



Same-day discharge among patients undergoing elective PCI: Insights from the VA CART Program

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Background Available data suggest that same-day discharge (SDD) after elective percutaneous coronary intervention (PCI) is safe in select patients. Yet, little is known about contemporary adoption rates, safety, and costs in a universal health care system like the Veterans Affairs Health System.

Methods Using data from the Veterans Affairs Clinical Assessment Reporting and Tracking Program linked with Health Economics Resource Center data, patients undergoing elective PCI for stable angina between October 1, 2007 and September 30, 2016, were stratified by SDD versus overnight stay. We examined trends of SDD, and using 2:1 propensity matching, we assessed 30-day rates of readmission, mortality, and total costs at 30 days.

Results Of 21,261 PCIs from 67 sites, 728 were SDDs (3.9% of overall cohort). The rate of SDD increased from 1.6% in 2008 to 9.7% in 2016 ($P < .001$). SDD patients had lower rates of atrial fibrillation, peripheral arterial disease, and prior coronary artery bypass grafting and were treated at higher-volume centers. Thirty-day readmission and mortality did not differ significantly between the groups (readmission: 6.7% SDD vs 5.6% for overnight stay, $P = .24$; mortality: 0% vs. 0.07%, $P = .99$). The mean (SD) 30-day cost accrued by patients undergoing SDD was \$23,656 (\$15,480) versus \$25,878 (\$17,480) for an overnight stay. The accumulated median cost savings for SDD was \$1503 (95% CI \$738-\$2,250).

Conclusions Veterans Affairs Health System has increasingly adopted SDD for elective PCI procedures, and this is associated with cost savings without an increase in readmission or mortality. Greater adoption has the potential to reduce costs without increasing adverse outcomes. (Am Heart J 2019;218:75-83.)

Most elective percutaneous coronary interventions (PCIs) in the United States are considered outpatient procedures, yet many patients still spend a night in the

hospital postprocedure.¹ Practicing same-day discharge (SDD) following elective PCI procedures in appropriately selected patients may increase hospital bed availability and improve patient satisfaction provided that it does not accentuate known complications, including vascular access complications and abrupt vessel closure.² A 2018 current consensus statement issued by the Society for Cardiovascular Angiography and Interventions provides a framework for selecting patients appropriate for SDD, as studies have begun to show that some a priori factors such as age and other comorbid conditions should not play a role in the discharge decision unless there is a clear need for extended hospitalization.³ Capitated health care systems may stand to benefit from considerable cost savings related to SDD.⁴⁻⁷ On the other hand, if SDD is associated with adverse outcomes such as procedure-related complications, repeat procedures, or hospital readmissions, costs could be higher than with postprocedural overnight stays.

Previous studies of SDD have significant limitations in generalizability (ie, strict inclusion criteria for their analyses or conducted on patients from a single center) and have not compared costs of SDD versus overnight

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stay.^{5,8-10} In this study, we leveraged data from the largest integrated health care system in the United States, the Veterans Affairs Healthcare System (VAHS), to (1) examine the change in use of SDD over time across the VAHS, (2) describe the patient and hospital characteristics associated with SDD after PCI, (3) compare the differences in 30-day readmission and mortality between SDD and patients observed overnight, and (4) examine the differences in mean accumulated 30-day cost between SDD and patients observed overnight.

Methods

Study cohort

The VAHS Clinical Assessment Reporting and Tracking (CART) Program is a national quality and safety program for invasive cardiac procedures performed by cardiologists within the VAHS. A feature of the CART Program is a clinical software application designed to collect standardized data on all coronary angiograms and PCIs. The software is embedded in the VAHS electronic health record and allows providers to enter patient and procedural information including operating and attending physicians, patient characteristics, cardiac and anatomical characteristics, in-laboratory medications and in-laboratory complications for >122,000 PCIs. A description of the CART Program data has been reported previously.^{11,12} Using these data, we identified the first, unstaged, elective PCI performed on patients between October 1, 2008, and September 30, 2016. October through September was chosen as a study year because this is a federal fiscal year. We included only elective PCI and excluded all patients with unstable angina; non-ST-segment elevation MI; ST-segment elevation MI; cardiogenic shock; use of intra-aortic balloon pump or ventricular support; and emergency, urgent, or salvage procedures. To avoid bias due to VAHS hospitals that were no longer operational or sites that had only recently begun performing PCIs, catheterization laboratories that performed <100 PCIs during the study period were excluded from the analysis.

