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Evaluation of a Nurse Practitioner-Led Care Management Model in Reducing Inpatient Drug Utilization and Cost

Executive Summary

- The aim of this research was to evaluate the economic impact of a collaborative nurse practitioner (NP) care management model on the use of pharmaceutical resources, with a focus on antibiotics, among general medicine inpatients.
- Although studies have shown the effectiveness of care management by NPs, especially as reflected on length of stay and hospital cost, little is known about their impact on drug cost.
- The researchers utilized pharmaceutical claims data of 1,200 subjects who participated in the Multidisciplinary, Physician, and Nurse Practitioner Study from 2000 to 2004 to assess the effect of the NP-led care management model on drug utilization outcomes.
- Study findings revealed that the intervention group was associated with significant reduction in drug cost and drug utilization; even though the intervention group was more likely to be given broad-spectrum or other antibiotics, its overall drug and antibiotic costs were lower than the control group.
- Drug management strategies such as de-escalation and intravenous-to-oral conversion facilitated by NPs may potentially produce both clinically and economically advantageous outcomes among general medicine inpatients.

The drastic increase in health care spending has surpassed the growth of the rest of the U.S. economy (Health Affairs, 2002). Hospital care and prescription drugs are responsible for much of the overall escalation in health care spending (Pear, 2004), and accounted for 30% and 11% of the total increase between 2002 and 2004, respectively (Smith, Cowan, Heffler, & Catlin, 2006). Expenditures on antibiotics make up approximately 15% to 30% of pharmaceutical costs, accounting for the largest proportion among drug categories (Ansari, 2001; Ansari, Gray et al., 2003). As managed care continues to penetrate the health care system, academic medical centers are facing tremendous pressure to minimize resource utilization, decrease costs, maintain or improve quality of care, and still provide an optimal teaching environment. Under these circumstances, cost savings from pharmaceutical expenditures are highly desirable to hospitals because they often receive reimbursement at a predetermined price based on diagnosis (Drew, 1998).

To improve inpatient care at a lower cost, Cowan et al. (2006) undertook a quasi-experimental study to investigate the effect of care management by a multidisciplinary team led by nurse practitioners (NPs) and a hospitalist medical director in the care of acutely ill medical patients. This current study aimed to continue the effort of Cowan et al. in evaluating the efficacy of care management by NPs while centering the scope on drug utilization outcomes.

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Background

The high costs of antibiotics and the variations in prescribing patterns have drawn a great deal of attention recently from experts and also made it a challenging as well as an important research topic to study. In the effort to promote rational use of antibiotics, in 1995 the Centers for Disease Control initiated its campaign against over-utilization of antibiotic agents (Mainous, Hueston, Davis, & Pearson, 2003). Furthermore, the American College of Physicians also published guidelines for reducing antibiotic use in adults in 2001 (Snow, Mottur-Pilson, Cooper, & Hoffman, 2001; Snow, Mottur-Pilson, & Gonzales, 2001a, 2001b; Snow, Mottur-Pilson, & Hickner, 2001). Thus, the importance of finding effective strategies for promoting rational use of antibiotics is apparent.

Substantial reduction in antibiotic prescribing and costs has been achieved in studies implementing a variety of interventions aimed at reducing overuse of antibiotics (Blanc et al., 1999; De Santis, Harvey, Howard, Mashford, & Moulds, 1994; Senn, Burnand, Francioli, & Zanetti, 2004; South, Royle, & Starr, 2003; Thuong et al., 2000). These studies suggest that there are opportunities for improving the utilization of antibiotics and reducing costs. For example, interventions such as reinforcing antibiotic guidelines (South et al., 2003), conducting educational campaigns (De Santis et al., 1994), and implementing protocols for reassessing ongoing therapy (Senn et al., 2004) have achieved cost savings in antibiotic utilization in hospital practice. Moreover, promptly switching patients from parenteral to oral antibiotics when they are eligible to make the transition can reduce costs associated with antibiotic treatments (Okpara, Maswoswe, & Stewart, 1995). Also, reductions in length of stay resulting from an early switch from parenteral to oral antibiotics may lower hospital costs significantly (Kuti, Capitano, & Nicolau, 2002). However, studies of inpatient and outpatient antibiotic utilization have primarily focused on strategies that only involved physicians because they have traditionally played the key role in the decision making of prescribing drug treatment.

