Neonatal Intensive Care Unit Use for Newborns With Relatively Lower Illness Acuity

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abstract

BACKGROUND AND OBJECTIVES: Neonatal intensive care unit (NICU) aggregate service and outcome descriptions focus on high-illness-acuity neonates. We sought to describe the high-level landscape of lower-acuity inborn NICU admissions (LAINAs).

METHODS: This cross-sectional study of a nearly three-quarters population sample from 2022 describes 120 California hospitals with inborn NICU admissions. Binary illness acuity stratification was based on high-acuity criteria—admission within 28 days of birth and either birthweight of 1500 g or less, gestation of 31 weeks 6 days or less, or more than 1500 g with at least 1 of the following: death, assisted ventilation for 4 hours or more whether intubated or not, early bacterial sepsis, major surgery requiring anesthesia, acute transport in or out, suspected encephalopathy/perinatal asphyxia, active therapeutic hypothermia, or seizures. Exposure: inborn NICU admission; main outcomes: LAINA categorization, diagnostic categories, patient-days, length of stay.

RESULTS: Of 44 330 total NICU admissions, 26 257 (59.2%) were LAINAs and accounted for 31.2% of all NICU patient-days. Mean length of stay for all NICU admissions was 12.9 days, compared with 8.0 days for LAINAs. The most common LAINA diagnostic categories included respiratory distress (43.0%), suspected infection (39.6%), admission policy based only on birthweight/gestational age (30.7%), hyperbilirubinemia (28.9%), and feeding difficulty (25.6%). NICUs varied widely in the diagnostic categories represented.

CONCLUSIONS: LAINAs outnumbered high-illness-acuity admissions in most NICUs, accounting for almost a third of NICU patient-days. These findings merit reflection and research on data elements needed to describe service provision and clinical outcome and on preferable hospital settings for clinical management.

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Dr Schulman conceptualized and designed the study, analyzed and interpreted the data, drafted the initial manuscript, and critically reviewed and revised the manuscript. Drs Gould, Lee, and Profit substantially contributed to the study conception and design, acquisition and interpretation of data, and critically reviewed and revised the manuscript. Dr Govindaswami substantially contributed to analysis and interpretation of data and drafting the initial manuscript and critically reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

WHAT'S KNOWN ON THIS SUBJECT: Neonatal intensive care unit (NICU) outcome assessment to guide quality improvement focuses on high-illness-acuity neonates at high mortality risk requiring complex critical care. Objective confirmation that such focus accurately reflects a unit's case mix by illness acuity is lacking.

WHAT THIS STUDY ADDS: The majority of NICU admissions are of relatively lower illness acuity, inviting consideration to expand the scope of NICU data collection and reflection and research on preferable settings for provision of certain medical interventions for newborns.

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INTRODUCTION

Since the neonatal intensive care unit (NICU) originated, variables describing service provision and outcome have focused predominantly on neonates at high mortality risk requiring complex critical care. Yet, in 1981, a study of cost at a large NICU reported that the majority of newborns "are admitted for less severe problems that can be treated rapidly and effectively."[1] At the time, the NICU admission rate among approximately 3.3 million births in the US was 5%.[1] NICU resource availability and use has grown substantially.[2–5] A recent study from 2 states reported 12% of births admitted to the NICU; the majority were gestational age (GA) of 35 weeks or more; of these, 21% met severe-acuity criteria.[6] Adjusted likelihood of NICU admission also has increased over time.[7] It is important to note that some cited investigations used birth certificate data, which tend to underreport admissions, particularly lower-acuity admissions occurring after the birth certificate was completed.[8,9] A large sample of California live births showed that by 2015, only 12% of inborn NICU admissions born at GA 34 weeks or more met California Perinatal Quality Care Collaborative (CPQCC) high-illness-acuity criteria.[10] NICU inborn admission rates varied 34-fold, and percentage of high illness acuity varied 40-fold.[10]

Hospital service configurations for well newborns have changed over time and vary across hospitals. Rooming-in care of newborns has increased, while demand for nurseries and other non-NICU wards decreased.[11] A recent survey of well newborn nursery providers at predominantly academic hospitals revealed considerable variation in available medical interventions within the mother/parent–infant dyad setting.[12] The range of such lower-level newborn care may depend on whether pediatric hospitalists are available. There are also recent efforts to move care out of the NICU. Guidelines for managing neonatal opioid withdrawal[13] resulted in decreased NICU admissions and unchanged median length of stay (LOS).[14] Otherwise healthy term newborns requiring intensive phototherapy had no difference in LOS or 30-day readmission and incurred lower cost when managed in a non–intensive care unit (ICU) setting.[15]

The current descriptive focus on high-illness-acuity admissions emphasizes associated process and outcome measures of interventions and complications, for example, mechanical ventilation, surgical procedures, chronic lung disease, and retinopathy. The descriptive status quo implies that care for relatively lower-acuity admissions needs little description and that the findings for the high-acuity admissions sufficiently inform the necessity and quality of care delivered to all admissions. However, it is not possible to extrapolate findings for 1 subpopulation to a different subpopulation.[16]

The present study aims to describe in greater detail than previously reported the high-level landscape of relatively lower-acuity inborn NICU admissions (LAINAs), including the proportion of total NICU admissions and patient-days, diagnostic categories, and LOS, thereby informing development of more comprehensive descriptions of the NICU service population and outcomes and stimulating research on preferable facility settings for medical management.

METHODS

California Children's Services (CCS), within the California Department of Health Care Services, seeks to broaden the range of NICU operational description to guide quality improvement. CCS confers approval for 3 levels of NICU care: intermediate, community, and regional, generally corresponding to American Academy of Pediatrics levels II, III, and IV, respectively.[17–19] CCS standards require annual reporting of specific variables. In 2022, CCS expanded care and outcome reporting requirements to include LAINA in addition to high-acuity patients.

Respecting challenges in collecting additional measures, the 2022 LAINA dataset describes NICU admission during the birth hospitalization by building upon variables typically found on a traditional NICU admission log: birth date, birth weight (BW), GA, admit date, discharge date, and discharge diagnoses/categories (Table 1). The dataset includes a variable identifying LAINA during the hospitalization associated with maternal delivery (yes/no). NICUs independently determined how they would categorize discharge diagnoses and extract the data elements from each medical record. Each CCS NICU self-reported patient-level data to CCS via CPQCC, which provided CCS with a NICU-level aggregated dataset.

TABLE 1. Discharge Diagnoses/Categories Listed in Descending Order of Estimated Frequency From a Survey of CCS NICU Medical Directors

Discharge Diagnoses/Categories
Suspected infection
Respiratory distress
Hypoglycemia
Hyperbilirubinemia
Temperature instability
Feeding difficulty
Admitted due to BW/GA admit policy
SGA
Perinatal transition monitoring
NAS
Dysmorphic/genetic anomaly
Apnea/cyanotic episode
Cardiac concern
Seizure/neurologic concern
Other

Abbreviations: BW, birth weight; CCS, California Children's Services; GA, gestational age; NAS, neonatal abstinence syndrome; NICU, neonatal intensive care unit; SGA, small for GA.

