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A COMPARISON OF THREE APPROACHES FOR ATTRIBUTING HOSPITALIZATIONS TO SPECIFIC DISEASES IN COST ANALYSES

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Abstract

Objectives: Calculations of healthcare costs rarely disclose the specific approach used to allocate the cost of hospitalizations by diagnosis. However, the type of approach used can have a major impact on the findings in the case of significant comorbidities. The present analyses compared three approaches for attributing Medicare DRG reimbursements (which were used as surrogates for average costs) for hospitalization by diagnosis.
Methods: Medical resource utilization data from the National Hospital Discharge Survey were analyzed using each of three allocation approaches: a) attributing 100% of the cost of hospitalization to the disease when it was the first-listed diagnosis; b) attributing a portion of the cost of hospitalization to the disease, depending on its position in the list of diagnoses and the relevance of any comorbidities; and c) an incremental analysis of cost based upon the hospitalization experiences of an age and gender matched cohort. These three approaches were applied to the cost of hospitalization for chronic obstructive pulmonary disease (COPD).
Results: The first approach projected 206,098 hospitalizations at $3,449 per hospitalization for a projected U.S. annual total of $711 million. The second approach projected 681,547 hospitalizations at $3,205 per hospitalization for a projected U.S. annual total of $2.2 billion. The third approach also projected 681,547 hospitalizations, but at $2,361 per hospitalization, for a projected U.S. annual total of $1.6 billion.
Conclusions: Expanding from the example on COPD, the limitations of each approach are described and their applications to other conditions are presented.

Keywords: Cost of Illness, DRG, Diagnosis, Hospitalization, Chronic obstructive pulmonary disease

Determination of the cost of medical resource utilization is critical for cost-of-illness analyses and cost-effectiveness calculations. Methodological guidelines for

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cost-of-illness analyses were developed two decades ago by a task force chaired by Dorothy P. Rice, then Director of the National Center for Health Statistics (9). These methodological guidelines have been extremely beneficial in uniting the field so that analyses use a common set of definitions and general approaches. Unfortunately, little else has been written to guide the practitioner in many of the specific methodological details inherent in conducting such research.

The general approaches most typically used in cost-of-illness calculations are secondary analysis of claims or utilization databases (12) or determining annual utilization in a group of individuals known to have the disease of interest (7). At the basis of all determinations of the cost of illness is the clear identification of a specific disease state and attributation of medical resource utilization to that disease. Doing so involves identifying the disease state in databases, usually by using *The International Classification of Disease, 9th Revision* (ICD-9) codes. This approach is straightforward when a single diagnosis is listed, as is often the case for outpatient and emergency department visits. However, uncertainty arises when multiple diagnoses are listed, as frequently occurs in hospitalization records and claims databases.

The critical question in these cases is how much of the cost of the medical resource utilization to attribute to a specific ICD-9 code when other diseases may have played a role in the utilization. For example, certainly the cost of a hospitalization for hip replacement should be attributed to osteoarthritis if the respective ICD-9 code appears in the first position of a list of diagnoses. Furthermore, any comorbidities listed as other diagnoses can probably be ignored when allocating cost for this type of surgical hospitalization. However, what about the cost of a medical hospitalization for stroke when hypertension, diabetes, and coronary heart disease are listed as diagnoses? How much of the cost of the hospitalization should be attributed to the first-listed diagnosis? Should any of the cost be allocated to the other listed diagnoses?

This issue arises whenever the cost of medical resource utilization must be allocated to a disease state, whether conducting chart reviews or secondary data analyses. There is no "gold standard" in terms of methodology. We found references to this problem going back many years (3), but could find no literature supporting the use of any specific approach. Furthermore, few cost-of-illness papers provide sufficient detail to inform the reader what methods were employed to identify utilization. Thus, we undertook to examine the effect of various approaches to allocating cost when multiple diagnoses are listed for hospitalizations.

For this example, we identified the cost of hospitalization for chronic obstructive pulmonary disease (COPD). COPD is a chronic disease affecting approximately 15 million individuals in the United States (8). Prevalence increases with age, rising in men from 7.5% at age 45–54 to 20% at age 75 and over (5). Hospitalizations for COPD are rarely surgical and, because comorbid conditions frequently occur in older individuals with COPD, multiple diagnoses predominate in hospitalization databases.

