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EXECUTIVE SUMMARY

Cost-to-charge ratios (CCRs) are distributed by the Healthcare Cost and Utilization Project (HCUP) as supplemental files that can be linked to HCUP State and nationwide databases. The CCRs, when combined with total charges found on inpatient discharge or emergency department visit records, are used to estimate hospital service delivery costs. Service delivery costs are those associated with treating a patient, including labor, supplies, and overhead. This report documents the methodology used to create the HCUP CCRs.

The HCUP CCRs rely on a national database of hospital accounting data: the Centers for Medicare & Medicaid Services (CMS) cost reports. The impetus for creating such a national database was Medicare prospective payment, which required calculation of service delivery costs for inpatients. This led to development of the cost reports, which were created to estimate national costs of service delivery for diagnosis-related groups. Costs contained in the cost reports include both direct costs associated with patient care and indirect costs. Not all costs incurred by a hospital are allowable in the cost reports.

HCUP CCRs are calculated as the ratio of total costs to total charges based on the cost report for specific hospitals. The CCRs are in turn applied to total charges, as reported on inpatient encounter records, to produce an estimate of service delivery cost. HCUP produces inpatient and emergency department CCRs, which can be applied to all HCUP State Inpatient Databases (SID) and State Emergency Department Databases (SEDD) using reported total charges. CCRs are also created for the following HCUP nationwide databases: National (Nationwide) Inpatient Sample (NIS), Kids' Inpatient Database (KID), Nationwide Emergency Department Sample (NEDS), and Nationwide Readmissions Database (NRD).

Development of the HCUP inpatient and emergency department CCRs starts with creation of summary data from the Healthcare Cost Report Information System (HCRIS) public use files. HCRIS contains costs and charges summarized by standard cost centers for each hospital. They are further summarized into service groupings used for calculation of the HCUP CCRs: routine care, specialty care, labor and delivery, ancillaries, and emergency department. HCUP data quality checks are performed at the service group level, and hospitals not satisfying the checks are marked as outliers, resulting in suppression of the hospital-specific CCR. At the end of this process, a single hospital-specific CCR is calculated for all hospitals passing the quality checks. When a hospital-specific CCR is missing because of outlier status or other missing data, an imputed CCR is provided, based on the hospital State and type (combinations of ownership, location, and bed-size category).

The HCUP CCR for Inpatient and Emergency Department Files are available for linkage to HCUP State and nationwide databases. User Guides for these files, available on the

HCUP User Support website, provide detail on linkage methods and data years available.[1]

[1] Cost-to-Charge Ratio Files. Healthcare Cost and Utilization Project (HCUP). November 2021. www.hcup-us.ahrq.gov/db/ccr/costtocharge.jsp. Accessed December 8, 2021.

INTRODUCTION

Cost-to-charge ratios (CCRs) are distributed by the Healthcare Cost and Utilization Project (HCUP) as supplemental files that can be linked to HCUP State and nationwide databases. The CCRs, when applied to the total charges found on inpatient discharge or emergency department visit records, produce estimates of hospital service delivery costs. *Charges* represent the amount a hospital billed for the case (prior to any contractual allowances or discounts); *service delivery costs* reflect the expenses incurred in the production of hospital services, such as wages, supplies, and utility costs. The charges and costs are distinct from the specific amounts that hospitals receive in payment.

This report documents the methodology used to create the HCUP CCRs. We first provide an overview of the CCR method, including background on the CCR methodology. Following this, we cover how CCRs for inpatient and emergency department services are created, as well as other topics related to use of the CCR methodology.

OVERVIEW OF THE CCR METHOD

In this section, we describe the origins of the CCR method, the types of costs that are captured in the CCR, and application of the CCRs to hospital administrative data.

Origins of the CCR Method

CCRs have likely been used on an ad hoc basis by hospitals for estimating service delivery costs for a considerable amount of time. Creation of CCRs requires charge and cost accounting data at the hospital level. The impetus for creating a national database of hospital accounting data was Medicare prospective payment, which was established by the Social Security Amendments Act of 1983, with implementation starting in 1984. At that time, the Centers for Medicare & Medicaid Services (CMS), then known as the Health Care Financing Administration (HFCA), established the inpatient prospective payment system (PPS) as a means of controlling rapidly increasing hospital expenditures that threatened solvency of the Medicare Trust Fund. The fundamental concepts behind the PPS were (1) creation of categories of inpatient encounters within which intensity of service delivery was similar (diagnosis-related groups, or DRGs) and (2) reimbursement to hospitals based on the costs of services within DRGs. This led to development of the cost reports, used by HCFA to estimate national costs of service delivery for DRGs, among other uses. DRG cost estimates relied on CCRs calculated from the cost reports and were integral to creation of DRG "relative weights," which determine payments to hospitals based on DRGs.[2]

CMS began releasing cost report files to the public around 1995.[3] Once the cost reports became accessible to the public, CCRs began to be used for estimating service delivery costs for individual hospitals, hospital systems, and peer groups. This in turn

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[2] Pettengill J, Vertrees J. Reliability and validity in hospital case-mix measurement. Health Care Financ Rev. 1982;4(2):101-28.