Researchers have compared the quality and effectiveness of care provided by NPs with that given by physicians. Results show that primary care provided by NPs is comparable to that provided by physicians as measured by patient satisfaction, health status, or health services utilization (Mundinger et al., 2000). In addition, NPs are highly skilled in providing comprehensive assessments and utilizing available resources, which result in clinical decisions that are safe as well as cost effective (Buchanan & Powers, 1997; Hylka & Beschle, 1995; Knaus, Felten, Burton, Fobes, & Davis, 1997; Mundinger et al., 2000; Rudy et al., 1998; Salkever, Skinner, Steinwachs, & Katz, 1992; Schultz, Liptak, & Fioravanti, 1994). Other studies have reported both favorable outcomes associated with the utilization of NPs in acute care settings, especially as reflected on reduced length of stay and hospital costs (Buchanan & Powers, 1997; Cowan et al., 2006; Hylka & Beschle, 1995; Schultz et al., 1994).

Although Hackner et al. (2001) and Diamond, Goldberg, and Janosky (1998) reported outcomes on inpatient drug costs associated with a hospitalist model, their findings were contradictory and the interventions did not involve NPs. The literature review suggests that a collaborative care management model involving NPs may affect inpatient drug utilization, but the impact is unclear.

Aims

Based on a secondary data analysis, the aims of the study were to determine the prevalence and patterns of drug utilization, with a focus on antibiotics, and to evaluate the effect of a NP-led care management intervention in reducing drug utilization and cost as compared to usual care among general medicine inpatients.

Methodology

The current study utilized a retrospective data analysis of pharmaceutical claims of the 1,200 subjects who participated in the Multidisciplinary, Physician, and Nurse Practitioner (MDNP) Study during 2000 to 2004 to evaluate the effect of the NP-led care management interventions on overall drug utilization and costs. The MDNP study was initially a prospective, quasi-experimental controlled trial conducted by Cowan et al. (2006) to assess the effect of a multidisciplinary care management team on organizational and patient outcomes for acutely ill, hospitalized general medicine patients (Afifi, Kotlerman, Ettner, & Cowan, 2007; Cowan et al., 2006; Ettner et al., 2006; Hays et al., 2006; Vazirani, Hays, Shapiro, & Cowan, 2005).

The methods and the primary findings of the initial MDNP study are described in detail elsewhere (Afifi et al., 2007; Cowan et al., 2006; Ettner et al., 2006; Hays et al., 2006; Vazirani et al., 2005). Briefly, the MDNP study utilized quasi-experimental pre and post-tests, repeated measures, and intent-to-treat strategies to examine the impact of its intervention on mortality, length of stay, re-admission, cost of health care, health-related quality of life (HRQOL), and patient satisfaction. Although several positive results associated with the MDNP intervention have been reported (Afifi et al., 2007; Cowan et al., 2006; Ettner et al., 2006; Hays et al., 2006; Vazirani et al., 2005), its effect on pharmaceutical utilization remained unknown.

Intervention. The NP-led interventions embedded in the MDNP model to optimize drug utilization included (a) the NPs attended daily multidisciplinary rounds to facilitate communication and collaboration among care providers, to streamline multidisciplinary interventions, and to minimize the turnaround time for laboratory testing, and medical and nursing interventions; (b) the NPs routinely maintained an updated medication list and reviewed treatment regimens to monitor drug therapy and to minimize unnecessary drug utilization; (c) the NPs assessed culture and susceptibility testing results twice daily to make suggestions regarding treatment regimens, or narrowing the antibiotic spectrum; and (d) the NPs promoted early intravenous-to-parenteral conversion for antibiotic treatment when indicated. In contrast with the daily multidisciplinary meeting, the control group received usual care from their attending physicians with weekly multidisciplinary meetings, but did not receive the NPs' interventions.

Sample and data source. The study population was hospitalized, acutely ill, general medicine patients in a tertiary academic medical center. The general medicine floor was divided into a control and an experimental unit. During the initial study period, 1,916 patients met the eligibility criteria; however, for logistical reasons, 197 were never approached. Of the remaining 1,719, 512 refused participation. A total of 1,207 patients were enrolled in the MDNP study. The experimental and control groups had 581 and 626 patients, respectively (Cowan et al., 2006).

A total of seven cases were eliminated from the sampling pool (N=1,207) recruited by the MDNP study. Among them, two were outliers with extremely high drug costs that were approximately five times the next highest cost, and the other five had no matching data from the pharmacy claims database, resulting in a sample of 1,200 subjects being utilized for the data analysis in the current study.