We examined hospitalizations for COPD in the 1990 National Hospital Discharge Survey (NHDS) (13;14). The NHDS is conducted by the National Center for Health Statistics, which takes considerable care to develop samples representative of the U.S. population. Each record is assigned a sampling weight that can be used to project the entire survey or portions of the survey to representative components of the U.S. population. This survey includes the diagnosis-related group (DRG) number assigned to the hospitalization and the discharge diagnoses (up to 7 positions). The costs for these hospitalizations are not available in the NHDS database.

Consequently, we used Medicare DRG reimbursements as a surrogate for costs, and all references to costs found subsequently in this paper should be interpreted as references to DRG reimbursements. For the present analyses, three approaches were compared for estimating the cost of hospitalizations for COPD.

1. *Approach A: First-listed diagnosis*—The simplest alternative is to identify only records where COPD was listed in the first diagnosis position. This straightforward approach leads to conservative cost estimates because it does not take into consideration the effect of comorbidities, which occur frequently in the COPD population.
2. *Approach B: Weighted attribution*—The second approach involves defining explicit decision rules that, when applied to a hospitalization, identify the proportion of the cost that should be attributed to COPD. We created decision rules based on the DRG, the position of the COPD diagnosis, the presence of other COPD-related and/or non-related diagnoses, and (for one class of DRGs), the length of stay.
3. *Approach C: Incremental*—The third approach involves computing the incremental cost of COPD. This approach first calculates the total costs of hospitalizations for individuals who have COPD (regardless of the position of COPD in the list of diagnoses). The approach subsequently calculates the total cost of hospitalization for an age-matched and gender-matched cohort without COPD. The incremental cost is then calculated as the difference between these two costs.

This paper presents the methodology used when calculating the cost of hospitalizations for COPD using each of these approaches, compares and contrasts the results, and offers recommendations for appropriate use of each of the three approaches.

METHODOLOGY

COPD is defined by the American Thoracic Society (1) as a disease state characterized by the presence of airflow obstruction due to chronic bronchitis or emphysema. For the present example, all cases of COPD in the 1990 NHDS were identified by extracting all discharges where one of the following ICD-9 codes was listed in any of the seven available diagnoses positions: ICD-9 code 491 (COPD and bronchitis [emphysema and bronchitis]); ICD-9 code 492 (emphysema); and ICD-9 code 496 (unspecified obstructive pulmonary disease).

The extraction of cases was restricted to those in the survey sample 45 years and older. This decision was based on preliminary analysis of the 1990 NHDS, which indicated that if the ICD-9 codes specified above were used, fewer than 3% of the hospital discharges for persons with any diagnosis of COPD were younger than age 45 years. Analyses were broken down into six age–sex strata: female/male aged 45–64, female/male aged 65–74, and female/male aged 75 and over, because these yielded a manageable number of cells with roughly equal numbers of hospitalizations for primary COPD in each cell.

Quantification of hospital costs in the NHDS requires further specification (and application) of cost structures to the underlying patterns of utilization described by the survey. For this example, hospitalizations were valued by applying the national average Medicare reimbursement (21) for each DRG. This system of estimating costs for medical resource utilization is valuable because these reimbursement rates are widely known, applicable nationally, conceptually straightforward,

and incorporate service intensity. In addition, DRG reimbursement rates are estimated to be reasonably close to actual cost and avoid the nonuniform inflation inherent in hospital charges.

Approach A: First-listed Diagnoses

Rules of sequencing multiple diagnoses codes dictate that the diagnosis that is primarily responsible for the patient's admission to the hospital be listed in the first diagnosis position in the discharge record and in claims databases (11). Under Approach A, the cost of hospitalizations was attributed to COPD only where one of the ICD-9 codes that we equated with COPD (i.e., 491, 492, 496) was listed in the first diagnosis position. In these cases, 100% of the cost of the hospitalization was attributed to COPD.