Study Sample

This study period was calendar year 2022 and included all infants at all 120 CCS-approved NICUs with inborn admissions, including those born at colocated maternal delivery services, therefore excluding CCS NICUs in freestanding children's hospitals without maternal delivery services. All 120 CCS-approved NICUs were required to report their LAINA data; none of these hospitals did not report their data. Approximately 20 California NICUs were not CCS approved and did not report this data; none were level IV. The analysis used the dataset available at the end of 2023.

Variable Definitions

LAINA did not meet CPQCC high-illness-acuity criteria of admission within 28 days of birth and either BW 1500 g or less, GA 31 weeks 6 days or less; or BW greater than 1500 g with at least 1 of the following: death, assisted ventilation for 4 hours or more whether intubated or not, early bacterial sepsis, major surgery requiring anesthesia, acute transport in or out, suspected encephalopathy/perinatal asphyxia, active therapeutic hypothermia, or seizures. The percentage of NICU admissions categorized as LAINAs was calculated by dividing the number of LAINAs at a reporting hospital by the total number of NICU admissions, expressed as a percentage. The denominator therefore reflects differing contributions of inborn and outborn NICU admissions across hospitals. The percentage of NICU patient-days attributed to LAINA was calculated by dividing the number of patient-days for LAINA by the total number of NICU patient-days, expressed as a percentage. Mean LOS for all NICU admissions reflected all illness acuity levels for inborn and outborn patients. Mean and median LOS for all LAINAs summarize duration of NICU stay at each NICU for all LAINAs.

Statistical Analysis

The unit of observation and unit of analysis were the individual NICU. This descriptive observational study stratified variables by level of NICU care, illness acuity, and BW/GA categories. The study did not test hypotheses about differences across subgroups because it was known a priori that these differed operationally or physiologically. We used Stata version 18 (StataCorp)[20] for all computations and graphical displays. To facilitate assimilating a large amount of tabular data, we created violin plots highlighting the median, IQR and values extending below and above by 1.5 times the IQR, and the relative number of data points for each value.

RESULTS

Table 2 describes the service population, total NICU admissions, LAINAs, respective patient-days, and LOS. In total, 120 reporting hospitals cared for at least 306 364 live births and admitted 44 330 to NICU, including outborn transfers; 26 257 were LAINA—59.2% of total NICU admissions. LAINAs accounted for 73.2% of all NICU admissions at intermediate NICUs, 61.7% at community NICUs, and 50.2% at regional NICUs (Figure 1A). LAINAs generally constituted the majority of NICU admissions even within the category's lower birthweight and preterm GA strata (Table 2, Figure 2).

LAINAs accounted for almost a third (31.2 percent) of total NICU patient-days. Percentage of LAINA patient-days was inversely related with level of care: 69.3% at intermediate NICUs, 34.7% at community NICUs, and 21.5% of NICU patient-days at regional NICUs (Table 2, Figure 1B). The mean value across hospitals for mean LOS for all NICU admissions, including LAINAs, was 12.9 days, compared with 8 days for only LAINAs.

Table 3 and Figure 3 describe the distributions for the percent of each LAINA diagnosis/category across all reporting NICUs. Categorical ordering reflects a priori estimated rank order by NICU medical directors. The median number of reported diagnosis/category assignments per patient was 1, and mean was 2.4. NICU-level reporting and analysis precluded determining other patient-level summary measures. Most common were respiratory distress (43.0%), suspected infection (39.6%), BW/GA admission policy (30.7%), hyperbilirubinemia (28.9%), and feeding difficulty (25.6%). At 29 hospitals, available specific diagnoses/categories were insufficient, hence categorized "other" (3.7% of all LAINAs, range 0%–75.3%, mean 3.4%, median 0).

Tables 2 and 3 inform data capture completeness by reporting the number of hospital-level observations making up the measures on each row.

Variation in percent of LAINAs stratified by BW and GA was wide and similar across strata (Figure 2). Variation in percent of LAINAs across specific diagnostic categories was wide and differed across categories; as detailed in Table 3 and Figure 3, LAINAs were a heterogeneous group. In Figure 3, the narrow separation between the symmetric curves on either side of the depicted range for suspected infection and several other diagnostic categories indicates that no particular subset of values was especially common. In contrast, other diagnostic categories, such as temperature instability and seizure/neurologic concern, displayed notable prominences in the distributional density of values.

DISCUSSION

This study describes for the first time the high-level landscape of care for LAINAs in a 2022 service population of at least 306 364 California live births (statewide total 419 485[21]). LAINAs constitute the majority of NICU admissions. Our findings uniquely reflect data directly reported by each NICU and are generally consistent with previous reports based on linked birth certificate data.[6,8] Building on earlier publications, the findings reveal opportunities

TABLE 2. Description of the Study Service Population, Total NICU Admissions, LAINAs, Respective Patient-Days, and LOS