Patient records from CART Program data were matched by a unique patient identifier and procedure date to administrative data in the VAHS Corporate Data Warehouse (CDW). Administrative data were extracted including admission and discharge dates; outpatient visit dates; and ICD-9/10 codes for primary cause of admission, CPT procedure codes, and type of outpatient visit. The VAHS Health Economics Resource Center (HERC) produces data on the cost of each patient's in-hospital stay and outpatient visit using the Average Cost Method developed on relative value units (RVU) taken from Centers for Medicare and Medicaid Services (CMS) assigned Diagnostic Related Group (DRG) weights. We included patients whose procedure dates, admission dates, and outpatient visit dates matched to ensure that

we could accurately compare SDD episodes to single-overnight episodes. Matched patient records were used to identify temporally contiguous records in the data sources, allowing identification of all inpatient stays greater than 1 day, which were removed from the cohort. The VAHS cardiac catheterization laboratories do not routinely schedule elective procedures for Saturdays or Sundays, and thus, weekend procedures were removed because of likely differences in discharge practices. Patients who experienced periprocedural in-laboratory complications, received mechanical support, or required multiple access sites during the procedure were also removed. The final analytic cohort used for the propensity matching consisted of the first unstaged, elective PCI procedures, free of complications, identified as either SDD or a maximum 1-day admitted length of stay (Figure 1).

To analyze outcomes of interest, a 2:1 propensity matched data set for SDD was created using a digit matching algorithm from those records in the analytic data set that had data capture across 43 patient-level risk factors. These factors are listed in Supplemental Table I. As a follow-up sensitivity analysis, VAHS purchased care files were joined to the propensity-matched data set. The purchased care files contain admission dates, primary cause for admission, and payment amounts made by the VAHS to outside entities that admit veterans requiring urgent and emergent health services.

Analytic outcomes and end points

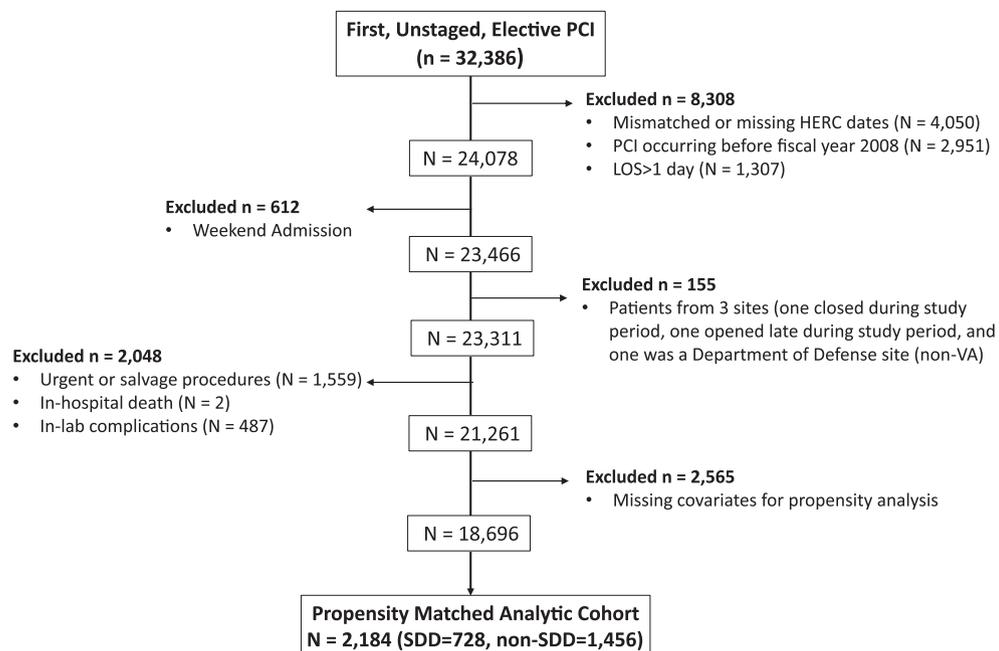
We examined the trend for SDD across years and compared the baseline characteristics in patients undergoing SDD versus those who had an overnight stay. We also compared the facility-level characteristics by quartile of percentage of SDD performed. We examined the total number of PCIs performed over the study period and the percentage that received SDD. We also assessed the percentage of SDD procedures by site. The end points of the study included 30-day all-cause readmission, all-cause mortality, and mean costs.

