SECTION 2: MEASUREMENT

Measuring the Cost of Neonatal and Perinatal Care

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ABSTRACT. **This article provides an overview of neonatal intensive care unit (NICU) treatment costs. It discusses data sources as well as the methods for measuring costs, contrasting the strengths and weaknesses of alternate approaches. In addition, detailed information on NICU treatment costs is presented from a nationally representative sample of 25 hospitals with NICUs. The sample consists of 3288 very low birth weight infants (≤1500 g at birth) with admission dates between January 1, 1993, and September 30, 1994. Information on median treatment cost per infant, ancillary costs, accommodation costs, length of stay, and cost per day are presented. In addition, ancillary costs are disaggregated further into those for respiratory therapy, laboratory, radiology, pharmacy, and all other ancillary services. *Pediatrics* 1999;103: 329–335; *NICU cost, VLBW cost.***

ABBREVIATIONS. NICU, neonatal intensive care unit; VLBW, very low birth weight; HCFA, Health Care Financing Administration; AHA, American Hospital Association.

Although advances in neonatal technology in the past decades have improved survival prospects significantly for infants born prematurely, these have come at a high cost. Neonatal intensive care stays are among the most expensive types of hospitalizations.[1] Quality improvement efforts will affect treatment costs because they will alter, in some way, the resources used in patient care. Because of the high cost associated with each day spent in the neonatal intensive care unit (NICU), quality improvement efforts that result in better patient outcomes and reduce the time spent in the NICU can potentially produce significant cost savings. However, treatment costs also may rise, because not all quality improvement efforts will necessarily reduce the resources used in patient care.

In this article, we first discuss how NICU treatment costs are measured. We then turn to a discussion of how treatment costs can be compared across institutions and, finally, present recent evidence of what is known about the costs of neonatal intensive care based on data obtained from the Cost and Resource Utilization project in the Vermont Oxford Network.

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MEASURING COSTS

Treatment costs often are measured by charges in the literature. Yet, charges for hospital stays are not accurate measures of cost, because they confound the actual costs of treatment with the pricing policies of hospitals. This is particularly problematic for comparisons across hospitals, for which pricing policies can vary widely. In a study of very low birth weight (VLBW) infants in the California Medicaid population, Rogowski and Harrison[2] found that the average charge for the initial hospitalization overestimated treatment costs by 53%.

However, even for comparisons of patients within a given hospital, the total charge for a patient's care is not an accurate measure of the cost of treatment. This is because the same mark-up is not applied to all services provided by a hospital. In fact, wide variation often exits in the mark-up rates for individual services within hospitals. As an example, different mark-ups are likely to be applied to respiratory care supplies than to antibiotics. The total charge for a given patient reflects the composition of services used in treatment and the size of the mark-ups applied to those services. Thus, the total charge represents a different mark-up over costs for each patient, depending on the types and amounts of services used in their treatment.

To measure treatment costs, therefore, it is necessary to disentangle the pricing policies of hospitals from data on charges. Figure 1 delineates the creation of hospital cost measures from data on hospital charges. These follow methods established in the literature.[3,4]

The basis for all measurements of hospital costs is data on hospital charges. Data on hospital charges can be obtained from several sources, including detailed bills, UB-92 forms, and state-mandated hospital charge abstracts. Each of these data sources varies in the level of detail on charges provided. The most detailed data are line-item bills. These list each service provided during the patient's stay with the associated charge. Such data, for a typical neonatal intensive care stay, are voluminous. For a typical hospital, there may be 10 000 charge codes used to create detailed patient bills. Alternately, more aggregated data exist on UB-92 forms. The UB-92 form is the standard Medicare bill and contains information on charges that is more aggregated than a detailed bill. Although few neonatal intensive care stays are billed to Medicare, most hospitals generate these forms for other types of patients as well, and this