	Number Hospital-Level Observations	1st %ile	10th %ile	Mean	50th %ile	90th %ile	99th %ile	Total Across All Hospitals
Total inborn live births	120	651	1075	2553.0	2171	4285.5	6977	306 364
Total NICU admits	120	85	138	369.4	308.5	698	1125	44 330
Regional NICUs	18	303	314	696.8	677	1123	1125	12 542
Community NICUs	87	77	143	331.7	288	559	1268	28 856
Intermediate NICUs	15	121	128	195.5	173	327	400	2932
BW, g								
≤1500	118	2	8	39.6	28.5	82	174	
1501–2000	118	9	14	46.5	42.5	88	158	
2001–2500	118	17	23	62.3	55	123	202	
2501–4000	118	39	77	200.7	161.5	408	590	
≥4001	118	4	7	23.6	19	50	86	
GA								
<32 wk	118	2	10	45.2	32	91	194	
32 wk 0/7 d-33 wk 6/7 d	118	5	10	35.1	27	66	127	
34 wk 0/7 d-36 wk 6/7 d	118	20	39	98.5	85.5	198	325	
37 wk 0/7 d-38 wk 6/7 d	118	22	28	80.5	69	152	246	
39 wk 0/7 d-41 wk 6/7 d	118	19	42	113.5	90.5	240	352	
≥42 wk 0/7 d	66	0	1	1.7	1	3	6	
Total LAINAs	120	56	90	218.8	178	407	664	26 257
Regional NICUs	18	144	156	350.1	336	568	664	6302
Community NICUs	87	47	84	204.7	177	403	801	17 809
Intermediate NICUs	15	88	90	143.1	125	203	316	2146
BW, g								
1501–2000	117	4	9	28.4	23	57	86	
2001–2500	118	7	18	44.9	38.5	91	116	
2501–4000	118	26	47	128.6	102	276	435	
≥4001	118	1	5	16.5	13	36	60	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	2	5	21.5	17	43	87	
34 wk 0/7 d-36 wk 6/7 d	118	19	29	72.9	60	141	283	
37 wk 0/7 d-38 wk 6/7 d	118	13	19	49.7	39.5	99	167	
39 wk 0/7 d-41 wk 6/7 d	118	10	27	73.0	55	155	245	
≥42 wk 0/7 d	48	0	1	1.3	1	2	4	
% LAINAs	120	33.96	41.52	61.7	63.4	78.4	84.2	59.22
Regional NICUs	18	33.96	34.55	50.8	52.8	65.0	72.9	50.3
Community NICUs	87	31.42	44.36	61.9	63.6	77.7	83.9	61.7
Intermediate NICUs	15	61.84	62.08	73.2	70.3	84.2	87.9	73.2
BW, g								
1501–2000	117	33.33	44.3	62.4	62.6	78.9	92.3	
2001–2500	118	38.46	50	73.3	77.0	89.3	94.8	
2501–4000	118	33.04	44.38	65.5	66.1	84.5	89.8	
≥4001	118	20	44.44	69.4	72.7	91.7	100	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	20	33.33	61.2	63.7	85.7	93.3	
34 wk 0/7 d-36 wk 6/7 d	118	40.34	54.84	74.8	77.4	90.5	94.6	
37 wk 0/7 d-38 wk 6/7 d	118	30.43	43.37	63.8	64.6	84.6	91.7	
39 wk 0/7 d-41 wk 6/7 d	118	35.29	42.31	65.5	68.3	85.9	91.8	
≥42 wk 0/7 d	47	25	50	84.9	100	100	100	
% LAINA patient-days	118	8.37	17.09	41.7	39.7	67.8	100	31.2
Regional NICUs	18	8.37	12.58	22.1	21.6	32.2	36.4	21.5
Community NICUs	86	6.36	19.79	40.2	40.0	61.4	89.4	34.7
Intermediate NICUs	14	50.38	52.06	76.0	75.0	100	100	69.3

(Continued on next page)

TABLE 2. Description of the Study Service Population, Total NICU Admissions, LAINAs, Respective Patient-Days, and LOS (Continued)

	Number Hospital-Level Observations	1st %ile	10th %ile	Mean	50th %ile	90th %ile	99th %ile	Total Across All Hospitals
BW, g								
1501–2000	117	16.45	28.39	51.3	52.2	72.7	96.3	
2001–2500	118	13.61	38.85	68.0	70.7	89.6	98.1	
2501–4000	118	18.5	31.43	62.6	67.1	87.4	93.5	
≥4001	118	3.15	28.7	63.7	66.7	98.8	100	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	9.78	28.74	57.6	59.3	82.9	100	
34 wk 0/7 d-36 wk 6/7 d	118	23.01	42.24	71.4	76.8	91.5	97.4	
37 wk 0/7 d-38 wk 6/7 d	118	11.68	27.18	60.5	64.5	87.8	97.7	
39 wk 0/7 d-41 wk 6/7 d	118	13.58	28.94	61.0	61.7	89.3	95.2	
≥42 wk 0/7 d	44	0	25	80.4	100	100	100	
Mean LOS all NICU admits	118	4.3	7.24	12.9	12.4	18.7	25.4	
BW, g								
1501–2000	118	8	14.35	20.5	20.2	27.6	33	
2001–2500	118	6.39	8	12.0	11.1	16.9	21.9	
2501–4000	118	2.55	3.42	6.1	6.2	8.7	13.5	
≥4001	118	1.86	2.77	5.7	5.4	8.6	15.1	
GA								
32 wk 0/7 d-33 wk 6/7 d	118	8.91	14.85	21.5	21.1	28.1	35.3	
34 wk 0/7 d-36 wk 6/7 d	118	4.99	7.31	10.6	10.4	14.2	16.2	
37 wk 0/7 d-38 wk 6/7 d	118	2.31	3.14	6.3	5.9	10.0	16.2	
39 wk 0/7 d-41 wk 6/7 d	118	2.15	2.62	5.0	4.7	7.7	12.1	
≥42 wk 0/7 d	65	0	1	10.3	6	28	56	
Mean LOS all LAINAs	118	4.15	4.88	8.0	7.9	11.2	13.3	
Regional NICUs	18	4.15	4.55	7.7	7.8	10.7	11.6	
Community NICUs	86	4.41	5.38	8.2	8.0	11.7	13.4	
Intermediate NICUs	14	3.5	4.3	6.8	7.3	8.4	10.3	
BW, g								
1501–2000	117	8.7	10.79	16.3	16.1	21.5	27.5	
2001–2500	118	5.05	6.82	10.8	10.7	14.6	17	
2501–4000	118	2.4	3.23	5.6	5.6	8.3	11.1	
≥4001	118	1.5	2.29	4.9	4.3	7.6	13.8	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	10.08	13.71	19.6	19.5	25.2	33.7	
34 wk 0/7 d-36 wk 6/7 d	118	4.85	6.52	9.9	9.9	13.2	16.5	
37 wk 0/7 d-38 wk 6/7 d	118	2.3	3	5.5	5.1	8.9	12	
39 wk 0/7 d-41 wk 6/7 d	118	1.97	2.51	4.4	4.1	6.9	9.2	
≥42 wk 0/7 d	47	0	1	8	5	20	56	
Median LOS all LAINAs	118	2	2.5	5.2	5	8	10	
Regional NICUs	18	2	2	4.3	3.5	7	8	
Community NICUs	86	2	3	5.5	5	9	11	
Intermediate NICUs	14	2	2	4	4	5	6.5	
BW, g								
1501–2000	117	6	10	15.1	15	20.5	27	
2001–2500	118	3.5	5	9.4	9.5	13	15.5	
2501–4000	118	1	2	3.5	3	6	7	
≥4001	118	1	2	3.7	3	6	12	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	6.5	14	18.4	18	24	33	
34 wk 0/7 d-36 wk 6/7 d	118	3	5	8.6	9	12	14.5	
37 wk 0/7 d-38 wk 6/7 d	118	1	2	3.7	3	6.5	8	
39 wk 0/7 d-41 wk 6/7 d	118	1	2	2.9	3	5	7	
≥42 wk 0/7 d	47	0	1	7.9	4	20	56	

Abbreviations: BW, birth weight; GA, gestational weight; LAINA, lower-acuity inborn NICU admission; LOS, length of stay; NICU, neonatal intensive care unit; %tile, percentile.

