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Association of a Bundled-Payment Program With Cost and Outcomes in Full-Cycle Breast Cancer Care

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IMPORTANCE Value-driven payment system reform is a potential tool for aligning economic incentives with the improvement of quality and efficiency of health care and containment of cost. Such a payment system has not been researched satisfactorily in full-cycle cancer care.

OBJECTIVE To examine the association of outcomes and medical expenditures with a bundled-payment pay-for-performance program for breast cancer in Taiwan compared with a fee-for-service (FFS) program.

DESIGN, SETTING, AND PARTICIPANTS Data were obtained from the Taiwan Cancer Database, National Health Insurance Claims Data, the National Death Registry, and the bundled-payment enrollment file. Women with newly diagnosed breast cancer and a documented first cancer treatment from January 1, 2004, to December 31, 2008, were selected from the Taiwan Cancer Database and followed up for 5 years, with the last follow-up data available on December 31, 2013. Patients in the bundled-payment program were matched at a ratio of 1:3 with control individuals in an FFS program using a propensity score method. The final sample of 17 940 patients included 4485 (25%) in the bundled-payment group and 13 455 (75%) in the FFS group.

MAIN OUTCOMES AND MEASURES Rates of adherence to quality indicators, survival rates, and medical payments (excluding bonuses paid in the bundled-payment group). The Kaplan-Meier method was used to calculate 5-year overall and event-free survival rates by cancer stage, and the Cox proportional hazards regression model was used to examine the effect of the bundled-payment program on overall and event-free survival. Sensitivity analysis for bonus payments in the bundled-payment group was also performed.

RESULTS The study population included 17 940 women (mean [SD] age, 52.2 [10.3] years). In the bundled-payment group, 1473 of 4215 patients (34.9%) with applicable quality indicators had full (100%) adherence to quality indicators compared with 3438 of 12 506 patients (27.5%) with applicable quality indicators in the FFS group ($P < .001$). The 5-year event-free survival rates for patients with stages 0 to III breast cancer were 84.48% for the bundled-payment group and 80.88% for the FFS group ($P < .01$). Although the 5-year medical payments of the bundled-payment group remained stable, the cumulative medical payments for the FFS group steadily increased from $16 000 to $19 230 and exceeded pay-for-performance bundled payments starting in 2008.

CONCLUSIONS AND RELEVANCE In Taiwan, compared with the regular FFS program, bundled payment may lead to better adherence to quality indicators, better outcomes, and more effective cost-control over time.

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Value-driven payment system reform is a potential tool for aligning economic incentives with improvement of quality and efficiency of health care and containment of cost. The move from fee-for-service (FFS) reimbursement to episode-based bundled payment is widely perceived as a better way to achieve value in the United States and worldwide,[1-6] including for cancer care.[7] The Center for Medicare & Medicaid Innovation recently announced the Oncology Care Model,[8] an innovative new payment model for administering chemotherapy, whereby oncologists will need to consider payment arrangements that include financial and performance accountability for episodes of care surrounding chemotherapy administration to patients with cancer.[8] Use of clinical pathways and bundled payment has been suggested as a strategy to reward physicians for equivalent or improved outcomes while reducing total costs of cancer care.[9,10] However, data are scant on bundled payment for oncologic conditions in the era of affordable care.[5]

The present study examines a pilot payment program from Taiwan focusing on breast cancer care. In 1995, Taiwan established a universal health insurance system operated by the National Health Insurance Administration (NHIA), formerly known as the Bureau of National Health Insurance, that covers more than 99% of Taiwan's 23 million residents. The NHIA is a universal, single-payer social health insurance system based on a public contract model offering comprehensive benefits.[11,12] Under the NHIA system, most health care services are reimbursed on an FFS basis. In 2001, the NHIA initiated pilot pay-for-performance (PFP) programs for pulmonary tuberculosis, asthma, diabetes, cervical cancer, and breast cancer. Some studies have begun to examine the effect of PFP programs on quality and health care expenses.[13-15] The PFP bundled-payment program for breast cancer is a voluntary program for participating hospitals. The criteria to join include having 100 or more patients per year, clinical guidelines or protocols, and availability of multiple-specialty services, including surgery, general internal medicine, medical oncology, radiation oncology, etc. If the hospital volume is less than the suggested 100 patients per year, hospitals can still be accepted by undergoing a special review by the NHIA.

