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A Standardized Relative Resource Cost Model for Medical Care: Application to Cancer Control Programs

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Medicare data represent 75% of aged and permanently disabled Medicare beneficiaries enrolled in the fee-for-service (FFS) indemnity option, but the data omit 25% of beneficiaries enrolled in Medicare Advantage health maintenance organizations (HMOs). Little research has examined how longitudinal patterns of utilization differ between HMOs and FFS. The Burden of Cancer Study developed and implemented an algorithm to assign standardized relative costs to HMO and Medicare FFS data consistently across time and place. Medicare uses 15 payment systems to reimburse FFS providers for covered services. The standardized relative resource cost algorithm (SRRCA) adapts these various payment systems to utilization data. We describe the rationale for modifications to the Medicare payment systems and discuss the implications of these modifications. We applied the SRRCA to data from four HMO sites and the linked Surveillance, Epidemiology, and End Results–Medicare data. Some modifications to Medicare payment systems were required, because data elements needed to categorize utilization were missing from both data sources. For example, data were not available to create episodes for home health services received, so we assigned costs per visit based on visit type (nurse, therapist, and aide). For inpatient utilization, we modified Medicare's payment algorithm by changing it from a flat payment per diagnosis-related group to daily rates for diagnosis-related groups to differentiate shorter versus longer stays. The SRRCA can be used in multiple managed care plans and across multiple FFS delivery systems within the United States to create consistent relative cost data for economic analyses. Prior to international use of the SRRCA, data need to be standardized.

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Measuring the Medical Cost of Cancer

Annually the cost of medical care for cancer accounts for about 5% of national health care expenditures and 10% of Medicare outlays (1–3). Much of what we know about the cost of preventing, diagnosing, and treating cancer in the United States comes from research based on the National Cancer Institute's (NCI) Surveillance, Epidemiology, and End Results (SEER) cancer registries, which are linked to Medicare claims from the Centers for Medicare and Medicaid Services (CMS) and known as the SEER–Medicare data (1,2,4,5). This rich data resource provides comprehensive health-care use and claims expense information about Medicare-covered services for persons aged 65 and over, and permanently disabled persons who receive care through the traditional Medicare indemnity program, living in one of the 17 US geographic regions covered by the SEER program. Numerous published studies have used the linked SEER–Medicare data to document the economic consequences of cancer among persons aged 65 and over and permanently disabled persons. The linked SEER–Medicare data serve as the primary information source for much of the health services research on cancer care in the United States (http://healthservices.cancer.gov/seermedicare/overview/publications.html) (6). Nationally Medicare data represent the experience of 75% of aged and disabled Medicare beneficiaries enrolled in the fee-for-service (FFS) indemnity option; unfortunately, this omits the experience of the 25% of aged and disabled beneficiaries enrolled in Medicare Advantage health maintenance organizations (HMOs) (11.8 million beneficiaries in April 2011) (7). FFS is a payment system in which an individual or institution is reimbursed based on the services actually used. This is in contrast to capitated payment systems, in which a set amount per individual is prepaid and is not based on the services used, as in the Medicare Advantage HMOs (8). There is no evidence that the SEER–Medicare data are not reflective of national enrollment patterns in FFS and HMOs. Previous research has found that expense patterns generated from SEER–Medicare and HMO data are roughly consistent (9–11); no studies, however, have systematically examined how cancer-specific and longitudinal patterns of resource and service use and overall expense differ between HMOs and Medicare. Building on the work of the Cancer Research Network [CRN (12–14)], the Burden of Cancer study (BURDEN) has developed a multisite, multipayer database to support analyses extending and complementing the linked SEER–Medicare data. Our study extends the literature on costs of cancer care to include nonaged adult HMO patients (aged 18–64 years) and adds HMO data to the literature that describes the cost experience for those aged 65 and over. To address our research aims, the research team developed a method to compare the costliness of cancer care

across multiple HMOs and between HMOs and Medicare FFS indemnity care on a consistent basis. To ensure that observed differences were not a result of differing costing (or pricing) methods and billing rules (bundling of services), we applied consistent costing weights to standardized Medicare FFS and HMO utilization data.

Here we describe the capture of cancer (and noncancer)-related medical care services as well as how we addressed data issues that arose in developing and implementing our standardized resource cost algorithm. We highlight 15 different Medicare payment systems and describe how our team adapted these systems to calculate relative service intensity of cancer care patterns between Medicare Advantage (capitated HMO contracts) and Medicare FFS (indemnity insurance) systems in the United States. We believe our algorithm can be applied in many different contexts if disease and procedure coding systems are sufficiently aligned. Although this algorithm was developed using Medicare FFS as its basis, it is important to note that the standardized relative resource cost algorithm (SRRCA) can be applied to any FFS data structure. Fishman et al. (15) (another chapter in this monograph) present the case for the importance of developing consistent data from a variety of health systems, both within the United States and internationally. Heterogeneity in health-care delivery systems, payment systems, insurance systems, and medical technologies provide the required practice variation to discover innovative care delivery models as well as relatively less safe delivery models. In this chapter, we show the need for standardized data in calculating a meaningful measure of resource use across health-care systems in the United States and across different countries.