We only included readmission costs from admission dates that matched in the CDW and HERC files to ensure that we did not include readmission costs unrelated to the PCI. The 30-day window for readmissions began on the day of procedure for SDD patients or on the day of discharge for an overnight stay and included any hospital admission occurring in the following 30-day period.

All-cause patient mortality is recorded in the CDW vital status file, which is updated quarterly from the Social Security Administration Death master file, the Beneficiary Identification Records Locator Subsystem death file, the VA Medicare Vital Status file, and the VAHS electronic health record. In-hospital death is flagged in the CDW administrative inpatient data, and deaths occurring in the cardiac catheterization laboratories are recorded by the CART Program.

Costs were accumulated from the HERC files. The HERC average cost method assumes that every health

Figure 1



Flow diagram demonstrating excluded patients, final analytic dataset, and propensity-matched data set. This flow diagram depicts the exclusion criteria used in the study. The final study population was 18,696 patients with a propensity-matched cohort of 2,184 patients (728 SDD patients).

care encounter has the average cost of all encounters that share its same characteristics. The cost function uses RVU built from CMS assigned DRG weights and includes length of stay and demographic and clinical information. By using the HERC costs for each patient's PCI encounter, the comparison of accumulated 30-day costs of SDD versus overnight stay procedures is independent of variations due to geographic and temporal factors and allows consistent comparison of costs from multiple locations, as well as adjustment for patient-level and site-level covariates.