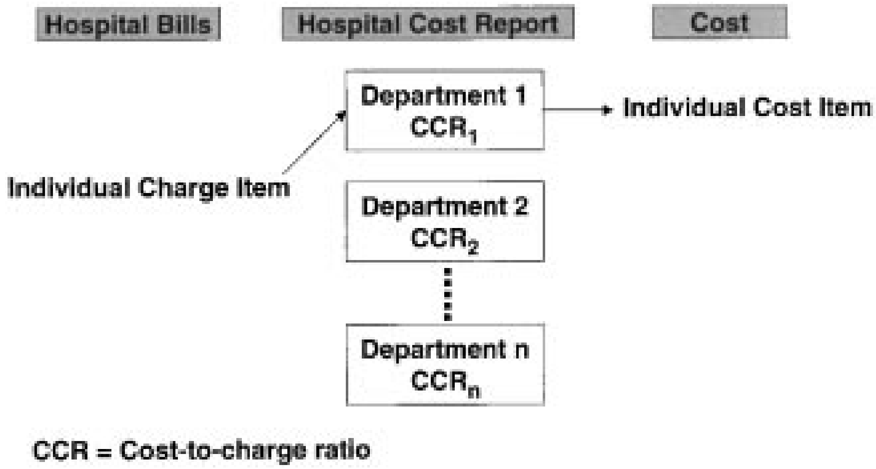

Fig 1. Measuring hospital costs.

type of data also can be used for measuring treatment costs for neonates. Data on these forms are aggregated to the UB code level. The UB codes are a list of standard codes for the types of services provided by hospitals. In contrast to detailed charge codes, there are approximately 100 UB-92 codes (and several hundred subcodes). As an example, the UB code for pharmacy is defined as "charges for medication produced, manufactured, packaged, controlled, assayed, dispensed and distributed under the direction of a licensed pharmacist." Additional subcategories may be used by hospitals for such items as generic drugs, nongeneric drugs, and intravenous solutions. Hospitals vary in their use of subcodes. Nonetheless, these types of data are aggregated and considerably less complex to use than are detailed line-item bills. Finally, data also exist as part of state-mandated hospital discharge abstracts. For example, the state of California mandates that data on all hospital discharges be provided to the Office of Statewide Health Planning and Development. These discharge abstracts contain information on the total charge for each stay. For the reasons noted above, a single total charge may not provide a good basis for the measurement of costs. However, detailed line-item bills, as well as UB-92 forms, provide good bases for the measurement of treatment costs.

As shown in Fig 1, data on an individual charge from a patient bill must be converted to a measure of cost. Then, the costs associated with each individual charge item are summed to arrive at the total cost associated with the stay. The key to the cost conversion methodology is the conversion factor, known as a cost-to-charge ratio, which is used to multiply each individual charge to create a measure of cost. These ratios are derived from hospital cost reports. A hospital cost report is a standard financial reporting form generated each year by hospitals as part of reporting requirements imposed by such large insurers as the Health Care Financing Administration (HCFA) for the Medicare program (form HCFA-2552) and, in some states, by regulatory agencies. For example, in the state of California, all hospitals are required to file a cost report to the Office of Statewide Health Planning and Development each year. Reports for HCFA and for individual state regulatory agencies are different. For example, the California cost reports contain more revenue-generating centers than do the HCFA cost reports and thus are more disaggregated (both of these types of reports are available publicly).

The aspect of cost reports that makes them valuable for cost measurement purposes is that for each revenue-generating center in the hospital, the cost report provides information from which a cost-to-charge ratio can be constructed. This ratio represents the average mark-up applied to services within that revenue-generating center during the reporting year. An example of a revenue-generating center is the laboratory; patients are billed for services provided by the laboratory. An example of a nonrevenue-generating activity are the services provided by hospital's administrators, which cannot be directly billed to patients. The charges on a patient's bill are generated only by revenue-generating centers within the hospital. Thus, the cost report provides conversion factors for all the charges that appear on the patient bill. Of course, individual charges have to be mapped to revenue-generating centers. This can be a nontrivial exercise. Cost reports generally contain 25 to 50 revenue-generating centers. UB-92 forms may contain hundreds of UB codes (with subcategories), whereas detailed line items contain thousands of codes.

The limitation of this cost conversion method is that a uniform factor is applied to all services within a given department in the hospital. Thus, the method will be most accurate when there is low variance in mark-up rates within departments. In addition, the measures of cost will be most accurate for a given patient population to be studied (in this case, neonates) when the services used by that patient population in a given department have a similar distribution of mark-ups as the services used by the general patient population in the hospital.