[3] See https://www.cms.gov/Research-Statistics-Data-and-Systems/Downloadable-Public-Use-Files/Cost-Reports/Cost-Reports-by-Fiscal-Year for a listing of cost report data years available for public use.

led to a focus on hospital cost-efficiency analysis and benchmarking. The Agency for Healthcare Research and Quality (AHRQ) developed a methodology for estimating hospital inpatient costs based on the cost reports in the early 2000s.[4] More recently, AHRQ developed a methodology for estimating the cost of treat-and-release emergency department visits.[5]

Costs Reported in the CMS Cost Reports

The HCUP CCRs are used to estimate service delivery costs based on costs reported in the CMS cost reports. What is included in these service delivery costs?

The charges and costs reported in the cost reports are grouped in *cost centers*. In the cost reports, cost centers represent departments or functions within the hospital that generate costs to operate. Table 1 lists the standard cost centers used by the cost reports for reporting of charges and costs.

Costs reported in the cost reports include both direct and indirect costs. Indirect costs are those required by the hospital to operate but not involving direct patient care. The cost reports refer to the cost centers with indirect costs only as *general service cost centers*. Examples of general service cost centers are General and Administrative (e.g., human resources or finance departments in the hospital) and Capital Contributions (buildings/fixtures and movable equipment). The cost reports group cost centers associated with direct costs of patient care as follows: inpatient routine, outpatient, and ancillary services. General service department (indirect) costs are allocated to the direct cost centers by means of accounting formulae and adjustments. Thus, the costs used by HCUP in calculating CCRs contain both direct and indirect costs.

Certain types of costs are not allowed in the cost reports. The Medicare *Provider Reimbursement Manual* contains detailed rules for what costs are allowed and not allowed.[6] Examples of costs not allowed in the cost reports are payments to physicians employed by the hospital, investment losses, and certain advertising or marketing expenses. Thus, costs reported in the cost reports may not agree with those reported in other financial statements created by hospitals.

CCR Calculations

The concept underlying the CCR method is straightforward. For a specific hospital *j,* a CCR can be computed from the CMS hospital cost report for a specific time period as follows:

$$CCR_j = COST_j / CHARGE_j. \quad (1)$$

[4] Friedman B, De La Mare J, Andrews R, McKenzie DH. Practical options for estimating cost of hospital inpatient stays. J Health Care Finance. 2002;29(1):1-13.
[5] Pickens GT, Moore B, Smith MW, McDermott KW, Mummert A, Karaca Z. Methods for estimating the cost of treat-and-release emergency department visits. Health Serv Res. 2021;56(5):953-61.
[6] Centers for Medicare & Medicaid Services. The Provider Reimbursement Manual - Part 2. Chapter 40. www.cms.gov/Regulations-and-Guidance/Guidance/Manuals/Paper-Based-Manuals-Items/CMS021935. Accessed December 8, 2021. https://www.cms.gov/Regulations-and-Guidance/Guidance/Manuals/Paper-Based-Manuals-Items/CMS021935, Chapter 40.

In equation (1), $COST_j$ is total Medicare allowable costs for the hospital and $CHARGE_j$ is the corresponding total charges. Thus, the CCR is the inverse of the mark-up rate (of costs to charges) for hospital *j*.

In practice, CCR_j so derived is applied to a secondary dataset from hospital *j* containing encounter data with total charges reported. The estimated service delivery cost for encounter *i* is then estimated using the following formula:

$$ENCOUNTER_COST_{ij} = CCR_j \times ENCOUNTER_CHARGE_{ij}. \qquad (2)$$

In equation (2), *i* indexes encounters and $ENCOUNTER_CHARGE$ is the total charge reported in the secondary dataset for encounter *i* and hospital *j.* In concept, encounters can occur in inpatient or outpatient settings, because the CCR contains charges and costs for all sites of care provided by the hospital. The cost structures of hospital inpatient and outpatient care differ markedly, so AHRQ has developed separate CCRs for inpatient and emergency department encounters, as described below.