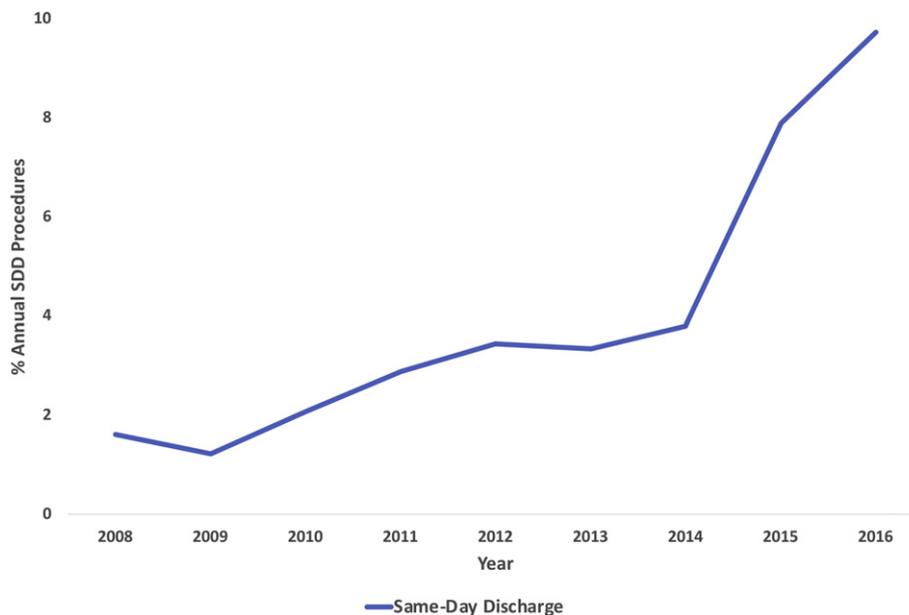
Statistical analyses

We calculated the overall proportion of patients in the analytic data set with SDD and the proportion stratified by fiscal year. Measurable trends over time in SDD were tested using a 2-sided, .05 α -level Cochran-Armitage test for trend on the proportion of patients with SDD within the 9 study fiscal years. Differences in baseline characteristics between SDD and overnight stay were tested using methods appropriate for the data type. Differences in proportions of the dichotomous valued covariates were tested using 2-sided Fisher exact tests and reported as counts and percentage. Framingham 10-year risk,¹³ National Cardiovascular Data Registry mortality points,¹⁴ New York Heart Association functional class, race, and hospital complexity were highly skewed and tested using the Mann-Whitney-Wilcoxon test. For all other continu-

ous covariate measures, *t* tests were applied and reported as means and SDs.

Analyses to measure the association between SDD and 30-day readmission, 30-day mortality, and 30-day accumulated mean costs were conducted for a propensity-matched data set rather than the full analytic cohort. In building the propensity-matched data set, an assumption was made that facility-level covariates would be associated with choice of SDD or overnight stay but not with outcomes and that patient-level risk factors would be associated with both outcomes and choice of SDD or overnight stay. For this reason, only patient-level covariates were included in the propensity score logistic model for SDD. To increase the power of the analyses, we used 2:1 matching without replacement. All of the SDD patients were matched to 2 patients with overnight stays. A digit matching algorithm was used that implements a stepwise approach to match the greatest number of significant digits in the propensity scores. Standardized differences were calculated for covariates used in the logistic model prior to matching and then again in the matched cohort.

Results for the analyses of 30-day readmission and costs were obtained from a Bayesian Markov Chain Monte Carlo (MCMC) model computed in JAGS.¹⁵ The MCMC model for readmission was a logistic mixed model of 4 fixed effects and terms for the hospital-level random effects. The MCMC model for cost was a generalized gamma mixed model consisting of 8 fixed effects and

Figure 2

Annual percentage of SDD procedures performed from 2008 to 2016. This figure illustrates the increase in the annual percentage of SDD procedures from 1.2% in 2009 to 9.7% in 2016.

terms for random hospital effects.¹⁶ A similar CART Program data analysis using a generalized gamma mixed MCMC model has been previously performed.¹⁷ We report the unadjusted mean accumulated 30-day costs for SDD and overnight stay patients and the median of the 30-day costs savings between the 2 groups using data from the MCMC model. Preprocessing of 43 patient-level and 8 site-level covariates with regression methods on 20 bootstrapped samples was used to retain covariates most significantly associated to the outcomes.

The study approved by the Colorado Multiple Institutional Review Board allowed for waiver of informed consent. Analyses were performed across platforms using Windows 7 Enterprise, Service Pack 1; SAS 9.4 TS Level 1 M3, SAS Institute Inc, Cary, NC; R, R Foundation for Statistical Computing, Vienna, Austria.; JAGS 4.2.0, Martyn Plummer¹⁵; and rjags.¹⁸ All tests were 2-sided with statistical significance declared at a .05 level.

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Results

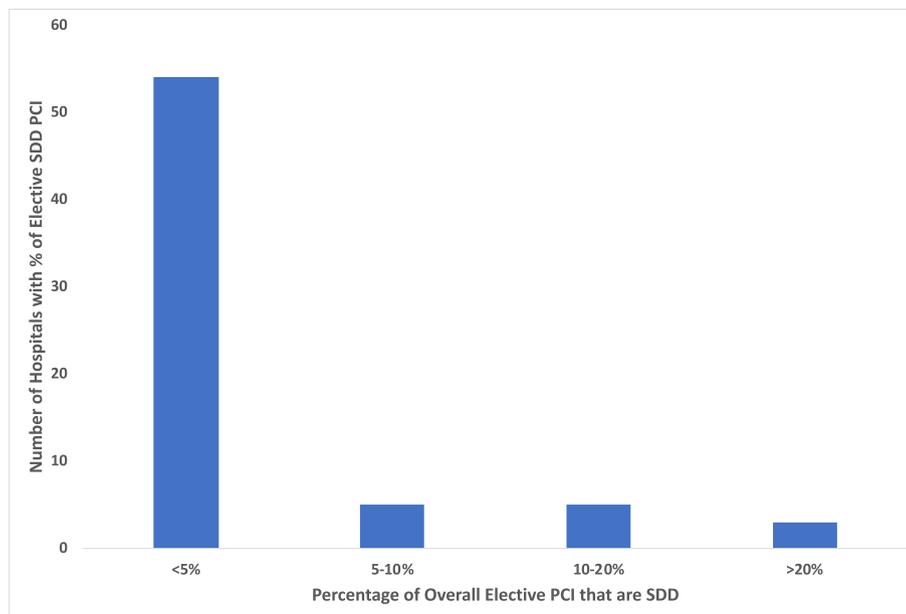
Of 121,539 PCIs performed during the study period, there were 32,386 PCIs that met the inclusion criteria