Methods

Data Sources

This research was conducted within four nonprofit integrated healthcare systems: Group Health Cooperative based in Seattle, WA, the Henry Ford Health System of Southeast Michigan, and the Northwest and Colorado regions of Kaiser Permanente. Each system provides comprehensive health services primarily through closed-panel delivery models and places an emphasis on preventive services and cancer screening. All four health systems provide care to enrollees from each key market segment—commercial group, Medicare, Medicaid, and individual/family—and each plan provides services to individuals of all ages. Institutional Review Boards at each site reviewed and approved this research.

Comprehensive utilization data were extracted for the BURDEN population for 2000–2008 from data warehouses maintained by the health plans. Data were standardized across health plans according to specifications established by the CRN's Virtual Data Warehouse (VDW) (12). In any analysis that compares utilization or cost data from multiple organizations or across delivery settings, it is critical that data be standardized to the largest extent possible. Otherwise, one can never be sure that any observed difference is due to differences in the care delivery setting, costing/pricing methodologies, or data structure. Cost data are not included in the VDW, so the development of the standardized resource cost algorithm was a high priority.

Costing Basics

Total expenditures by health-care providers and third-party payers are the sum of the products of units of various inputs and the prices paid for each input. For the purposes of this analysis, we distinguish between production costs and standardized costs. *Production costs* of medical care services are defined as actual expenses incurred by providers in delivering care to individual patients or specified populations. These expenditures usually represent historical accounting costs, if derived from providers' financial management systems, or historical prices, if derived from bills or paid third-party claims. The key attribute of production expenses is that prices of the same input will likely vary across provider and location, and over time. This variation can confound differences in the physical units of medical care services if low-cost services are substituted for high-cost services. *Standardized costs* are computed by applying the same price for each class of inputs across providers and over time, so that the observed variance in expenses is determined only by variations in mix and volumes of the various medical care services delivered to patients. A standardized costing scheme represents a set of relative resource intensity weights, akin to resource-based relative value units (RVUs) (16,17). Relative resource weights derive their face validity from knowing the types, intensity, and complexity of specific medical care services.

Our Model

The foundation for our model is counts of standardized specific services provided to individual patients. Rather than starting from total monetary expenditures, we require that all medical care be defined by standardized procedure and facility classifications across all care sources. We developed relative monetarized resource weights for each service type. The sum of the products of service quantities and monetary weights generates a monetarized relative resource intensity value that can be compared across patients, providers, systems, and time. This approach removes the effects of inflation in input costs and medical care prices, as well as regional differences in input prices. By weighing each service type with fixed monetary values, we can compute an overall index of relative costliness of treatments, episodes of care, and total annual medical care consumption.

Because our primary research aim was to compare Medicare indemnity and capitation systems, we could have selected either HMO-based relative resource weights or Medicare payment schedules. Deriving HMO-based resource weights was not feasible given the scope of our work, as it would have required, for each of our sites, obtaining and mapping the HMO's cost accounting data onto a standardized cost report and then deriving an overall average unit cost estimate for each service. Therefore, we elected to base our algorithm on the 15 different payment systems Medicare uses to reimburse FFS providers of health-care services. Unless specifically noted, all costs have been converted to 2008 dollars. As our focus is on measuring resource intensity versus the effects of geographical payment modifiers, we made no adjustment for geographic input price differences or other adjustments (eg, health professional shortage areas or indirect medical education adjustments).

We applied our algorithm to both Medicare claims and HMO data. This approach meant that we treated a brief physician

office visit with a continuing patient the same in all HMOs in our sample and in the Medicare claims data. Because our HMO data are defined in terms of health-care encounters, rather than health insurance claims, we had to roll up Medicare claims data into relevant encounters to make them comparable to HMO data. Encounter data systems measure bundles of service use defined by facility, clinician, time, and patient. Claims, by contrast, link providers to patients, but individual claims can contain information on multiple encounters, and services provided to patients on a specified date can appear in multiple claims. HMOs represent integrated health-care delivery systems and health insurers. Most group-model HMOs have a predominance of capitation business, and their claims data systems are used mostly for out-of-plan emergency care and outside referrals.

Perspective is an essential element in measuring costs. Possible perspectives include society, payer, health-care system, provider, and family (18). For this analysis, our perspective is that of the health-care system. Hence, we want to capture the relative intensity of the resources used in stays, encounters, dispensings, procedures, etc., rather than the split billing between payers and patients or the revenues actually collected versus bad debt write-offs.

Medicare Payment Systems and HMO Adaptations

Medicare's payment systems are defined by the physical site of care—hospitals, medical offices, ambulatory surgery centers, pharmacies, home health agencies, hospices, skilled nursing facilities, psychiatric and substance abuse hospitals, and rehabilitation hospitals—and by professional service versus facility service. In this section, we describe how we approximate the same types of facility and professional services across prepaid HMOs and FFS practice.

Inpatient Care: Short-Term Stays in General Hospitals

For acute inpatient care, Medicare reimburses hospitals per stay based on diagnosis related groups (DRGs). The payment formula consists of a base DRG-specific payment, an adjusted area wage index, an indirect medical education allowance, a disproportionate share hospital allowance, and an outlier component. The intent of DRG payment is to reimburse institutions for facility-based costs and shift some of the financial risks to hospitals by paying a fixed rate regardless of actual lengths of stay or resources consumed. Professional fees are paid separately via the physician payment system, which uses the Medicare Fee Schedule (MFS) tied to the Healthcare Common Procedure Coding System (HCPCS).

