Beyond Severity of Illness: Evaluating Differences in Patient Intensity and Complexity for Valid Assessment of Medical Practice Pattern Variation

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A growing body of research indicates that severity-adjustment alone does not adequately explain legitimate differences in charges, costs, and length of stays within diagnosis related groups (DRGs) across providers. In order to validly compare resource utilization across providers, other patient attributes such as age and the number of complications and comorbidities (CCs) managed during the patient stay must be accounted for to address the full range of patient characteristics that affect the need for varying levels of resource consumption. In an era of unprecedented public scrutiny and consumerism the need to more fully adjust for differences in patient characteristics across providers could not be greater.

In response to this need, a Severity, Intensity, and Complexity (SIC) model has been developed which integrates leading severity measurement techniques with specific patient age cohorts and CC clusters to account for differences in patient intensity and complexity. The calibration and construction of the SIC model was based on a modified version of the CMS relative weight methodology utilizing an all-payer national database of general, acute, non-federal US hospitals which represented all four census regions of the country. Research indicated age and number of CCs significantly improved the ability to explain legitimate variation in medical practice patterns beyond severity of illness alone as indicated by improved reduction of variance (R^2) statistics for both charges/costs and length of stay. Moreover, the model was found to be useful in conducting meaningful comparative assessments of individual provider performance utilizing clinical demand indices to adjust for differences in illness severity, intensity, and complexity. Key Words: severity, intensity, complexity, age cohorts, and CC clusters.

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With the Center for Medicare and Medicaid Services (CMS) release of the diagnosis related groups (DRGs) in 1983, came the criticism that while DRGs identified Medicare patients with similar diagnoses and resource requirements for prospective payment, they did not adequately adjust for specific patient characteristics that needed to be accounted for to accurately compare provider outcomes—namely charges, costs, and lengths of stay. This deficiency was primarily attributed to unaccounted differences in patient severity of illness within DRGs. Consequently, the hospital industry saw a proliferation of various severity systems designed to account for differences in illness severity within DRGs for the express purpose of evaluating outcomes variation across hospitals and physicians. DRG-based severity systems originating from this initial body of research include Yale Refined-DRGs (R-DRGs), 3M All Patient Refined-DRGs (APR-DRGs), and HSS All Payer Severity-adjusted DRGs (APS-DRGs). Each of these severity systems define a specific hierarchy of complications and comorbidities (CCs) that substantially increase a patient's need for charges/costs within the same DRG and typically assign patients to one of three or four severity classes based on the identification of the single most resource intensive CC. While these severity systems further improve the ability to explain legitimate differences in patient charges/costs and length of stay within DRGs, they do not account for other differences in patient characteristics that legitimately increase the need for resource utilization. Generally, a severity system alone only explains 50 percent of charge/cost variation and 40 percent of length of stay. An expanded set of demographic and clinical characteristics that should be accounted for to more fully adjust for differences in patient characteristics include the patient's age and the number of CCs treated and managed during the patient stay. Together, age and the number of CCs provide a means for accounting for patient intensity and complexity of care. The purpose of this article, then, is to describe the development and application of a Severity, Intensity, Complexity (SIC) model which appropriately accounts for differences in patient illness severity, age, and number of CCs for valid assessment of medical practice pattern variation. The APS-DRGs were selected for this study since their taxonomy is based on the commonly understood CMS DRGs, although APR-DRGs may be used as well for those organizations that prefer 3M's approach to severity classification. The following section overviews the origin and structure of the APS-DRGs for determining patient severity of illness.

The Origin and Structure of APS-DRGs

Building upon CMS's Severity-Modified DRG (S-DRG) research[1] and its own experience in constructing and updating DRG, R-DRG, and neonatal classification algorithms,[2] HSS developed the APS-DRGs.[3] They are an expansion of both the S-DRGs and the Yale R-DRGs and are designed to be applicable to all hospitalized patients, regardless of illness type or payer classification. Like S-DRGs and R-DRGs, the APS-DRGs use both principal and secondary diagnoses, as well as the occurrence and degree of surgery, as discriminating variables in patient classification and severity evaluation. In a very few instances, the patient's age, discharge status, or birth weight may be taken into account.