(Figure 1). After linking to HERC and CDW data and applying all exclusion criteria, there were 21,261 patients with a single index PCI. The records were distributed across 67 cardiac catheterization laboratories. After propensity matching, there were a total of 728 SDD patients (3.9% of overall study cohort). There was a significant increase in annual proportion of SDD procedures from 2009 to 2016 ($P < .001$), with an annual percentage of SDD that ranged from 1.2% in 2009 to 9.7% in 2016 (Figure 2). The median annual number of PCIs performed at each site during the study period was 307 (166-429). The median annual percentage of PCIs at each site that were SDD was 1.5% (0.6%-3.9%). Figure 3 shows the variation in SDD utilization among sites.

In the propensity-matched cohort overall, there were 1,465 (67.1%) patients who underwent femoral access; 678 (31.0%), radial access; and 30 (1.4%), brachial access. In the overnight stay group, 1,144 (78.6%) underwent femoral access, whereas 291 (20.0%) underwent radial access. In the SDD group, 321 (44.0%) underwent femoral access, whereas 387 (53.2%) underwent radial access.

Table I summarizes the baseline patient-level and procedural characteristics for the overall analysis population of SDD patients versus patients observed overnight (prior to propensity matching). SDD patients less frequently had a history of atrial fibrillation, peripheral artery disease, prior CABG, and prior valve disease ($P < .05$ for all characteristics). Overall, patients in the

Figure 3



Variation in percentage of SDD elective PCIs among the VA health system sites. This figure depicts that most hospitals were using SDD in less than 5% of elective PCI procedures.

SDD group were less likely to receive periprocedural bivalirudin and received less contrast compared with patients observed overnight ($P < .01$ for all). Table II describes facility-level characteristics, stratified by percentage of SDD.

Standardized differences in the matched data set using propensity scores derived only from the patient-level characteristics showed a decrease in the magnitude of the differences for 34 of the 43 characteristics, indicating a good match across all patients (Supplemental Table D). From the 21,261 patients in the analytic data set, 18,696 (88%) were used for propensity score matching.

Readmission and mortality

There were 728 SDD patients matched to 1,456 overnight stays in the propensity-matched data set. Among patients with SDD, there were 54 readmissions (7.4%) within 30 days, of which 49 occurred in the VAHS and 5 occurred outside VAHS. Among patients with overnight stays, there were 95 (6.5%) readmissions within 30 days. Of 130 total readmissions, most (73.1%) did not involve ischemic heart disease ($n = 95$). Using a logistic mixed-model MCMC, adjusted for anxiety disorder, prior valve disease, and hospital-level average number of PCIs with random effects for hospital of service, SDD was not significantly associated with 30-day readmission: odds ratio (OR) = 1.14 (95% CI 0.94-1.37). A sensitivity analysis was performed that included the number of readmissions in purchased care facilities

outside the VA hospital network. It was consistent with the primary analysis: OR = 1.10 (95% CI 0.92-1.31). Among patients with overnight stays, the median IQR time to readmission was 11 days,^{5,17} and it was 10^{2,21} among SDD patients.

