Abbreviation: CHF, chronic heart failure.

**Table 4.** The prevalence of statin treatment in newly diagnosed CHF stratified by comorbidities.

COMORBIDITIES	TOTAL NUMBER OF PATIENTS	PREVALENCE OF STATIN USE, N (%)
Hypercholesterolemia	1137	950 (83.6)
Ischemic heart disease	1037	836 (80.6)
Diabetes mellitus	919	716 (77.9)
Cerebrovascular disease	218	159 (72.9)
Hypertension	1785	1225 (68.6)
Chronic kidney disease	419	281 (67.1)
Cardiomyopathy	145	86 (59.3)
Atrial fibrillation	499	263 (52.7)
Mitral valve disease	377	194 (51.5)
Aortic valve disease	234	119 (50.9)

Abbreviation: CHF, chronic heart failure.

prescribed statins at their first-time diagnosis of CHF. A significant increase in linear trend of statin treatment was also observed during the study period with the prevalence of statin treatment approaching 65% in 2013, suggesting that statin treatment has gained acceptance in CHF patients despite limited evidence of its efficacy in this population.

The high prevalence of statin treatment in CHF patients in our study appears consistent with other studies. A cross-sectional study in an outpatient setting at a tertiary-care hospital in Australia has documented that 65% of CHF patients aged >60 years were prescribed statins.<sup>14</sup> The causes of CHF were determined as non-ischemic in nearly 60% of the patients in the study. An earlier observational study in the United States also reported statin use in 62% of CHF patients.<sup>15</sup> In a large, multicenter study to explore adherence to guideline-recommended medications in 36 countries found that 64% of CHF patients received statin treatment.<sup>16</sup> However, a lower prevalence of the statin treatment in CHF patients has also been reported. A study conducted in African patients with their

first-time diagnoses of CHF during hospitalization reported that 37% of the cohort were prescribed statin after discharge.<sup>17</sup> The cause of CHF was determined as non-ischemic in most (90%) of the cohort, a possible reason for the lower prevalence of statin treatment in this study. Because the prevalence of statin treatment in CHF patients seems high, the significant issue would be whether the treatment with statins in most CHF patients as reported in these studies is judicious.

In this study, the prevalence of statin treatment was high (83.6%) among CHF patients with a diagnosis of hypercholesterolemia (Table 4). Furthermore, hypercholesterolemia was the strongest predictor of statin treatment (OR=4.88, 95% confidence interval [CI]=3.88-6.14), independently of other comorbidities. This finding implies that in CHF patients high blood cholesterol might be regarded by prescribers as an important factor in making decision to prescribe statins. This observation could be the result of an overemphasis on high cholesterol as a propelling factor for statin treatment in general population. Consequently, hypercholesterolemia becomes an important

**Table 5.** Univariable analysis of factors associated with statin treatment.

VARIABLES	STATINS (%) (N = 1908)	NO STATINS (%) (N = 1537)	CRUDE ORs <sup>a</sup> (95% CI)	P-VALUE
Age ≥65 years	1213 (63.6)	780 (50.7)	1.69 (1.47–1.94)	<.001
Male	782 (41.0)	592 (38.5)	1.11 (0.96–1.27)	.141
<b>Comorbidities</b>				
Hypertension	1225 (65.8)	560 (36.4)	3.35 (2.91–3.87)	<.001
Hypercholesterolemia	950 (49.8)	187 (12.2)	7.16 (5.97–8.58)	<.001
Ischemic heart disease	836 (43.8)	201 (13.1)	5.18 (4.34–6.19)	<.001
Diabetes mellitus	716 (37.5)	203 (13.2)	3.95 (3.32–4.70)	<.001
Chronic kidney disease	281 (14.7)	138 (9.0)	1.75 (1.41–2.17)	<.001
Atrial fibrillation	263 (13.8)	236 (15.4)	0.88 (0.73–1.07)	.193
Mitral valve disease	194 (10.2)	183 (11.9)	0.84 (0.67–1.04)	.104
Cerebrovascular disease	159 (8.3)	59 (3.8)	2.27 (1.66–3.15)	<.001
Aortic valve disease	119 (6.9)	115 (7.0)	1.23 (0.90–1.67)	.175
Cardiomyopathy	86 (4.5)	59 (3.8)	1.02 (0.78–1.33)	.210
<b>Co-prescribed drugs</b>				
ACEIs or ARBs	1395 (73.1)	661 (43.0)	3.60 (3.11–4.17)	<.001
Loop diuretics	1201 (63.0)	793 (51.6)	1.59 (1.39–1.83)	<.001
Aspirin	1134 (59.4)	298 (19.4)	6.09 (5.20–7.14)	<.001
Beta-blockers	930 (48.7)	345 (22.5)	3.29 (2.82–3.83)	<.001
DHP-CCBs	428 (22.4)	166 (10.8)	2.39 (1.96–2.92)	<.001
Thiazide diuretics	408 (21.4)	169 (11.0)	2.20 (1.81–2.69)	<.001
Aldosterone antagonists	323 (16.9)	236 (15.4)	1.12 (0.93–1.35)	.212
Digoxin	215 (11.4)	253 (16.5)	0.64 (0.53–0.76)	<.001
Organic nitrates	149 (7.8)	20 (1.3)	6.42 (3.99–10.87)	<.001
NDHP-CCBs	106 (5.6)	20 (1.3)	4.46 (2.73–7.63)	<.001
Amiodarone	51 (2.7)	30 (2.0)	1.38 (0.86–2.26)	.165