The high drug costs of the two outliers resulted from receiving antihemophelic factor VIII, which cost approximately $15,000 per dose. Even though both outliers were from the intervention group, we believe that removing them is unlikely to bias the results because they were the only two subjects receiving the agent among the whole sample, and the use of that particular agent is unlikely to be related to the care delivery model or the clinicians.

Main outcome measures. The three outcome measures used to compare drug utilization between the control and the experimental groups are total drug cost, daily drug cost, and drug days (defined later). Subgroup analyses were also performed for antibiotic utilization. Because quinolones have become the most costly and commonly prescribed broad-spectrum antibiotics (Linder, Huang, Gonzales, & Stafford, 2005), the usage of this group of drugs was particularly evaluated.

Total drug cost accounts for the costs of all pharmaceuticals consumed during a patient's hospital stay. Daily drug cost is calculated by dividing total drug cost by length of stay in days. A drug day is each day a drug was used and charged on the patient's account. For example, if a patient was charged for two drugs for a period of 5 days, 10 drug days would be applied to the patient. In addition, drug cost to hospital cost ratio is calculated to show the proportion of the spending in drug therapy to the total cost of the hospitalization.

The cost of each drug was obtained directly from the financial service department of the organization. Each cost was built by a cost accounting system called Product Line Management System (PLMS), which carries four basic unit costs for each drug or service provided: variable direct cost, fixed direct cost, variable indirect cost, and fixed indirect cost.

Direct costs are costs charged to a cost center that produces revenue such as pharmacy, radiology, and clinical laboratories. In this case the direct costs would be the acquisition costs of purchasing the drugs. Costs allocated from a non-revenue (or overhead) department or a patient care supporting department such as financial services and administration are indirect costs. A second layer of cost allocation, variable versus fixed costs, is also applied to the calculation for total costs. While per unit costs of a service remain constant, variable costs change when volume changes. For example, the cost of x-ray films would change with the number of x-rays taken. Finally, fixed costs are costs that do not change with volume. For example, the cost of the x-ray machine does not change regardless of the number of x-rays taken. The Charge Description Master (CDM) then generated the various costs for each patient for each line item (drug in this case) that was charged to the patient. Therefore, the CDM costs used in this study are pharmacy costs allocated down to each drug. The cost includes the acquisition cost of the drug as well as the costs for supplies, equipments, space, salaries, and benefits required for the administration of that drug. All cost values are presented in 2003 U.S. dollars.

Data analysis. Descriptive statistics were applied to examine the distribution of the independent and dependent variables. Differences between the control and the experimental groups on variables with continuous data were compared using t-tests if data had an approximate normal distribution, or Wilcoxon tests otherwise. Proportions were compared by chi-square tests to assess differences between the two groups for categorical variables. The correlation matrix was examined to determine bivariate associations. Multiple linear regression and multiple logistic regression were applied in multivariate analyses for continuous and binary outcomes, respectively, to determine factors associated with drug/antibiotic use and drug/antibiotic cost. Cost data were logarithmically transformed when indicated in order to better approximate a normal distribution. All statistical analyses were done using SAS Version 9.1 (SAS Institute Inc., Cary, NC).

Results

There were no significant differences in demographic characteristics between the two groups except that the experimental group had more male patients (49% vs. 43%, p=0.04) and the control group had more patients with Asian ethnicity (7% vs. 4%, p=0.0038). Table 1 shows the distribution of the patient characteristics by group and the results.

Total drug cost. The mean drug cost for the hospital stay was $743.98 per patient, ranging between $0.48 and $35,760.48. Table 2 presents the mean, standard deviation, minimum, and maximum of the drug data. Due to lack of normality for total drug cost data, the Wilcoxon Score (rank sum) test was performed to test the mean difference. The results show that the experimental group spent significantly less on drugs ($636 vs. $844, p=0.002), which was confirmed by a t-test on log-transformed drug cost (p= 0.005).

Daily drug cost. The total sample had a mean daily drug cost of $92, ranging from $0.48 to $1,413 (see Table 2). Similar to the total drug cost, the data did not have a normal distribution. Even though the experimental group had a lower mean ($88.5) than the control ($95.8), neither the Wilcoxon non-parametric test (p=0.22) nor the t-test on log transformed daily drug cost (p=0.44) shows significance in the difference.

