Chapter 2

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INTRODUCTION

With the evolution of perinatal medicine and the development of associated medical technology in the 1960s, many hospitals introduced neonatal intensive care units (NICUs). Intensive care units for adults had already been established in most hospitals, and the similar needs of newborns for sophisticated, intensive treatment became apparent (15). In the United States, the primary growth in special units for neonatal intensive care, combining high technology and highly trained staff, occurred in the 1970s. By 1976 the Committee on Perinatal Health[1] had proposed guidelines for the regionalization of maternal and perinatal health services that included a three-tiered system of hospital care (34). Level III hospitals serve as regional centers and provide the most intensive neonatal care. Level II facilities have many but not all components of newborn intensive care services, and Level I hospitals provide normal newborn care with no special units for the care of seriously ill infants. The concept of regionalization is that high-risk mothers and infants are screened and referred or transported to the appropriate level of care. Success depends on the coordinated relationship among hospitals in the system.

Despite these guidelines, recommendations published by the American Academy of Pediatrics in 1977 (2), and guidelines jointly issued by the American Academy of Pediatrics and the American College of Obstetricians and Gynecologists in 1983 (4) outlining the responsibilities and requirements of the three hospital levels, there is no standard national application of what constitutes Level II or Level III care **(25).** Some States evaluate each hospital's perinatal services and assign levels. In other States, the regional system is informal, and each hospital classifies its own services. An earlier study by OTA on neonatal intensive care identified only four States in 1978 that forced adherence to specific standards through licensure or certificate-of-need authorities (25),

[1]The Committee on Perinatal Health was a joint effort by the American Medical Association, the American College of Obstetricians and Gynecologists, the American Academy of Family Physicians, and the American Academy of Pediatrics.

SUPPLY

The confusion over which hospitals deliver intensive v. less specialized newborn care complicates data collection and analysis. As a definitional minimum, Level III NICUs have the capability to provide ongoing respiratory support and are staffed by a full-time neonatologist. But today many Level II units also have these capabilities. The true distinction between the two levels of care may lie with the kinds of patients treated, rather than in equipment and staffing capabilities. Level II hospitals are more likely to provide short-term respiratory support, stabilize very sick or very preterm patients, and then refer more complicated cases, especial y those requiring surgery, to Level 111 units (144)

Because of these ambiguities, most inventories group Level II and Level III hospitals together. Table 1 presents the most recent estimate of the combined number of Level II and Level III units identified by the National Perinatal Information Center in a survey of hospitals offering perinatal and neonatal special care. The reported 1983 totals of **534** NICUs and **7,684** NICU beds represent a nationwide increase of 3 percent in available neonatal intensive care beds and a decrease

Photo credit: Children's Hospital National *Medical Center, Washington, DC*

Level III hospitals provide the most sophisticated intensive care for newborns.

Table I.—Supply of Neonatal Intensive Care Units (NICUs) and Beds in the United States, 1983

Region	Number of hospitals	Number of NICU beds
Northeast	100	1,622
South Atlantic	81	1,003
North Central	135	2,391
South Central	92	1,218
West	122	1,413
Other	4	37
Total	534	7,684

SOURCE: **National** Perinatal Information Center, unpublished data from the American Hospital Association's 1983 Annual Survey of Hospitals, Providence, Rl, December 1986.

of 13 percent in the number of NICUs since an earlier OTA assessment estimated the number of units and beds in 1978 (25). To illustrate the confusion over definitions, Ross Laboratories, which initially surveyed hospitals in 1978 and then informally updated its inventory, lists more than twice as many Level II and Level III hospitals (1,137) on its 1986 roster (138). In part, this difference is accounted for by the inclusion in the Ross Laboratories' inventory of military hospitals and all special care units for newborns. It is also likely that the National Perinatal Information Center underestimates the number of Level II units, but the magnitude of the difference is still unexplained.

The actual number of Level 111 units, fully staffed by neonatologists and capable of providing the most sophisticated prolonged life support, is probably close to *420.* About 485 hospitals reported that they had NICUs in **1983 on the American Hospital Association's Annual Survey of Hospitals, but further investigation by the National Perinatal Information Center refined that figure to about 420 (144). Through interviews with maternal and child health officials and other experts in the field, some hospitals were dropped from the list** while others were added.

Even Level III hospitals have varying capabilities. Forty children's hospitals have NICUs. These children's hospitals, along with many university hospitals, tend to provide the most sophisticated neonatal intensive care, often in conjunction with specialized pediatric surgery, Neonatologists sometimes refer to these centers as Level IV hospitals.