Abbreviations: ACEIs, angiotensin-converting enzyme inhibitors; ARBs, angiotensin receptor blockers; CI, confidence interval; DHP-CCBs, dihydropyridine calcium channel blockers; NDHP-CCBs, non-dihydropyridine calcium channel blockers; OR, odds ratio.

<sup>a</sup>Univariable logistic regression analysis.

factor associated with statin treatment in CHF patients as in general population. Because statins have not been shown to provide cardiovascular benefits with certainty in CHF patients and the benefit-to-risk ratios for CHF patients may vary according to their atherosclerotic vascular risk, an initiation of statin treatment based mainly on cholesterol level may lead to an injudicious use of statins in this population. Therefore, this finding should raise concerns among policymakers for a closer investigation into its impacts on clinical and economic outcomes among CHF patients.

We also observe that 50.2% of CHF patients without a diagnosis of hypercholesterolemia received statin treatment (Table 5). One likely explanation for this observation could be that physicians may have prescribed statins to patients whom they perceived to be at high risk of ASCVD regardless of baseline cholesterol levels, thereby the diagnosis of hypercholesterolemia was not provided in the medical record. Consistent with this explanation, we found the high prevalence of statin treatment in CHF patients with IHD, cerebrovascular disease, and diabetes (80%, 73%, and 78%, respectively). In addition, IHD, cerebrovascular disease, and



**Table 6.** Multivariable analysis of factors associated with statin treatment.

VARIABLES	ADJUSTED ORs <sup>a</sup>	95% CIs	P-VALUE
Age ≥65 years	1.14	0.96–1.37	.142
Male	1.21	1.02–1.44	.031
Comorbidities			
Hypercholesterolemia	4.88	3.88–6.14	<.001
Ischemic heart disease	2.71	2.18–3.36	<.001
Diabetes mellitus	1.95	1.55–2.46	<.001
Cerebrovascular disease	1.64	1.12–2.40	.012
Hypertension	0.95	0.77–1.18	.660
Chronic kidney disease	1.13	0.84–1.52	.420
Atrial fibrillation	0.90	0.68–1.17	.420
Mitral valve disease	1.13	0.85–1.12	.403
Aortic valve disease	1.36	0.94–1.97	.106
Co-prescribed drugs			
ACEIs or ARBs	3.44	2.87–4.13	<.001
Aspirin	2.79	2.30–3.40	<.001
NDHP-CCBs	2.35	1.30–4.24	.004
Beta-blockers	1.51	1.23–1.84	<.001
Organic nitrates	2.04	1.16–3.58	.013
Digoxin	0.65	0.50–0.86	.002
DHP-CCBs	1.23	0.94–1.61	.129
Loop diuretics	0.95	0.79–1.15	.599
Thiazide diuretics	0.78	0.60–1.02	.071
Amiodarone	1.02	0.57–1.84	.945

Abbreviations: ACEIs, angiotensin-converting enzyme inhibitors; ARBs, angiotensin receptor blockers; CI, confidence interval; DHP-CCBs, dihydropyridine calcium channel blockers; NDHP-CCBs, non-dihydropyridine calcium channel blockers; OR, odds ratio.

<sup>a</sup>Adjusted for all covariates shown in the table.

diabetes were all significant predictors of the statin treatment, independently of other factors including hypercholesterolemia. The high prevalence of statin treatment in these patients indicates a high degree of prescribers' compliance with the guideline available in the study period,<sup>18</sup> as these patients are generally considered at high risk of ASCVD and will derive the most benefit from statin therapy. Of note, diabetes was considered as an IHD risk equivalence by the guideline.<sup>18</sup> However, the beneficial effect of statins is not well established in CHF patients. In CORONA<sup>10</sup> and GISSI-HF<sup>11</sup> trials, rosuvastatin did not significantly reduce cardiovascular outcomes in CHF patients with or without IHD. Thus, the relevant guidelines in management of blood cholesterol in adults did not recommend the initiation of statins in CHF patients unless with other indications for their use.<sup>9,12</sup> The

observation that a high proportion of CHF patients with IHD, cerebrovascular disease, and diabetes were prescribed statins suggests that prescribers may view statin treatment as providing more benefits than harms to CHF patients with the aforementioned comorbidities.