Average drug days. Overall, drug days ranged from 2 to 1,572 days per patient, with a mean of 73 and a median of 36. The average

Table 1.
Comparison of Patient Characteristics Between Groups

Variables	Intervention Group (n=581)	Control Group (n=626)	*p* Value for Difference
Gender	(%)	(%)	
Male	49	43	0.040*
Races	(%)	(%)	0.038*
White	70	66	
African American	17	17	
Asian	4	7	
Other	9	10	
Ethnicity	(%)	(%)	0.520
Hispanic or Latino	20	19	
Mean Age (M±SD) in Years	55±19		N/A
Age Groups	(%)	(%)	0.280
18-29	9	12	
30-49	31	29	
50-64	27	24	
65-74	15	18	
75-84	12	12	
≥85	6	5	
Payer	(%)	(%)	0.590
Managed care contract	47	48	
Medicare/Medi-Cal	49	46	
Other	4	6	
Severity of Illness at Admission	(%)	(%)	0.640
Mild	12	12	
Moderate	50	51	
Major	32	33	
Catastrophic	6	4	
Mortality Risk at Admission	(%)	(%)	0.800
Mild	41	44	
Moderate	31	31	
Major	25	23	
Catastrophic	2	2	
Disposition after Discharge	(%)	(%)	0.290
Home	76	77	
Long-term care	7	8	
Home health	6	5	
Other	11	10	

* Statistically significant as p<0.05

Table 2.
Drug Utilization Outcomes of the Entire Sample

Variable	Sample Size	Mean	Standard Deviation	Minimum	Maximum
Total Drug Cost (US$)	1,200	744	2,254	0.48	35,760
Daily Drug Cost (US$)	1,200	92	122	0.48	1,413
Drug Days	1,200	73	119	2	1,572
Drug Cost Ratio	1,200	0.05	0.06	0.0004	0.55
Total Antibiotic Cost (US$)	683	268	872	0.19	13,165
Daily Antibiotic Cost (US$)	683	28	45	0.05	454
Antibiotic Drug Days	683	10	16	1	218

Table 3.
Comparison of Unadjusted Drug and Antibiotic Utilization Outcomes Between Groups

	Intervention (n=577)	Control (n=623)	*p* Value	Method
Drug Cost (US$)	636	844	0.005*	T-test on log scale
Daily Drug Cost (US$)	89	96	0.22	T-test on log scale
Drug Days (days)	66	80	0.001*	T-test on log scale
Drug Cost Ratio (%)	5	6	0.22	T-test on log scale
Drug Cost > Mean (%)	16.1	22.5	0.005*	Chi-square test
Antibiotic Cost (US$)	208	317	0.03*	T-test on log scale
Antibiotic Days (days)	9	11	0.009*	T-test on log scale
Daily Antibiotic Cost (US$)	26	31	0.31	T-test on log scale
Use of Antibiotics (%)	53.7	59.9	0.03*	Chi-square test
Use of Quinolones (%)	12.1	16.2	0.04*	Chi-square test

* The result achieved the 0.05 level of significance.

drug days for the experimental and the control groups are 65.7 and 79.9, respectively. Both t-test (p=0.03) and Wilcoxon score test (p=0.003) show that the experimental group had a significantly lower number of drug days per patient.

Approximately 5% of total hospital cost was spent on drug therapy among the total sample. The difference in the drug cost ratios between the two groups, 0.05 for experimental versus 0.06 for control, was not statistically significant. However, unadjusted drug cost, drug days, antibiotic cost, and antibiotic days were significantly lower for the intervention group, and the same trend persisted when we examined the percentage of patients who had drug costs higher than the mean, patients who were prescribed antibiotics, and patients who were given quinolones (see Table 3).

Based on the drug utilization outcomes measured in the study without controlling for other covariates, the MDNP intervention is associated with decreased pharmaceutical resource utilization per hospitalization episode.

Multivariate analyses: Adjusted drug utilization outcomes. In this retrospective investigation, analyses on drug and antibiotic utilization and comparisons between the intervention and the control groups were performed. All drug utilization outcomes were analyzed and results reported in natural logarithm scale.

After adjusting for patients' demographic and clinical factors (see Table 4), the patients who received the MDNP intervention consistently had less drug and antibiotic days, spent less on antibiotics alone and on overall drug costs, and were less likely to incur high drug costs. Although no significance was found, daily drug cost and daily antibiotic cost were also examined to account for patients' length of stay (LOS) and to detect possible balloon effects, an indication that the excessive resource utilization was shifted to another area or the same amount was spent or utilized in a shorter time frame.