Ideally, one would have a cost-to-charge ratio for each detailed line item. In practice, however, this is not possible, and departmental cost-to-charge ratios are the best types of data available. However, software from commercial vendors generally create measures of cost based on more disaggregated data than those typically available on cost reports. However, unless all hospitals use exactly the same commercial software, measures of treatment cost will not be comparable across hospitals because of differences in indirect cost allocations. The allocation of indirect costs is a key issue in the uniform measurement of treatment costs across institutions.

Indirect costs are those that cannot be billed directly to patients. These include, for example, items such as administrator salaries. Figure 2 illustrates how hospital cost reports allocate indirect costs to revenue-generating centers. The cost report contains information on the direct costs associated with each revenue-generating center during the reporting period covered by the cost report. In addition, all indirect costs from the nonrevenue-generating centers are allocated to these revenue-generating centers. Indirect cost allocations are made using accounting rules that are sometimes arbitrary, such as those based on the square footage occupied by the department. From the perspective of cost measurement, however, the use of a single cost-reporting instrument for all hospitals ensures that these allocations are made in a uniform manner across all hospitals. Because indirect costs can be substantial, the use of uniform cost-reporting instruments is necessary to create measures of treatment cost that are comparable across institutions.

The HCFA cost-reporting instrument is the only method readily available that provides for the creation of uniform cost measures across hospitals located in geographically diverse areas in the United States. The HCFA cost report, however, incorporates information for all patients treated in the hospital, not just for the population of interest here, neonates. In particular, neonatal intensive care and adult intensive care are combined into a single department. (Coronary intensive care and special care are separated into their own departments.) Thus, from a measurement perspective, the question arises as to how different the adult and neonatal intensive care cost-to-charge ratios are. The nursing intensity of the NICU is higher than that for adult intensive care. On the other hand, indirect allocations are made based on floor space. In a study of the costing of pediatric services, Miller[5] found that the NICU had disproportionately low allocations of indirect costs because of the small floor space occupied by these units. These two factors work in opposite directions, suggesting that the use of the HCFA cost-reporting instrument for the measurement of accommodation costs will not be subject to large measurement errors. There are no studies that address this issue directly. However, as a partial test of this hypothesis, in the study of VLBW infants in California, Rogowski and Harrison[6] compared ratios constructed for NICUs only with those that were constructed pooling adult and neonatal intensive care units and found the differences to be quantitatively small.

Similarly, the question arises as to how similar the cost of ancillary services used by neonates are to those incurred by adults. The Pediatric Costing Study[5] provided some evidence on this point as well. The study concluded that among the major ancillary services (such as laboratory, radiology, pharmacy, and medical supplies), the cost of those used by children did not differ significantly from those used by adults. Thus, in general, the HCFA cost-reporting form, although not designed specifically to measure neonatal intensive care costs, is a good source of cost conversion data for NICU patients. Its primary advantage is its universality, which should be weighed against any potential limitations in measurement.

Many hospitals have software from commercial vendors to measure treatment costs. In interpreting cost measures from commercial vendors, it is important to note that these will not necessarily be identical to those created using other methods, such as using the HCFA cost report because indirect cost allocations are made in different ways. Similarly, comparisons across hospitals of treatment costs generated by different commercial software packages will be noncomparable.

Finally, it should be noted that hospital costs, as measured from the hospital bill, include only the institutional portion of the stay. Physician costs also are an important component of the overall cost of the hospital stay. However, information on physician charges is difficult to obtain in a manner that captures all physician care provided. Most physicians or physician groups bill directly for their services, and collection of comprehensive billing data therefore are difficult. It is possible, however, to observe physician