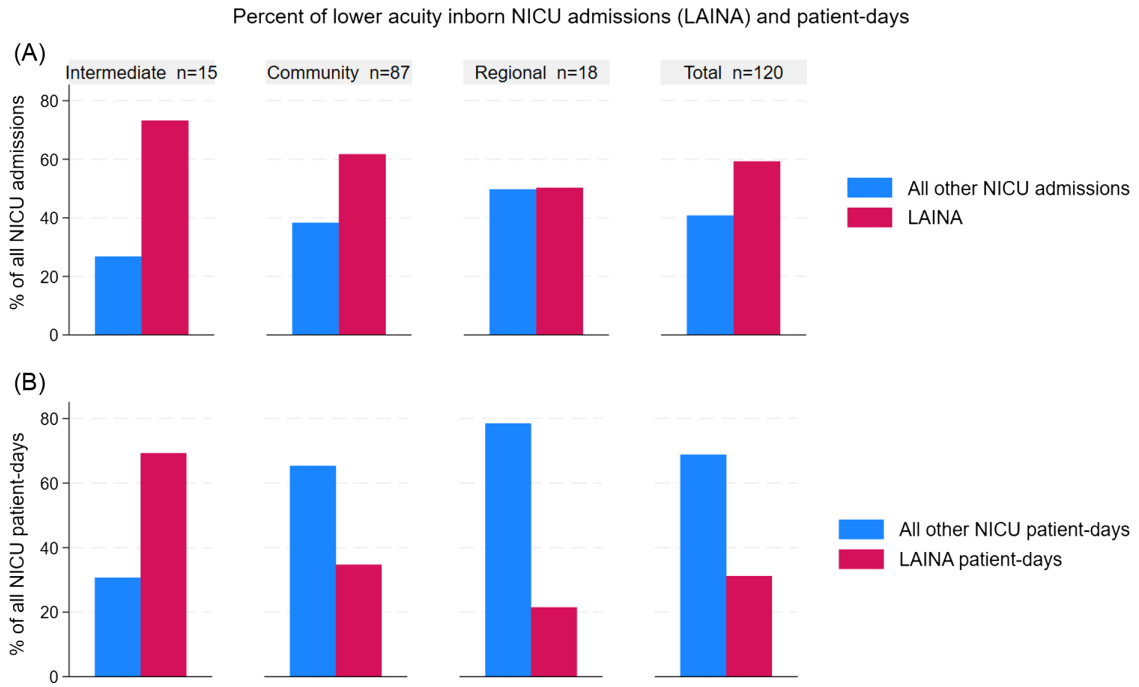

FIGURE 1.
(A) Percent of neonatal intensive care unit (NICU) admissions, identified as lower-acuity inborn NICU admissions (LAINAs) or all other NICU admissions, stratified by NICU level of care. (B) Percent of NICU patient-days, attributed to LAINAs or all other NICU admissions, stratified by NICU level of care.

for improvement in the scope of data collection describing NICU inputs, operations, and outcomes and invite reflection and research on preferable settings for provision of certain medical interventions for newborns.

NICU data collection based on binary illness acuity categorization has restricted the evaluative focus largely to high-mortality-risk patients requiring complex critical care, thereby hindering, or biasing, description of overall NICU care and outcomes. As efforts to inform operational NICU oversight evolve, analytical stratification may reveal new options for categorizing NICU patients, for example, by NICU service lines.[22] Multilevel statistical modeling methods could help answer whether site of care may operate as an independent outcome determinant and whether some predictor variables operate differently at the individual patient level or hospital level. For example, race/ethnicity may influence some outcomes with different magnitude or direction at the individual or hospital level, reflecting disparities in care provision.[22–26]

Is the NICU the preferable care setting for the complete range of neonatal pathophysiology? Potential harms of NICU admission are well known, including separation of mother/parent–infant dyad interfering with bonding and breastfeeding, parental stress, increased medical interventions, medication errors, and infection risk.[27–33] It may be time to recognize that calling the place that cares for all infants whose clinical care needs cannot be met in the mother/baby unit, newborn nursery, or at home a "NICU" obscures appreciation of the actual extent of service heterogeneity—and, in doing so, perhaps implicitly contributes to the current bias toward collecting high-acuity process and outcome measures. It could be better, perhaps, to rename it the neonatal comprehensive care unit (NCCU, an acronym sounding similar to NICU).[34] Furthermore, perhaps in at least some hospitals the range of care needs may be better served by a NICU and a lower-acuity neonatal unit. One survey of academic pediatricians revealed significant variation in criteria for which infants could remain in a mother/parent–infant dyad and available medical interventions.[12]

What constitutes effective, necessary, and sufficient NICU care?[34] NICU admissions decreased 25% and patient-days decreased 7% at Kaiser Permanente Southern California between 2010 and 2018, which is attributed to policy changes including BW/GA-based mandatory admission of well-appearing newborns and evaluation/management of suspected infection.[35] Almost all resource-use reductions related to infants of greater GA and higher BW. Notable as these results are, it remains unclear whether further reductions might be achievable and which rate is the right goal. Another study of California NICU admissions between 2010 and 2018 found a constant admission rate in the aggregated analysis but an increase in rate for infants at higher BW and GA; rates increased at non-Kaiser hospitals but decreased at Kaiser hospitals.[36]