Taking LOS into account, the magnitude of the intervention

Table 4.
Multivariate Analysis of NP Intervention Effect on Drug and Antibiotic Utilization Adjusting for Age, Race, Latino Ethnicity, Gender, Severity of Illness, Mortality Risk, Baseline Mental Status, and Baseline Physical Status

	β or Odds Ratio (OR)	*p* Value	Method
Logged Drug Cost	β = -0.25	0.002*	Multiple regression
Logged Drug Days	β = -0.20	0.001*	Multiple regression
Logged Daily Drug Cost	β = -0.05	0.40	Multiple regression
Logged Antibiotic Cost	β = -0.31	0.02*	Multiple regression
Logged Antibiotic Days	β = -0.24	0.002*	Multiple regression
Logged Daily Antibiotic Cost	β = -0.11	0.32	Multiple regression
High Drug Cost	OR = 0.60	0.002*	Logistic regression
Use of Antibiotics	OR = 1.35	0.014*	Logistic regression
Use of Quinolones	OR = 1.39	0.05*	Logistic regression

* The result achieved the 0.05 level of significance.

effect on drug utilization, as measured by daily drug cost, became insignificant; however, the other variables, including age, severity, baseline mental and physical status, and use of antibiotic and quinolones, retained their prediction power. The results imply that the effect of the MDNP intervention on drug utilization was only modest when individual LOS was adjusted. Although negative coefficient estimates were obtained from the multiple linear regression analyses on daily costs, which indicated a cost-decreasing effect, the magnitude was not statistically significant.

Specifically, controlling for patient characteristics, the following results from multivariate analyses were demonstrated:

1. The intervention group was associated with significant reduction in overall drug cost, drug days, antibiotic cost, and antibiotic days per hospitalization episode.
2. Taking patients' demographic and clinical factors into account, the intervention group consistently had less drug days and antibiotic days, spent less on antibiotics and on overall drug cost, and were less likely to incur high drug cost without compromising clinical and patient outcomes.
3. Even though the patients in the intervention group were more likely to receive quinolones or other antibiotics, the overall drug and antibiotic costs were still lower for the intervention group.
4. Adjusting for individual LOS, the differences in costs as measured by daily drug cost and daily antibiotic cost between the two groups were insignificant.

Discussion

While decreased drug costs were strongly associated with shorter LOS, it is reasonable to argue that the effective drug therapy prescribed and managed by the MDNP team was part of the cause of the reduction in LOS. This result supports research that has shown that decreased LOS is associated with optimal drug therapy or management (Dooley et al., 2004). Specifically, effective antibiotic therapy has been demonstrated to improve clinical outcomes such as re-admission (Dooley et al., 2004) and survival rate (Dooley et al., 2004; Elhanan, Sarhat, & Raz, 1997) as well as to reduce overall medication costs (Gendel, Azzam, Braun, Levy, & Krivoy, 2004).

It is noteworthy that the intervention in the current study adversely increased the likelihood of using quinolones or other antibiotics without raising the antibiotic costs or overall drug costs. Several possible factors could have contributed to the positive outcomes. First, prophylactic or presumptive use of antibiotics may have been given immediately, but then terminated or de-escalated after timely microbiological workup. Second, intravenous-to-oral conversion may have been performed more often and promptly, which would have saved not only the higher acquisition cost of the parenteral medication but also other indirect costs associated with administering the drug intravenously. Third, the intervention group may have used antibiotic therapy more diligently and had a lower rate of failing the initial treatment regimen. Failure results in a different regimen needing to be implemented, which would then cause extra cost of drugs, staff time, and likely prolongation of hospital stay. Finally, even though broad-spectrum antibiotics should be used prudently due to their high costs and potential to cause antibiotic resistance, the intervention team may have prescribed the treatment regimens effectively and judicially, which resulted in favorable clinical and cost outcomes.

With these possible explanations postulated, the major deterrent for drawing inferences is that the process measures, such as the rate of inappropriate empiric regimens, the rate of changes in treatment regimen based upon microbiological diagnosis, and the rate of intravenous-to-oral conversion, were not documented or examined. The researchers were unable to confirm the appropriateness of antibiotic use and thus the conclusions need to be examined in light of these process variables.

