ORIGINAL RESEARCH

Advanced Practice Provider Versus Physician-Only Outpatient Follow-Up After Acute Myocardial Infarction

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***Background*—**Physician shortages and reimbursement changes have led to greater use of advanced practice providers (APPs). Prevalence of and outcomes associated with APP care following myocardial infarction are unknown.

***Methods and Results*—**We examined outpatient cardiology or primary care visits within 90 days post-myocardial infarction among 29 477 Medicare-insured patients aged ≥65 years from 364 hospitals in Acute Coronary Treatment Intervention Outcomes Network Registry. We compared medication adherence, all-cause readmission risk, mortality, and major adverse cardiovascular events between patients seen by APPs versus physicians only. Overall, 11% of myocardial infarction patients were treated by an APP. Patients seen by APPs were more likely to have diabetes mellitus (37% versus 33%) and heart failure (20% versus 16%), be discharged to a nursing facility (21% versus 13%) and had more outpatient visits within 90 days post-discharge (median 6 versus 5, $P<0.01$ for all) than those seen by physicians only. Adherence to evidence-based medications (adjusted odds ratio, 0.98; 95% confidence interval, 0.89–1.08) and readmission risks (adjusted hazard ratio, 1.11; 95% confidence interval, 0.99–1.26) were similar between patients seen by APPs versus physicians only. Risks of 90-day mortality (adjusted hazard ratio, 1.18; 95% confidence interval, 0.98–1.42) and major adverse cardiovascular events (adjusted hazard ratio, 1.06; 95% confidence interval, 0.90–1.23) were also similar between patients seen by APPs versus physicians only.

***Conclusions*—**APPs were likely used to provide more frequent monitoring of high-risk post-MI patients. Medication adherence, readmission risk, mortality, and major adverse cardiovascular events did not differ substantially between patients seen by physician-APP teams than those seen by physicians only. **(*J Am Heart Assoc*. 2018;7:e008481. DOI: 10.1161/JAHA.117.008481.)**

Key Words: adherence • advanced practice providers • myocardial infarction • nursing • readmission

National practice changes in response to limited physician availability, scheduling inflexibilities, reimbursement considerations, and other factors have resulted in more patients receiving care from advanced practice providers (APPs). APPs currently include nurse practitioners (NP) and physician assistants. Currently, 21 states and the District of Columbia permit independent practice for nurse practitioners.[1] The Association of American Medical Colleges estimates that by 2020, there will be a shortage of >90 000 physicians.[2] A report from the American College of Cardiology estimated that by 2025, there will be a shortage of 16 000 general cardiologists; and by 2050, the number of practicing cardiologists will need to double to accommodate demand.[3] In current practice, frequently cited reasons for integrating APPs into clinical practices include resident duty hour restrictions and a need to improve continuity of care and timely patient access to care.[4] In primary care practices focused on maintenance of health, evidence suggests that APPs provide quality of care comparable to that of physicians while improving upon patient satisfaction.[5–9]

How post-myocardial infarction (MI) care differs between patients managed by physician-APP teams or by physicians only is unknown. Using data from the ACTION Registry (Acute Coronary Treatment Intervention Outcomes Network Registry) linked to the Center for Medicare and Medicaid Services (CMS) claims data, we examined national patterns of APP use in the care of post-MI patients. We hypothesized the following: (1) post-MI patients with greater comorbidity burden or peri-MI complications will more likely be cared for by physician providers only to facilitate complex decision-making, while APPs will more likely be used to conduct routine

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Clinical Perspective

What Is New?

- Changes in reimbursement and physician shortages have led to the increased need for advanced practice providers (APPs) to increase access to care.
- In a US population of 29 477 Medicare-insured patients at 364 hospitals, roughly 11% of post-myocardial infarction (MI) patients were treated by an APP within 90 days after MI discharge.
- Post-MI patients seen by physician-APP teams had more comorbidities and were more clinically complex compared with those patients seen by physicians only.
- Medication adherence, readmission risk, mortality, and major adverse cardiovascular events did not differ substantially between patients seen by physician-APP teams compared with those seen by physicians only.

What Are the Clinical Implications?

- Though the minority of post-MI patients are seen by physician-APP teams, our study suggests that a team-based approach to post-MI outpatient care may be beneficial for patients with complex comorbidities compared with physician-only follow-up.

secondary prevention of post-MI patients; (2) there is substantial variability between hospitals in the proportion of patients who receive follow-up care with an APP; (3) post-MI patients cared for by APPs will have no significant difference in secondary prevention medication adherence, or risks of readmission, mortality, or major adverse cardiovascular events (MACE) compared with patients treated by physician providers only.

Methods

The data, analytic methods, and study materials will not be made available to other researchers for purposes of reproducing the results or replicating the procedure. As the data are the property of the NCDR (National Cardiovascular Data Registry), the authors of this publication are not authorized to make the data available to other researchers without consent of the NCDR.