Medicare DRG payments represent risk-adjusted payments for inpatient episodes, a switch from cost-based reimbursement. Payment by DRG shifts the incidence of variations in facility costs per stay within a DRG category from Medicare to the hospital, with allowances for additional marginal payments for cost and day outliers. The intent of the SRRCA is to capture differences in resource intensity of care (rather than risk sharing), so we modified the DRG payment system from a stay-based reimbursement to an average expense per hospital day for each DRG. This allowed us to capture how varying lengths of stay within a DRG affected total resource use. Using Medicare claims data, we first converted all expenses to 2008 dollars and then calculated a daily rate per DRG. In calculating the daily rate, we included only those costs associated with the Medicare Provider Analysis and Review (MEDPAR) DRG price amount ("the amount that would have been paid if no deductible, coinsurance, primary payers or outliers were involved") and any outlier payments ("the amount of additional payment approved due to an outlier situation over the DRG allowance for the stay"). We did not include any additional payments (medical education, organ acquisition, technology, disproportionate share hospitals, critical access hospitals, and sole community hospitals). For each hospital stay, this DRG-specific per diem rate was multiplied by the actual length of stay for each patient's hospitalization to calculate the HMO facility component for inpatient costs.

To calculate the professional services component for inpatient stays, we used the Medicare claims data. Professional bills associated with an inpatient stay were identified based on the overlap between dates of service on hospital (including admission and discharge dates) and physician claims. We then created a professional fee coefficient based on the ratio of total professional costs to total facility costs per DRG. To obtain total inpatient costs (facility and professional), the HMO facility component was multiplied by one plus the professional fee proportion. This approach maintained the resource intensity differences with longer lengths of stay for professional services and also addressed, if present, missing data on professional services in HMOs with internally owned hospitals (19).

In October 2007, Medicare released a new version of the DRGs with major revisions. As there is not a direct correspondence between the two versions, we created two sets of DRG daily facility coefficients and professional fee ratios, one using data from January 2000 to September 2007, and the other using data from October 2007 through December 2007. Ideally we should have a longer time window to calculate the second set of coefficients, but 2007 was the latest year available when we obtained the data.

In calculating both the daily DRG facility rate and the professional service ratio, we examined the data for extreme outliers that could disproportionately affect the cost coefficients. Except for true data errors, outliers can represent actual resource use; hence, an outlier had to be extreme to the point of implausibility and to have a significant influence on the coefficient values before we considered truncation. Surprisingly, even with our high volume of utilization data, we did not need to truncate. Those few records that were identified as erroneous were not used in calculating the ratio.

To the extent possible, we followed Medicare rules for inpatient reimbursement. Emergency room admissions that resulted in hospital admissions were rolled into the ensuing hospital stay. Our day-based inpatient costing algorithm automatically adjusts for interhospital transfers, both in and out of HMO hospitals. We followed the same methodology in costing HMO and Medicare data.

Inpatient Rehabilitation Facilities and Long-Term Care Hospitals

Combined care in inpatient rehabilitation facilities and long-term care hospitals accounts for less than 2% of Medicare expenditures. No such facilities or hospitals were owned by or served as contract service providers for any of the study HMOs. To be eligible for Medicare coverage in an inpatient rehabilitation facility, a patient must be able to participate in and benefit (achieve measurable improvements in functional health status) from 3 or more hours of

therapy per day. This is a relatively restrictive criterion for coverage, so few individuals receive this benefit. Prior to 2002, Medicare reimbursed these facilities based on average incurred cost. After 2002, 385 rehabilitation-based case-mix groups (CMGs) were derived, and predetermined payment rates for each grouping were created (20). Unfortunately, CMGs cannot be calculated from variables contained in the VDW. Therefore, we computed an average daily rate for rehabilitation services from Medicare claims data and multiplied it by lengths of stay at inpatient rehabilitation facilities to compute relative costliness estimates for each inpatient rehabilitation facility patient.

Long-term care hospital stays are assigned a DRG value, but under the Medicare payment system, these DRGs have a different weight than the DRGs from acute care hospitals. Because utilization in such hospitals was relatively rare and difficult to identify in the HMO data, we did not develop a separate algorithm. Costs were assigned using the acute inpatient algorithm.

Psychiatric Hospitals

No psychiatric hospitals were owned by or served as primary contract service providers for any of the study HMOs. Because of this and the low incidence of admission to these facilities, it is difficult to identify and categorize this type of utilization in our HMO data systems. Utilization of this type in the HMO data is most likely classified as either institutional stay or rehabilitation and was assigned the average daily rate for rehabilitation stays.

Ambulatory Care

Physician Services (Including Imaging). For reimbursement under Medicare, physicians' services are classified by HCPCS codes and are paid via the MFS. The MFS summarizes three underlying components into relative resource weights—physician work (time and skill), practice expenses, and professional liability. These three relative weights are added together to obtain an overall RVU. Because medical care is provided across the country in vastly different markets, to calculate the payment for a service, the RVU is multiplied by a dollar conversion factor, and to account for differences in input costs (prices) across geographic regions, one of three geographic indexes is used to adjust the RVU.

Medicare uses two separate fee schedules to pay for physician services depending on the care delivery setting. For physician services provided in a facility setting, such as a hospital, a schedule with lower rates is used. Hospitals receive additional facility payments, so the costs to physicians to practice in this setting are less. If care is provided in noninstitutional settings, such as an ambulatory care clinic or physician's office, then the fee schedule with higher payment rates is used, as this payment covers all practice expenses. Payments to providers can also be adjusted if the care is not provided by a physician, if payment modifiers are present, if the area is identified as a health professional shortage area, or if the provider is not participating in Medicare's physician and supplier program (20).