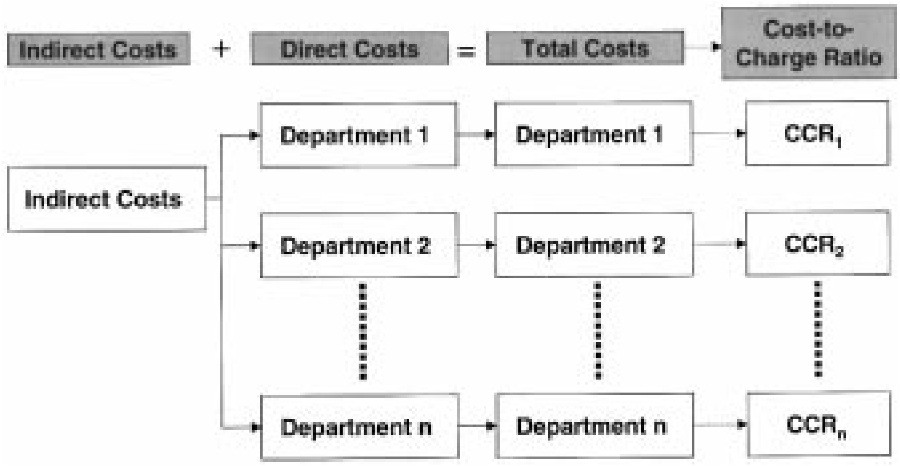

Fig 2. Hospital cost reports.

costs in studies that are conducted on certain groups of insured patients because all claims can be observed. For example, in a study of VLBW infants in the California Medicaid population, Rogowski and Harrison[2] found that physician costs represented 16.7% of the cost of the initial hospitalization.

COMPARING COSTS ACROSS INSTITUTIONS

From the section above on cost measurement, a number of important points emerge with respect to comparing treatment costs across hospitals. The first is that charges for the patients are not accurate measures of treatment costs, neither for comparisons of treatment costs across patients within a given hospital nor for comparisons across hospitals. Charges are particularly problematic for multiinstitutional comparisons, because they confound information on costs with the pricing policies of individual hospitals. The second is that it is possible to create measures of treatment cost from charge data. The important point to note in multiinstitutional comparisons is that exactly the same method for measuring costs must be applied across all institutions so that indirect cost allocations are made uniformly. Otherwise, the cost measures will be noncomparable. Cost measurement based on the HCFA cost reports is the only methodology available currently for the creation of uniform costs across hospitals at the national level.

In addition, in comparing costs across hospitals, several other factors need to be taken into consideration. First, the cost of hospital inputs, both labor and capital, varies widely across different regions of the United States. For example, hospitals in New York City will have higher input costs than those located in rural Iowa. The goal of comparing costs across institutions is to compare the efficiency of providing patient care. Thus, the ideal measure of costs would be one that controlled for differences in the costs labor and capital across hospitals. Fortunately, it is possible to do this, because measures of the cost of hospital inputs have been created by HCFA for use in adjusting DRG payments to hospitals for differences in these costs under Medicare's prospective payment system. These adjustment factors are published annually in the *Federal Register* as part of the updates to the Medicare program regulations. Use of geographic adjustment factors permits the computation of costs as if each hospital faced the average cost of labor and capital in the United States. This type of cost measure typically is not provided by commercial vendors. Finally, because of inflation, costs must be adjusted, if necessary to reflect differences in the year in which they were incurred. The standard inflation adjustment is based on the medical component of the consumer price index, which is generated annually by the US Bureau of Labor Statistics (for example, see BLS[7]).

In benchmarking costs across institutions, it also is important to adjust for the severity of illness of patients across hospitals. Because costs are related to illness severity, failure to adjust for differences in case mix will penalize hospitals with more severely ill patients. However, few sources of data exist to create adjusters for the NICU patient mix. For example, few hospitals collect information on birth weight in their data systems. To some extent, the more refined versions of the DRG grouper, which contain breakdowns by birth weight groups, provide a means to adjust for differences across hospitals in case mix.[8] Data systems such as the Vermont Oxford Network are particularly valuable for this purpose, because the Network collects data on clinically important patient characteristics that can be linked to cost data to be able to adjust treatment costs observed for differences across hospitals in patient mix.

Finally, in benchmarking costs, it often is desirable to compare costs with a peer group of institutions. When patient mix is not observable, selecting hospitals that treat similar types of patients is one way to proxy for the mix of patients. In addition, hospital costs are known to vary with hospital characteristics. For instance, teaching hospitals have higher costs than do nonteaching hospitals.[9] Thus, the ability to compare costs across a peer group of institutions often is desirable by hospital administrators. Commercial data systems often are limited in this regard. Commercial reporting services can only benchmark data across the hospitals that subscribe to their services. The number of hospitals with NICUs typically is small. In addition, the comparison units may be quite different, ranging from tertiary centers to hospitals with small level-two units. Some hospitals have organized into peer groups for such comparison purposes, such as a number of children's hospitals. Data systems with large numbers of NICUs such as the Vermont Oxford Network provide a large set of hospitals for finding a peer group of institutions. Finally, when comparing cost data across hospitals, it is important to consider differences in transfer policies. The length of stay and, therefore, cost of an infant at an individual hospital may vary considerably depending on their transfer status.