The National Cardiovascular Data Registry ACTION Registry is the largest quality improvement registry of MI patients in the United States. Participating hospitals collect detailed in-patient data, including demographics, clinical characteristics, and in-hospital treatments and outcomes, via medical record review using a standardized set of data elements and definitions.[10] The institutional review boards of each reporting hospital approved participation in the ACTION Registry. Since all data are abstracted retrospectively and anonymously without unique patient identifiers, institutional review boards waived the need for patient informed consent. To obtain data on APP usage and post-discharge outcomes, patients aged ≥65 years were linked to Center for Medicare and Medicaid Services claims records using 5 indirect identifiers (date of birth, sex, hospital ID, date of admission, date of discharge), as previously described.[11]

Starting with the 43 576 MI patients who were enrolled in Medicare Part A & B fee-for-service plans before discharge at 369 US hospitals in the ACTION Registry between August 2007 and December 2009, we excluded patients who died during the index admission (n=3173), were transferred to another hospital (n=2079), were discharged to hospice (n=860) or requested comfort measures only (n=535), left against medical advice (n=109), and those who did not have their first cardiology or primary care outpatient follow-up visit within the first 30 days after hospitalization (n=6432). For linked patients with multiple MI hospitalization records in ACTION-Registry, we excluded 911 subsequent ACTION Registry records so that follow-up began at the start of the first admission. The final analysis population included 29 477 MI patients aged ≥65 years discharged alive after an MI at 364 US hospitals.

National provider identifier (NPI) and taxonomy codes from Medicare outpatient facility claims and carrier claims were used to determine whether the outpatient cardiology or primary care clinic encounter (inclusive of primary care, internal medicine, family practice, geriatric medicine providers) was conducted and billed independently by an APP. Currently the legal requirements of most states require APPs to work in coordination and under the supervision of a physician, thus APP care is defined by a team-based approach involving both APPs and physicians.

Using Medicare Part D Drug Event data (Medicare Part D), we assessed adherence to the following secondary prevention medication classes among those prescribed at discharge after MI: β-blocker, statin, $P2Y_{12}$ receptor inhibitor, and angiotensin converting enzyme inhibitor or angiotensin receptor blocker. Medication adherence was defined as the proportion of days covered of at least 80% for each medication within 90 days post-discharge among patients who were alive and enrolled in Medicare Part D for 3 months before the index admission to determine their supply at discharge (and censored if/when they drop Medicare Part D enrollment). Furthermore, patients were excluded if they did not have a full 90-day follow-up period, similar to previous studies.[12,13] We also examined rates of readmission, mortality, and MACE. MACE was defined as any of the following events: death, heart failure (HF) readmission (*International Classification of Diseases, Ninth Revision [ICD-9]*: 428, 402.01, 402.11, 402.91, 398.91, 404.x1, and 404.x3), acute MI readmission (410.x1), or

stroke readmission (346.6x, 433.x1, 434.x1, 430, 431, or 436). We defined time to first readmission, death, or MACE as the number of days between the date of discharge and the respective event.

The ACTION Registry in-hospital mortality prediction risk model was derived and validated in a population of patients with MI.[14] Briefly, the model consists of the following variables: age, systolic blood pressure, heart rate at admission, presence of heart failure and/or shock on admission, ST-segment changes, initial serum creatinine, initial troponin (ratio over institutional upper limit of normal), and the presence or absence of prior peripheral artery disease to estimate predicted in-hospital mortality risk. As a summary measure of patient risk factors, we calculated the ACTION in-hospital mortality risk score (ACTION mortality risk score) for each patient, and patients were divided into low (<30), medium (30–40), and high risk (>40) categories.[14] We used the thresholds defined in the initial derivation of the ACTION mortality risk score,[14] which have been used in other analyses.[15] As in prior studies,[16] in-hospital major bleeding was defined as a hemoglobin decrease of ≥4 g/dL, intracranial hemorrhage, documented or suspected retroperitoneal bleed, any red cell blood transfusion with baseline Hb ≥ 9 g/dL, or any red cell transfusion with Hb <9 g/dL and a suspected bleeding event. Given that a majority of patients undergoing coronary bypass graft surgery (CABG) receive blood transfusions related to the surgery, bleeding events were considered only if they occurred before CABG while post CABG bleeding was not.[17]

Patients were categorized into 1 of 2 groups based on whether they had physician-only outpatient visit(s) or had at least 1 APP outpatient visit within 90 days after discharge from the index MI hospitalization. Patient baseline characteristics, including demographics, medical history, presentation features, in-hospital treatments, discharge medications, discharge status, and hospital characteristics were compared among groups. Categorical variables were presented as frequencies (percentages), and differences between groups were assessed using Chi-Square tests. Continuous variables were presented as median values (25th, 75th percentiles) and were compared using Wilcoxon rank-sum tests.