For the breast cancer bundled-payment program initiated in 2001, the NHIA reimbursed health care institutions with a bundled payment for a guideline-based, stage-specific treatment rather than an FFS. This program also offered bonus payments to institutions at the end of years 1 through 5 after the patients' initial treatments if the institution's year-end rates of overall and event-free survival equaled or exceeded the standard set by the NHIA. The purpose of this study is to examine the effect on outcomes and health care expenditures of the PFP bundled-payment program for breast cancer in Taiwan. We also compare the adherence to quality indicators, survival rates, and medical payments (excluding bonuses paid) between bundled-payment and FFS groups reimbursed by the NHIA.

Key Points

Question What is the association between a bundled payment pay-for-performance program with cost and outcomes for breast cancer care in Taiwan?

Findings In this propensity score–matched study, the 5-year event-free survival rates for patients with stages 0 to III breast cancer were 84.48% for the pay-for-performance bundled-payment group and 80.88% for the fee-for-service (FFS) control group. The 5-year medical expenses in the FFS group steadily increased from 2004 to 2013, whereas payments for the bundled-payment group remained stable.

Meaning Compared with regular FFS programs, bundled payment may lead to better adherence to quality indicators, better outcomes, and more effective cost control over time.

Methods

Data Sources

Data for this study were obtained from the Taiwan Cancer Database (TCDB), the National Health Insurance Claims Data (NHCD), the National Death Registry, and the NHIA PFP bundled-payment enrollment file. The TCDB is a population-based cancer registry developed and maintained by the Health Promotion Administration of the Ministry of Health and Welfare of Taiwan since 2004. The TCDB data included sex, cancer stage, and tumor grade and/or differentiation codes. The NHCD maintained by the NHIA gave the study medical enrollment file and claims data for all services reimbursed by the NHIA. We used available NHCD files from January 1, 2003, to December 31, 2013, including ambulatory care expenditures by visit, details of ambulatory care orders, details of inpatient orders, and inpatient expenditures by admissions; we also included copayments from patients. We used the NHCD to obtain primary and secondary diagnostic codes, procedure codes, and billing records for claims reimbursed by the NHIA. This study was evaluated and exempt from the need for approval and patient informed consent by the institutional review board of the Koo Foundation Sun Yat-Sen Cancer Center.

Sample Selection

The initial selection included only female patients with newly diagnosed breast cancer from January 1, 2004, to December 31, 2008, with a documented treatment start date from the TCDB. Each patient was followed up for 5 years, with the last follow-up data available on December 31, 2013. The selected patients were linked to the NHCD from January 1, 2003, to December 31, 2013, to obtain claims data and expense records. We selected patients by primary and/or secondary diagnostic codes and procedure codes in the NHCD, which included at least 1 related code for surgery, chemotherapy, radiotherapy, or hormone therapy and time of first treatment from 2004 to 2008. Among those patients selected, we included patients with stages 0 to III breast cancer who received all their treatments in a single hospital during the 18 months after starting

their first breast cancer treatment, the period when most patients are expected to complete their initial course of treatment to achieve remission. We also included patients with stage IV cancer who received all their breast cancer treatment at a single hospital. We identified patients by the enrollment file maintained by the NHIA to identify those who participated in the bundled-payment program. A total of 26 741 patients fulfilled these inclusion criteria, including 5714 patients in the bundled-payment group and 21 027 patients in the FFS group.

Matching Data

To reduce selection bias owing to the lack of random assignment for participants in the bundled-payment program, we performed a 1:3 case-control match of patients in the bundled-payment program vs FFS control individuals using a propensity score method.[16,17] We designated 4 variables for matching (ie, age, cancer stage, pretreatment comorbidity score, and year of treatment initiation). The pretreatment comorbidity score was calculated using the Charlson Comorbidity Index,[18,19] determined from patients' NHIA claims data 1 year before the date of each patient's first treatment for breast cancer. The final study population after matching of 17 940 eligible patients included 4485 (25%) in the bundled-payment group (this number represents the entire population of patients treated under the bundled-payment program) and 13 455 (75%) in the FFS group.