COSTS OF NEONATAL INTENSIVE CARE—RECENT EVIDENCE

In this section, we provide information on treatment costs for VLBW infants that were created as part of the Cost and Resource Utilization Study of the Vermont Oxford Network (with funding from the Center for the Future of Children of the David and Lucile Packard Foundation). The study collected information on treatment costs in 25 hospitals in the Vermont Oxford Network.[10] Data on treatment costs are provided in Tables 1 and 2 for infants admitted to those hospitals between January 1, 1993, and September 30, 1994 ($N = 3288$). The sample of infants in the study are those enrolled in the Vermont Oxford database, excluding delivery room deaths. Infants enrolled in the database have birth weights between 501 g and 1500 g, and were admitted to the hospital's NICU within 28 days of birth.

The characteristics of the sample of hospitals is presented in Table 3. Comparisons are made to the universe of hospitals in the United States as defined in the 1992 Annual Survey of Hospitals by the American Hospital Association (AHA). In that year, 796 hospitals reported having some neonatal intensive care beds. An intensive care unit was defined as one

TABLE 1. Median Treatment Costs and Length of Stay for Very Low Birth Weight Infants

	N	Total Cost	Accommodation Cost	Ancillary Cost	Length of Stay	Cost Per Day
All infants	3288	$49 457	$35 521	$13 872	49	$1115
Birth weight						
501–750 g	601	$89 546	$59 318	$28 094	79	$1483
751–1000 g	811	$78 455	$54 259	$23 288	72	$1200
1001–1250 g	861	$49 097	$35 460	$13 376	49	$1059
1251–1500 g	1015	$31 531	$24 609	$ 6224	35	$ 932
Gestational age						
<24 Wk	95	$ 6874	$ 1534	$ 4044	1	$2346
24–26 Wk	772	$95 560	$64 300	$30 430	82	$1372
27–29 Wk	1237	$61 724	$43 543	$17 663	58	$1133
30–32 Wk	916	$35 106	$26 846	$ 7235	39	$ 945
>32 Wk	268	$19 295	$16 104	$ 3099	25	$ 854
Location of birth						
Inborn	2574	$48 973	$35 292	$13 694	49	$1083
Outborn	714	$50 922	$36 358	$14 745	46	$1239
Discharge status						
Died on day 1	92	$ 2435	$ 968	$ 1517	1	$2423
Died after day 1	326	$19 548	$ 7633	$11 667	8	$2443
Transferred	556	$33 953	$23 848	$ 9973	29	$1226
Home	2314	$59 608	$42 795	$15 992	59	$1030

Note: Admissions are from 1/1/93 to 9/30/94. All dollar amounts are in 1994 constant dollars.

TABLE 2. Median Ancillary Costs for Very Low Birth Weight Infants

	N	Total Ancillary Cost	Respiratory Therapy	Laboratory	Radiology	Pharmacy	Other Ancillary	Ancillary Cost Per Day
All infants	3288	$13 872	$ 3112	$3308	$ 942	$2258	2474	$ 323
Birth weight								
501–750 g	601	$28 094	$ 8678	$6550	$1671	$3717	4054	$ 546
751–1000 g	811	$23 288	$ 7421	$5494	$1475	$3668	3726	$ 382
1001–1250 g	861	$13 376	$ 2884	$3205	$ 900	$2195	2554	$ 301
1251–1500 g	1015	$ 6224	$ 1044	$1720	$ 473	$1101	1382	$ 194
Gestational age								
<24 Wk	95	$ 4044	$ 718	$1400	$ 418	$1356	650	$1414
24–26 Wk	772	$30 430	$10 212	$7272	$1830	$4507	4336	$ 493
27–29 Wk	1237	$17 663	$ 4974	$3985	$1130	$2920	3132	$ 331
30–32 Wk	916	$ 7235	$ 1209	$2010	$ 558	$1312	1583	$ 208
>32 Wk	268	$ 3099	$ 301	$1037	$ 267	$ 431	769	$ 134
Location of birth								
Inborn	2574	$13 694	$ 3049	$3267	$ 900	$2181	2409	$ 309
Outborn	714	$14 745	$ 3510	$3401	$1184	$2708	2762	$ 389
Discharge status								
Died on day 1	92	$ 1517	$ 195	$360	$ 178	$ 336	263	$1500
Died after day 1	326	$11 667	$ 2077	$3703	$1199	$2015	2068	$1446
Transferred	556	$ 9973	$ 2079	$2466	$ 706	$2071	1681	$ 387
Home	2314	$15 992	$ 4062	$3628	$1047	$2489	3002	$ 272