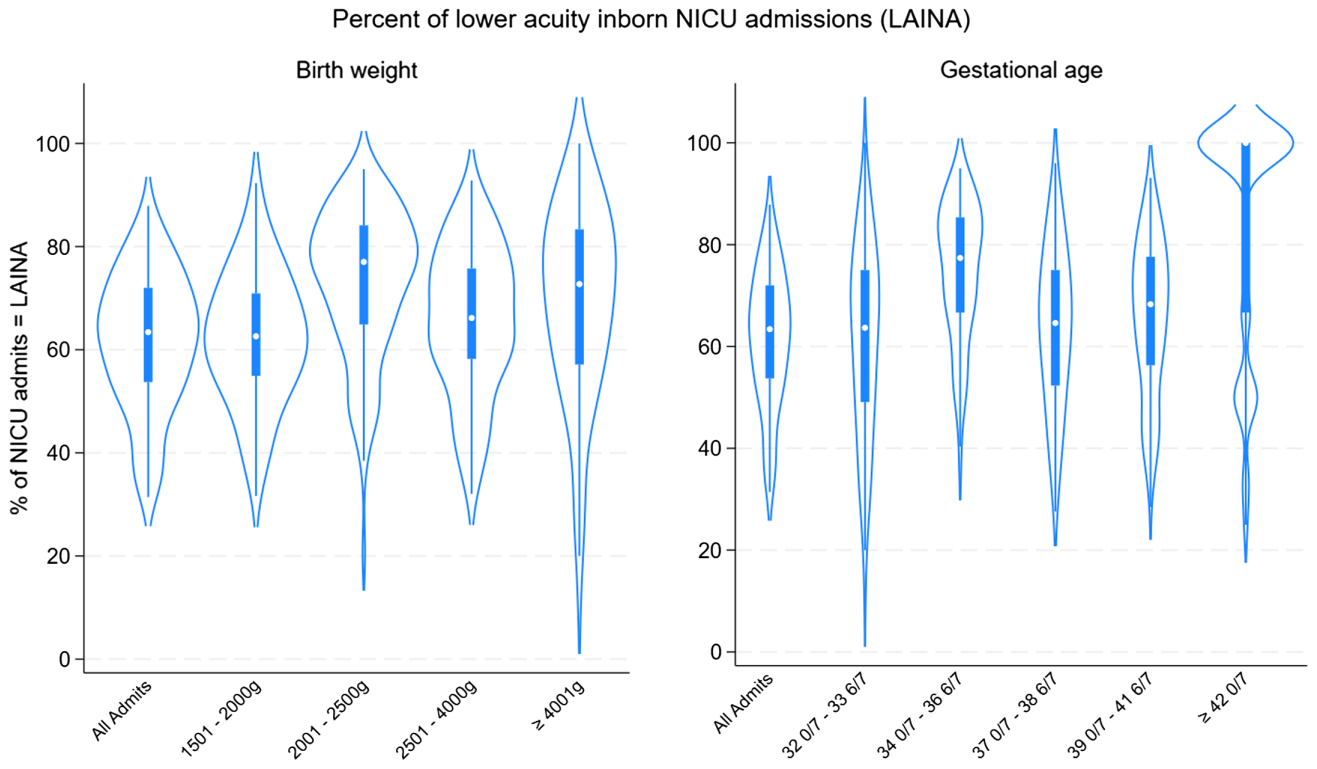

FIGURE 2.
Percent of lower-acuity inborn NICU admission (LAINA), stratified by birth weight and gestational age. Shaded rectangle contains IQR and median (white dot); lines above or below the rectangle delimit values 1.5 times the IQR; symmetric curves to either side estimate distribution density (relative number of points at each value of vertical axis). NICU, neonatal intensive care unit.

Although neonatal mortality has substantially declined since 1990,[37] investigators raise questions about potentially excessive NICU care.[11,38,39] Live singleton newborns at 35 to 42 weeks GA and BW of 1500 g or more born at hospitals with more NICU beds per 1000 live births than the median value had higher odds of NICU admission.[8] However, questions remain about confounding by obstetric/fetal case mix; obstetric referral selection bias may exist at some hospitals with greater numbers of NICU beds. Supply-sensitive care describes clinical services for which frequency of use relates to system capacity.[40] In the Medicare database, resource supply is the main determinant of health care usage[40]; areas with high supply levels are the same areas as those with the most unwarranted health care.[40] This additional care does not result in improved patient outcomes.[41] Health-policy researchers see high potential for available supply to increase utilization in NICUs.[7,42,43] Supply-sensitive care can sustain a positive feedback loop in which hospital administration concludes the utilization data warrant further NICU expansion.[34] Researchers ask whether variation in NICU resource use signals overuse.[8,34,44,45] The number of available NICU beds the day before an infant's birth affects that infant's probability of NICU admission.[43] One empty bed increases NICU admission risk in California and New York by about 1%, and "the average infant in California is born with 2.5 empty beds available in the NICU and the average infant in New York is born with 10 empty beds available"; thus, "assuming infants are born on days between 2.5 and 10 empty beds", … "between 2.5% and 10% of NICU patients are admitted due to the number of beds available when they are born."[43] Providers may differ in their thresholds for LAINA based on bed availability and facility options for medical management.

Although the present study sampled almost three-quarters of California births and NICU admissions in 2022, the findings are subject to several limitations. Approximately 20 non-CCS California NICUs were not required to and did not report; none were level IV. This may bias findings toward lower LAINA counts. California data from 2021 for neonatal abstinence syndrome (NAS) offer some perspective on concerns for underestimation of LAINA and categorical representation. Among all 420 754 births,[46] there were 1204 NAS newborn hospitalizations[47]; in the present study, among at least 306 364 live births, there were 1171 LAINAs assigned to the NAS category—a number within 3% of the statewide total for the previous year. Nevertheless, the low end of the range of values for many diagnostic categories was 0, raising concern for accuracy of at least some categorical assignments.

TABLE 3. Description of the Distributions of Each LAINA Diagnosis/Category Across All Reporting NICUs

	# Observations	1st %ile	10th %ile	Mean	50th %ile	90th %ile	99th %ile	Total Across All Hospitals
LAINA: # Dx with suspected infection	120	0	10	86.6	64.5	180.5	418	10 388
LAINA: % with suspected infection	120	0	7.79	37.9	37.3	74.6	89.5	39.6
BW, g								
1501–2000	117	0	0	33.0	30	77.8	100	
2001–2500	118	0	0	34.8	31.7	69.7	91.3	
2501–4000	118	0	10.29	42.0	43.1	77.0	95.4	
≥4001	118	0	0	42.6	39.7	86.4	100	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	0	0	43	42.2	87.9	100	
34 wk 0/7 d-36 wk 6/7 d	118	0	2.13	32.8	28.9	72.5	90.8	
37 wk 0/7 d-38 wk 6/7 d	118	0	5.26	36.9	35.6	70	94.4	
39 wk 0/7 d-41 wk 6/7 d	118	0	11.63	46.2	46.2	81.0	95.2	
≥42 wk 0/7 d	47	0	0	52.7	50	100	100	
LAINA: # Dx with respiratory distress	120	0	29	94.1	80.5	178.5	369	11 298
LAINA: % with respiratory distress	120	0	25.0	42.9	43.2	60.8	71.1	43.0
BW, g								
1501–2000	117	0	11.1	38.2	38.5	66.1	75	
2001–2500	118	5.13	15.6	36.1	36.2	57.1	67.9	
2501–4000	118	16.19	28.6	47.6	48.7	66.7	77.1	
≥4001	118	0	25	57.6	58.3	88.9	100	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	0	19.05	52.2	55.5	81.2	100	
34 wk 0/7 d-36 wk 6/7 d	118	8.82	18.75	37.9	38.4	56.2	66.1	
37 wk 0/7 d-38 wk 6/7 d	118	10.53	26.3	44.6	42.5	64.9	76.8	
39 wk 0/7 d-41 wk 6/7 d	118	12.24	28.9	49.1	47.9	69.7	84.2	
≥42 wk 0/7 d	47	0	0	53.9	50	100	100	
LAINA: # Dx with hypoglycemia	120	0	7	39.9	29	89.5	184	4792
LAINA: % with hypoglycemia	120	0	5.9	18.0	17.7	30.3	46.4	18.2
BW, g								
1501–2000	117	0	0	15.1	12.9	32.3	59.1	
2001–2500	118	0	5.3	21.1	18.1	40.9	62.6	
2501–4000	118	0.77	4.4	17.0	15.9	29.5	47.9	
≥4001	118	0	7.1	33.0	32.5	55.5	100	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	0	0	14.6	11.4	40	57.1	
34 wk 0/7 d-36 wk 6/7 d	118	0	7.3	22.4	21.6	40	55.1	
37 wk 0/7 d-38 wk 6/7 d	118	0	7.3	22.9	22.0	39.2	60.4	
39 wk 0/7 d-41 wk 6/7 d	118	0	2.9	13.5	12.8	25.5	37.6	
≥42 wk 0/7 d	47	0	0	9.6	0	50	100	
LAINA: # Dx with hyperbilirubinemia	120	0	6.5	63.2	50	135	295	7590
LAINA: % with hyperbilirubinemia	120	0	5.3	28.3	27.9	60.6	74.6	28.9
BW, g								
1501–2000	117	0	0	39.8	38.7	81.8	96.1	
2001–2500	118	0	3.7	33.5	31.0	72.7	83.7	
2501–4000	118	0	5.3	25.5	22.5	51.1	71.6	
≥4001	118	0	0	24.4	20	58.3	88.9	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	0	0	46.7	50	90.9	100	
34 wk 0/7 d-36 wk 6/7 d	118	0	2.7	34	30.9	73.7	83.9	
37 wk 0/7 d-38 wk 6/7 d	118	0	4.6	25.7	21.8	53.2	75	
39 wk 0/7 d-41 wk 6/7 d	118	0	2.9	21.2	17.2	47.4	68.9	
≥42 wk 0/7 d	47	0	0	7.4	0	0	100	