HMOs are reimbursed on a capitated basis; as a consequence, they do not face the same financial incentive to record procedures performed (HCPCS) as their FFS counterparts (19,21). However, coding practices are improving as a result of increased CMS enforcement of regulations directed at Medicare Advantage plans for accurate coding of diagnoses and procedures. This applies to the data HMOs are required to provide CMS for making risk adjustments to capitation payments. Other incentives for improved data capture include the increased use of computerized physician order entry systems, which require detailed coding, and, in some HMOs, internal incentive payments for physicians. The implications of this for HMOs are an increase, over time, in the number of HCPCS codes recorded per encounter and a reduction, over time, of outpatient encounters with no codes.

Along with the increase in coding, we have seen an increased use of homegrown procedure codes, which are problematic in multisite studies or studies using standardized codes for costing. Often the use of homegrown codes results from a desire to capture a finer level of detail than the corresponding standard code. In these cases, HMOs usually have a crosswalk available to convert codes back to standard HCPCS. If a significant volume of homegrown codes are encountered, they cannot be ignored and need to be either translated back to the most similar standardized code, or assigned costs using a different method.

We assessed our capture of HCPCS codes, and for the majority of outpatient encounters, relied on the fee schedule to estimate costs. For encounters with missing, incomplete, or homegrown procedure codes with no crosswalk, we assigned the evaluation and management code that was used most frequently in that care setting.

Hospital Outpatient Services. Services provided in the hospital outpatient setting are captured using HCPCS codes. Codes representing similar resource use and clinical characteristics are grouped together into 570 ambulatory patient care groups. Medicare reimburses a set amount for each group, which covers the facility portion of the costs (hospital operating and capital costs). The professional component is paid separately under the MFS (20).

HMOs may not always capture both the professional and facility codes associated with hospital outpatient care, particularly if services are provided within HMO-owned and operated facilities by salaried providers. HMO encounter systems identify if a service was provided, typically through a facility code, and often use revenue codes and *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM) procedure codes instead of *Current Procedural Terminology*, 4th Edition (CPT-4) codes, which are required in the ambulatory patient care grouper. Therefore, to capture the facility portion, we computed facility to professional fee ratios for hospital outpatient encounters in the SEER–Medicare data and applied these ratios to professional costs based on HCPCS codes for each hospital outpatient encounter.

Ambulatory Surgical Centers. Since 1982, Medicare has covered surgical procedures provided in freestanding or hospital-based ambulatory surgical centers that are designated facilities (22). These surgical facilities are reimbursed for a limited subset of procedures (approximately 2300). Payments to them are based on fee schedules and have both professional and facility components. The professional component is reimbursed according to the physician fee schedule. To calculate the facility portion, procedure codes are grouped and reimbursed at preestablished amounts. Prior to 2008, there were nine surgical facility payment groups; after 2008, the groups were expanded to several hundred and were phased in over a 4-year period. If multiple procedures are performed during

the same encounter, the facility is reimbursed fully for the most expensive procedure and receives 50% of the standard payment for remaining procedures (20).

The procedures performed in surgical facilities can be done in other settings, so not every delivery system has such designated facilities. Therefore, the first step in the costing process is to identify whether there is such a facility in the health-care delivery system. The next step is to assign the procedure codes into payment groups. Given that 8 out of 9 years of our study period occurred prior to 2008, we employed the original nine-group payment system in the SRRCA. Otherwise, we followed Medicare's methodology to derive cost weights for utilization.

Laboratory Services

Medicare reimburses laboratory procedures provided in an outpatient setting based on a HCPCS fee schedule. Laboratory services provided during an inpatient stay are bundled into the DRG payment and not paid using this schedule. In addition, some laboratory services provided as a fixed complement to dialysis treatment are also bundled into monthly dialysis payments.

For laboratory services, the first step in the SRRCA was to convert any local laboratory codes to standard HCPCS codes. The next step was to identify any dialysis laboratory codes that needed to be removed because they were already implicitly included in dialysis payments. Once these steps were completed, we followed the Medicare reimbursement model. For codes that could not be converted, we assigned an overall average payment for a laboratory test.

Post-Acute Care

Skilled Nursing Facilities. To be eligible for skilled nursing facility (SNF) care, Medicare requires at least a 3-day hospital stay prior to admission to an SNF. Medicare reimburses SNFs based on a prospective payment system that uses a set daily rate based on an individual's resource utilization group (RUG). There are 44 RUGs, each of which groups patients who are relatively similar with respect to the intensity of their needs for nursing and rehabilitation care (physical therapy, speech therapy, occupational therapy, etc.) and assistance with "activities of daily living." The daily rate contains a fixed amount for routine care and then a variable amount per RUG for nursing and therapy services (20).

Unfortunately, unlike the DRGs used for inpatient reimbursement, the grouping variables for the RUG system were not commonly available in HMO data systems and they were not included in Medicare claims data. Therefore, the SRRCA could not replicate the Medicare RUG method directly. Using Medicare claims data, we calculated an overall flat daily SNF rate and then multiplied by length of stay to obtain SNF costs for each stay. This method relies on varying lengths of stay to capture differences in resource intensity. Ideally, an additional severity measure to differentiate patients with varying clinical needs would be included in a costing algorithm. However, SNF service use is not a major overall contributor to total health-care costs in the BURDEN study population; therefore, we did not develop a severity measure that could be applied to both Medicare FFS and HMO data consistently.