NOTE: Admissions are from 1/1/93 to 9/30/94. All dollar amounts are in 1994 constant dollars.

that is "separate from the newborn nursery providing intensive care to all sick infants including those with the very lowest birthweights (less than 1500 g). NICU has the potential for providing mechanical ventilation, neonatal surgery and special care for the sickest infants born in the hospital or transferred from another institution. A full-time neonatologist serves as director of the NICU." In 1992, 984 hospitals reported having any neonatal intensive or intermediate care beds. A neonatal intermediate care unit is defined as one that is "separate from the normal newborn nursery and that provides intermediate and/or recovery care and some specialized services including immediate resuscitation, intravenous therapy, and capacity for prolonged oxygen therapy and monitoring." As shown in Table 3, the sample of hospitals in the Cost and Resource Utilization Study generally are larger hospitals than the universe of hospitals with NICU beds (a total bed size of 454 compared with 398), and also have more NICU beds (24.5 vs 17.1) and more neonatal intermediate care beds (6.2 vs 4.0). They also are more heavily weighted toward teaching and children's hospitals. The geographic distribution is fairly similar to the universe of hospitals with NICUs, but with fewer hospitals in the South and more in the Central regions of the United States. The study hospitals also are more likely to be located in cities of population between 250 000 and 2.5 million, but are less likely to be located in the largest metropolitan areas (>2.5 million in population). They also are more likely to be private, nonprofit organizations and less likely to be for-profit or public hospitals.

Table 1 presents information on treatment costs for these infants, in 1994 constant dollars. The median treatment cost across all infants was $49 457, with an average length of stay of 49 days. Treatment costs have a long right tail, however, with some patients

TABLE 3. Characteristics of Hospital Sample (Percentage Distribution)

	AHA Hospitals With Any NICU Beds (N = 796)	AHA Hospitals With Any NICU or Intermediate Beds (N = 984)	Study Hospitals (N = 25)
Ownership			
Public	18.0	17.2	4.0
Private nonprofit	73.6	73.4	92.0
Private for-profit	8.4	9.5	4.0
Rural population	6.5	8.4	4.0
Urban population	93.5	91.6	96.0
<100 000	1.6	1.9	4.0
100 000–250 000	10.4	10.6	4.0
250 000–500 000	14.2	13.8	20.0
500 000–1 000 000	13.4	12.6	28.0
1 000 000–2 500 000	24.7	24.1	32.0
>2 500 000	29.0	28.6	8.0
Region			
Northeast	18.8	19.4	16.0
South	37.7	38.0	20.0
Central	22.0	21.8	44.0
West	21.5	20.7	20.0
Teaching	47.7	43.1	64.0
Children's hospital	5.0	4.2	12.0
Hospital bed size	398	374	454
NICU beds	17.1	13.8	24.5
Intermediate beds	4.0	4.7	6.2
Total NICU and intermediate beds	21.1	18.5	30.7

Source: 1992 American Hospital Association Annual Survey of Hospitals.

being very expensive to treat. The 90th percentile of treatment costs in the sample of infants in the study was $130 377, with a maximum of $889 136. Length of stay is similarly skewed, with the 90th percentile being 99 days and the longest length of stay 632 days.

Treatment cost varies inversely with birth weight, with a median treatment cost of $89 546 for infants with birth weights between 501 g and 750 g and $31 531 for infants in the 1251 g to 1500 g range. This reflects differences in both the median length of stay, which decreases with birth weight, and in the intensity of treatment during each day of the stay. Median cost per day also is inversely related to birth weight.

As seen in breakdowns by discharge status, infants who died in the NICU, whether on day 1 or after day 1, had median costs per day that were at least twice as high those for infants who went home or were transferred to another hospital. Infants who were outborn had higher costs than those who were inborn. Both length of stay and median costs per day were higher for outborn infants.