Encounter-specific cost estimates are usually further aggregated for reporting and analysis, often to the total hospital, service line (e.g., medicine or surgery),) or more detailed categories, such as Medicare Severity-Diagnosis Related Group (MS-DRGs).

Derivation of CCRs From the CMS Hospital Cost Reports

The cost reports are made available to the public through the Healthcare Cost Report Information System (HCRIS). HCUP downloads the HCRIS public use file (PUF) at a point in time when most hospitals have filed cost reports. The HCUP convention has been to obtain the HCRIS PUF after the first quarter of the second year following the HCRIS data year. For example, the HCRIS 2019 data were extracted from the 2019 PUF available in April 2021.

Inpatient charges, outpatient charges, and total costs are extracted from HCRIS data by hospital identifier (CMS Certification Number, or CCN) and HCRIS standard cost center. Additional financial and hospital characteristics data are also extracted at this time. This intermediate dataset (the HCRIS Extract) is used for creation and quality assurance of the inpatient and emergency department CCRs.

CREATION OF CCRS FOR INPATIENT SERVICES

Definition of HCUP Service Groups

After the HCRIS extract has been prepared, the cost report standard cost centers are mapped into the following HCUP service groups (see Table 1):

- Routine Care Group
- Specialty Care Group
- Labor & Delivery Services Group
- Intermediate Care Services (Ancillary Services Group 1)
- All Other Non-Accommodation Cost Centers (Ancillary Services Group 2)
- Emergency Services Group

The Routine Care, Specialty Care, Labor & Delivery, and two Ancillary Services Groups are used for calculation of the inpatient CCR. The Emergency Services Group is used to calculate the emergency department CCR.

There are several reasons that the service groupings are used in the calculations. First, grouping standard cost centers can lessen the impact of data entry errors at the hospital level and limit the effect of any misalignment in the mapping of cost and charge data from the hospital accounting systems to the HCRIS cost centers. Second, the proportion of charges attributed to inpatient stays is used to calculate costs, and this proportion varies markedly across service groups. As such, inpatient charge proportions based on service groups should produce more accurate cost estimates than those based on all cost centers. Third, the creation of service-group-level CCRs allows for more sensitive data quality checks (i.e., outlier identification).

Table 1. Assignment of HCRIS Cost Centers to HCUP Service Groups

HCRIS Standard Cost Center Description	Inpatient CCRs					Emergency Department CCRs
	Routine Care Group	Specialty Care Group	Labor & Delivery Group	Ancillary Services Group 1	Ancillary Services Group 2	Emergency Services Group
Adults & Pediatrics (General Routine Care)	X					
Intensive Care Unit		X				
Coronary Care Unit		X				
Burn Intensive Care Unit		X				
Surgical Intensive Care Unit		X				
Other Intensive Care		X				
Inpatient Psychiatric Facility Subprovider				X		
Inpatient Rehabilitation Facility Subprovider				X		
Other Subprovider				X		
Nursery		X				
Skilled Nursing Facility				X		
Nursing Facility				X		
Other Long-Term Care				X		
Operating Room, Endoscopy, Prostheses					X	
Recovery Room					X	
Delivery Room & Labor Room			X			
Anesthesiology & Acupuncture					X	
Radiology-Diagnostic					X	X
Radiology-Therapeutic					X	
Radioisotope					X	

HCRIS Standard Cost Center Description	Inpatient CCRs					Emergency Department CCRs
	Routine Care Group	Specialty Care Group	Labor & Delivery Group	Ancillary Services Group 1	Ancillary Services Group 2	Emergency Services Group
CAT Scan					X	X
MRI					X	
Cardiac Catheterization Lab					X	
Laboratory					X	X
PBP Clinical Lab Service Program Only					X	
Whole Blood & Packed Red Blood Cells					X	
Blood Storing, Processing, & Transfusing					X	
Intravenous Therapy					X	
Respiratory Therapy					X	
Physical Therapy					X	
Occupational Therapy					X	
Speech Pathology					X	
Electrocardiology					X	
Electroencephalography					X	
Medical Supplies Charged to Patients					X	
Implants Charged to Patients					X	
Drugs Charged to Patients					X	X
Renal Dialysis					X	
Ambulatory Surgery Center (Non-distinct Part)					X	
Other Ancillary					X	
Rural Health Clinic					X	
Federally Qualified Health Center					X	
Clinic					X	
Emergency Room					X	X
Observation Beds					X	X
Other Outpatient Service					X	
Home Program Dialysis					X	
Ambulance Services					X	
Durable Medical Equipment -Rented					X	
Durable Medical Equipment -Sold					X	

HCRIS Standard Cost Center Description	Inpatient CCRs					Emergency Department CCRs
	Routine Care Group	Specialty Care Group	Labor & Delivery Group	Ancillary Services Group 1	Ancillary Services Group 2	Emergency Services Group
Other Reimbursable Cost Centers (excluding Home Health Agency and Comprehensive Outpatient Rehabilitation Facility)					X	

Abbreviations: CAT, computerized axial tomography; CCR, cost-to-charge ratio; HCRIS, Healthcare Cost Report Information System; HCUP, Healthcare Cost and Utilization Project; MRI, magnetic resonance imaging; PRP, provider-based physician.