Home Health Services. For individuals who are homebound due to a medical condition and require skilled nursing care, Medicare provides temporary skilled nursing, therapy, social work, and home health aide services. In 2000, Medicare adopted a prospective payment system for each 60-day episode of home health care. For patients who receive fewer than five visits, Medicare reimburses by visit type. All other patients are classified based on their underlying health condition, level of functioning, and use of services into one of 80 home health resource groups and are reimbursed at a predetermined rate for the episode of care (20). For extremely complicated patients, marginal outlier payments are calculated.

As was the case for the SNF algorithm, lack of adequate data prevented us from adapting the Medicare home health services payment algorithm to HMOs. Classification variables for the home health resource groups are not available in HMO clinical data systems. As a replacement, using Medicare claims data we created average payments per home health service visit by clinical discipline (nursing, physical therapy, occupational therapy, speech therapy, social work, aide services, etc.) and applied them to their respective HMO utilization elements. Although this method does not capture varying patient care intensity within a visit, it will capture the differences in numbers and types of visits received among patients.

Services for Special Populations

Outpatient Dialysis. Medicare covers both hemodialysis and peritoneal dialysis and does not differentiate between the two for reimbursement purposes. Dialysis is covered using a predetermined "composite" rate that bundles reimbursement for the services, supplies, and equipment used for dialysis treatment into one payment. The composite rate is adjusted by age categories and two body measurement variables—body mass index and body surface area. Providers bill separately for physician services and certain medications and laboratory tests that are not included in the composite rate (23).

The SRRCA uses the base composite rate of $132.68 for dialysis costs for freestanding dialysis facilities in 2008. We do not adjust for patient characteristics as body measurement variables were not consistently available from HMO data systems. Provider and laboratory utilization not covered under the composite rate was weighted using the appropriate algorithm.

Hospice Services. Under Medicare, hospice services are authorized for people with a life expectancy of less than 6 months, and enrollment disallows payment for any curative treatment for the underlying terminal condition. Hospice covers a wide variety of services, including physician services and skilled nursing care; physical, occupational, and speech therapy; social work; certain drugs; and home health aide services. Medicare reimburses hospice care based on a fee schedule, which contains a predetermined daily rate for the following four categories: routine home care, continuous home care, inpatient respite care, and general inpatient care. Routine home care accounts for 95% of hospice care days and is the default payment category used by Medicare unless it is demonstrated that services from one of the other categories were provided (24). As long as the patient is enrolled in hospice, Medicare pays the daily rate regardless of the amount of services delivered (20).

Currently the SRRCA uses the 2008 routine home care daily rate of $135.11 as the basis for hospice costs. The vast majority

of hospice care (if not all) provided by the study HMOs falls into this category. In addition, the data required to classify patient days into the payment groups are not available on HMO automated data systems. HMOs vary in how they provide hospice services—some have internal hospice departments and others contract out these services. For HMOs with internal hospice departments, patients enrolled in hospice are given the opportunity to choose an external hospice provider. For some HMOs, data on the patients' duration and use of external hospice services are not available. In these cases, length of hospice enrollment was estimated using death date as a proxy for hospice end date.

Other Services

Ambulance. Prior to 2002, ambulance services were reimbursed by Medicare based on incurred cost. Since 2002, 14 HCPCS codes have been used to establish a base payment, which distinguishes level of service, supplies, and mileage (20). Separate payments are made for mileage for surface and air transport. Ambulance utilization is an incredibly small portion (less than 1%) of Medicare's outlay for medical services. Because of the fact that it is not an important cost driver for our study population, and our inability to obtain mileage estimates, we did not cost this service.

Durable Medical Equipment. Medicare covers certain types of durable equipment needed for medical treatment. Disposable items are not covered under this benefit. Equipment is divided into one of six groups, and is then further classified into about 2000 product groups. Using a fee schedule based on HCPCS codes, Medicare reimburses a fixed amount for each product group (25). As with any of the payment systems relying on HCPCS, homegrown codes must be converted to legal HCPCS codes to be counted. Care should also be taken to ensure durable medical equipment (DME) was captured in the utilization data. For at least one of the study sites, DME utilization was recorded in a database that was not commonly used in the automated clinical data. Once DME codes were located and converted to standard HCPCS, the SRRCA followed the Medicare method closely.

Pharmacy. Relative costs for outpatient prescription drugs are based on the published average wholesale price for a 30-day supply using the National Drug Code classification schema. A few prescription drugs from HMO databases may not have valid codes because of repackaging or other HMO-specific formulations, or drug-specific identifiers may be missing entirely. In the event that drug-specific information is not available, the costing model draws on therapeutic class information and assigns the average cost for all drugs within that class.

A summary of the Medicare payment systems and our HMO modifications is presented in Table 1.

Results

In this section, we provide examples to illustrate how the SRRCA assigns costs to utilization when following Medicare costing and when using novel, standardized approaches, and we briefly summarize the products we have developed.