Outcome Measurement

We defined event-free and overall survival rates, medical payments, and adherence to quality indicators as outcomes to evaluate the bundled-payment program. The National Death Registry from January 1, 2004, to December 31, 2013, was linked to the overall data set to identify survival time. Receipt of additional chemotherapy or radiotherapy (as defined by claims data) 18 months after the first breast cancer treatment was defined as evidence of a recurrence in stages 0 to III cancer because actual recurrence events were not coded in the available databases.

The TCDB regularly collects data on adherence rates and staging. We thus used the TCDB's collection to calculate adherence rates to quality indicators. Quality indicators were developed by a joint effort of our institution and the Health Promotions Administration,[20] with modifications contributed by experts from RAND Health, Santa Monica, California.[14]

Medical Payment Measurement

To compare the medical costs of the initial phase of breast cancer care between the bundled-payment and FFS groups, we aggregated 5-year medical payments per patient by starting with the date of the first treatment. These payments represent the actual medical expense reimbursed by the NHIA for both groups and include copayments from patients. The PFP bonus payment was not included in the calculation for the bundled-payment group because not every institution met the criteria for bonus payments and because the exact amounts paid to participating institutions were kept confidential by the NHIA and not made available to our research team. The additional bonus payments are estimated (from participating institutions) to range from 0 to 7% of the medical payment. Because the bonus information was not available, we performed a sensitivity analysis by adding bonuses of 1.75%, 3.5%, 5.25%, and 7% to the medical payment for the bundled-payment group for the 5-year period.

Statistical Analysis

We used the Kaplan-Meier method to estimate overall and event-free survival rates. The log-rank test compared survival rates between groups in each cancer stage. We used the Cox proportional hazards regression and stratified proportional hazards regression models to examine the effect of the bundled-payment program on overall and event-free survival by adjusting for grade and/or differentiation and patient volume. We have tested the assumption of proportionality for the Cox analysis. Violation of assumption was addressed by stratification for nonkey variables (eg, tumor grade and patient volume) when applicable.[21] For the key independent variable (ie, PFP bundled payment), we added a time-dependent interaction term to address the time dependency. Results were stratified by grade and/or differentiation and reported as weighted mean adjusted hazard ratios for time-dependent variables, when applicable.

For comparing medical payments, we used the unpaired 2-tailed *t* test. We used the χ^2 test to compare adherence rates between groups. We defined statistical significance as $P < .05$. We used SAS (version 9.1; SAS Institute Inc) and SPSS (version 20.0; IBM Corp) software for data management and statistical analysis.

Results

The study population included 17 940 women (mean [SD] age, 52.2 [10.3] years). Detailed clinical characteristics of the bundled-payment (n = 4485) and the FFS (n = 13 455) groups are listed in **Table 1**. After matching, no significant differences between groups were found in matched variables, including age, cancer stage, pretreatment comorbidity score, and year of first treatment. In the bundled-payment group, 1473 of 4215 patients (34.9%) with applicable quality indicators were 100% adherent to quality indicators compared with 3438 of 12 506 patients (27.5%) with applicable quality indicators in FFS group ($P < .001$) (**Table 2**). Patients with stage I, II, or III breast cancer in the bundled-payment group had significantly better adherence rates (Table 2). Among the 7 core indicators related to the care process, the bundled-payment group had significantly better adherence rates in cytologic or histologic preoperative confirmation, axillary node dissection for 10 or more nodes in patients with invasive cancer, and radiotherapy for invasive cancer compared with the FFS group (**Table 3**).

Results from the log-rank test showed that, for patients with stages 0 to III breast cancer, patients in the bundled-payment group had better event-free survival than patients in the FFS group (**Table 4**). The 5-year event-free survival rates of all patients with stages 0 to III breast cancer were 84.48% for the bundled-payment group vs 80.88% for the FFS group