For hospital level analyses, hospitals with ≤25 patients for the entire study period (134 hospitals, totaling 1432 patients) were excluded, to ensure reasonable precision of hospital APP usage rates. Hospitals were categorized into 3 groups: low APP usage (<5% of all MI patients treated by APP), intermediate APP usage (5%–20%), and high APP usage (>20%) within 90 days of discharge. The proportion of patients with ACTION mortality risk score >40, 30 to 40, and <30 seen by APPs among high-, intermediate-, and low-APP care hospitals was compared using a χ^2 test.

Among patients who survived to 90 days post-discharge, we examined the relationship between APP care and evidence-based medication adherence within 90 days. A mixed-effects logistic regression model for composite adherence, treating each medication as an opportunity for adherence and including hospitals as a random effect, was performed. Covariates included in the model adjustment are age, sex, body mass index, race, length of stay during the index MI admission, prior MI, prior percutaneous coronary intervention, prior CABG, prior HF, prior stroke, prior peripheral artery disease, prior atrial fibrillation, diabetes mellitus, hypertension, dyslipidemia, current or recent smoker within the past year, MI type (non–ST-segment–elevation myocardial infarction [NSTEMI] versus ST-segment–elevation myocardial infarction [STEMI]), in-hospital procedures (percutaneous coronary intervention or CABG), in-hospital complications (heart failure, cardiogenic shock, stroke, and major bleeding), laboratory results (lowest hemoglobin, initial serum creatinine, and peak troponin ratio), discharge medications from the index admission (β-blockers, angiotensin converting enzyme inhibitors or angiotensin receptor blockers, statins, and $P2Y_{12}$ receptor inhibitors), transferred in from another acute care hospital status, hospital teaching status (membership in the Council of Teaching Hospitals), socioeconomic status (percentage of people aged ≥25 years with a high school diploma, and median household income obtained from the Area Resource File based on the zip code of patient residence), and number of in-patient hospitalizations within 1 year before the index MI admission.

Furthermore, to explore the association between APP care and all-cause readmission, mortality, and MACE, a landmark analysis was performed. All-cause readmission, mortality, and MACE were evaluated from a landmark time of 90 days post-discharge (after which APP status was known) and until 6 months after discharge from the index hospitalization. Cumulative incidence for all-cause readmission accounting for the competing risk of death was compared between APP care using the Gray test.[18] Unadjusted Kaplan–Meier event rates for mortality and MACE were reported and log-rank test was used to access whether the differences between the curves were statistically significant at 0.05 level. Cox proportional hazards regression models, stratified by the discharging hospital, were performed where robust standard errors were used to account for clustering of patients within hospitals adjusting for the same list of covariates listed above. Secondary models additionally adjusted for the total number of visits within 90 days of discharge.

The percentage of missing data was low, <2% for most covariates, except for lowest hemoglobin (6.5%) and peak troponin (5.7%). For modeling, missing values of the continuous covariates were imputed to the MI type and sex-specific median of the non-missing values. For categorical variables, missing values were imputed to the most frequent group.

All statistical analyses were performed using SAS software (version 9.4, SAS Institute). The Duke Clinical Research Institute conducted all analyses. This project was supported by a grant from the Agency for Healthcare Research and Quality (U19H2O21092).

Results

Among the 29 477 MI patients discharged alive from 364 US hospitals, 3093 (11%) had at least 1 outpatient visit with an APP within 90 days after hospital discharge, while the remainder had all follow-up visits with physicians only. Over time, there was little change in the proportion of patients who received outpatient APP care within 90 days post-discharge (473 [10%] in 2007, 1151 [10%] in 2008, and 1469 [11%] in 2009). Most of the 2961 (95.7%) patients who were seen by an APP also had a physician visit within the first 90 days post-discharge; most of these patients (97%) had their first outpatient visit after discharge with a physician then an APP. The mean time from discharge to first physician follow-up was 10.6 and 31.8 days to first APP visit. Patients in the APP group had a mean of 2 (SD:2) independent APP visits within the first 90 days. The overall number of outpatient visits within 90 days post-discharge was higher for patients seen by an APP (mean 7 versus 6, $P<0.01$) than patients seen by physicians only.

The characteristics of patients seen by APPs versus physicians only are shown in Table 1. Overall, patients seen by APPs were more likely to be female and to have diabetes mellitus, prior peripheral artery disease, or heart failure than those patients seen by physicians only. The incidence of in-hospital cardiogenic shock and heart failure were slightly higher among patients seen by an APP, but the median length of index hospital stay was not substantially different between groups. Patients seen by APPs were more likely to be discharged to a skilled nursing facility (21% versus 13%, $P<0.01$) than those seen by physicians only. There was no significant difference in rates of β-blocker, angiotensin-converting enzyme inhibitor or statin prescription at discharge between the 2 groups. Patients seen by APPs were less likely to undergo in-hospital percutaneous coronary intervention and to be discharged with a $P2Y_{12}$ receptor inhibitor.