Approach B: Weighted Attribution

Under Approach B, the cost of hospitalizations attributable to COPD was computed using a set of defined decision rules that allocated a proportion of the costs for each hospitalization to COPD. The specific decision rule applied depended on whether the hospitalization was classified on the basis of its DRG code as having occurred: a) for the medical management of COPD; b) for a reason that commonly occurred for people with COPD and uncommonly for people without COPD (a list of these "DRGs associated with COPD" can be found in the legend to Table 1); or c) for other DRGs unassociated with COPD.

Once the proper classification was established for the hospitalization based on its DRG code, the decision rule depended on whether COPD was the first-listed, second-listed, or third-listed diagnosis code, and whether a "related disorder" was a primary or secondary diagnosis code. "Related disorders" were defined as disorders that are common consequences of COPD or part of a closely related syndrome (a list of diagnosis codes for related disorders can be found in the legend to Table 1).

The specific decision rules applied are found in Table 1 and are summarized below.

1. COPD (DRG 88): For medical management of COPD (DRG 88), 100% of the cost of these hospitalizations was attributed to COPD (incidently, for DRG 88, COPD was always the first-listed diagnosis).
2. DRGs associated with COPD: Five different decision rules were applied to allocate the cost of these DRGs. If COPD was a) the only listed diagnosis, b) the first-listed diagnosis, or c) the second-listed diagnosis with a related first-listed diagnosis, then 100% of the cost was allocated to COPD. If COPD was the second-listed diagnosis with an unrelated first-listed diagnosis, then 50% of the cost was allocated to COPD. If COPD was the third-listed diagnosis, with a first- or second-listed related diagnosis, then 67% of the cost was allocated to COPD.
3. Other DRGs: For all DRGs that were not associated with COPD (i.e., not DRG 88 or not listed in the footnote of Table 1), and for which COPD was a second- or third-listed diagnosis (it was never first-listed in these cases), costs of hospitalizations were computed based on the extent of additional length of stay due to the COPD. This formula attributed 60% of the daily cost of extended hospital days by COPD patients in excess of the average length of stay for those without COPD. The rationale for taking 60% rather than 100% is that Medicare reimburses proportionately less for lengths of stay beyond the national average corresponding to each DRG because service and cost intensity generally decline as a hospital stay progresses.

Table 1. Cost of Hospitalizations Attributed to COPD by Approach Component: Approach B-Weighted Attribution of COPD

DRG for hospital stay	Position of COPD in list of diagnoses	Portion of cost attributed to COPD	Projected number of hospitalizations	Projected annual U.S. payment
COPD (DRG 88)	First diagnosis listed	100%	201,109	$627,614,933
Associated with COPD[a]	Only diagnosis listed	100%	0	$0
Associated with COPD[a]	First diagnosis listed	100%	5,663	$60,927,561
Associated with COPD[a]	Second diagnosis with first diagnosis related[b]	100%	289,281	$1,080,885,448
Associated with COPD[a]	Second diagnosis with first diagnosis unrelated	50%	36,647	$79,769,889
Associated with COPD[a]	Third diagnosis with first or second diagnosis related[b]	67%	125,013	$334,793,417
Unassociated with COPD	Listed in second or third position	60% of extra days	23,834	$2,605,498
Total			681,547	$2,186,596,746

[a] DRGs associated with COPD were defined as the following diagnosis-related group codes: upper respiratory infections (DRGs 68–70), respiratory system operating room procedures (DRGs 76–77), respiratory infections and inflammations (DRGs 79–81), pulmonary edema and respiratory failure (DRG 87), pneumonia and pleurisy (DRGs 89–91), interstitial lung disease (DRGs 92 and 93), pneumothorax (DRGs 94 and 95), bronchitis and asthma (DRGs 96 and 97), respiratory signs and symptoms (DRGs 99 and 100), other respiratory system diagnoses (DRGs 101 and 102), respiratory system diagnosis with ventilator support (DRG 475), and heart failure and shock (DRG 127).