A significant proportion (63.6%) of elderly CHF patients were prescribed statins in this study (Table 5). Although the older persons are at an increased risk of ASCVD by the effect of their advanced age alone, the evidence for efficacy of statins in this population is limited, particularly in elderly CHF patients. The PROSPER trial, specifically investigating the effect of pravastatin in the older population, found no significant reduction in overall mortality by pravastatin compared with placebo.<sup>19</sup> In a recent study using real-world data in

elderly statin users aged >65 years following acute coronary syndromes, the number of myocardial infarction and deaths that could be prevented by aggressive statin treatment was projected as negligible.<sup>20</sup> Taken together, these findings should caution the extrapolation of potential benefits and harms of statin use from the younger to the elderly patients, given the higher prevalence of multi-comorbidities, potential adverse drug effects, drug interactions due to polypharmacy, and limited life expectancy in the elderly population.<sup>21,22</sup>

To better understand the factors associated with the decision to initiate statin treatment, we have chosen to investigate factors that were available clinically in everyday practice, including other drugs concurrently prescribed for CHF patients. We found a strong association between guideline-recommended drugs for CHF patients with statin treatment in this study.<sup>3</sup> ACEIs/ARBs, beta-blockers, and organic nitrates increase the odds of receiving statins, whereas digoxin lowers the likelihoods of statin treatment. Our results agree with a study reporting that a higher rate of statin treatment was associated with other standard-of-care therapies in a large managed-care population with IHD and diabetes in the United States.<sup>23</sup> This finding implies that statins might be viewed as cardiovascular protective measures in the same way as other therapeutic agents, including ACEIs/ARBs or beta-blockers, in CHF patients. Whether statins provide cardiovascular benefits more than harms to CHF patients is still controversial,<sup>9,12,15</sup> and the economic outcomes of statin treatment among CHF patients in real-world practice have not been evaluated. Taken together, we believe that this message should be conveyed to health care professions to promote a cautious use of statins in this population.

Interestingly, we found a strong association between NDHP-CCBs and statin use (OR = 2.35, 95% CI = 1.30–4.24). The NDHP-CCBs were generally not recommended in CHF patients with reduced ejection fraction (EF) due to their harmful effects in this population. In addition, NDHP-CCBs, namely, verapamil and diltiazem, are known to increase the serum level of simvastatin; thus, their concurrent use with simvastatin should limit the maximum daily dose of simvastatin to not more than 10 mg daily.<sup>24–26</sup> The observation that the use of NDHP-CCB increases the likelihood of statin treatment is certainly of concern and should be further investigated for its suitability.

Simvastatin at moderate-intensity dose (20 mg daily) was the major statin prescribed in our study. A few reasons could explain this observation. Thai patients, like other Asian races compared with Westerners, are perceived to gain similar benefits at lower statin doses but are more susceptible to adverse effects from the statin treatment, possibly leading to a lower dose of statin therapy in this study.<sup>27</sup> This perception may lead to a substantial proportion of Asian patients receiving the moderate-intensity statin treatment. However, a recent study conducted in Canada found that statin use does not confer any

higher risk of serious adverse effects in Chinese compared with their non-Chinese counterparts with similar baseline health.<sup>28</sup> Other possible reasons for the high prevalence of simvastatin use include the fact that simvastatin was the only statin available generically in Thailand during the study period and costs significantly less compared with other statins. In addition, simvastatin was listed as a first-line drug for management of hypercholesterolemia by the Thai National Essential Drug List, whereas atorvastatin was indicated only for those who cannot achieve their low-density lipoprotein cholesterol (LDL-C) goal with simvastatin,<sup>29</sup> providing an example of the effectiveness of implementing an essential drug list as a tool to control drug use and accessibility in developing countries including Thailand.<sup>30,31</sup>

Some limitations of this study merit discussion. First, the observational and cross-sectional nature of our data makes it difficult to establish the causal relationship between predictors and statin treatment. However, our findings are well consistent with previous studies in the general population; we believe this may partly argue for the result validity. To our knowledge, most of the previous studies on the prevalence and predictors of statin treatment mainly focus on general population or patients with diabetes. Therefore, this research will add to the current knowledge of statin treatment in CHF patients. Second, we lack some other potential predictors of statin treatment, for example, lipid levels, EFs, and severity of CHF. These unmeasured confounders may affect the prescribers' decision to prescribe statins for their patients. Third, statins could have been discontinued in the future visits; thus, our findings may not reflect the prevalence of statin treatment in a longer follow-up period. Last, this study recruited patients from the outpatient clinics affiliated with a public, tertiary-care hospital; thus, generalizability of the results to other settings requires further confirmation.

## Conclusions

In this study, statins were prescribed to more than half of the newly diagnosed CHF patients. Independent predictors of statin treatments include hypercholesterolemia and comorbidities indicative of high atherosclerotic vascular risk as well as drugs recommended as cardiovascular protective therapy for CHF patients. These findings should promote further discussion among public policymakers to improve statin treatment and quality of care in CHF patients.

## Author Contributions

Both PK and AJ conceived and designed the study. PK performed data analysis. Both PK and AJ jointly drafted and agreed upon the final version of the submitted manuscript.

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