The basic process of assigning APS-DRGs is reflected in Exhibit 1. First, the CMS DRG and major diagnostic category (MDC) are assigned. Second, the consolidated DRGs are assigned using the same underlying structure as the CMS S-DRG model. Third, each secondary diagnosis is evaluated to determine if it meets criteria for designation as a CC or a Major CC. Fourth, each consolidated DRG is split into three resource-based severity classes: no CCs (class 0), with a CC (class 1), or with a Major CC (class 2). Lastly, the final severity class and APS-DRG are assigned using a consistent nomenclature. Thus, the APS-DRGs begin with a nationally recognized and clinically acceptable model and apply a uniform structure that can be easily represented. Unlike S-DRGs, the APS-DRGs use a fourth digit numeric designation beyond the three standard numeric digits to provide linkages back to the underlying severity classification system (*e.g.*, APS-DRG 1270, 1271, and 1272).

The APS-DRGs further improve upon the S-DRGs by developing a severity model for neonates, a major segment of the all-payer patient population. This neonatal model reflects the body of scientific literature that has emerged over time with regard to classifying newborns into similar resource-based categories and with regard to measuring severity of illness.[4] The single most important variable in explaining survival outcomes and length of stay among neonates is birth weight.

For the APS-DRGs, a combination of birth weight and diagnoses are used to define a set of initial neonatal classes. A second important risk factor is the presence of respiratory distress. The APS-DRG model recognizes this factor through evidence of respiratory assistance or the presence of respiratory distress syndrome. A third critical dimension in classifying newborns is their discharge disposition. Here, APS-DRGs take into account the fact that newborns who either die or are transferred shortly after birth are likely to be more severely ill. There are 21 neonatal APS-DRGs.

APS-DRGs have been subjected to extensive testing for clinical and statistical validity. The core structure of APS-DRGs reflects an extensive body of research undertaken and supported by CMS. The S-DRGs have been evaluated by the developers and by other government groups, including the Agency for Healthcare Research and Quality (AHRQ), the Prospective Payment Assessment Commission (ProPAC), and the Office of Management and Budget.

While HSS has relied on the work of CMS and other agencies to validate the core classification system used by APS-DRGs, considerable effort has been devoted to understand and validate aspects that most clearly differentiate APS-DRGs from the S-DRGs and other DRG-based severity systems. More extensive testing has been done using 1.5 million discharges from Release 1 of the National Inpatient Sample (NIS) from AHRQ's Healthcare Cost and Utilization Project.[5] The study sample contained all discharges that took place in sample hospitals during the fourth quarter of calendar year 1992. Comparisons were made among APS-DRGs, S-DRGs, and version 12.0 DRGs. Variance in average charge and length of stay were examined, using untrimmed data. APS-DRGs consistently outperformed the other two measures, even for the Medicare and non-Medicare subgroups.

Since their inception in 1995, the APS-DRGs have been assigned to nearly 180 million patient records and are currently used by numerous hospital associations, health systems, hospitals, and insurers across the country. The next section describes The Delta Group's development, validation, and application of the SIC model for further explaining variance in charges, costs, and length of stay not explained by severity of illness by incorporating the use of additional patient characteristics associated with the intensity and complexity of patient care.

Exhibit 1. Basic Process for Assigning APS-DRGs

1. Prepare Data

Assemble required variables:
- ⇒ ICD-9-CM diagnoses and procedure codes
- ⇒ Age
- ⇒ Discharge Status
- ⇒ Birth weight (for neonates)

Assign CMS DRG and MDC

2. Assign Consolidated DRG (CDRG)

CDRG assignment is based on the CMS DRG and may, in a limited number of cases, be reassigned using:
- ⇒ Age
- ⇒ Procedures
- ⇒ Discharge Status

3. Assign CC Severity Class to Each Secondary Diagnosis

Evaluate each secondary diagnosis to determine if it is a CC, Major CC, or neither.

Determine if the CC or Major CC is excluded for the principal diagnosis, MDC, or CDRG.

4. Assign Final Severity Class and APS-DRG to Discharge

Severity Class	Description	Examples
0 (Low)	no CC or Major CC	Heart failure and shock without CC (APS-DRG 127<u>0</u>)
1 (Moderate)	at least 1 non-excluded CC	Heart failure and shock with hypertension (APS-DRG 127<u>1</u>)
2 (High)	at least 1 non-excluded Major CC	Heart failure and shock with acute renal failure (APS-DRG 127<u>2</u>)

Where, APS-DRG group number is equal to DRG plus severity class XXXY; XXX is DRG and Y is severity class.