Table 1. Clinical Characteristics in the Study Population by Payment Group

Clinical Characteristic	Payment Group, No. (%) of Patients[a] Bundled (n = 4485)	FFS (n = 13 455)	*P* Value
Propensity Score–Matched Characteristics			
Age, y			
<40	393 (8.8)	1235 (9.2)	.80
40-49	1515 (33.8)	4583 (34.1)	
50-64	1993 (44.4)	5907 (43.9)	
≥65	584 (13.0)	1730 (12.9)	
Year of first treatment			
2004	740 (16.5)	2085 (15.5)	.37
2005	759 (16.9)	2392 (17.8)	
2006	869 (19.4)	2541 (18.9)	
2007	986 (22.0)	2997 (22.3)	
2008	1131 (25.2)	3440 (25.6)	
Cancer stage			
0	207 (4.6)	592 (4.4)	.16
I	1492 (33.3)	4697 (34.9)	
II	1893 (42.2)	5696 (42.3)	
III	668 (14.9)	1874 (13.9)	
IV	215 (4.8)	566 (4.2)	
Unknown	10 (0.2)	30 (0.2)	
Pretreatment comorbidity score[b]			
0	3051 (68.0)	9166 (68.1)	.44
1	908 (20.2)	2796 (20.8)	
≥2	526 (11.7)	1493 (11.1)	
Unmatched Characteristics			
Grade or differentiation code[c]			
1[d]	584 (13.0)	1959 (14.6)	<.001
2[e]	1833 (40.9)	6135 (45.6)	
3[f]	1779 (39.7)	3595 (26.7)	
Unknown	289 (6.4)	1766 (13.1)	
Patient volume per hospital			
<50	8 (0.2)	539 (4.0)	<.001
50-99	12 (0.3)	1599 (11.9)	
≥100	4465 (99.6)	11 317 (84.1)	

Abbreviation: FFS, fee for service.

[a] Percentages have been rounded and may not total 100.

[b] Calculated as Charlson Comorbidity Score, with higher scores indicating more comorbidities.

[c] The codes are based on several classification schemes used by different pathologists to denote breast cancer grade or differentiation from January 1, 2004, to December 31, 2013, including Bloom-Richardson (Nottingham) scores (3-5; 6 and 7; and 8 and 9); Bloom-Richardson Grade (low, intermediate, or high); nuclear grade (1/3 or 1/2; 2/3; 3/3 or 2/2); terminology (well differentiated; moderately differentiated; or poorly differentiated); and histologic grade (I/III or 1/3; II/III or 2/3; III/III or 3/3).

[d] Defined in the Taiwan Cancer Database as Bloom-Richardson (Nottingham) scores 3 to 5; Bloom-Richardson low grade; nuclear grade 1/3 or 1/2; well differentiated; and histologic grade I/III or 1/3.

[e] Defined in the Taiwan Cancer Database as Bloom-Richardson (Nottingham) scores 6 and 7; Bloom-Richardson intermediate grade; nuclear grade 2/3; moderately differentiated; and histologic grade II/III or 2/3.

[f] Defined in the Taiwan Cancer Database as Bloom-Richardson (Nottingham) scores 8 and 9; Bloom-Richardson high grade; nuclear grade 3/3 or 2/2; poorly differentiated; and histologic grade III/III or 3/3.

(*P* < .01). By separate stage, the 5-year event-free survival rates of patients in bundled-payment vs FFS hospitals were 96.14% and 95.44%, respectively (*P* = .75), for patients with stage 0 cancer; 92.09% vs 90.67%, respectively (*P* = .02), for patients with stage I cancer; 85.31% vs 80.46%, respectively (*P* < .01), for patients with stage II cancer; and 61.53% vs 53.04%, respectively (*P* < .01), for patients with stage III cancer. Event-free survival was not applicable to patients with stage IV cancer because *event free* was defined as the absence of recurrence 18 months after initial treatment (Table 4). On the other hand, the 5-year overall survival for patients in the bundled-payment group was similar to that for patients in the FFS group; only patients with stage II cancer showed better overall survival, with 91.92% for the bundled-payment group vs 90.64% for the FFS group (*P* = .01) (Table 4).

The results from the Cox proportional hazards regression and stratified proportional hazards regression models showed that the event-free survival was significantly better in the bundled-payment group compared with the FFS group. The event-free hazard ratio of all cases in stages 0 to III was 0.82 (95% CI, 0.76-0.88) in the bundled-payment group after adjusting for tumor grade and patient volume. When the group was stratified by cancer stage, the risk-adjusted hazard ratio was 1.03 (95% CI, 0.50-2.14) for stage 0; 0.82 (95% CI, 0.68-0.99) for stage I; 0.79 (95% CI, 0.70-0.88) for stage II; and 0.80 (95% CI, 0.70-0.91) for stage III.