[b] Related disorders were defined as the following ICD-9 diagnosis codes: acute bronchitis and bronchiolitis (ICD-9 code 466), pneumonia (ICD-9 codes 482 and 486), influenza (ICD-9 code 487), bronchitis (ICD-9 code 490), asthma (ICD-9 code 493), other diseases of the lung (ICD-9 code 518), general symptoms (ICD-9 code 780), symptoms involving respiratory system and other chest symptoms (ICD-9 code 786), disorders of fluid, electrolyte, and acid-base balance (ICD-9 code 276), and heart failure (ICD-9 code 428).

Approach C: Incremental

Under Approach C, the cost of hospitalizations attributable to COPD was estimated by computation of the incremental cost of certain types of hospitalization. As with Approach B, three groups of hospitalizations were defined based on the DRG.

1. COPD (DRG 88): All of the cost of hospitalizations for medical management of COPD (DRG 88) were attributed to COPD.
2. DRGs associated with COPD: Costs of hospital admissions attributable to COPD for DRGs associated with COPD (specified in the footnote of Table 1) were computed using an incremental attribution approach. First, the number of persons with COPD was estimated by age and gender categories using U.S. census data (22) and published age-sex specific prevalence rates (8). These figures were normalized to reflect an estimated total of 14.25 million persons with COPD over age 45. Second, for all DRGs associated with COPD and for which COPD was a first-, second-, or third-listed diagnosis, 100% of the costs were summed by age and gender category. Third, using U.S. census data and the previously calculated number of individuals with COPD, the number of individuals who do not have COPD was estimated in age and gender categories. Fourth, 100% of the costs for all DRGs associated with COPD and for which COPD was not a first-, second-, or third-listed diagnosis were totaled by age and gender categories. Fifth, for each age and gender category, the costs calculated in step 4 were multiplied by the ratio of the number of individuals with COPD in that category to the total number of individuals without COPD in that category. The resultant costs were those for a 14.25 million age- and gender-matched cohort of individuals without COPD. Sixth, the costs in step 5 were subtracted from the costs in step 2 to yield incremental costs attributable to COPD (that is, the extent to which individuals with COPD will have a greater number of these types of hospitalizations than an age- and gender-matched cohort). These incremental costs were summed over age and gender categories to yield a total incremental cost attributable to COPD.
3. Other DRGs: For all DRGs that were not associated with COPD (i.e., not listed in the footnote of Table 1), incremental costs of hospitalization for persons with COPD were computed based on the extent of additional length of stay due to COPD. This formula attributed 60% of the daily cost of extended hospital days by COPD patients in excess of the average length of stay for those without COPD.

The rationale for this approach may be easiest to understand using DRGs 68–70 (otitis media and upper respiratory infection) as an example. Persons with COPD have a higher rate of these types of hospitalizations than do an age- and gender-matched cohort that does not have COPD. Thus, an incremental analysis identifying the cost of this increased rate of hospitalization justifiably attributes this cost to COPD.

On another note, we separated out DRG 88 (medical management of COPD) so that the structure of the methods would be parallel for Approaches B and C and thus easier to compare. However, if we had included DRG 88 along with the "associated DRGs" in the incremental analysis, the results would have been the same because no one in an age- and gender-matched cohort without COPD would have been hospitalized for COPD, and thus all of the hospitalizations would have been counted as "incremental."

RESULTS

Cost of Hospitalizations Using Approach A

Using Approach A, all records from the 1990 NHDS where one of the ICD-9 codes for COPD was listed in the first diagnosis position were identified. This approach

Table 2. Cost of Hospitalizations Attributed to COPD by Approach Component: Approach C—Incremental COPD

DRG for hospital stay	Projected number of hospitalizations	Projected annual U.S. payment
COPD	201,109	$627,614,933
Associated with COPD	456,604	$979,420,289
Unassociated with COPD	23,834	$2,605,498
Total	681,547	$1,609,640,720

projected 206,098 hospitalizations per year, with an average payment of $3,449, for a total projected annual U.S. payment of $710,876,149.

Cost of Hospitalizations Using Approach B

Using Approach B, the number and cost of hospitalizations for persons with COPD was determined by a set of decision rules, as defined above. Table 1 presents the projected number of hospitalizations and cost by component of the decision rule.