UTILIZATION

Again reflecting data from Level II and Level 111 units combined, table 2 shows that infants spent over 2 million days in NICUs in 1983, maintaining an average NICU occupancy rate of 73 percent. There was considerable variation in occupancy by geographic area, with the North Central region reporting only a 65-percent occupancy rate and the Northeast and the Western regions each reporting an 80-percent occupancy rate. As the national occupancy rate for all hospital beds

Table 2.—Neonatal Intensive Care Unit Days of Care and Occupancy in the United States, 1983

Region	Patient days	Occupancy (percent)
Northeast	471,395	80
South Alantic	277,582	76
North Central	569,545	65
South Central	300,771	68
West	411,961	80
Other	8,468	63
Total	2,039,722	73

SOURCE National Perinatal Information Center, unpublished data from the American Hospital Association's 1983 Annual Survey of Hospitals, Providence, RI December 1986

was 76 percent in 1983, the widely expressed concern that NICU beds are filled to overcapacity was not substantiated by these data (5). Of course, the experience of individual neonatal intensive care units varies widely, and some NICUs do report regular over-utilization (47,143).

The number of admissions to NICUs, and therefore the average length of stay, is not available from national databases. Based on total patient days and average lengths of stay reported by several groups of Level III centers (see table 3), OTA estimates that between 150,000 and 200,000 infants are admitted annually to neonatal intensive care units, or between *4* to *6* percent of all newborns.

Between *50* and 80 percent of all admissions to NICUs are low birthweight infants; there is considerable variation across centers (110,130,186). While the proportion of infants born weighing between 1500 and 2500 grams has decreased somewhat relative to total births over the last 10 years (currently 5.5 percent of all births), the proportion of very low birthweight infants has increased slightly (170). About 39,000 very low weight infants are born annually (a little more than 1 percent of all births), and virtually all of them require neonatal intensive care. In 1984, almost 17,000 of the very low birthweight infants weighed less than 1000 grams at birth.

Individual Level III centers report a trend toward increasing admissions of infants weighing under 1000 grams. Whereas these extremely low birthweight infants may have constituted 5 or 6 percent of admissions in the 1970s, in the 1980s they represented 10 to 12 percent and even 29 percent of all admissions to the NICU (48,87, 126,129,186). At least one report also documents a shift in the distribution of birthweights within the under 1000-gram birthweight group. From 1974 to 1983 at the University of Alabama in Birmingham, the proportion of admissions in the 501- to 700-gram category nearly doubled while the proportion of admissions in the 901- to 1000-gram group decreased (57).

Information on length of stay by birthweight category is shown in table 3. The average length of stay in *1984* for all sick newborns in those

Table 3.–Length of Stay by Birthweight Group, 1984

	Average length of stay (days)		
Birthweight (grams)	Maryland Level III hospitals	Children's hospitals	San Francisco Level III hospitals
< 750	39.2	57.7	40.8
751-1000	65.3	59.1	56.3
1001-1500	46,4	45.4	41.2
1501-2000	21.1	25.0	17.9
2001-2500	7,8	16.6	10.0
>2500	4,4	11.3	8.4
Total < 1500	49.1	50.4	44.9
Total < 2500	23,8	31.6	29.5
Total all infants	10.3	17.1	18.8

[a] In Maryland's seven hospitals with Level III Neonatal Intensive Care Units (N ICUs), includes all newborns who fall into the major diagnostic category (M DC) for neonates, MDC 15, excluding normal newborns.
[b] In a sample of 13 children's hospitals. includes all neonates admitted under age 28 days, except normal newborns and infants who died or were transferred within 24 hours of birth The latter are included in the total for all Infants
[c] In two San Francisco hospitals with Level III NICUs includes all infants admitted to the NICUs

SOURCES Information Service Center, Inc Baltimore, MD, unpublished data, prepared under contract with the Of fice of Technology Assessment July 1986, N ational Association of Children Hospitals and Related Institutions, Inc., Alexandria VA, unpublished data, August 1986 and C S Phibbs, University of Call fornia. San Diego, unpublished data, March 1987

centers reporting data ranged from 10 to 19 days while the average length of stay for very low birthweight infants ranged from 45 to 50 days. As expected, the length of hospital stay increases as birthweight decreases. For extremely low birthweight infants under 1000 grams who survive to hospital discharge, it takes at least 70 to 90 days in the hospital to reach the necessary size and maturity so that continuous professional nursing care is no long required (see table 5). The implications of other risk factors for length of stay are discussed n the following section on costs.