The Severity, Intensity, and Complexity (SIC) Model

In addition to including a measure of illness severity, the SIC model further evaluates resource need using measures of intensity and complexity as discriminating variables based the patient's age and number of CCs present during hospitalization. As displayed in Exhibit 2, once a patient is assigned to an APS-DRG, they are stratified into one of five age cohorts and one of two CC clusters. A clinical demand index (CDI) is then calculated for each terminal group to determine the collective resource requirement for patients with these characteristics. The CDIs were constructed to reflect the relative clinical demand for charge/cost and length of stay associated with each patient, where 1.00 represents the average demand for the DRG. Consequently, a CDI of 1.20 indicates a 20 percent greater demand for charges/costs or length of stay than the DRG, while a CDI of 0.80 indicates a 20 percent lesser demand. By taking into account the differences in severity, intensity, and complexity of patients, the CDI provides practitioners with a complete "clinical adjustment" for validly assessing variation in medical practice patterns.

Methodology

The methodology used to develop CDIs was derived from the CMS DRG relative weight algorithm for calculating hospital case mix indices.[6] The modified relative weight methodology for calculating CDIs is as follows:

- All patient records were terminally classified by APS-DRG, age cohort, and CC cluster;
- Charges were standardized to remove the effect of wage differences in rural and urban areas;
- Statistical outliers were trimmed by removing all cases outside of three standard deviations from the DRG mean of the log distribution of charges; and
- Average standardized charge for each terminal group was divided by the national average charge across all DRG classifications to determine the relative clinical demand index for charges (CDI $) and then normalized to the DRG level for ease of interpretation within specific DRGs.

Exhibit 2. Trimmed R^2 for Charges/Costs and Length of Stay by DRG-Based Patient Classification Systems (CI=95%)

Indicator	Patients	DRGs	R-DRGs	APR-DRGs	SIC Model*
Charges/ Costs	All	.52	.56	.60	.66
	Medical	.34	.46	.50	.62
	Surgical	.51	.54	.59	.86
ALOS	All	.38	.44	.49	.57
	Medical	.35	.43	.44	.65
	Surgical	.39	.44	.50	.86

* Using APS-DRGs for severity classification

In the same manner, average length of stay (ALOS) for each terminal group was computed (excluding statistical outliers) and divided by the national ALOS across all DRGs and normalized to the DRG to determine the relative clinical demand index for length of stay (CDI LOS).

Database

The nationally representative database for constructing CDIs relied on hospital UB-92 data and comprised 11.8 million discharges across 32 states. The dataset included all clinical case types and payer classifications and was representative of general, acute, non-federal hospitals throughout the United States with respect to bed size, teaching status, and urban/rural designation. The database was also geographically representative covering all four Census Bureau regions of the country. The database did not include psychiatric or rehabilitation hospitals, although some hospitals did have specialty units represented.

Validation

With the SIC model's inclusion of age cohorts and CC clusters within APS-DRG severity classes, the total number of terminal patients groups expanded to 11,300 compared to 1,130 using severity classification alone. The model's expansion of terminal groupings dramatically improved the homogeneity of patients within each group and as a result significantly increased the explanatory power of the model to predict charges/costs and ALOS when compared to conventional severity systems. The most common statistical measure used to

Exhibit 3. Effect of Differences in Patient Clinical and Demographic Characteristics on DRG Charges and Length of Stay