Treatment costs also vary with gestational age, being highest for infants with gestational ages between 24 and 26 weeks. These infants have the longest median lengths of stay, at 82 days. However, although cost per day decreases with gestational age after 24 weeks, the highest costs per day are for infants with gestational ages <24 weeks, averaging $2346, which is 70% higher than the cost per day of infants in the next highest gestational age range. This is likely to attributable to the higher rates of death among these infants.

Accommodation costs account for the majority of overall treatment costs. The median accommodation cost is $35 521, compared with a median ancillary cost of $13 872. However, some infants have very high accommodation and ancillary costs. The 90th percentile of accommodation costs among infants in the study was $85 568, with maximum of $454 899. Ancillary costs are similarly skewed. The 90th percentile of ancillary costs is $46 175, with a maximum of $434 236.

Table 2 provides information on the breakdowns of ancillary costs by the major types of ancillary services: respiratory therapy, laboratory, radiology, pharmacy, and all other ancillary services. Overall, median ancillary service costs are related inversely to birth weight, with sharp drops in ancillary costs at 1000 g of birth weight. For instance, infants with birth weights that are 1001 to 1250 g have median ancillary costs that are approximately half of those for infants with lower birth weights. Ancillary costs per day in the hospital also are inversely related to birth weight.

Infants who are discharged home from the hospital have the highest total ancillary cost, with a median of $15 992 compared with $11 667 for infants who died after day 1, and lower amounts for other infants (who were either transferred or died on day 1). However, infants who died after the first day in the hospital had a median length of stay of 8 days compared with 59 for infants who went home, reflecting a high use of ancillary services among infants who eventually die during their hospital stay. This is reflected in the high ancillary costs per day for children who died (~$1500), compared with those who went home ($272) or were transferred ($387).

Median ancillary costs are highest for infants with gestational ages of 24 to 26 weeks. However, ancillary costs per day are much higher for infants with gestational ages <24 weeks than for all other groups ($1414 compared with $493 for the next highest gestational age group). This undoubtedly is related to their higher mortality rates. Ancillary costs are approximately comparable for inborn and outborn infants, although costs per day in the hospital are somewhat higher for outborn infants ($389 vs $309).

Respiratory care costs had a median value of $3112, with the highest costs incurred by infants with birth weights <750 g and with gestational ages of 24 to 26 weeks. Respiratory care costs were almost twice as high for infants who went home than for those who were transferred or died (after day 1), $4100 compared with $2100. Respiratory care costs also are highly skewed, with the 90th percentile in the sample being $16 125 and the maximum $237 032.

Laboratory care costs had a median value of $3308 for infants in the study. These costs are related inversely to birth weight and are highest for infants with gestational ages between 24 and 26 weeks, with a median value of $10 212. Laboratory costs are highest for infants who die after day 1, closely followed by infants who go home. Again the former group has a much shorter length of stay, providing evidence of fairly intensive use of laboratory services for infants who die. Laboratory services also are skewed, with the 90th percentile in the sample being $11 480 and the maximum $50 405.

The median radiology cost is $942. Radiology costs follow the same general pattern as do laboratory costs. They also are skewed, with the 90th percentile being $3613 and the maximum $23 713.

Median pharmacy costs are $2258. They are comparable between infants who died (after day 1) and infants who were transferred, with somewhat higher costs for infants going home. Again, pharmacy costs are skewed, with some patients having high costs. The 90th percentile of pharmacy costs is $7806, with a maximum of $144 993.

Finally, all other ancillary costs, including such items as medical supplies, account for $2474 in median costs. Because this is a residual category, it is difficult to interpret the observed patterns.

CONCLUSION

Neonatal intensive care costs are high. Quality improvement efforts will likely change the resources used in patient care and thus treatment costs. With existing data from hospital billing systems, it is possible to create measures of treatment costs in a way that provides comparability across institutions. Use of comparable data are important to be able to properly assess the effects of quality improvement efforts on treatment costs. Quality improvement efforts may increase or decrease costs depending on how they affect resources used in patient care. However, given the high cost of these stays, improvements in patient outcomes that reduce the time spent in the NICU have the potential to create significant cost savings, which may, in some cases, offset institutional investments into quality improvement efforts.

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