Patients with APP visits were more likely to be discharged from hospitals in the Midwest and from non-teaching hospitals compared with patients with physician-only follow-up (Table 1). Figure 1 demonstrates the distribution of post-discharge APP usage across hospitals. The median proportion of MI patients with APP follow-up within 90 days post-discharge among hospitals was 10% (25th, 75th percentiles: 6.1%, 13.3%); 10% of hospitals discharged >20% of MI patients to APP care within the first 90 days of discharge. Patients with higher ACTION mortality risk score were more likely to receive APP follow-up than patients with lower ACTION mortality risk score, regardless of hospital frequency of referral for APP follow-up (Figure 2).

Figure 3 demonstrates 90-day adherence to secondary prevention medications prescribed at discharge. There were no differences in adherence to β-blockers, statins, angiotensin-converting enzyme inhibitors or angiotensin receptor blockers, and $P2Y_{12}$ receptor inhibitors between patients cared for by APPs and those cared for by physicians only. After multivariable adjustment, APP follow-up was not associated with composite medication adherence when compared with follow-up conducted by physicians only: adjusted odds ratio 0.98, 95% confidence interval (CI) 0.89 to 1.08.

In landmark analyses, 90-day all-cause readmission rates were 16.3% (95% CI 14.7%–18.0%) for patients seen by an APP versus 13.8% (95% CI 13.4%–14.3%) for patients followed by physicians only ($P<0.01$). However, this difference was no longer statistically significant after multivariable adjustment: adjusted hazard ratio (HR) 1.11, 95% CI 0.99 to 1.26. Ninety-day mortality rates were 4.9% (95% CI 4.2%–5.8%) for patients seen by an APP versus 3.6% (95% CI 3.4%–3.9%) for patients seen by a physician alone ($P<0.01$) (Table 2). Ninety-day MACE rates were 7.8% (95% CI 6.9%–8.9%) for patients seen by APPs versus 6.4% (95% CI 6.1%–6.8%) for patients seen by physicians only ($P<0.01$). There was no significant difference after multivariable adjustment for either 90-day mortality (adjusted HR 1.18, 95% CI 0.98–1.42) or MACE (adjusted HR 1.06, 95% CI 0.90–1.23) when comparing patients seen by APPs versus physicians only. After further adjustment for total number of visits within the first 90 days after discharge, there remained no significant difference in readmission risk (adjusted HR 1.09, 95% CI 0.96–1.23), mortality (adjusted HR 1.17, 95% CI 0.97–1.41), or risk of MACE (adjusted HR 1.04, 95% CI 0.89–1.22) when comparing patients seen by APPs versus physicians only.

Discussion

In this nationwide study of APP use and characteristics of patients seen by APPs, we observed that ≈1 in 10 MI patients received outpatient care by an APP within 90 days post-discharge, although the first post-discharge visit was virtually always with a physician. Patients seen by a physician and APP combination were more likely to have comorbid conditions and in-hospital complications than patients seen in follow-up by physicians alone. There were no significant differences in medication adherence, or risks of readmission, mortality, and MACE between patients seen by APPs versus physicians only.

Early follow-up of the post-MI population has been associated with improved medication adherence.[19]

Table 1. Baseline Characteristics of Post-MI Patients Cared for by APPs Versus Physicians Alone Within 90 Days of Discharge