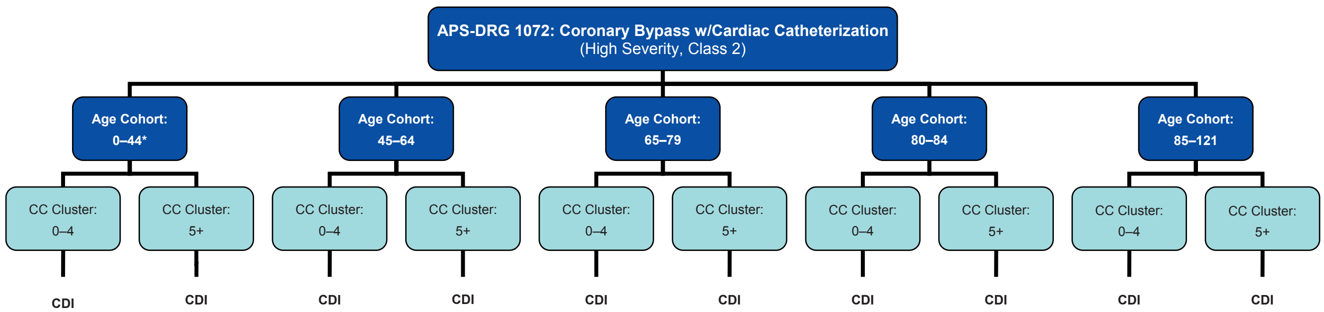
DRG 107: Coronary Bypass with Cardiac Catheterization

Analysis Category Based on Differing Patient Characteristics	# of Cases	Average Charge Per Case	% Increase in Charges	P-value*	ALOS	% Increase in ALOS	P-value*
Analysis I: ***Age Cohort Effect within CC Cluster and Severity Class***							
Age 45–64 years (0–4 CCs; High Severity—Class 2)	480	$65,611			7.6		
Age 80–84 years (0–4 CCs; High Severity—Class 2)	60	$79,190	20.7%	<.001	9.3	22.4%	<.001
Analysis 2: ***CC Cluster Effect within Age Cohort and Severity Class***							
0–4 CCs (Age 45–64 Years; High Severity—Class 2)	480	$65,611			7.6		
5+ CCs (Age 45–64 Years; High Severity—Class 2)	3,827	$94,150	43.5%	<.001	11.6	52.6%	<.001
Analysis 3: ***Age Cohort and CC Cluster Combined Effect Within Severity Class***							
Age 45–64 years; 0–4 CCs (High Severity—Class 2)	480	$65,611			7.6		
Age 80–84 years; 5+ CCs (High Severity—Class 2)	1,170	$106,935	63%	<.001	14.0	84.2%	<.001
Analysis 4: ***Age Cohort and CC Cluster Effect Between Severity Classes***							
High Severity—Class 2; Age 45–64 years; 0–4 CCs	480	$65,611			7.6		
Moderate Severity—Class 1; Age 80–84 years; 5+ CCs	1,896	$78,992	20.4%	<.001	10.4	36.8%	<.001

*Calculated using Independent-Samples T-test.

compare patient classification systems is reduction of variance (R^2) which measures the proportion of variation that is explained by the system. Models with R^2 values greater than .50 are normally considered to have good explanatory power, where 1.0 would indicate a perfect linear relationship between observed and predicted values. As shown in Exhibit 2, R^2 statistics for charges/costs and ALOS were computed using a confidence interval (CI) of 95 percent for each DRG-based patient classification system using trimmed data. The R^2 was computed separately for medical patients, surgical patients, and for all patients combined. A comparison of R^2 statistics shows the SIC model explains substantially more variation in charges/costs and ALOS for all patients, medical patients, and surgical patients when compared to systems that adjust for severity alone. Note the R^2 for all patients combined is occasionally higher than either the medical or surgical patients separately. Since the charge/cost and ALOS for surgical patients tends to be higher than medical

Exhibit 4. Structure of the Severity, Intensity, and Complexity (SIC) Model



*Becomes an age cohort of 0–17 for 126 APS-DRGs based on CMS DRG assignment.
CDI = Clinical Demand Index.

patients, the variation across all patients combined is high. However, once DRG assignment is used to classify the patient into a medical or surgical group, there is less variation to explain since the medical/surgical assignment itself reduces the variation.

The improved explanatory power associated with accounting for age cohort and CC cluster within a DRG severity class is vividly demonstrated by an analysis of the variation in charges and ALOS of patients with differing age cohorts and CC clusters.

For instance, Exhibit 3: Analysis 1 isolates the effect of age and indicates that for patients assigned to the highest severity level (class 2) and the same 0–4 CC cluster in DRG 107: Coronary Bypass with Cardiac Catheterization the average charge still varies by 20.7 percent or $13,579 per case between age cohorts (from $65,611 to $79,190 for patients age 45 to 64 years versus 80 to 84 years respectively) (P<.001). Similarly, ALOS varies by 22.4 percent or 1.7 days per case (from 7.6 days to 9.3 days) (P<.001).