Comparing Costs: Inpatient Care

At 34%, inpatient care (acute care hospitals) represents the largest component of Medicare spending and is an important driver of overall expenditures (20). Using actual records from the Medicare claims data for three of the most frequent DRGs, Table 2 illustrates how the Medicare payment compares with the results generated from the SRRCA. As was expected, for shorter hospital stays, the SRRCA generates a smaller estimate than the Medicare payment. Average stays generate very similar estimates, and for longer stays, the SRRCA estimate is greater than Medicare's. In each of the examples, we see that the Medicare payment method generates a tighter distribution between stays with a low and high length of stay. For example, in comparing the difference between the low and high payment value for congestive heart failure (DRG 88), when the length of stay is 9 days different, the Medicare payment difference is $6636, whereas the difference from the HMO estimate is $9763.55.

Comparing Costs: Physician Services

The next largest component, at 20% of Medicare spending, is physician services. Table 3 shows cardiology office visits from both HMO and SEER–Medicare data, costed using the SRRCA. As expected, the office visits that coded the same HCPCS procedure receive the same cost, independent of delivery system. Table 4 provides examples of relatively low- and high-cost oncology outpatient visits from both HMO and SEER–Medicare data based on the SRRCA.

Summary of Products Developed

In developing our SRRCA and preparing to answer the questions raised in the BURDEN study, we have created two products. The first is the SRRCA, a comprehensive set of costing algorithms that can be applied to both HMO and FFS data when standardized facility, procedure, service, and product codes are available. SRRCA facilitates the comparison of relative resource intensity within and across delivery systems. The second product is the infrastructure to convert SEER–Medicare claims data into encounter-based data so that they are more directly comparable to HMO data. This second product is important because it can be adapted to convert data from other large, claims-based systems, making even more comparisons possible.

Discussion

Key Considerations

Transforming Medicare claims data to an encounter format is an endeavor. Large numbers of files and variables and a steep learning curve are associated with using these data. Converting claims data to an encounter format requires significant programming and logic infrastructure. For example, in encounter-based systems, all information pertaining to a hospital stay is found in one file. In Medicare data, one must gather information from a facility-based file (MEDPAR) with physician or supplier bills (national claim history and possibly hospital outpatient statistical analysis file) in order to join all the data about an inpatient stay. To further complicate joining these data, there is no variable that directly links data from multiple files together. Therefore, programming rules

Table 1. Summary of Medicare's payment systems and adaptations for use on health maintenance organization (HMO) utilization data (21)*

Care setting	% of Medicare spending†	Medicare method‡	Adaptation for HMOs
Acute care hospitals	34%	• Facility: DRG • Professional: reimbursed independently via HCPCS codes	• Facility: converts Medicare DRG to daily rate multiplied by LOS • Professional: uses Medicare claims data to calculate professional to facility cost ratio per DRG, then multiply facility component
Psychiatric facilities	1%	Prior to 2003, payments based on average incurred operating costs; post-2003 per diem PPS	N/A
Physician services	20%	Fee schedule based on HCPCS codes approximately 7000	Fee schedule based on HCPCS codes when available, otherwise average cost per department
Hospital outpatient	7%	• Facility: fee schedule based on APC approximately 570 groups • Professional: reimbursed under physician system	• Facilty: fee schedule based on APC when available; otherwise, average cost • Professional: uses Medicare claims data to calculate professional to facility cost ratio
Ambulatory surgical centers	1%	• Facility: fee schedule based on procedures classified into nine payment groups; payment groups expanded in 2008 • Professional: physician fee schedule	• Facility: fee schedule based on pre-2008 payment groups when available; otherwise, average cost • Professional: physician fee schedule
Laboratory services	2%	Fee schedule based on HCPCS codes	Fee schedule based on HCPCS codes
Skilled nursing facilities	6.5%	Daily payment rate based on RUG-III group	Average daily rate based on Medicare claims data multiplied by LOS
Home health services	6%	If less than five visits in 60-day period, paid per visit type; otherwise, uses an episode payment method based on 80 HHRGs	Average rate per visit based on Medicare claims data
Inpatient rehabilitation facilities	1%	Prior to 2002, paid on average incurred cost per discharge; post-2002, paid on predetermined rates for 385 CMGs	Average daily rate based on Medicare data
Long-term care hospitals	Lt 1%	Prior to 2002, paid under TEFRA; post-2002, paid by LTC–DRGs	Uses acute inpatient algorithm
Outpatient dialysis	2%	Paid a composite rate per dialysis treatment	Composite rate per dialysis treatment
Hospice services	1%	Per diem rate for each eligible day	Per diem rate
Ambulance		Prior to April 2002, reported costs; April 2002–March 2007, blended method of fee schedule based on HCPCS and reported costs; since April 2007, use only fee schedule	N/A
Durable medical equipment	3%	Fee schedule based on product groups	Fee schedule based on product groups

* APC = ambulatory payment classifications; CMG = case-mix group for intensive rehabilitation products; DRG = diagnosis-related group; HCPCS = Healthcare Common Procedure Coding System; HHRG = home health resource group; LOS = length of stay; LTC = long-term care; N/A = not applicable; PPS = prospective payment system; RUG-III = resource utilization group; TEFRA = Tax Equity and Fiscal Responsibility Act.

† Based on 2003 data, does not sum to 100% because payments to Medicare Advantage programs are excluded.