COST

Neonatal intensive care is expensive, ranking among the most costly of all hospital care.[2] Average hospital costs for low birthweight babies in 1984 ranged from $11,670 to $39,420 (see table 4).[3] Among 10 diagnoses studied by Showstack and his colleagues, infants with respiratory distress syndrome (a major problem among premature, low weight babies) had substantially higher hospital charges than any other group, including patients with acute myocardial infarction or kidney transplantation (154). The costs for the sickest and tiniest infants in neonatal intensive care rank with the most expensive medical procedures that are performed today, like cardiac or bone marrow transplantation (96,145).

The distribution of costs among patients in the neonatal care nursery is highly skewed. A significant portion of the variation among infants in

[2]The costs for physicians' services in NICUs are not reflected in this section because data on physician charges were unavailable. Estimates vary, but physicians' charges probably raise overall medical care charges by about 15 percent (79,128). Typically, neonatologists charge a daily visit fee for each patient in the NICU and additionally bill all procedures, such as catheterization, separately. Other consulting physicians also charge for their services. With the extremely long hospital stays of most very low birthweight infants, physicians' charges can become a substantial liability for patients' families.

[3]The three data sources in tables 4 and 5 show such a wide range in hospital costs in part because they report on different populations. The data from the Maryland and children's hospitals include all newborns who are hospitalized (except normal newborns), while the data from the San Francisco hospitals include only NICU admissions. Because the majority of the larger low birthweight infants (those with birthweights between 1500 grams and 2500 grams) do not require intensive care, the cost data for these birthweight categories, although reflecting average *hospital* costs, underestimate NICU costs. Box A provides a full explanation of the databases and their limitations.

Table 4.—Hospital Cost by Birthweight Group, 1984

Birthweight (grams)	Average hospital costs		
	Maryland Level III hospitals	Children's hospitals	San Francisco Level III hospitals
< 750	$25,069	$48,773	$58,053
751-1000	38,750	47,068	76,387
1001-1500	22,266	32,530	53,663
1501-2000	8,594	16,370	20,845
2001-2500	2,898	13,794	16,751
>2500	1,202	9,358	14,601
Total < 1500	26,737	38,171	60,015
Total < 2500	11,666	23,639	39,421
Total all infants	4,411	13,416	26,946

[a]In Maryland's seven hospitals with Level III Neonatal Intensive Care Units (NICUs), includes all newborns who fall into the major diagnostic category (MDC) for neonates, MDC 15, excluding normal newborns. Charges are converted to costs through a weighted cost-to-charge ratio derived from the Maryland Health Services Cost Review Commission's ratios for individual hospitals and their relative contribution to total births.

[b]In a sample of 13 children's hospitals, includes all neonates admitted under age 28 days, except normal newborns and infants who died or were transferred within 24 hours of birth (The latter are included in the total for all infants.) Costs are derived from a cost finding methodology employed by National Association of Children's Hospitals and Related Institutions and adjusted for labor differentials.

[c]In two San Francisco hospitals with Level III NICUs, includes all infants admitted to the NICUs. Charges are adjusted to costs using Medicaid's cost-to-charge ratio.

SOURCES: Information Service Center, Inc., Baltimore, MD, unpublished data, prepared under contract with the Office of Technology Assessment, July 1988; National Association of Children's Hospitals and Related Institutions, Inc., Alexandria, VA, unpublished data, August 1988; and C.S. Phibbs, University of California, San Diego, unpublished data, March 1987.

Box A.—How To Interpret the Data in Tables 3, 4, and 5

Tables 4 and 5 show such a wide range of costs because the three data sources that are cited report on somewhat different populations. The seven Level III hospitals in Maryland have the lowest costs. These data include all infants born in the hospitals who are assigned to the diagnosis-related groups (DRGs) for neonates (excluding normal newborns). Because of inconsistencies in coding, these data may include some infants older than 28 days who return to the hospital for routine surgical corrections of congenital anomalies and may exclude some seriously ill newborns who are assigned to non-neonate DRGs that describe the organ system involved with their problems (109). Any newborn weighing less than 2500 grams is included in this classification because of his low birthweight, regardless of the extent of medical problems. Thus especially in the heavier low birthweight groups, the Maryland data underestimate NICU costs because many of the babies, though hospitalized, are not sick enough to warrant intensive care.