Exhibit 3: Analysis 2 further demonstrates that charges and ALOS also differ considerably between CC clusters when severity level and age cohort remain constant ($65,611 average charge for patients with 0–4 CCs versus $94,150 for those with five or more CCs—an increase of 43.5 percent) (P<.001). Likewise, the need for a higher ALOS was observed for patients with five or more CCs (11.6 versus 7.6 days—a 52.6 percent increase) (P<.001).

However, the most pronounced variation in resource need occurred from adjusting for differences in both age cohort and CC cluster for patients with the same severity of illness as displayed in Exhibits 4 and 5 (detail provided in Analysis 3 of Exhibit 3). This combined adjustment revealed a 63.0 percent variation in average charge per case ($65,611 versus $106,935) (P<.001) and an 84.2 percent increase in ALOS (7.6 days to 14.0 days) (P<.001). Moreover, research revealed the effect of differences in both age cohort and CC cluster persisted even across patients with differing levels of illness severity within the same DRG.

Exhibit 3: Analysis 4 illustrates this finding where moderately ill (severity class 1) bypass patients between the ages of 80 to 84 years with five or more CCs were compared to patients with the highest illness severity (class 2) but in the age range of 45 to 64 years with four or less CCs. The analysis shows that less severely ill, older patients with more CCs on average required 20.4 percent more resource consumption than more severely ill, younger patients with fewer CCs ($78,992 versus $65,611) (P<.001) and a 36.8 percent greater need for length of stay (10.4 days versus 7.6 days) (P<.001).

These results demonstrate, in addition to severity-adjustment, valid comparisons of outcomes must incorporate appropriate measures of intensity and complexity of care if hospitals, and physicians are to identify legitimate opportunities to improve medical practice patterns and if consumers and payers are to accurately identify providers with favorable outcomes. Not to adjust for these confounding characteristics will often misdirect improvement activities causing widespread frustration and inappropriate use of performance improvement resources. If clinical utilization is to be properly managed and medical staffs are to support

Exhibit 5. Effect of Patient Age Cohort and CC Cluster on Length of Stay Within the Same DRG Severity Class (p<.001)

DRG 107: Coronary Bypass w/Cardiac Catheterization—High Severity, Class 2

performance improvement efforts, the assessment of charges, costs, and length of stay must also adjust for patient intensity and complexity characteristics.

In addition to the aforementioned findings and conclusions, a growing body of scientific literature supports The Delta Group's research that further adjustment for patient intensity and complexity is required. As Petryshen states:

> When used alone, current computerized severity measurement systems are inadequate for outcomes monitoring. A more comprehensive model for outcomes monitoring is required, one that adjusts outcomes for risk factors, severity of illness, and complexity of care.[7]

This conclusion is widely documented by primary research performed at various universities and academic medical centers and is summarized as follows:

- The Department of Pathology at the University of Colorado School of Medicine examined the variation in laboratory charges/costs and length of stay for older medical patients within the same severity class using the Refined-DRG methodology. They selected discharge abstracts from four medical DRGs at five large academic hospitals (n = 15,265) and five mid-sized community hospitals (n = 10,540). Patients 80 years of age or older were found to require longer lengths of stay and higher laboratory costs than middle-aged patients at each of the academic and community hospitals.[8]
- Research performed at the Department of Surgery at Columbia University College of Physicians and Surgeons revealed length of stay for coronary artery bypass graft patients without heart failure symptoms (n = 900) was significantly prolonged by advanced age even after adjusting for patient severity of illness using the New York Heart Association's four severity classifications.[9]
- The Department of Medicine at Beth Israel Hospital regressed length of stay for hip fractures based on patient age/sex, DRG, and severity score and concluded hospitals (n = 80) differed widely in their mean length of stay for hip fractures, and severity adjustment alone did little to explain these differences.[10]
- The Division of General Medicine and Primary Care at Beth Israel Hospital reviewed 11 sever-

Exhibit 6. DRG Charge Comparison by Physician (Clinically Adjusted)