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TABLE 3. Description of the Distributions of Each LAINA Diagnosis/Category Across All Reporting NICUs (Continued)

	# Observations	1st %ile	10th %ile	Mean	50th %ile	90th %ile	99th %ile	Total Across All Hospitals
LAINA: # Dx with temperature instability	120	0	0	11.7	5	28	93	1400
LAINA: % with temperature instability	120	0	0	5.0	2.5	10.8	33.7	5.3
BW, g								
1501–2000	117	0	0	8.6	0	22.6	75	
2001–2500	118	0	0	8.1	3.8	20	59.1	
2501–4000	118	0	0	3.8	2.2	10.3	22.8	
≥4001	118	0	0	1.5	0	7.1	13.3	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	0	0	7.4	0	27.0	90	
34 wk 0/7 d-36 wk 6/7 d	118	0	0	6.8	8.6	17.5	47.2	
37 wk 0/7 d-38 wk 6/7 d	118	0	0	4.9	3.5	11.8	29.1	
39 wk 0/7 d-41 wk 6/7 d	118	0	0	3.3	1.7	9.6	20.4	
≥42 wk 0/7 d	47	0	0	4.8	0	0	100	
LAINA: # Dx with feeding difficulty	120	0	3	56.1	35.5	124.5	297	6729
LAINA: % with feeding difficulty	120	0	2.5	25.1	20.2	56.5	70.2	25.6
BW, g								
1501–2000	117	0	0	44.4	42.9	87.5	100	
2001–2500	118	0	3.7	37.4	33.3	77.8	89.3	
2501–4000	118	0	2.3	19.1	14.4	47.2	61.6	
≥4001	118	0	0	14.7	6.5	46.1	70.6	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	0	0	49.5	48.1	100	100	
34 wk 0/7 d-36 wk 6/7 d	118	0	1.9	33.8	30.0	75	84.9	
37 wk 0/7 d-38 wk 6/7 d	118	0	2.3	19.8	14.2	50	62.9	
39 wk 0/7 d-41 wk 6/7 d	118	0	1.1	14.8	8.9	37.8	63.8	
≥42 wk 0/7 d	47	0	0	25.2	0	100	100	
LAINA: # admitted due to BW/GA admit policy	120	0	21.5	67.23	56	117	312	8072
LAINA: % admitted due to BW/GA admit policy	120	0	17.1	31.3	30.7	47.2	61.0	30.7
BW, g								
1501–2000	117	25	63.6	84.7	90	100	100	
2001–2500	118	19.0	41.2	64.3	65.1	85	97.7	
2501–4000	118	0	3.0	12.0	10.4	21.0	38.9	
≥4001	118	0	0	3.7	0	12.5	28.6	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	26.1	71.4	89.3	100	100	100	
34 wk 0/7 d-36 wk 6/7 d	118	12.5	37.7	63.8	62.8	92.6	100	
37 wk 0/7 d-38 wk 6/7 d	118	0	0	5.3	2.8	13.6	33.3	
39 wk 0/7 d-41 wk 6/7 d	118	0	0	0.9	0	2.3	9.1	
≥42 wk 0/7 d	47	0	0	0	0	0	0	
LAINA: # Dx with SGA	120	0	2	18.2	13	42	79	2190
LAINA: % with SGA	120	0	1.5	8.2	8.0	14.7	19.0	8.3
BW, g								
1501–2000	117	0	5.3	29.8	28.6	50	63.3	
2001–2500	118	0	0	15.1	14.1	28.9	57.7	
2501–4000	118	0	0	2.7	2.1	5.5	11.9	
≥4001	118	0	0	0.0	0	0	0	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	0	0	5.6	0	13.5	40	
34 wk 0/7 d-36 wk 6/7 d	118	0	2.5	12.2	11.7	21.7	35.4	
37 wk 0/7 d-38 wk 6/7 d	118	0	0	11.6	10.3	23.7	41.9	
39 wk 0/7 d-41 wk 6/7 d	118	0	0	4.2	3.1	10.2	20	
≥42 wk 0/7 d	47	0	0	7.4	0	0	100	

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TABLE 3. Description of the Distributions of Each LAINA Diagnosis/Category Across All Reporting NICUs (Continued)