There were 2 in-hospital deaths, and these patients were excluded from the propensity-matched analysis. Thirty-day mortality did not differ significantly between the groups (0% for SDD vs 0.07% for an overnight stay, $P = .99$).

Cost

The unadjusted accumulated mean 30-day cost for patients with SDD was \$23,656 (SD: \$15,480). Among patients with overnight stays, the mean 30-day cost was \$25,878 (SD: \$17,480). After adjustment using the MCMC model, there was an association between SDD and lower 30-day accumulated costs (median \$1,503 [95% CI \$738-\$2,250]) (Figure 4).

Discussion

In this national study of the VAHS, we showed several important findings: (1) although the practice of SDD after elective PCI has increased over time, the overall rate of SDD is still quite low; (2) there is significant variation in SDD across VAHS PCI centers that is not accounted for by patient characteristics; (3) after adjusting for potential measured confounders, SDD was not associated with an

Table I. Baseline characteristics of SDD patients versus patients observed overnight from the overall analysis cohort

	Overall (N = 21,261)	SDD (n = 847)	Overnight stay (n = 20,414)	P value
Demographics				
Age, y	65.2 (8)	64.8 (8)	65.2 (8)	.16
Male	98.5%	98.9%	98.5%	.38
White race	86.6%	81.7%	86.8%	<.01
Medical history/comorbidities				
BMI*	31.0 (5.7)	31.3 (5.6)	31.0 (5.7)	.20
Prior PCI	35.1%	36.4%	35.0%	.42
Prior CABG	24.2%	19.1%	24.4%	<.01
Prior MI	34.5%	33.4%	34.5%	.53
Prior stroke/TIA	5.9%	5.0%	5.9%	.30
Prior valve disease	6.0%	4.1%	6.1%	.02
Congestive heart failure	19.7%	17.7%	19.8%	.15
Hypertension	89.8%	91.6%	89.7%	.07
Dyslipidemia	91.3%	92.6%	91.2%	.19
Atrial fibrillation	9.3%	6.7%	9.4%	<.01
Tobacco use (ever)	63.1%	66.9%	62.9%	.02
Diabetes	48.2%	49.7%	48.2%	.40
Chronic kidney disease	15.1%	14.0%	15.1%	.41
Dialysis	2.2%	2.5%	2.2%	.64
Peripheral arterial disease	18.3%	15.3%	18.4%	.03
Chronic obstructive pulmonary disease	19.5%	18.4%	19.5%	.45
Sleep apnea	22.4%	25.3%	22.3%	.04
Framingham 10-y Risk Score*	16 (10-25)	16 (10-25)	16 (10-25)	.16
NCDR Mortality Risk Score*	10 (8-17)	10 (6-15)	10 (8-18)	.04
VA Complexity Score* [‡]	7 (3-14)	7 (3-12.5)	7 (3-14)	.26
In-hospital features				
GFR*	76.5 (23.4)	76.8 (23.0)	76.5 (23.4)	.71
Total cholesterol*	168.7 (41.6)	169.6 (44.1)	168.7 (41.5)	.55
LDL*	95.0 (34.6)	95.8 (38.1)	95.0 (34.5)	.54
Systolic blood pressure*	133.7 (13)	134.8 (12.6)	133.6 (13.0)	<.01
Procedural characteristics				
Periprocedural bivalirudin	30.1%	23.4%	30.4%	<.01
Mean contrast used (mL) ^{†‡}	175.9 (529.9)	141.7 (82.4)	177.4 (541.5)	<.01
Mean fluoroscopy time (min) [†]	22.5 (241.6)	15.9 (18.2)	22.8 (247.1)	<.01

NCDR, National Cardiovascular Data Registry; BMI = body mass index; CABG = coronary artery bypass grafting; TIA = transient ischemic attack; GFR = glomerular filtration rate; VA = Veteran's Affairs; LDL = low-density lipoproteins; min = minutes.

* Reported as median (IQR).

† Reported as mean (SD).