In terms of cost analysis, the 5-year cumulative medical payments of the bundled-payment group were initially higher than those of the FFS group except for patients who started treatment after 2008 (the **Figure** shows the mean payments for both groups). Although the 5-year medical payments of the bundled-payment group remained relatively stable from 2004 to 2008, payments for the FFS group steadily increased from 2004 to 2008. After 2008, the expenses for patients in the FFS group exceeded those in the bundled-payment group (Figure). When we performed a sensitivity analysis of different bonus

Table 2. Adherence to Quality Indicators by Cancer Stage and Payment Group

Cancer Stage	Payment Group, No. (%) of Patients[a] Bundled (n = 4215)	FFS (n = 12 506)	*P* Value
All, % of adherence			
<100	2742 (65.1)	9068 (72.5)	<.001
100	1473 (34.9)	3438 (27.5)	
0, % of adherence			
<100	64 (31.5)	182 (32.0)	.90
100	139 (68.5)	387 (68.0)	
I, % of adherence			
<100	950 (64.1)	3508 (76.4)	<.001
100	533 (35.9)	1084 (23.6)	
II, % of adherence			
<100	1568 (83.8)	4736 (86.0)	.02
100	304 (16.2)	770 (14.0)	
III, % of adherence			
<100	155 (24.2)	608 (34.2)	<.001
100	486 (75.8)	1168 (65.8)	
IV, % of adherence			
<100	3 (23.1)	27 (50.0)	.08
100	10 (76.9)	27 (50.0)	
Unknown, % of adherence			
<100	2 (66.7)	7 (77.8)	.70
100	1 (33.3)	2 (22.2)	

Abbreviation: FFS, fee for service.

[a] Indicates patients with applicable quality indicators.

Table 3. Differences in Adherence Rates of Key Breast Cancer Quality Indicators

Indicator No.	Indicator Description	Adherence Rate, No. (%) Bundled-Payment Group	FFS Group	*P* Value
1	Cytologic or histologic confirmation before definitive surgery	3770/4178 (90.2)	10 025/12 250 (81.8)	<.001
2	Patients with ductal carcinoma in situ do not undergo axillary node dissection	114/139 (82.0)	244/326 (74.8)	.09
3	Axillary node dissection with ≥10 axillary lymph nodes for patients with invasive cancer	2249/2550 (88.2)	5808/7159 (81.1)	<.001
4	Radiotherapy for invasive cancer after breast conservation surgery	1158/1240 (93.4)	2971/3553 (83.6)	<.001
5	Tumor size recorded	3831/3969 (96.5)	11 259/11 686 (96.3)	.61
6	Adjuvant chemotherapy for patients 50 y or younger with positive axillary lymph nodes	460/533 (86.3)	1200/1439 (83.4)	.12
7	Adjuvant chemotherapy or hormone therapy for patients older than 50 y with positive axillary lymph nodes	1020/1108 (92.1)	2500/2772 (90.2)	.07

Abbreviation: FFS, fee for service.

levels, we found that even if all hospitals received the top 7% bonus payment, the mean 5-year medical payments for the FFS group would still exceed those of the bundled-payment group for patients who started their treatment in 2008 (mean FFS payment, $19 230; mean PFP bundled payment, $19 110) (Figure). Mean PFP bundled payment without a bonus for patients who started treatment in 2008 was $17 860.

Discussion

The PFP bundled-payment program, when compared with the FFS program, demonstrated better adherence to treatment quality indicators, improved survival, and more effective cost control over time in breast cancer treatment. Cheng et al[14] previously published the association between optimal adherence to treatment quality indicators and outcomes of breast cancer. The present study showed that patients in the bundled-payment program may have significantly improved 5-year event-free survival, especially for stages I, II, and III cancer. In stage 0 cancer, where most patients are expected to do well, and in stage IV cancer (advanced disease), with few patients and with event-free survival (defined as absence of relapse 18 months after initial treatment) not applicable, we did not expect to see meaningful differences in survival with payment reform.