‡ For complete description, see http://www.medpac.gov/publications%5Ccongressional_reports%5CMar03_AppA.pdf.

and logic must be developed and extensively tested to ensure the correct data are being linked. Another challenge in working with Medicare claims data is the lack of consistency in information or certain variables available across the different types of files. Another requirement is adequate computing capacity to process the extremely large Medicare data files. The BURDEN study obtained utilization data from 1999 to 2007, which involved loading over 1100 text files, containing over 100 million encounters.

The issues involved in measuring the production costs of healthcare services have been well documented (26–28). Cross-national,

Table 2. Comparison of Medicare reimbursement to standardized relative resource cost algorithm (SRRCA) for selected inpatient encounters*

DRG†	LOS, d	SRRCA base facility payment, USD‡	SRRCA professional ratio§	SRRCA total payment, USD‖	Medicare payment, USD¶	Difference#
088	1	$1180.20	0.182	$1394.79	$3362.92	−$1969
088	3	$1180.20	0.182	$4184.38	$4124.49	$60
088	10	$1180.20	0.182	$11 158.34	$9999.17	$1159
127	2	$1344.82	0.194	$3211.42	$6010.64	−$2799.22
127	5	$1344.82	0.194	$8028.55	$8043.01	−$14
127	8	$1344.82	0.194	$12 845.67	$9933.48	$2912.19
209	3	$2665.88	0.207	$9653.16	$13 913.90	−$4261
209	5	$2665.88	0.207	$16 088.59	$16 073.30	$15
209	7	$2665.88	0.207	$22 524.03	$21 540.72	$983

* DRG = diagnosis-related group; HMO = health maintenance organization; LOS = length of stay; MEDPAR = Medicare Provider Analysis and Review; NCH = national claim history; OUTSAF = outpatient statistical analysis file.

† 088 = chronic obstructive pulmonary disease; 127 = heart failure and shock; 209 = major joint and limb reattachment procedures of lower extremity.

‡ (MEDPAR DRG price + Outlier amount)/Total days for DRG.

§ (Allowed noninstitutional professional charges for associated NCH bills + Allowed institutional outpatient charges for associated OUTSAF bills)/(MEDPAR DRG price + Outlier amount).

‖ HMO total payment = HMO facility payment × (1 + HMO professional ratio) × LOS.

¶ Medicare payment = MEDPAR DRG price + Outlier amount + Allowed noninstitutional professional charges for associated NCH bills + Allowed institutional outpatient charges for associated OUTSAF bills.

(SRRCA total payment) – (Medicare payment).

Table 3. Examples of cardiology office visits from health maintenance organization (HMO) and Medicare costed with the standardized relative resource cost algorithm (SRRCA) physician services algorithm*

Data system	ID	HCPCS procedure code	Procedure count	Procedure cost, USD†	Encounter cost
HMO	H1	93325	1	$36.00	$305.83
HMO	H1	93320	1	$83.00	
HMO	H1	93307	1	$186.83	
HMO	H3	J0152	3	$208.05	$252.01
HMO	H3	93018	1	$17.43	
HMO	H3	93016	1	$26.53	
Medicare	S2	80053	1	$14.78	$152.34
Medicare	S2	36415	1	$4.17	
Medicare	S2	99214	1	$72.76	
Medicare	S2	93000	1	$20.46	
Medicare	S2	85025	1	$10.99	
Medicare	S2	80061	1	$29.18	
Medicare	S3	93325	1	$36.00	$305.83
Medicare	S3	93320	1	$83.00	
Medicare	S3	93307	1	$186.83	

* HCPCS = Healthcare Common Procedure Coding.

† Cost per procedure × Procedure count.

multisystem, and multisite economic research can be challenging because of differences in financial incentives and care delivery patterns between national and private health systems, and between HMOs and FFS providers, as well as varying ability to capture key utilization and costing data elements within and across health-care systems and organizations (19,21,29).

An inherent complication of measuring the output of a personal service, such as health care, is that the individual is also an intrinsic input to the production process—that is, no service is produced if the customer does not participate in receiving the service. This unique aspect of personal services presents barriers to output measurement because every individual has unique genomic and behavioral profiles. The practical implication is that we have resorted to measuring services by their inputs, such as medication prescriptions or doctor office visits.

Relative resource intensity schemes allow different utilization types (inpatient, home health, pharmacy, outpatient visits) to be combined into one common metric and provide a measure of overall health-care resource intensity. However, prior to examining these data, care must be taken to be sure the underlying utilization events from each utilization category—such as hospital stays and days, or outpatient visits—are accurately captured, thoroughly examined, and understood. Once service units are converted into monetary values and aggregated, it is difficult to identify inaccurate data points. In

Table 4. Examples of oncology-related visits from health maintenance organization (HMO) and Medicare costed with the standardized relative resource cost algorithm (SRRCA) physician services algorithm*

Data system	ID	HCPCS procedure code	Procedure count	Procedure cost†	Encounter cost
HMO	H4	77295	1	$940.75	$1630.49
HMO		77300	2	$158.44	
HMO		77334	3	$531.30	
HMO	H5	36415	1	$4.95	$282.99
HMO		38221	1	$78.08	
HMO		99245	1	$199.96	
Medicare	S6	76370	1	$163.39	$964.73
Medicare		77290	1	$465.04	
Medicare		77334	1	$177.10	
Medicare		99244	1	$159.20	
Medicare	S7	36415	1	$4.95	$112.74
Medicare		84153	1	$25.52	
Medicare		84403	1	$36.18	
Medicare		99213	1	$46.09	

* HCPCS = Healthcare Common Procedure Coding.