‡ The VA Complexity Score is a score recently developed using VA CART data to assess anatomical complexity and longitudinal risk of patients undergoing revascularization.²⁴

Table II. Baseline facility-level characteristics stratified by quartiles of site percentage of SDD

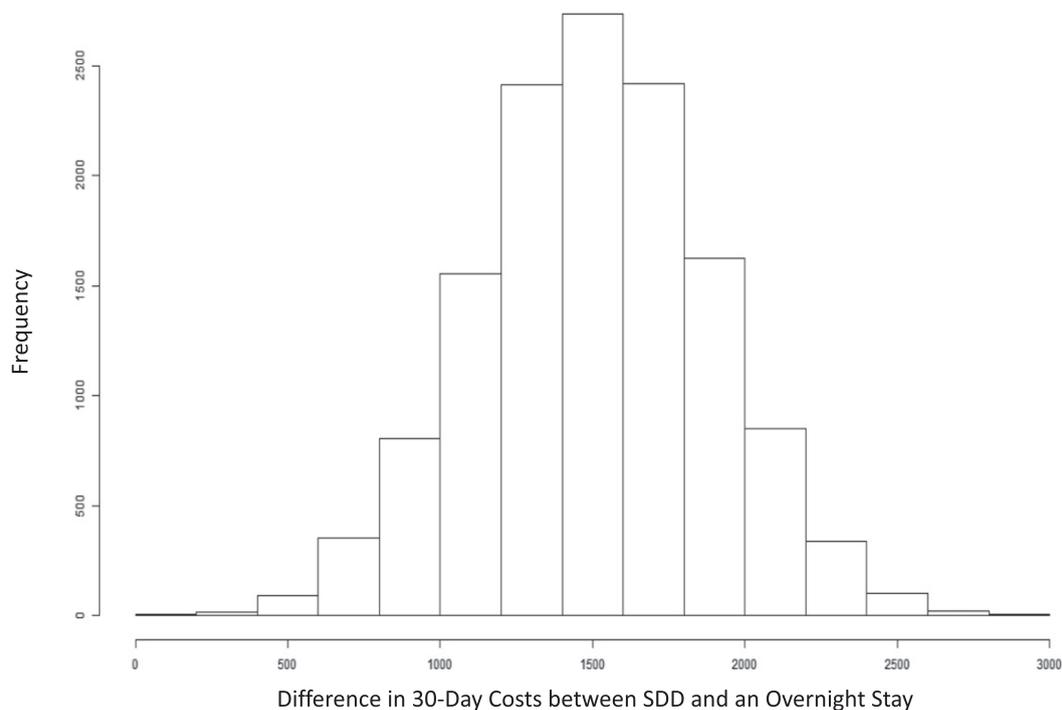
Facility-level characteristics	SDD ≤ 0.5%*	0.5% < SDD ≤ 1.4%	1.4% < SDD ≤ 3.8%	SDD > 3.8%
No. of sites	16	17	17	17
Average annual cardiac catheterization volume	493.7 (279.8)	617.9 (207.3)	541.6 (201.4)	547.8 (235.4)
Average annual PCI volume	141.2 (98.0)	201.8 (96.3)	206.2 (109.1)	189.8 (103.7)
Average no. of operating beds	171.2 (89.6)	190.2 (81.7)	154.5 (78.4)	161.2 (54.6)

* Percentage of site's PCI procedures that are SDD.

increased risk for adverse outcomes compared with overnight stay; and (4) SDD was associated with 30-day cost savings compared with overnight stay. These data from a large integrated "universal" health care system suggest that broader implementation of SDD after elective PCI has the potential to increase health care value by reducing costs without increasing adverse outcomes.