The initial payments for the bundled-payment group were higher than those for the FFS group. This difference was

Table 4. 5-Year Survival by Breast Cancer Stage

Payment Group by Cancer Stage	5-y Event-Free Survival					5-y Overall Survival				
	No. of Patients	Survival Rate, %	*P* Value[a]	AHR (95% CI)	*P* Value[b]	No. of Patients	Survival Rate, %	*P* Value[a]	AHR (95% CI)	*P* Value[b]
All										
Bundled	4260	84.48	<.01	0.82 (0.76-0.88)[c,d]	<.01	4485	87.29	.36	0.98 (0.90-1.07)[c]	.71
FFS	12 859	80.88				13 455	87.31			
0										
Bundled	207	96.14	.75	1.03 (0.50-2.14)	.94	207	98.55	.93	1.22 (0.37-3.99)	.74
FFS	592	95.44				592	98.65			
I										
Bundled	1492	92.09	.02	0.82 (0.68-0.99)	.04	1492	96.58	.74	0.94 (0.73-1.20)	.62
FFS	4697	90.67				4697	96.47			
II										
Bundled	1893	85.31	<.01	0.79 (0.70-0.88)[c,d]	<.01	1893	91.92	.01	0.82 (0.70-0.97)[c]	.02
FFS	5696	80.46				5696	90.64			
III										
Bundled	668	61.53	<.01	0.80 (0.70-0.91)[c]	<.01	668	70.96	.12	0.93 (0.81-1.09)[c]	.38
FFS	1874	53.04				1874	68.89			
IV										
Bundled	215	NA	NA[e]	NA[e]	NA	215	22.79	.19	1.08 (0.90-1.3)[d]	.40
FFS	566	NA				566	27.92			

Abbreviations: AHR, adjusted hazard ratio; FFS, fee for service; NA, not available.

[a] Calculated using the log-rank test.

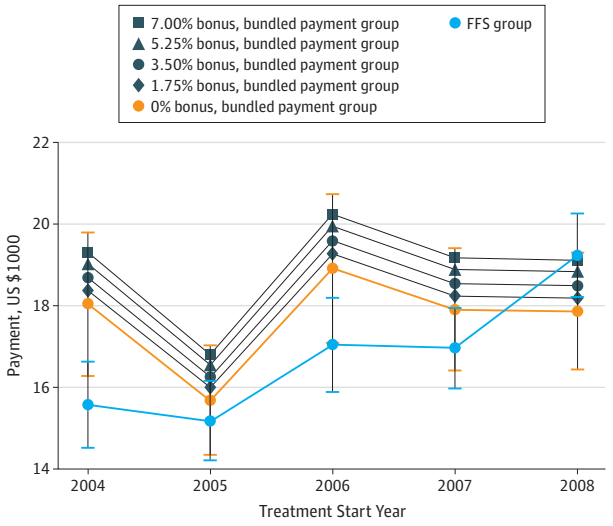
[b] Calculated using the Cox proportional hazards regression model, adjusted by cancer grade and patient volume of the hospital.

[c] Stratified by grade or differentiation (described in Table 2).

[d] Indicates weighted mean AHR.

[e] We did not include patients with stage IV cancer in the model for event-free survival because *event free* was defined as absence of recurrence 18 mo after initial treatment.

Figure. Line Plot of Mean 5-Year Cumulative Expenses Over Time



Expenses are aggregated starting with the first date of the first treatment, with sensitivity analysis for bonus payments in the pay-for-performance bundled-payment group. Error bars indicate 95% CI. FFS indicates fee for service.

intended by the NHIA to encourage health care institutions to enroll in the bundled-payment program. We have observed in our study that, although payment for the bundled-payment group had been stable, the payment for the FFS group steadily increased year by year and eventually exceeded that of the bundled-payment group in 2008 (Figure). Thus, PFP bundled payment may have helped in cost containment for breast cancer care. The bundled-payment system is known to encourage physicians of different specialties and nurses to function as a team to improve the quality of breast cancer care[12,14] and to reduce use of procedures of little or no value. We hypothesized that expensive procedures (eg, computed tomographic scans), unplanned hospitalizations, and the length of stay will decrease for the bundled-payment group (unpublished data; C.J.W., S.H.C., J.-Y.W. et al; September 2016) owing to the use of preventive strategies (eg, granulocyte-stimulating factors to reduce neutropenia-related infections, selection of chemotherapy agents, and use of more effective antiemetics), improved coordination of care, and wiser adoption of proven follow-up tests and procedures.