	# Observations	1st %ile	10th %ile	Mean	50th %ile	90th %ile	99th %ile	Total Across All Hospitals
LAINA: # admitted for perinatal transition monitoring	120	0	0	13.5	2	38.5	113	1618
LAINA: % admitted for perinatal transition monitoring	120	0	0	4.9	1.36	15.3	32.6	6.2
BW, g								
1501–2000	117	0	0	2.8	0	6.7	42.3	
2001–2500	118	0	0	3.6	0	10.7	41.9	
2501–4000	118	0	0	6.0	1.8	19.0	42.3	
≥4001	118	0	0	6.9	0	26.3	50	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	0	0	3.6	0	10	62.5	
34 wk 0/7 d-36 wk 6/7 d	118	0	0	3.6	0	12.1	30.4	
37 wk 0/7 d-38 wk 6/7 d	118	0	0	5.8	1.8	16.9	46.1	
39 wk 0/7 d-41 wk 6/7 d	118	0	0	6.7	1.9	21.9	47.7	
≥42 wk 0/7 d	47	0	0	5.3	0	50	100	
LAINA: # Dx with NAS	120	0	1	9.8	7	24	41	1171
LAINA: % Dx with NAS	120	0	0.8	5.1	3.6	10.7	22.2	4.5
BW, g								
1501–2000	117	0	0	2.1	0	7.0	14.3	
2001–2500	118	0	0	4.7	3.1	11.1	33.3	
2501–4000	118	0	0.8	6.5	4.7	8	24.6	
≥4001	118	0	0	1.8	0	7.1	25	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	0	0	2.7	0	7.1	33.3	
34 wk 0/7 d-36 wk 6/7 d	118	0	0	4.3	2.9	11.1	30.8	
37 wk 0/7 d-38 wk 6/7 d	118	0	0	8.0	5.5	19.4	40.9	
39 wk 0/7 d-41 wk 6/7 d	118	0	0	5.4	3.4	13.3	27.3	
≥42 wk 0/7 d	47	0	0	17.7	0	100	100	
LAINA: # Dx with dysmorphic/chromosomal anomaly	120	0	0	7.2	2	22	53	869
LAINA: % with dysmorphic/chromosomal anomaly	120	0	0	3.1	1.6	7.7	22.5	3.3
BW, g								
1501–2000	117	0	0	2.3	0	8.3	26.9	
2001–2500	118	0	0	2.8	0	8.6	23.2	
2501–4000	118	0	0	3.8	2.2	9.4	24.7	
≥4001	118	0	0	1.8	0	5.3	25	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	0	0	2.1	0	8.3	25	
34 wk 0/7 d-36 wk 6/7 d	118	0	0	2.4	0.9	6.1	18.9	
37 wk 0/7 d-38 wk 6/7 d	118	0	0	4.4	2.5	12.3	25.7	
39 wk 0/7 d-41 wk 6/7 d	118	0	0	3.5	1.6	9.8	24.2	
≥42 wk 0/7 d	47	0	0	2.7	0	0	100	
LAINA: # Dx with apnea/cyanotic episode	120	0	0.5	20.6	10.5	65.5	127	2470
LAINA: % with apnea/cyanotic episode	120	0	0.2	8.6	6.6	19.4	28.4	9.4
BW, g								
1501–2000	117	0	0	17.3	12.5	43.6	56.2	
2001–2500	118	0	0	12.7	9.9	30.8	46.4	
2501–4000	118	0	0	6.2	4.4	14.8	22.0	
≥4001	118	0	0	5.0	0	15.9	33.3	

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TABLE 3. Description of the Distributions of Each LAINA Diagnosis/Category Across All Reporting NICUs (Continued)

	# Observations	1st %ile	10th %ile	Mean	50th %ile	90th %ile	99th %ile	Total Across All Hospitals
GA								
32 wk 0/7 d-33 wk 6/7 d	116	0	0	21.6	13.4	59.5	72.7	
34 wk 0/7 d-36 wk 6/7 d	118	0	0	11.2	9.1	29.0	44.9	
37 wk 0/7 d-38 wk 6/7 d	118	0	0	6.2	4.4	15.5	25	
39 wk 0/7 d-41 wk 6/7 d	118	0	0	4.6	3.0	12.4	18.4	
≥42 wk 0/7 d	47	0	0	1.1	0	0	50	
LAINA: # Dx with cardiac concern	120	0	0	14.8	8.5	35.5	95	1776
LAINA: % with cardiac concern	120	0	0	6.1	4.0	15.5	25.5	6.8
BW, g								
1501–2000	117	0	0	4.7	0	14.3	38.5	
2001–2500	118	0	0	5.4	2.6	14.8	27.8	
2501–4000	118	0	0	6.6	4.6	14.8	25	
≥4001	118	0	0	9.6	5.8	28.6	44.4	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	0	0	6.3	0	20	50	
34 wk 0/7 d-36 wk 6/7 d	118	0	0	5.0	2.7	15.6	28.6	
37 wk 0/7 d-38 wk 6/7 d	118	0	0	7.5	5.3	17.4	38	
39 wk 0/7 d-41 wk 6/7 d	118	0	0	6.7	5.3	14.8	25.5	
≥42 wk 0/7 d	47	0	0	0	0	0	0	
LAINA: # Dx with seizure/neurological concern	120	0	0	4.3	1	10.5	34	519
LAINA: % with seizure/neurological concern	120	0	0	1.9	1.0	5.4	13.6	2.0
BW, g								
1501–2000	117	0	0	1.6	0	7.1	25.4	
2001–2500	118	0	0	1.0	0	4.4	13.3	
2501–4000	118	0	0	2.4	1.4	7.0	15.4	
≥4001	118	0	0	2.3	0	10	33.3	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	0	0	1.3	0	3.4	33.3	
34 wk 0/7 d-36 wk 6/7 d	118	0	0	1.3	0	3.7	14.1	
37 wk 0/7 d-38 wk 6/7 d	118	0	0	2.5	0	7.8	16.7	
39 wk 0/7 d-41 wk 6/7 d	118	0	0	2.6	0	8.1	18.0	
≥42 wk 0/7 d	47	0	0	6.9	0	0	100	
LAINA: # with other Dx, not specified	120	0	0	8.7	0	25.5	107	1043
LAINA: % with other Dx, not specified	120	0	0	3.4	0	12.6	55.4	4.0
BW, g								
1501–2000	117	0	0	2.3	0	7.7	37.1	
2001–2500	118	0	0	2.7	0	7.0	57.1	
2501–4000	118	0	0	4.0	0	12.8	69.6	
≥4001	118	0	0	4.3	0	14.3	66.7	
GA								
32 wk 0/7 d-33 wk 6/7 d	116	0	0	2.8	0	4.5	61.1	
34 wk 0/7 d-36 wk 6/7 d	118	0	0	2.7	0	7.1	42.9	
37 wk 0/7 d-38 wk 6/7 d	118	0	0	4.1	0	16.7	61.5	
39 wk 0/7 d-41 wk 6/7 d	118	0	0	4.1	0	13.5	71.0	
≥42 wk 0/7 d	47	0	0	7.4	0	0	100	

Abbreviations: #, number; BW, birth weight; Dx, diagnosis; GA, gestational age; LAINA, lower-acuity inborn NICU admission; NAS, neonatal abstinence syndrome; NICU, neonatal intensive care unit; SGA, small for GA; %tile, percentile.

The CPQCC high-illness-acuity criterion "acute transport in or out" could include infants of otherwise low acuity and result in underestimating the actual burden of otherwise-defined low-acuity illness. Self-reporting and independently determined diagnostic categorization by individual NICUs could affect observed variation and data accuracy.