Studies performed in non-VAHS hospitals have shown that SDD after elective PCI has increased over the last decade, but most patients are still observed overnight. The reasons for the growth in SDD outside the VAHS are unclear but may be driven by the improved safety of PCI coupled with patient preference and health system financial pressures. In our study, 1 in 10 veterans undergoing elective PCI is being discharged home the

Figure 4



Generalized regression model of 30-day accumulated average savings of patients undergoing SDD. After adjustment, there was an association between SDD and lower 30-day accumulated costs (median \$1,503 [95% CI \$738-\$2,250]).

same day, a rate slightly higher than the reported rates in studies of non-VAHS hospitals.⁴ Despite the increase, we also found that there was significant variation in the use of SDD across VAHS sites, with most sites using SDD in less than 5% of their patients. This mirrors data from non-VAHS hospitals and suggests that barriers to the adoption of SDD are likely similar in both settings. One potential barrier is concern over the risk to the patient if they are not observed overnight. Overnight stay affords the opportunity to monitor for adverse clinical events such as acute stent thrombosis or bleeding. However, 2 studies have shown that such events are likely to manifest either within 6 hours of the PCI or more than 24 hours after the procedure, with no events occurring during the overnight period.^{19,20} In addition, an overnight stay potentially provides time for medication titration and patient education. Although we did not specifically examine these elements, the center-level variation we found in the VAHS may reflect differing levels of such strategies across sites.

One important difference between VAHS and non-VAHS hospitals is that care for veterans is paid for largely through taxpayer dollars. It is a priority to ensure that any care strategy is not associated with increased costs, particularly from downstream readmissions. Our study showed that SDD was associated with a 30-day accumu-

lated average cost savings of just over \$1,500. For a “universal” health care system like the VAHS, this is potentially a significant sum if applied across all PCI patients eligible for SDD. We did not examine the source of these cost savings, but other studies have shown that costs savings from SDD are likely driven by inpatient costs such as those related to supplies and room and board.⁴ These fiscal issues may be magnified in a single-payer integrated system like the VAHS. In the context of recent legislation that mandates referral of veterans to non-VAHS facilities for care if there is limited access through the VAHS,²¹⁻²³ greater adoption of SDD after elective PCI may allow VAHS hospitals to care for more veterans through increased inpatient bed availability. Thus, a strategy of SDD among selected patients undergoing PCI in the VA system could result in increased value to the taxpayer, while providing safe care for Veterans.

There are several limitations of this study. First, this is a retrospective, observational study and may have residual confounding. Second, as the VAHS is a single-payer model, the results of the cost analysis may not be generalizable to nonfederal facilities. However, our data may be applicable to other integrated health systems that use capitated payment models. Third, our data extend through fiscal year 2016, and the rates of SDD and practices may have further evolved over the past 2 years.

The cost savings that we calculated and report are based on weights from CMS DRGs and RVUs, which are assumed to reflect relative costs in the VAHS. Fourth, we are not able to calculate indirect and opportunity costs, and the HERC data Average Costing Method averages costs across all PCI encounters that share similar characteristics. Additionally, just over 2,500 patients were excluded from the propensity matching analysis because of missing covariates, which could have impacted the propensity matching.

Conclusion

The use of SDD within the VAHS for elective PCI has significantly increased with no resultant increase in readmission or mortality risk. There was an accumulated 30-day average cost savings for patients who had SDD compared with patients with an overnight stay. Greater adoption of SDD has the potential to significant increase health care value for veterans without resultant adverse outcomes.

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ahj.2019.09.003>.

Author contributions

J. A. Rymer: Dr Rymer had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Dr Rymer contributed to the conception and design of the study, the data analysis, the data interpretation, the manuscript drafting, and the critical revision of the manuscript.

C. I. O'Donnell: Dr O'Donnell contributed to the data analysis, conception and design of the study, the manuscript scripting, data analysis, statistical analysis, the data interpretation, and the critical revision of the manuscript.

M. E. Plomondon: Dr Plomondon contributed to the data analysis, statistical analysis, the data interpretation, and the critical revision of the manuscript.

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A. H. Seto: Dr Seto contributed to the data analysis, statistical analysis, the data interpretation, and the critical revision of the manuscript.

C. D. Helfrich: Dr Helfrich contributed to the data analysis, statistical analysis, the data interpretation, and the critical revision of the manuscript.

S. V. Rao: Dr Rao contributed to the conception and design of the study, the data analysis, the data interpretation, the manuscript drafting, and the critical revision of the manuscript.

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