The number of hospitalizations captured by each of the components of the decision rule indicates that nearly one-third of the hospitalizations for persons with COPD were for DRG 88—medical management of COPD. Two-thirds of hospitalizations captured in this decision rule are where persons with COPD are hospitalized for conditions associated with COPD. Of particular note, approximately one-half of the hospitalizations were for persons who have COPD listed as the second diagnosis with a COPD-related diagnosis listed in the first position. The analysis of the effect of COPD on length of stay for hospitalizations unassociated with COPD indicates a slightly longer stay for persons with COPD compared with persons without COPD (this factor contributed less than 1% to the total cost). The total indicates that the annual U.S. payment for hospitalizations for COPD is $2.2 billion and the average cost per hospitalization is $3,205.

Cost of Hospitalizations Using Approach C

Using Approach C, the number and cost of hospitalizations for persons with COPD was determined for each of the components of the incremental analysis, as shown in Table 2.

The number of hospitalizations captured by each of the components of the decision rule indicates that about one-third of the cost of hospitalizations for persons with COPD were for DRG 88—medical management of COPD. More than half of the cost of hospitalizations was for hospital stays where persons with COPD had other respiratory conditions. The analysis of the effect of COPD on length of stay for hospitalizations unassociated with COPD indicates a slightly longer stay for persons with COPD compared to persons without. The total indicates that the annual U.S. payment for hospitalizations for COPD is $1.6 billion and the average incremental cost per hospitalization is $2,361.

DISCUSSION

The annual cost of hospitalizations for COPD (valued as DRG reimbursements) is summarized in Table 3. The first obvious difference between the three approaches is in the projected number of hospitalizations. Approach A projected less than one-third the number of hospitalizations of the other two approaches, reflecting the

Table 3. Cost of Hospitalizations Attributed to COPD by Approach

Approach	Projected number of hospitalizations	Average payment per hospitalization	Projected annual U.S. payment
A: First-listed COPD	206,098	$3,449	$710,876,149
B: Weighted attribution COPD	681,547	$3,205	$2,186,596,746
C: Incremental COPD	681,547	$2,361	$1,609,640,720

fact that Approach A sampled only cases where COPD was the first-listed diagnosis. The projection of 206,098 hospitalizations using Approach A is consistent with that reported by the National Center for Health Statistics, because they use this same approach when they report findings from this database (13). In contrast to this sampling scheme, Approaches B and C sampled all cases where COPD was either a first-listed diagnosis, a second-listed diagnosis, or a third-listed diagnosis. The current projection of 681,547 hospitalizations falls between that reported by the National Center for Health Statistics (13) for first-listed COPD (209,000) and for all-listed COPD (1.891 million), which is based on the appearance of COPD in any of the seven available diagnoses positions. For Approaches B and C, we chose to limit the sample to cases where COPD was in the first-, second-, or third-listed position because this sampling scheme optimally differentiated DRGs associated with COPD from others. Thus, the difference (1.891 million − 681,547 = 1.209 million) represents hospitalizations in persons with COPD but for reasons unassociated with their COPD.

There are also differences among the three approaches in the average hospitalization cost. Average hospitalization costs (calculated as DRG reimbursements) were $3,449 with Approach A, $3,205 with Approach B, and $2,361 with Approach C. Under Approach A, 100% of the hospitalization cost is attributed whenever COPD is listed as the first diagnosis. In contrast, Approach B accounts for 100% of the hospitalization cost for DRG 88 (medical management of COPD), for a portion of the cost of hospitalization for admissions when the DRGs are associated with COPD (other than DRG 88), and for a fraction of the increased days of stay for DRGs that are not associated with COPD. Approach C yielded the lowest average cost because only incremental costs for COPD were determined, portioning out the hospitalization costs expected in this age- and gender-matched cohort. Another reason for the significant difference in average payments resulting from the attribution rules is that in some of the hospitalizations where COPD is listed as the first diagnosis, the Medicare reimbusement rates for these DRGs are particularly high. Examples of these include DRG 475 (respiratory system diagnosis with ventilator support) and DRG 477 (nonextensive operating room procedure unrelated to principal diagnosis).