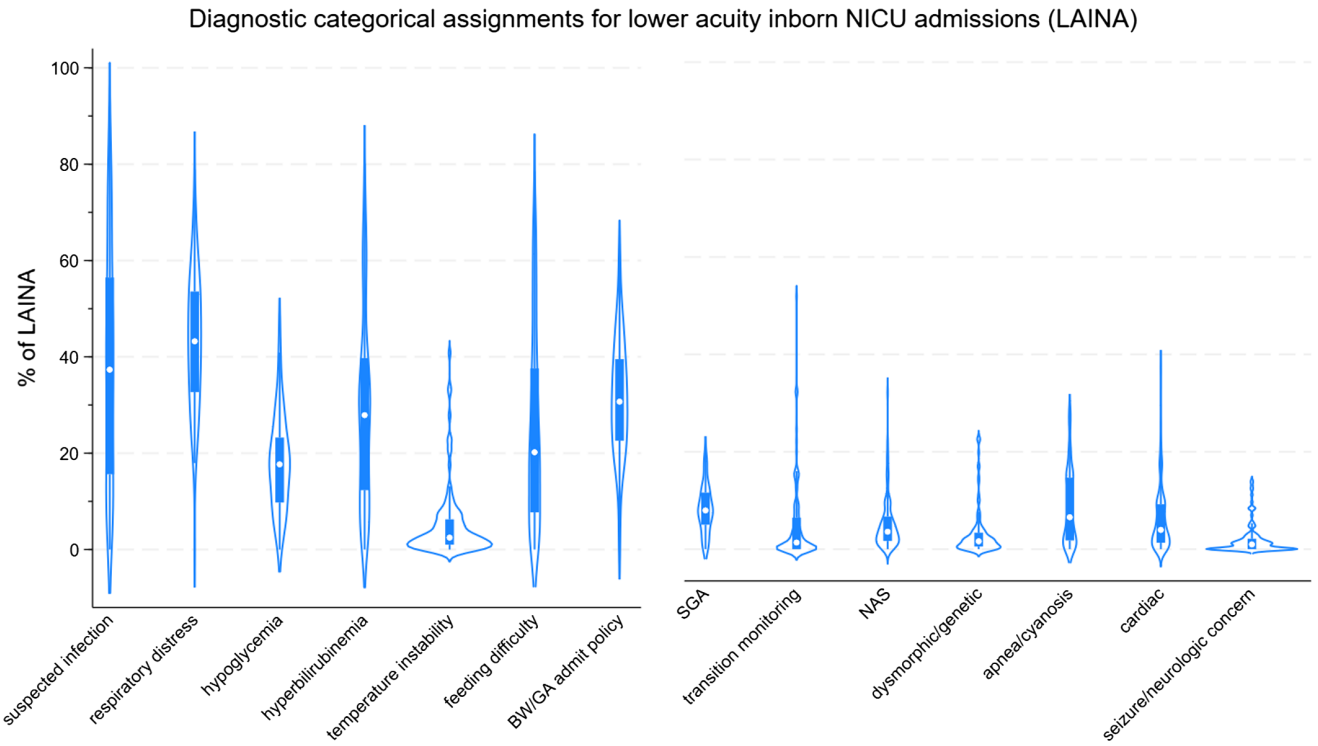

FIGURE 3.
The range of values across all neonatal intensive care units (NICUs) for percent of lower-acuity inborn NICU admissions (LAINAs) assigned to each specific diagnostic category; "other" applied to 3.7% of LAINAs and is not shown. BW, birth weight; GA, gestational age; NAS, neonatal abstinence syndrome; SGA, small for GA.

Computing an aggregate NICU admission rate using Table 2 would likely yield an overestimate because some hospitals without a NICU may have transferred cases antenatally, skewing case mix at receiving facilities. Additionally, we counted outborns among total NICU admissions, while the count of total births may not reflect births at some referring hospitals. The mean value across hospitals for mean LOS for all NICU admissions—including LAINAs—reflects surviving infants born at very low GA, skewing the distribution of values from which mean LOS for all NICU admissions is computed.

This study's findings invite expanding the breadth and depth of this inquiry. NICUs outside California do not routinely collect data describing their LAINAs. The LAINA variable array in California is relatively sparse; it is insufficient to understand the observed wide variation in resource use and diagnostic categorization or to inform concerns about resource overuse or underuse. It is thus currently unclear what guides NICU providers regarding care and outcomes they do not measure.[16] Understanding why the percentage of LAINAs with suspected infection varies more widely than any other diagnosis/category (Figure 3) may be facilitated by establishing pathophysiological explanatory diagnoses for infants with suspected infection and negative blood culture. The wide variation in the percentage of LAINAs with hyperbilirubinemia may be illuminated by accounting for institutional variation in GA/BW/postnatal age/bilirubin levels/pathophysiology warranting NICU admission. However, evaluating resource use for hyperbilirubinemia is further complicated by lack of measurement and recording of phototherapy dosage, duration, and type of delivery unit.[48] Reflection on LAINA solely due to BW/GA-based NICU admission policies could be informed by discerning those infants whose care needs indeed could be met in the mother–baby unit or newborn nursery. For patients at relatively lower risk of mortality/serious morbidity, it is important to establish what other outcome variables inform determination of effective, necessary, and sufficient NICU care. Undoubtedly, the process of improving oversight of care for these patients will entail reiterative learning cycles.

One approach to evidence-based determination of effective/necessary care could entail clinical trials in NICU/non-NICU settings for specified subgroups differing only in where/how they receive care. Another could entail expanding case-selection criteria for morbidity/mortality review meetings to include cases lacking objective diagnoses explaining the need for LAINA, with the intent of promoting diagnostic strategies and tactics for identifying what the underlying problem, in fact, was. Particularly applicable for suspected infection, such meetings could

strive to identify root-cause conditions, such as virus, retained fetal lung fluid, thermal instability, or mismanagement. This approach could be further leveraged via quality-improvement collaboratives.

CONCLUSION

In a sample of almost three-quarters of California births and NICU admissions, approximately 60% of all NICU admissions are of relatively lower illness acuity, accounting for almost a third of all NICU patient-days; associated diagnostic categorization varies substantially across NICUs. These findings support (1) expanding current approaches to describing aggregated NICU inputs, services, and outcomes, broadening the focus beyond mainly patients of high illness acuity; (2) reconceptualizing neonatal care—rather than binary categorization of illness acuity, perhaps by pathophysiological groups mapping with patient care needs; and (3) developing criteria for medically necessary LAINA care.

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ABBREVIATIONS

BW: birth weight
CCS: California Children's Services
CPQCC: California Perinatal Quality Care Collaborative
GA: gestational age
LAINA: lower-acuity inborn NICU admission
LOS: length of stay
NAS: neonatal abstinence syndrome
NICU: neonatal intensive care unit.

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