	Overall (n=29 477)	Physician-Only Visit Within 90 Days (n=26 384)	APP Visit Within 90 Days (n=3093)	*P* Value
Demographics				
Age, y	76.0 (70.0, 82.0)	76.0 (70.0, 82.0)	77.0 (70.0, 83.0)	<0.01
Female	13 340 (45.3)	11 817 (44.8)	1523 (49.2)	<0.01
White race	26 429 (89.7)	23 630 (89.6)	2799 (90.5)	0.11
Past medical history				
Body mass index, kg/m^2	27.2 (24.0, 30.9)	27.1 (23.9, 30.9)	27.5 (24.1, 31.2)	<0.01
Prior PCI	7023 (23.8)	6297 (23.9)	726 (23.5)	0.61
Prior CABG	6036 (20.5)	5359 (20.3)	677 (21.9)	0.04
Prior MI	7864 (26.7)	6994 (26.5)	870 (28.1)	0.05
Prior heart failure	4781 (16.2)	4158 (15.8)	623 (20.1)	<0.01
Hypertension	23 414 (79.4)	20 925 (79.3)	2489 (80.5)	0.11
Dyslipidemia	18 527 (62.9)	16 565 (62.8)	1962 (63.4)	0.39
Current/recent smoker	4504 (15.3)	4035 (15.3)	469 (15.2)	0.84
Diabetes mellitus	9762 (33.1)	8607 (32.6)	1155 (37.3)	<0.01
End stage renal disease	3969 (13.5)	3508 (13.3)	461 (14.9)	0.02
Peripheral arterial disease	4052 (13.7)	3555 (13.5)	497 (16.1)	<0.01
ACTION mortality risk score	34.0 (29.0, 40.0)	34.0 (29.0, 40.0)	35.0 (30.0, 41.0)	<0.01
In-hospital features				
STEMI (vs NSTEMI)	9372 (31.8)	8446 (32.0)	926 (29.9)	0.02
PCI	16 252 (55.1)	14 615 (55.4)	1637 (52.9)	<0.01
CABG	2758 (9.4)	2436 (9.2)	322 (10.4)	0.03
Cardiogenic shock	1415 (4.8)	1229 (4.7)	186 (6.0)	<0.01
Heart failure	2396 (8.1)	2092 (7.9)	304 (9.8)	<0.01
Major bleeding	3549 (12.0)	3162 (12.0)	387 (12.5)	0.40
Length of stay	4.0 (3.0, 7.0)	4.0 (3.0, 6.0)	4.0 (3.0, 7.0)	<0.01
Discharge medications				
Aspirin	27 466 (97.4)	24 625 (97.5)	2841 (96.7)	0.01
$P2Y_{12}$ inhibitors	21 381 (72.7)	19 200 (73.0)	2181 (70.6)	0.01
β-blockers	26 574 (95.8)	23 807 (95.9)	2767 (95.2)	0.20
ACE inhibitors	16 402 (63.6)	14 672 (63.5)	1730 (64.4)	0.31
Statins	25 092 (88.0)	22 484 (88.0)	2608 (87.5)	0.45
Discharge characteristics				
Discharged to home	25 707 (87.2)	23 240 (88.1)	2467 (79.8)	<0.01
Discharged to skilled nursing facility	4011 (13.6)	3352 (12.7)	659 (21.3)	<0.01
Cardiac rehabilitation referral	18 812 (75.1)	16 910 (75.0)	1902 (76.0)	0.34
Hospital characteristics				
Teaching hospital*	8352 (28.3)	7594 (28.8)	758 (24.5)	<0.01
Total hospital beds	411 (283, 621)	411 (283, 622)	403 (276, 574)	<0.01
Region				<0.01
Midwest	10 905 (37.0)	9553 (36.2)	1352 (43.7)	

Continued

Table 1. Continued

	Overall (n=29 477)	Physician-Only Visit Within 90 Days (n=26 384)	APP Visit Within 90 Days (n=3093)	*P* Value
West	3367 (11.4)	2995 (11.4)	372 (12.0)	
Northeast	2672 (9.1)	2423 (9.2)	249 (8.1)	
South	12 533 (42.5)	11 413 (43.3)	1120 (36.2)	

Continuous variables expressed as median (25th, 75th percentiles), categorical variables presented as n (%). ACE indicates angiotensin-converting enzyme; ACTION; Acute Coronary Treatment Intervention Outcomes Network; CABG, coronary artery bypass grafting; MI, myocardial infarction; NSTEMI, non–ST-segment–elevation myocardial infarction; PCI, percutaneous intervention; STEMI, ST-segment–elevation myocardial infarction.
*Membership in the Council of Teaching Hospitals.

Increasingly, hospitals, payers, and policymakers are focusing on early outpatient follow-up post-discharge to reduce preventable readmissions. The frequency of post-MI patients receiving outpatient care from APPs observed in our study underscores practice changes in the United States as a result of physician supply being outweighed by demand.[3,20] APPs have become increasingly critical sources of care for MI patients, as well as in many other disease states.[2] Larson and colleagues performed an analysis of primary care in Washington state, and found that APPs contribute to >20% of primary care in urban areas and nearly 25% of primary care in rural areas.[21] With the growing shortage of both primary care and cardiology physicians, we expected APPs to expand access to care, and in particular to facilitate early follow-up post-MI. Surprisingly, we observed that virtually all first follow-up visits post-discharge were with a physician provider, rather than an APP.