Calculation of Inpatient CCRs

Calculation of the inpatient CCRs proceeds as follows:

- For each hospital and service group (Routine, Specialty, Labor & Delivery, Ancillary 1, and Ancillary 2), inpatient charges, outpatient charges, and total costs are summed.
- Next, by hospital and service group, total costs are transformed to estimated inpatient costs by multiplying the proportion of inpatient charges and total costs. (Note that Ancillary Services Group 2 is the only service group with outpatient charges and is thus the only service group for which estimated inpatient costs are in practice calculated.)
- Following this, Ancillary Services Groups 1 and 2 are combined into one Ancillary Services Group.
- Service-group-level inpatient CCRs are calculated as the ratio of estimated inpatient costs to inpatient charges.
- Hospital-level inpatient CCRs are calculated by summing the service group inpatient costs and then dividing by the sum of the service group charges.

Inpatient CCR Quality Control Edits

Some hospitals submit data to HCRIS that result in calculated CCRs that are extremely large or small. HCUP employs data quality edits to ensure that hospital-specific inpatient CCRs are in a reasonable range (i.e., are not outliers). A hospital-specific inpatient CCR is set to missing (masked) if any of the following conditions are met:

- The hospital cost report is not present in HCRIS, is incomplete, or has a reporting period of less than 180 days.
- The HCUP hospital ID cannot be linked to the hospital cost report.
- The hospital is identified as a CCR outlier, based on any of the following conditions being true:
    - The Routine Care Group inpatient CCR is less than 0 or greater than 4.
    - The Labor & Delivery Group inpatient CCR is greater than 4.
    - The Specialty Care Group inpatient CCR is greater than 4.
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    - The Combined Ancillary Services Group CCR is less than 0 or greater than 4.
    - The hospital-wide inpatient CCR is less than 0.05 or greater than 2.

CREATION OF CCRS FOR EMERGENCY DEPARTMENT SERVICES

Definition of HCUP Emergency Services Group

The following six cost report standard cost centers were selected for the HCUP Emergency Services Group (see Table 1): Emergency Department, CAT Scan, Laboratory, Drugs Charged to Patients (Pharmacy), Diagnostic Radiology, and Observation Beds.

These cost centers were chosen based on the distribution of charges, by cost center, for the 2017 HCUP State Emergency Department Databases (SEDD). Summed, these costs centers accounted for approximately 90 percent of the charges associated with emergency department treat-and-release visits in the SEDD.

Calculation of Emergency Department CCRs

Calculation of the emergency department CCRs proceeds as follows:

- For each hospital, inpatient charges, outpatient charges, and costs are summed for cost centers in the Emergency Services Group.
- By hospital, total costs for emergency services are transformed to estimated outpatient costs by multiplying total costs by the proportion of outpatient charges.
- Finally, the emergency department CCR is calculated as the quotient of emergency services outpatient costs and charges. Note that this CCR is applicable to treat-and-release (outpatient) emergency department encounters because it is based on outpatient charges and estimated outpatient costs.

Emergency Department CCR Quality Control Edits

The quality control edits for the emergency department CCRs include those noted above for the inpatient CCRs and contain one additional check. A hospital-specific emergency department CCR is set to missing (masked) if any of the following conditions are met:

- The hospital cost report is not present in HCRIS, is incomplete, or has a reporting period of less than 180 days.
- The HCUP hospital ID cannot be linked to the hospital cost report.
- The hospital is identified as a CCR outlier, based on any of the following conditions being true:
    - The Routine Care Group inpatient CCR is less than 0 or greater than 4.
    - The Labor & Delivery Group inpatient CCR is greater than 4.
    - The Specialty Care Group inpatient CCR is greater than 4.
    - The Combined Ancillary Services Group CCR is less than 0 or greater than 4.
    - The hospital-wide inpatient CCR is less than 0.05 or greater than 2.
    - The Emergency Services Group CCR is less than 0 or greater than 4.