† Cost per procedure × Procedure count.

addition, one must understand the underlying utilization events that are driving costs to derive effective policy implications from cost data.

We have demonstrated that the SRRCA can be used in multiple HMOs and across alternate reimbursement and delivery systems within the US health-care system. The next logical step would be to evaluate how the SRRCA can be used to compare US health-care costs with those of other countries. The Center for Medicare and Medicaid Innovation "encourages widespread adoption of practices that deliver better health care at lower cost (30)." The United States and other countries could benefit tremendously from the ability to evaluate each others' models of care. Using the SRRCA for international comparisons depends on data harmonization issues. Specifically, are physical utilization elements defined consistently so that one can make meaningful comparisons, and are the resource intensity classes reasonably matched to approximately the same utilization events across countries? Currently the answer is no. In an international overview of case-mix classification systems in 25 countries, French and colleagues found that DRG and procedure coding varies by country (31). With respect to utilization, wide variations are observed internationally in average hospital lengths of stay (32), which implies either fundamental differences in the health status of different populations, differences in norms about appropriate lengths of stay, differences in the product of a hospital day, or all of the above.

Anderson and colleagues discuss the potential distortions that can arise in international comparisons of health-care systems when expenditures are compared with the actual resources used for health production (32). They discuss how evaluations change when comparing the use of inputs, suggesting that what is primarily driving differences are large differences in input prices. A standardized costing methodology would help eliminate these distortions. However, care must be taken to ensure that comparable health service products are being evaluated and that the overall context of care is understood. In the case of hospital care, for example, analysis of occupancy rates, hospital admission rates per 1000 population, average lengths of stay, hospital days per 1000 population, and hospital staffing per bed can generate useful insights regarding the magnitude of both crossnational and intracountry variations in resource intensity; for example, which countries achieve shorter stays by intensifying services per day (including using more highly trained staff), and which countries accept longer lengths of stay for lower service intensity per day.

Strengths and Weaknesses

Collaborating to achieve standardized crossnational data and data sharing can be a valuable cancer research and health policy tactic. An important strength of our SRRCA is its ability to make relative cost comparisons within and across systems. Although the application described here is for use within the United States, the fact that the SRRCA is based on comprehensive service-specific utilization profiles means that its application in a crossnational context could facilitate understanding of similarities and differences across health-care systems in terms of patterns of care for diseases and other health problems.

One weakness we acknowledge is an inability to generate absolute cost estimates, especially for subsets of the population. The lack of a severity adjustor in the SNF algorithm is an example of one of the underlying causes of this issue. It also should be noted that by adopting the perspective of the health-care system we are not capturing the full opportunity costs of resources used in receiving health care—for example, patient travel time and transportation costs. Our algorithm also will not detect changes or differences in resource intensity within a specified procedure, inpatient day, or product over time or place. For example, if we are comparing hospitals with predominantly master's degree–prepared nurses to hospitals with predominantly associate's and bachelor's degree–trained nurses, the content of inpatient days will not be homogeneous across these settings.

An additional limitation of our SRRCA is the complexity of the underlying data structure required. This is a direct reflection of the fragmentation of the health-care system in the United States. Current efforts by the federal government to encourage adoption of electronic medical record systems, together with meaningful use requirements that include the ability to transmit harmonized data through secure web portals, augur significant improvements in availability of detailed clinical and utilization data for measuring quality of care and performance of health-care systems. The

challenge to researchers is to keep abreast of this informatics revolution and gain the content knowledge and informatics skills required to extract and analyze these rich datasets. The health-care industry, like the banking industry, will not revert to paper charts and bills once it has adopted electronic information and billing systems.

Although we expect the basic paradigm of the SRRCA to remain unchanged, we are still completing some ongoing work, which may involve some adjustments. For example, we will examine if we are accurately capturing resource intensity for inpatient stays that have a truncated length of stay due to death, especially if it occurs close to admission. We are also examining procedure capture across time in the HMO data to ensure poor coding capture is not artificially lowering costs.

Future enhancements to the SRRCA include improving the algorithms for psychiatric facilities and long-term care hospitals, adding an intensity measure to the SNF algorithm, and further evaluating and updating how to infer resource coefficients for missing data.

Conclusions

We have developed a standardized, comprehensive algorithm to support economic analyses comparing resource intensity within and across different health systems. An understanding of utilization and resource use is essential to policy and research strategies to determine what does and does not work as expected and where potential savings in health-care expenditures may be realized. We must be able to understand these costs regardless of the care setting: in national health systems, community health systems, HMOs, cancer control programs, oncology practices, and alternative cancer treatment settings. Differences in health-care financing and delivery systems and in patterns of cancer treatment can be scrutinized to highlight factors that appear to be related to higher versus lower rates of utilization, expenditures, and outcomes (33). A cross-national perspective can be especially valuable because structural and behavioral factors thought to be immutable by internal clinical and policy leaders may be revealed to be changeable across nations and cultures and, even more importantly, to be binding constraints on reducing health-care outlays in specific types of systems or cultures.

In closing, a quote from Voltaire seems appropriate: "Don't let the perfect be the enemy of the good." This is not to imply we should stop trying to improve our data or methods, but rather to acknowledge that although they are imperfect we must still push forward and use what we have to understand and improve the performance of health-care delivery systems.

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