We had hypothesized that post-MI patients with greater comorbidity burden or more complicated MI courses would more likely be cared for by physician providers only to

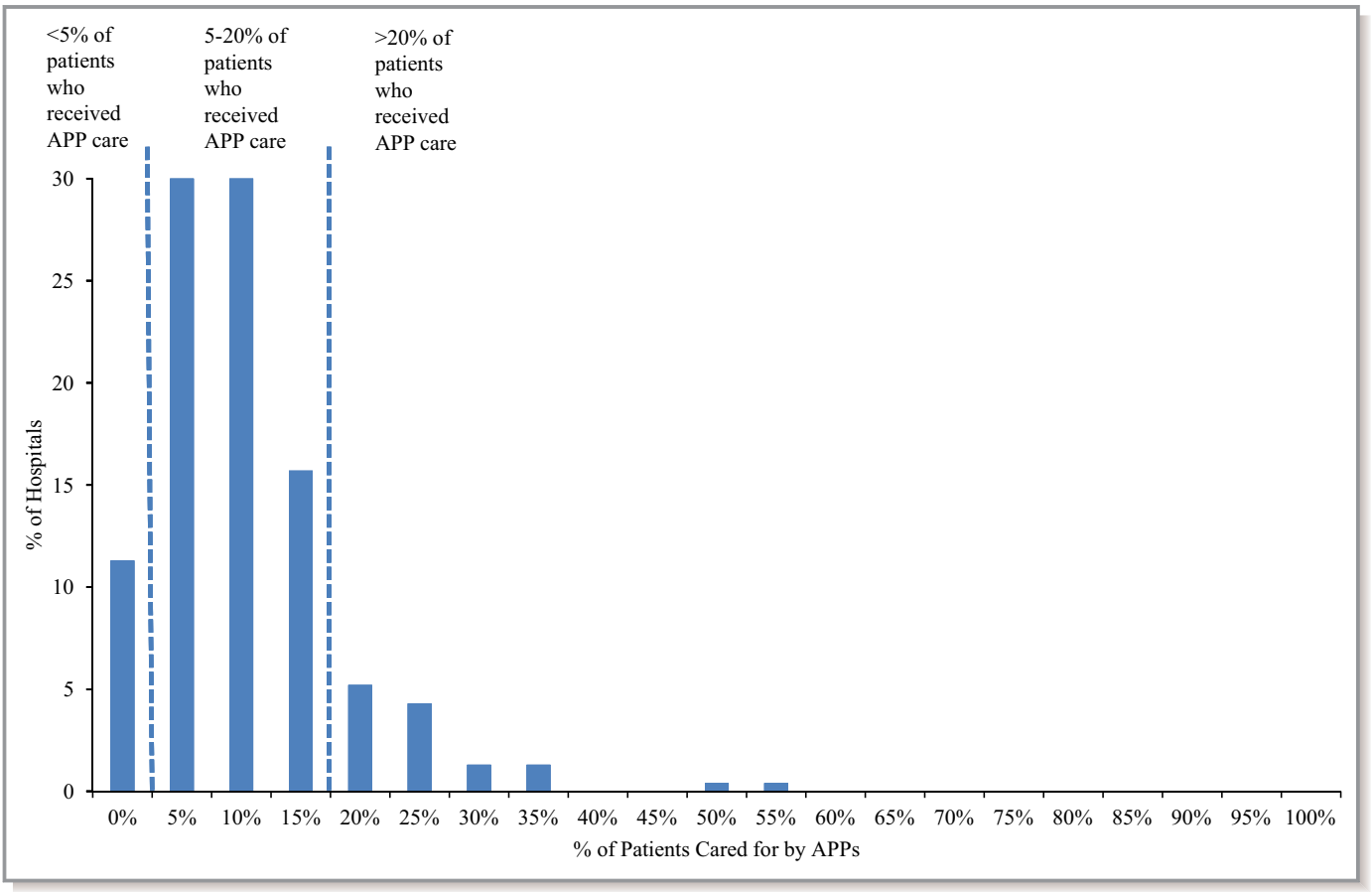

Figure 1. Distribution of APP care across hospitals within 90 days of discharge. Number of hospitals indicated at the top of each bar. APP indicates advanced practice providers.

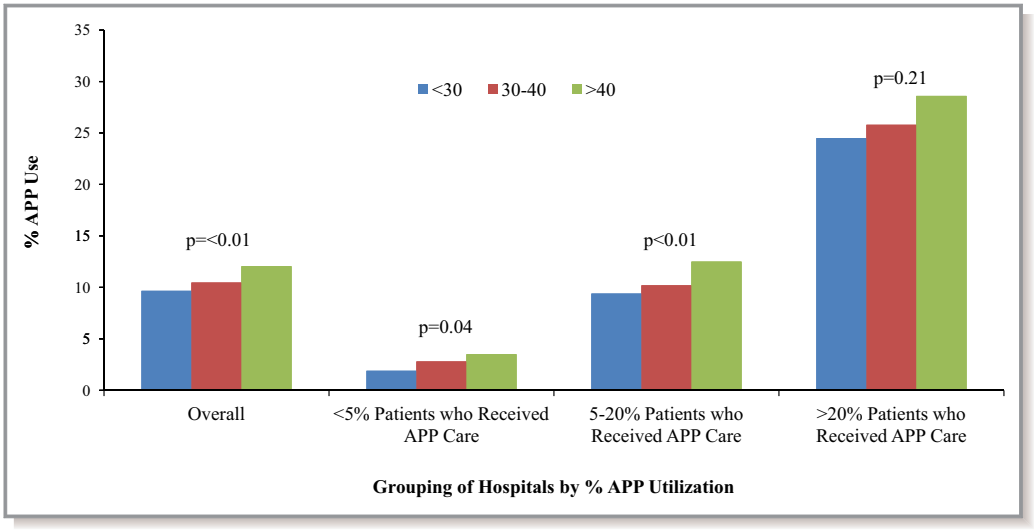

Figure 2. Percentage of patients who received APP care within 90 days of discharge stratified by ACTION mortality risk score. APP indicates advanced practice provider.