Conversely, the other 2 data sources, 13 children's hospitals and 2 university-affiliated San Francisco hospitals, tend to overestimate average NICU costs. Most children's hospitals do not have obstetrical services, and they typically serve as super-referral centers for the most difficult and complicated cases, often those requiring complex surgery. They, along with many university hospitals, are sometimes referred to as Level IV facilities because their caseloads require such intensive care. These data sources reflect average costs for the sickest infants.

There are several additional caveats about these data. The data from the children's hospitals include all admissions of infants under 28 days of age, but like the Maryland data, it is not known which infants actually received care in the intensive care unit. For example, very complicated surgical patients with congenital problems often are placed in pediatric intensive care units instead of NICUs even if they are newborns. And because children's hospitals are almost exclusively referral *centers,* many of the babies return to their original hospitals after surgery or to complete recuperation. Such transfer policies underestimate true lengths of stay and concomitant costs for these newborns.

The two San Francisco hospitals constitute the only data source that reports only on infants admitted to the NICU. Thus it is the best source of information on the cost experience of the heavier birthweight infants (over 1500 grams) in NICUs. However because one of these hospitals is also a surgical center for infants with congenital anomalies, these data may overestimate typical NICU costs for the larger infants. Moreover, the same hospital has an aggressive program for back-referring infants to their originating hospitals which explains, in part, the generally shorter lengths of stay reported by the San Francisco hospitals compared with the children's and Maryland hospitals. Finally this database is limited by the size of the population. The San Francisco hospitals had a total caseload of 580 infants while the Maryland hospitals and the children's hospitals each report on over 5,000 infants. There were 290 low birthweight infants in the San Francisco hospitals. The Maryland hospitals had 1,540 infants and the children's hospitals had 2,240 infants in their low birthweight populations.

cost and length of stay is explained by four measures of risk: birthweight, survival to hospital discharge, assisted ventilation, and surgical intervention (109,13 o). A study on costs in 13 children's hospitals conducted by the National Association of Children's Hospitals and Related Institutions in 1984 found that these factors explained 45 percent of the variation in costs among neonatal cases when the extreme outliers were removed from the calculation (111). A different study of admissions to six Level 111 NICUs in California found 42 percent of the variation in costs was explained by these factors plus two others: multiple births and discharge to another hospital (130).

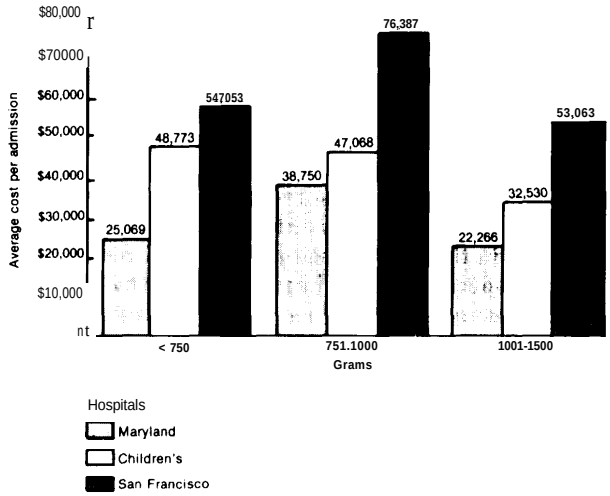
Birthweight has the greatest explanatory power. Costs increase as birthweight falls. The average hospital costs for very low birthweight babies range from $26,740 to $60,015. (See table 4.) Infants in the 750- to 1000-gram birthweight group, which uses resources very intensively, have average costs between $38,750 and $76,390. The average hospital costs for infants with birthweights below 750 grams are lower than the average costs

for those infants in the 750- to 1000-gram group because so many of the tiniest babies die within a short time of birth, thus incurring fewer expenses (figure 1).

If only survivors are counted, costs increase across birthweight groups. (See table 5.) Because of the high mortality experienced at the lowest birthweights, survival to discharge is the most important factor in explaining variations in costs for infants with birthweights under 1500 grams. A large percentage of these premature newborns die within a very short time after birth and consume minimal resources. Another substantial portion of the infants live past the first critical 24 to 72 hours and consume considerable resources, but eventually die. The children's hospital data indicate that even if only this latter group, infants who use resources intensively but ultimately die, is considered, on average survivors are still more expensive (109). As expected, the tiniest infants who survive, those with birthweights from 500 to 750 grams, have the highest costs and hospital stays, from $61,700 to $149,180 and from 87 to 109 days respectively.