Given that the three approaches varied in both the number and cost of hospitalizations, it is not surprising that they also differed substantially in the total annual U.S. hospitalization costs projected for COPD. Approach A, based on taking only utilization encounters with COPD listed as the first diagnosis, projected a total cost of $711 million. Approach B, using a set of decision rules designed to capture, through partitioning of costs, resource utilization for COPD, projected a total cost of $2.2 billion. Approach C, designed to assess the incremental costs of COPD, projected a total cost of $1.6 billion. The total cost of hospitalization for patients with COPD is sizable given any of these approaches.

The estimated costs from Approach A are one-third those of Approach B and one-half those of Approach C. The cost estimates derived from Approach A are the most straightforward, and therefore perhaps the easiest to defend. This approach of only considering the first-listed diagnosis is commonly used in cost analyses (10;23;27) and is the approach reported by the National Center for Health Statistics in reporting summary statistics from the NHDS (13;14). However, the cost estimates using Approaches B and C are arguably more representative of the true cost of treating COPD because these estimates capture a portion of the care provided to people with COPD who receive treatment for comorbidities that are clinically associated with COPD.

When comparing Approaches B and C, it can be seen from Tables 1 and 2 that the first and third components of these approaches are identical. The first component estimates the cost of hospitalizations ($628 million) just for the medical management of COPD (DRG 88). Using either approach, this figure is a large portion of the total cost and is completely defensible when estimating the cost of hospitalizations for COPD. The third component estimates the cost of care ($2.6 million) related to extra days of stay, indicating that when persons with COPD are hospitalized for reasons unassociated with their COPD, they incur a small amount of additional cost on a per-person basis. A combination of these two components was used by Rice and her colleagues in various cost-of-illness analyses (18;19;20). It is the second component that differs and produces estimates for Approach B that are $575 million greater than for Approach C. Approach B apportions cost using a set of decision rules that were viewed appropriate by a panel of clinicians and health economists knowledgeable about COPD. Attribution methodologies similar to this approach have been used previously in cost-of-illness analyses of other diseases (15). Approach C apportions cost using an incremental analysis similar in concept to that advocated by Ray, Thamer, and their colleagues (16;17;25). Incremental analysis has also frequently been used in cost analyses (2;4;6;24;26) and has been especially popular when the cost of care for cancer has been estimated (2;4;6;24).

Potential Limitations

Each of these approaches has advantages and disadvantages. The following are the most serious limitations of each approach.

Approach A is attractive because it is so straightforward, but it can greatly underestimate the rate of utilization for a condition that contributes to other diseases. For example, the second most common DRG in persons with COPD was pneumonia (DRGs 89–91), in which case pneumonia was the first-listed diagnosis (ICD-9 codes 482–487) and COPD was the second-listed diagnosis, reflecting its role as an underlying cause. Approach A would entirely miss such hospitalizations in its exclusion of all but first-listed diagnoses. Another example of this phenomena is hypertension. Hospitalizations for first-listed hypertension are rare, but hypertension is a major risk factor for many cardiovascular conditions and is a complicating factor in many hospitalizations. Using Approach A would greatly reduce estimates of the cost of hypertension and similar underlying conditions.

The greatest limitation when using Approach B is the potential for double-counting. Care must be taken in designing decision rules so that if the cost of all diseases were summed, the total cost would not exceed 100% of the annual cost of all hospitalizations. In the current example, the decision rules made sense to a panel of clinicians who were focusing on capturing all the cost of COPD. However, this set of decision rules may have been overly generous in its allocation of utilization

to COPD. Consequently, if these decision rules were applied to a number of related conditions, double-counting could occur. It is easy to see that double-counting cannot occur with Approach A. Our simulations suggest that under many reasonable situations, the degree of double-counting with Approach C is negligible, but further examination of this issue is warranted.

The greatest disadvantage of the incremental analysis in Approach C is that it requires good prevalence data for the condition under investigation, preferably by gender and age category. Such data are not always available. The usefulness of Approach C in projecting accurate utilization rates is compromised by any weakness or uncertainty in the estimates of prevalence.