facilitate complex decision-making, while APPs will more likely be used to conduct follow-up of post-MI patients for routine secondary prevention. In contrast, our analyses indicated that post-MI patients seen by APPs within the first 90 days had greater comorbidity burden and were more likely to be discharged to a skilled nursing facility than patients cared for by physicians alone. As the first post-MI visit was virtually always with a physician provider, it appears that discharging hospitals are not the ones triaging patients to physician versus APP follow-up. This suggests that at the first follow-up visit, physicians are potentially identifying a group of patients with complex comorbidities requiring more frequent follow-up. These patients are triaged to a team-based care model involving an APP. This is supported by the observation that the number of outpatient visits within 90 days post-discharge was higher for patients seen by an APP than patients seen by physicians only.

There are clear regional differences in APP usage across the United States; greater APP use was observed in the Midwest, whereas post-MI care in the South relies more

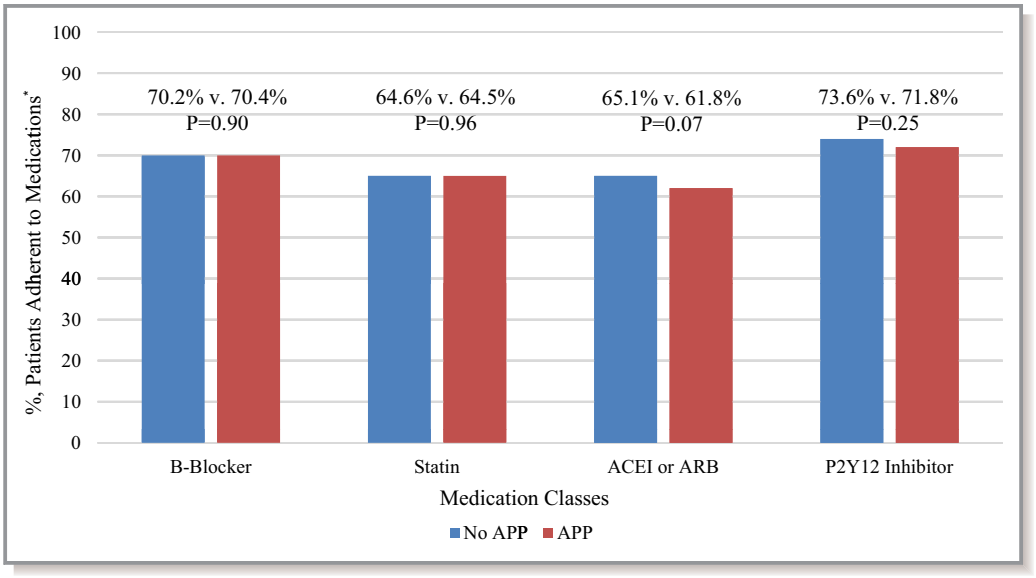

Figure 3. Proportion of patients adherent to each medication at 90 days after discharge. *Defined as proportion of days covered with >80% coverage at 90 days post-discharge. Patients stratified according to whether they were seen by an APP or physician alone within 90 days of discharge. ACEI indicates angiotensin-converting enzyme inhibitor; APP, advanced practice provider; ARB, angiotensin II receptor blocker.

Table 2. Observed Rates and Adjusted Risks of 90-Day All-Cause Readmission, Mortality, and MACE Comparing APP Visits Versus Physician-Only Visits (Reference Group)

	Observed Rates for APP Visits (95% CI)	Observed Rates for Physician-Only Visits (95% CI)	Adjusted HR (95% CI)*	Additionally Adjusted for Total Number of Visits Within 90 Days HR (95% CI)
Outcomes				
All-cause readmission (n=20 681)	16.3% (14.7–18.0)	13.8% (13.4–14.3)	1.11 (0.99–1.26)	1.09 (0.96–1.23)
Mortality (n=28 004)	4.9% (4.2–5.8)	3.6% (3.4–3.9)	1.18 (0.98–1.42)	1.17 (0.97–1.41)
MACE (n=25 316)	7.8% (6.9–8.9)	6.4% (6.1–6.8)	1.06 (0.90–1.23)	1.04 (0.89–1.22)

ACEI indicates angiotensin converting enzyme inhibitor; ARB, angiotensin II receptor blocker; CABG, coronary artery bypass grafting; CI, confidence interval; HR, hazard ratio; MACE, major adverse cardiovascular events, MI, myocardial infarction; NSTEMI, non–ST-segment–elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-segment–elevation myocardial infarction.