IMPUTATION OF CCRS

Following the inpatient and emergency department CCR edits for data quality and outlier detection, there will be hospitals with CCRs marked as unusable, based on the criteria just described, for both inpatient and emergency department CCRs. In both cases, imputations are performed so that a CCR is assigned to all HCUP hospitals.

The imputation model creates estimated CCRs by using either the hospital type average within State or the State average if hospital sample size is insufficient. Seven hospital type categories are employed:

1. Investor-owned, under 100 beds
2. Investor-owned, 100 or more beds
3. Not-for-profit, rural, under 100 beds
4. Not-for-profit, rural, 100 or more beds
5. Not-for-profit, urban, under 100 beds
6. Not-for-profit, urban, 100–299 beds
7. Not-for-profit, urban, 300 or more beds

The imputation model is built by computing mean CCRs for hospitals passing the inpatient or emergency department CCR edit checks described above. Averages are computed by State, and by hospital type within State, weighting by number of hospital beds. HCUP hospitals with missing CCRs are assigned imputed CCRs by hospital type; if this is not possible due to missing data on hospital type, the State average CCR is assigned.

How frequently is the imputation process used? In 2019, the inpatient CCR File contained hospital-specific CCRs for 4,240 HCUP hospitals (83.7 percent). A total of 824 hospitals (16.3 percent) were assigned group average CCRs, with all but 4 imputations calculated by hospital type within State. Among the 3,646 hospitals in the emergency department CCR File in 2017, 3,297 had a hospital-specific CCR assigned (90.4 percent), 336 were assigned imputed ratios by hospital type within State (9.2 percent), and 13 used State averages. Table 2 shows the breakdown of CCR type by data source.

Table 2. 2019 SID and SEDD CCR Imputation Frequencies

Hospital CCR Assignment Category	State Inpatient Databases (SID)		State Emergency Department Databases (SEDD)	
	Number of Hospitals	Percent of Hospitals	Number of Hospitals	Percent of Hospitals
All hospitals	5,068	100.0	3,646	100.0
Hospital-specific CCR assigned	4,240	83.7	3,297	90.4
Imputed CCR: hospital type within State	824	16.3	336	9.2
Imputed CCR: State only	4	0.1	13	0.4

Abbreviation: CCR, cost-to-charge ratio.

USE OF CCRS WITH HCUP STATE AND NATIONWIDE DATABASES

The CCRs are delivered as supplemental files that can be linked with the HCUP SID, SEDD, NIS, KID, NEDS, and NRD. These HCUP databases contain total charges for each discharge or visit. Each hospital's CCR can be linked to the HCUP data file using the appropriate HCUP hospital identifier variable. See the inpatient CCR User Guide[7] and emergency department CCR User Guide[8] for information on linking the CCR supplemental file to State and nationwide databases. These user guides provide implementation details on how inpatient and emergency department service delivery costs can be calculated from information in the HCUP CCR Files.

For all available data years of the CCR for Central Distributor (CD)-SID and CD-SEDD and through data year 2011 for the CCR-NIS and CCR-KID, the hospital-specific all-payer CCR and the hospital group average all-payer CCR are provided when available. For the CCR for CD-SID and CD-SEDD, AHRQ routinely masks the hospital-specific CCRs for all States that restrict their hospital identification on the SID or SEDD; in addition, the hospital-specific CCR may be masked at the request of the HCUP Partner. Thus, for CCR Files corresponding to the SID and SEDD, hospital-specific CCR values may be suppressed for that reason, in addition to the conditions for suppression noted above.

For all available data years of the CCR-NRD and CCR-NEDS, and beginning with the 2012 CCR-NIS and CCR-KID, a single CCR is provided, with values based on the hospital-specific all-payer CCR when available or the group average all-payer CCR otherwise. The CCRs in these files are randomly perturbed and capped at a value of 1.87 in order to preserve hospital anonymity. The 2012 change to the CCR data element in the CCR-NIS and CCR-KID was intended to enhance the confidentiality of the databases. These changes did not affect statistical reliability of the estimates.

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[7] Agency for Healthcare Research and Quality. User Guide: Cost-to-Charge Ratio (CCR) for Inpatient Files. Healthcare Cost and Utilization Project. October 2021. www.hcup-us.ahrq.gov/db/ccr/ip-ccr/IPCCR-UserGuide-2012-2019.pdf,. Accessed December 8, 2021.

[8] Agency for Healthcare Research and Quality. User Guide: Cost-to-Charge Ratio (CCR) for Emergency Department Files. Healthcare Cost and Utilization Project. October 2021. www.hcup-us.ahrq.gov/db/ccr/ed-ccr/EDCCR-UserGuide-2012-2019.pdf. Accessed December 8, 2021.