DRG 107: Coronary Bypass with Cardiac Catheterization

(1) Physician	(2) # of Cases	(3) Clinical Demand Index ($)	(4) Actual Charge Per Case	(5) Rank Order: Actual Charge Per Case (1 = lowest)	(6) Clinically Adjusted Charge Per Case*	(7) Rank Order: Adjusted Charge Per Case (1 = lowest)	(8) Agreement Between Actual and Adjusted Rank Order
A	33	0.99	$53,457	4	$54,051	2	No; better
B	29	0.94	$52,787	3	$56,232	4	No; worse
C	25	1.11	$60,238	6	$54,534	3	No: much better
D	22	0.83	$49,828	1	$59,816	6	No; much worse
E	18	1.01	$59,197	5	$58,453	5	Yes; neutral
F	14	1.05	$51,831	2	$49,402	1	No; better
Peer Group	119	1.00	$55,121	6	$55,173	6	

Data Source: 2003 Virginia Health Information (VHI) statewide database derived from non-confidential patient level information in accordance with Virginia law. Disclaimer: VHI does not represent that the use of VHI data is appropriate for analysis nor does it endorse or support any conclusions or inferences that may be drawn from the use of the data.

*The calculation for column 6 is a result of dividing column 4 by column 3 (calculation performed at the patient level with clinical demand indices expanded to the 32nd decimal place).

ity systems and concluded no severity measure explained the two-fold differences in average length of stay across 105 acute care hospitals for patients (n = 18,016) receiving medical treatment for pneumonia. A lack of adjustment for differences in other patient characteristics were cited as likely factors contributing to the sub-optimal explanatory power of the severity systems.[11]

- The Department of Health Policy and Management at Johns Hopkins University's Bloomberg School of Public Health found per capita Medicare expenditures increased with the number of chronic conditions from $213 among beneficiaries without a chronic condition to $13,973 among beneficiaries with four or more types of chronic conditions.[12]
- The Institute for Health and Aging at the University of California at San Francisco conducted a study which revealed the majority of persons with chronic conditions are not elderly and chronic conditions affect all ages. Because patients with chronic conditions have greater health needs at any age, their costs are disproportionately higher.[13]
- The Department of Medicine at McMaster University developed multiple linear regressions models to identify independent predictors of direct medical cost and hospital length of stay across 158 patients with peptic ulcer disease. Age and comorbid illness were associated with higher cost and length of stay in univariate analysis and age persisted as an independent predictor of direct medical cost and length of stay in a stepwise multiple linear regression.[14]

Application

A practical example of utilizing the SIC model to properly evaluate medical practice patterns is shown in Exhibit 6 where charge-based CDIs have been assigned to each physician to reflect the severity, intensity, and complexity of their patients treated over a 12-month period. Observe that physician D is treating the least resource intensive bypass patients as noted by a CDI of .83 (which is to say these patients require 17 percent less in charges than the average patient in DRG 107), while physician C is treating the most resource intensive patients with a CDI of 1.11–indicating an 11 percent greater need for charges than the average bypass patient and 28 percent more than physician

D's patients. Exhibit 6 also demonstrates differences in CDIs across physicians and has particular relevance for accurate analysis of variation in practice patterns in that physician D's actual "unadjusted" charges appear to be lowest among physicians treating bypass patients (at $49,828) but are in fact the highest (at $59, 816) once differences in patient severity, intensity, and complexity are taken into account using CDIs to perform a thorough clinical adjustment of the patient data. Without this type of comprehensive adjustment, performance improvement efforts would be grossly misdirected and the attainment of improvement goals would remain elusive. In like manner, a comparative analysis of performance among hospitals by payers and employers could be equally misguided resulting in less than equitable contracting arrangements.

Conclusion

The increased interest in comparing resource utilization across health care providers underscores the importance of adjusting for patient differences beyond severity of illness alone. A more comprehensive approach should account for differences in patient intensity and complexity. The age and number of CCs associated with hospitalized patients has been found to significantly improve the ability to explain legitimate variation in medical practice patterns and serve as meaningful indicators of increased patient intensity and complexity. Finally, adjustment for patient characteristics must balance the need to improve statistical predictability with the requirement that the system be clinically coherent. Combining these two approaches (statistical and clinical), the SIC model provides a system that is statistically sound and one that can be readily accepted and endorsed by clinicians.

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