Under the Patient Protection and Affordable Care Act, the Centers for Medicare & Medicaid Services also announced a Bundled Payments for Care Improvement Initiative in 2013, which included 4 new payment models in which reimbursement for medical services delivered during defined episodes of care is bundled together.[22] Accountable care organizations that take responsibility for the cost and quality of care delivered to the patients will receive a share of the savings they achieve for Medicare.[1,2,23] A recent announcement by the US Secretary of Health and Human Services states that department aims to tie 85% of all Medicare FFS payments to quality or value by 2016 and, more importantly, to tie 30% of Medicare payments to quality or value through alternative

payment models by the end of 2016.[24] The Department of Health and Human Services is engaging state Medicaid programs and private payers to progress toward value-based payment and planning to develop and test new payment models, including the Oncology Care Model.[8] Bach et al,[7] Newcomer,[9] and Weil[25] have suggested that bundled payment offers a good strategy to achieve improved outcomes and control costs for cancer care. The United Healthcare study[26] also demonstrated improved outcomes with fewer hospitalizations in an episodic payment group. However, evidence is insufficient to support such a bundled-payment approach for cancer across the full cycle of care. Our study suggests that full-cycle bundled payment can help to improve outcomes (ie, event-free survival) and contain health care costs for comprehensive treatment of oncologic conditions, such as breast cancer.

Limitations

Our study has several limitations. First, participation in a PFP bundled-payment program is voluntary; participants may be better performing institutions than those reimbursed under the FFS plan. Patients in Taiwan may freely choose hospitals under the national health insurance program, although they do not have the knowledge of which payment model (FFS vs PFP bundled payment) arrangement the hospital has with the NHIA for breast cancer care. Therefore, patients were unlikely to select hospitals based on payment models. To reduce selection bias owing to the lack of random assignment for participants in the PFP bundled-payment program, we performed a 1:3 case-control propensity score match of patients in the bundled-payment (vs FFS) program and adjusted for hospital patient volume. We were not able to analyze outcomes by individual physicians or teams of physicians because the data were not available. If we had to redesign the program, we would use randomized analysis. However, at the time of the study (2004-2008 when patients were enrolled, with the subsequent 5-year follow-up to 2013), randomization was not a political option. To entice institutions to join, the NHIA determined that the program has to start as a voluntary pilot bundled-payment program, with variable bonuses for participating institutions based on annual patient survival.

Second, we did not include the PFP bonus payment in our calculation because the amounts of such payments to hospitals were kept confidential and were unavailable to our research team. However, we performed a sensitivity analysis and showed that, even if we assume the top bonus level of 7%, the FFS group will still exceed the bundled-payment group for those patients starting treatment in 2008. Third, commonly collected patient markers are lacking in the database. From 2001 to 2016 (the present), knowledge and treatment of breast cancer have evolved. Many of the commonly collected individual patient markers were not routinely collected across the multiple institutions in Taiwan during the time of our study, including estrogen receptor status, *ERBB2* (formerly *HER2*), *BRCA1/2*, etc. Moreover, no prebundled payment data are available. The bundled-payment program was initiated in November 2001, but the TCDB, the main data source for this study that includes cancer stage information, was only begun in 2004. Therefore, no preintervention data are available. Finally, another limitation resides in the fact that we reluctantly used administration of chemotherapy or radiotherapy 18 months after the first breast cancer treatment as evidence of recurrence because actual recurrence events were not coded in the available databases.

Conclusions

The rising costs of health care will increase the overall financial burden on health care systems and the nation. Such a heavy burden takes away important resources for fundamental research, technological innovation, and more effective prevention. Our study has demonstrated that PFP bundled payment for breast cancer care may contribute to cost containment, better adherence to quality care, and improved outcomes. Our approach, which spans a period of 15 years, shows promise and deserves further study.

ARTICLE INFORMATION

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Study concept and design: Wang, Cheng, Wu, C.-L. Lin, Huang.
Acquisition, analysis, or interpretation of data: Wang, Cheng, Wu, Y.-P. Lin, W.-H. Kao, C.-L. Lin, Chen, Tsai, F.-Y. Kao, Huang.
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