Recommended Applications

We have mentioned that each of the approaches has limitations. In terms of COPD, Approach A has the greatest disadvantage because it does not take into account the associated comorbidities that frequently produce hospitalizations in this population. However, which approach should be used for other diseases? We believe the answer depends on the disease and we offer the following recommendations:

- *Approach A is recommended for diseases where the reasons for hospitalization are straightforward and where there are no significant associated comorbidities influencing the DRGs or length of stay.* Approach A is the easiest methodology to apply, and there are instances when it is the most appropriate approach. For example, the most frequent reason for hospitalization is childbirth (13). These hospitalizations are quite straightforward to categorize, and for many analyses they can probably be attributed to specific diagnostic codes without regard for comorbidities.
- *Approach B is recommended for diseases where the reasons for hospitalization can be logically attributed to specific conditions, even when comorbidities occur.* Decision rules, such as those used in Approach B, require expert opinion to define and must be tailored to specific clinical conditions. It is unlikely that there would be universal endorsement of any one set of decision rules. However, for some conditions, this approach is the most appropriate. For example, hospitalizations involving psychiatric disorders can either be primarily for treating the specific disorder (e.g., hospitalization for medical management of an acute schizophrenia episode) or the psychiatric disorder may or may not complicate the hospitalization for a nonpsychiatric condition (e.g., hospitalization for coronary disease in a person with schizophrenia). The hospitalization could even be a blending of the two involving active interventions for both medical and psychiatric conditions (e.g., hospitalization for orthopedic injury in a person with poorly managed schizophrenia). In such a case, the DRG chosen and the order of the diagnoses are critical in discerning the reasons for hospitalization. Use of decision rules is the best means for allocating the appropriate cost to conditions when the specific DRG and/or order of diagnoses are critical for capturing the underlying reason for treatment. In defining the decision rules, care must be taken to develop algorithms that apportion the "right" amount of utilization to each underlying cause.
- *Approach C is recommended for diseases where there are typically comorbidities influencing the DRGs or length of stay.* Hospitalizations for many chronic conditions and for conditions often linked to other diseases would fall into this category. Examples of such conditions are certain cardiovascular diseases and metabolic disorders (e.g., hypertension, diabetes, renal disease). Likewise, many hospitalizations that typically occur in the elderly would be best handled by this approach. For example, hospitalization for pneumonia is not uncommon in elderly populations for a host of reasons, and this approach is best at dealing with the underlying rate when attributing cost to a specific condition.

Policy Implications

It would be helpful to eventually develop standards for methods for attributing utilization to specific diseases. However, the development of such standards at this point would be premature because we do not yet know the generalizability of the present findings to other conditions.

Attributing medical resource utilization to a specific disease or intervention is at the core of most types of cost analysis. The issues addressed in this paper are key to cost-of-illness analysis, cost-effectiveness analysis, cost-utility analysis, and cost-benefit analysis. Certainly the cost of a specific illness depends on the amount of medical resource utilization that is attributed to that illness. Likewise, the results of cost-effectiveness and similar analyses are dependent on the degree to which an intervention cost is offset by reduced utilization as an effect of that intervention. The approach to attributing utilization can have a direct effect on the projected cost-effectiveness (or lack thereof) of an intervention.

We urge that, at the very least, future cost analyses include greater methodological detail. Information on the specific approach to allocating costs in the case of comorbidities is rarely mentioned in cost-of-illness papers. As shown in the COPD example presented here, the allocation approach can have major impact on the findings related to medical resource utilization and cost.

The approaches described here have the greatest application in the United States and other countries with similar reimbursement systems, especially those that involve DRGs. The application of these approaches to other systems, such as those countries that employ annual budgets for hospitals, is less apparent. However, even in systems where cost cannot be partitioned by disease, it is often useful to attribute utilization to a specific condition. For example, one of these approaches could be used to project annual occupancy rates for a hospital if a new service (e.g., dialysis unit) is introduced at that hospital or at another hospital in the same market area. The principles described here could be applied to situations where it is desirable to estimate how much utilization (e.g., length of stay, number of procedures, types of surgeries) is "spent" on specific diseases, even if cost never enters the equation.

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