Table 6 shows costs and lengths of stay for newborns who require assisted ventilation for more than 72 hours. Unfortunately, virtually all infants born weighing under 750 grams and most infants in the 750- to 1000-gram birthweight group do require prolonged respiratory assistance. Only 15 percent of the under 1000 gram survivors shown in table **6** did not require assisted ventilation. The average costs of these nonventilated extremely low

Figure 1.— Hospital Cost by Birthweight Group, 1984



SOURCE: Office of Technology Assessment (see table 4), 1987.

birthweight survivors are only a third of the *$63,750* required to care for the infants on assisted ventilation. For all low birthweight babies, average hospital costs increase almost fourfold, from $11,470 to $40,550, if assisted ventilation is required. The use of assisted ventilation over 72 hours explains between 20 and 36 percent of the variation in costs among infants who weigh less than 1500 grams (109). For the heavier low birthweight babies, those in the **1500- to 2500-gram group, the most important explanatory factor is whether surgery is required. About 12 percent of the variation** in costs among cases is explained by surgical intervention (109).

Table 5.—Hospital Cost and Length of Stay Per Very Low Birthweight Survivor, 1984

	Maryland Level III hospitals		San Francisco children's hospitals		Level III hospitals	
Birthweight (grams)	ALOS[d]	Mean $	ALOS[d]	Mean $	ALOS[d]	Mean $
> 750	97.9	$61,706	87.4	$67,892	108.5	$149,184
751-1000	86.2	48,290	71.4	54,805	66.4	88,028
1001 -1500	48.5	21,848	47.3	32,168	44.8	56,276
Total	61.5	31,426	56.3	40,514	55.1	71,417

[a] In Maryland's seven hospitals with Level III NICUs, includes all newborns who fall into the major diagnostic category (MDC) for neonates, MDC 15, excluding normal newborns
[b] In a sample of 13 children's hospitals includes all neonates admitted under age 28 days, excePt normal newborns.
[c] In two San Francisco hospitals with Level III NICUs, includes all infants admitted to the NICUs.
[d] ALOS denotes average length of stay (days).

SOURCES Information Service Center, Inc., Baltimore, MD, unpublished data, prepared under contract with the Office of Technology Assessment, July 1986; National Association of Children's Hospitals and Related Institutions, Inc., Alexandria, VA, unpublished data, August 1986, and C.S.Phibbs, University of California, San Diego, unpublished data, March 1987

Table 6.—Hospital Cost and Length of Stay for Newborns[a] Requiring Assisted Ventilation, 1984

	Assisted ventilation		No assisted ventilation	
Birthweight (grams)	Mean $	ALOS[c]	Mean $	ALOS[c]
< 1000	$63,753	79,2	$22,694	50.5
1001-1500	40,055	53.9	17,732	35.2
1501-2000	47,951	49.6	11,364	23.1
2001-2500	23,233	23.2	8,709	13.0
>2500	29,112	27.7	5,383	8.0
Total < 1500	49,295	63.8	18,559	37.8
Total < 2500	40,548	49.4	11,474	20.4
Total all infants	35,322	39.5	6.555	10.4

[a]Data excludes normal newborns, Infants transferred to another hospital within 4 days of birth, and all infants who died before discharge
[b]Infants required mechanical ventilation forover3 days
[c]A Los denotes average length of stay (days)

SOURCE National Association of Children's Hospitals and Related Institutions, Inc., Alexandra. VA, unpublished data, August 1986

More of the increase in the costs of neonatal intensive care over time is due to a sicker case mix than to the use of more services or general inflation. In comparing admissions to the NICU at the University of California, San Francisco between 1976-78 and 1983-84, Phibbs and his colleagues found that mean charges increased from $6,230 to $25,230. The cost to treat similar types of cases increased **30 percent, and this change was attributed to technology and higher prices. Inflation accounted for another 23 percent, and the remaining 47-percent increase** in overall charges was attributed to a change in the kinds and severity of cases (94). The caseload in this Level III nursery became much more concentrated with extremely low birthweight infants and with infants who required complex surgery than in earlier years. The researchers hypothesized that the sicker case mix was caused by increased regionalization and greater availability of Level II beds (94).

Other researchers in the same institution followed the hospital course of infants with respiratory distress syndrome as part of a larger study of costs and changes in clinical practice. They found that between 1972 and 1982 resource use increased more for infants with respiratory distress syndrome than for any of the other nine diagnoses studied. They concluded that these newborns received increasing quantities of services over the decade and that the most difficult costs to contain are those for such critically ill patients (154).