Current literature documenting the relationships of NPs or other types of advance practice nurses and the use of pharmaceuticals is very limited. Of those that examined their impact on drug therapy, the majority compared NP prescribing patterns with physicians (Feldman, Bachman, Cuffel, Friesen, & McCabe, 2003; Hooker & Cipher, 2005; Ladd, 2005; Running, Kipp, & Mercer, 2006) or physician assistants (Cipher, Hooker, & Guerra, 2006; Hooker & Cipher, 2005); others examined their prescribing behaviors (Gutierrez & Sciacca, 2000; Shell, 2001; Talley & Richens, 2001; Wright & Neill, 2001) and adherence to practice guidelines (Ansari, Shlipak et al., 2003) in non-comparable populations or settings (Ansari, Shlipak et al., 2003; Butler, Rees, Kinnersley, Rollnick, & Hood, 2001; Gutierrez & Sciacca, 2000; Jones et al., 2002; Shell, 2001; Talley & Richens, 2001; Wright & Neill, 2001). None of the studies reported the effect of care management intervention that involved NPs on drug costs.

Investigators from the initial MDNP study published several other significant findings associated with the MDNP model. Cowan and colleagues (2006) found that the collaborative care management carried out by the physician, NPs, and other multidisciplinary members in the MDNP team decreased LOS by 1 day (5 vs. 6 days, $p<0.0001$), and was associated with a $1,591 possible gain per patient for the organization by discharging patients 1 day early and increasing patient throughput.

With regard to cost reduction, the magnitude of cost savings from inpatient drug use as demonstrated in the current study was not expected to outweigh the intervention cost because cost reduction realized from pharmaceutical services was only part of the effect. Also, in addition to the interventions carried out by the NPs to reduce unneeded drug use and facilitate care delivery, the larger model encompassed several other components. However, the in-depth assessment of the economic costs versus benefits by Ettner et al. (2006) showed that after adjusting for the intervention cost, such as the NP's salary and the time spent on the intervention by other members in the team, the model was still cost effective. Briefly, the MDNP team intervention, which integrated hospitalist medical director, NPs, and multidisciplinary care management, produced a conservative estimate of $978 net cost saving per patient during the index hospital stay (Cowan et al., 2006; Ettner et al., 2006).

In addition, Vazirani et al. (2005) examined the impact of the MDNP intervention on communication and collaboration among care providers. They found that, compared to the control group, the physicians in the intervention group reported better collaboration with nurses, and better communication with fellow physicians. They also reported better collaboration with NPs than with staff nurses. With these positive outcomes that resulted from the implementation of the MDNP intervention, patient satisfaction and HRQOL were not compromised and appeared to be comparable (Hays et al., 2006).

Furthermore, by reporting data on the various drug utilization outcomes that are scarce in the literature, the findings from this study adds to the body of knowledge on the patterns and prevalence of drug utilization among general internal medicine inpatients. The relationships between lower drug utilization and cost and the NP intervention shown in this study also shed light on possible cost-saving effects associated with the NP-led care management model. The relatively low drug to hospital cost ratio (5%) was expected by the researchers because patients accrue much higher costs during inpatient stay due to the high intensity of expensive medical treatments, facility charges, and professional services. However, considering the fact that the intervention was implemented in a large-university affiliated medical center where clinical staff, particularly resident physicians, are constantly changing, and the difficulty in maintaining a randomized, controlled, research setting, the more than 20% reduction in mean drug cost per hospitalization episode is relatively substantial and could potentially lead to major cost savings for the organization.

Conclusion

The collaborative practice among the multidisciplinary team facilitated by the NPs has streamlined the care delivery process, reduced drug utilization and cost, and appears to have subsequently shortened LOS. By documenting the economic impact on drug utilization, the results of this study are useful in evaluating the advantages of dedicating NPs in acute care settings to achieve quality care and contain inpatient drug costs. It is also evidenced that the cost savings produced by the MDNP intervention outweighed its intervention cost. Therefore, the overall results demonstrated that the NP care management model applied in the MDNP study has the potential to provide quality care at a lower cost among general medicine inpatients.

As demand and responsibility given to NPs is increased, their role and impact on prescribing practice, cost savings, and clinical outcomes bear further exploration. Future research is also needed in antibiotic management and antibiotic resistance. In the effort to promote rational use of antibiotics or other medications to contain costs and improve the quality of drug therapy, research that validates specific role components or functions of NPs in relation to specific quality outcomes or cost-effectiveness measures are essential. **$**

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