*Adjustment variables=age, sex, body mass index, race, length of stay during the index MI admission, prior MI, prior PCI, prior CABG, prior heart failure, prior stroke, prior peripheral artery disease, prior atrial fibrillation, diabetes mellitus, hypertension, dyslipidemia, current or recent smoker within the past year, MI type (NSTEMI vs STEMI), in-hospital procedures (PCI or CABG), in-hospital complications (heart failure, cardiogenic shock, stroke, and major bleeding), laboratory results (lowest hemoglobin, initial serum creatinine, and peak troponin ratio), discharge medications from the index admission (β-blockers, ACEIs or ARBs, statins, and $P2Y_{12}$ receptor inhibitors), transferred in from another acute care hospital status, hospital teaching status (membership in the Council of Teaching Hospitals), socioeconomic status (percentage of people aged ≥25 years with a high school diploma, and median household income obtained from the Area Resource File based on the zip code of patient residence), and number of in-patient hospitalizations within 1 year before the index MI admission.

heavily on physician-only care. This finding may be attributed to interstate differences in licensing practices. Many states in the Southeast require collaborative agreements between a physician and nurse practitioner that mandate physician presence during APP visits, limit APP prescribing privileges, or limit APP scope of practice.[1] Academic hospitals were less likely than non-teaching hospitals to use APPs in post-discharge follow-up; this was unexpected as tighter Accreditation Council for Graduate Medical Education (ACGME) restrictions on trainee work hours have been posited as a primary driver of outpatient APP usage.[4]

Recent studies have demonstrated comparable care quality, whether primarily administered by APPs or by physicians.[8,22,23] One small prospective study showed improvements in secondary prevention target goals, including statin use at follow-up and smoking cessation, for post-MI patients cared for by nurse practitioners versus usual care.[22] Another study of coronary heart disease, heart failure, and atrial fibrillation patients using data from the PINNACLE (Practice Innovation and Clinical Excellence) study demonstrated comparable care delivery for those patients treated by both physicians and APPs versus physicians alone.[22] For the post-MI patients in this study, we examined care quality in terms of evidence-based medication adherence, and risks of readmission, mortality, and MACE. While there remains room for improvement in evidence-based secondary prevention medications, as only 60% to 70% of patients are adherent within 90 days post-discharge; there were no significant differences in adherence between patients cared for by APPs versus physicians only. While observed 90-day all-cause readmission rates were higher among patients receiving APP care, this difference was no longer significant after adjusting for the comorbidity differences between patients seen by physicians only versus those seen by APPs. As patients with complex comorbidities are often more likely to have complicated medication regimens and higher risk of readmission and mortality, our study, showing comparable post-discharge medication adherence rates, readmission risk, and risks of mortality and MACE between physicians only and physician-APP teams, suggests that a team-based approach to post-MI outpatient care may be beneficial for patients with complex comorbidities, compared with physician-only follow-up. In part, the benefit may be explained by the ability for more frequent follow-up intensity, and opportunities for patient education. These results are reassuring as we continue to evolve our team-based care model to address outpatient follow-up needs for post-MI patients.

Our study had several limitations. First, the ability to use claims data to separate out patients who were truly seen by an APP alone or by an APP in conjunction with a physician during that visit is complex. Under Medicare, practices are incentivized to bill APP encounters under a physician's provider number ("incident billing") to maximize reimbursement as billing under an APP provider number results in reimbursement of only 75% to 85% of the physician rate. This may have led to underestimation of when APPs were primarily caring for the patient. Second, most patients seen by an APP also had an encounter with a physician provider within the first 90 days post-MI, therefore we cannot describe outcomes for patients who received care from an APP only. Third, many variables affect outpatient follow-up decisions and medication adherence and discontinuation decisions which may have not been captured in our data source. Given the retrospective design of the study, it is not possible to determine if APP or

physician care contributed directly to medication adherence and clinical outcomes. Fourth, administrative data do not allow for distinction between appropriate medication discontinuation and non-adherence. Our data source measures medication adherence based on prescriptions filled; it is not possible to determine whether patients ingested the medications. Finally, our data does not allow for distinguishing care performed by a nurse practitioner versus a physician assistant.

Conclusions

One in 10 post-MI patients in the United States received team-based care involving an APP within 90 days of discharge. Patients receiving care from an APP were more likely to have comorbid conditions and in-hospital complications, thus APPs were likely used to provide more frequent post-discharge monitoring of higher risk MI patients. Medication adherence and risks of readmission, mortality, and MACE do not differ substantially between patients seen by APPs or physicians only.

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