Association of Neonatologist Continuity of Care and Short-Term Patient Outcomes

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Objectives To describe neonatologist continuity of care and estimate the association between these transitions and selected patient outcomes.

Study design We linked Children's Hospitals Neonatal Database records with masked neonatologist daily schedules at 4 centers, which use 2- and 3-week and 1-month "on service" blocks to provide care. After describing the neonatologist transitions, we estimated associations between these transitions and selected short-term patient outcomes using multivariable Poisson, logistic, and linear regression analyses, independent of length of stay (LOS) and case-mix. We also completed analyses after stratifying the cohort by LOS, birthweight, age at admission categories, and selected diagnoses.

Results Stratified by LOS, patient transitions varied between centers in both unadjusted ($P < .001$) and multivariable analyses (adjusted incidence rate ratio; 95% CI for center B = 3.98 (3.81-4.15), center C = 4.92 (4.71-5.13), center D = 4.2 (4.0-4.4), $P < .001$), independent of LOS, gestational age, birthweight, surgical intervention, ventilator duration, and mortality. Only central venous line duration (adjusted incidence rate ratio 1.015, 95% CI 1.01-1.02) was minimally and independently associated with the number of transitions. No differences were observed in ventilator duration, oxygen use at neonatal intensive care unit discharge, bloodstream infections, or urinary tract infections. Surviving infants with meconium aspiration, hypoxic ischemic encephalopathy, cerebral infarction, bronchopulmonary dysplasia, and diaphragmatic hernia demonstrated similar findings.

Conclusions Transitions in neonatologists are frequent in regional neonatal intensive care units but appear unrelated to short-term patient outcomes. Future work to define continuity of care and develop effective strategies that promote longitudinal inpatient management is needed. *(J Pediatr 2019;212:131-6)*.

Infants in regional neonatal intensive care units (NICUs)[1] are frequently referred with congenital anomalies, life-threatening morbidities related to preterm birth, and/or diagnostic dilemmas that require complicated management strategies. These infants often have prolonged hospitalizations and their neonatologists provide both daily patient care and longitudinal management. Many neonatologists also balance educational, research, and administrative responsibilities. Institutions and their NICUs address these competing pressures with variable staffing models[2] that influence continuity of care.

Many NICUs, providers, and families prefer greater continuity of physician care, but the value it contributes toward patient management and outcomes is not known. Longer intensive care unit (ICU) service durations could promote continuity, but may contribute to physician fatigue and diagnostic or management biases. Conversely, shorter ICU rotations may provide more novel clinical perspectives but may limit the longitudinal view of care plans. Evaluation of staffing models and continuity of care has been minimal for neonatologists. Studies focused on continuity of care provided by trainees show conflicting results on length of stay (LOS) and adverse events.[3-6] Generalizing these conclusions to attending physicians is difficult, as their experience and patient care role are different from trainees, particularly in academic hospitals.[7-9] The few studies that examine continuity of care among attending physicians observed association with physician

BSI	Bloodstream infection
CHND	Children's Hospitals Neonatal Database
CVL	Central venous line
ICU	Intensive care unit
LOS	Length of stay
NICU	Neonatal intensive care unit
UTI	Urinary tract infection

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metrics such as burnout but not with patient outcomes,[10-13] with the exception of 1 finding of decreased LOS.[14]

Quantifying the effects of continuity of care could benefit patients, neonatologists, and NICUs in optimizing staffing models and promoting other strategies to retain longitudinal clinical perspectives for patients. Our objective was to describe the continuity of neonatologist care in different staffing models and evaluate its effects on selected short-term patient outcomes in regional NICUs. We hypothesized that neonatology transitions were widely varied for NICU patients, yet had minimal impact on patient outcomes.

Methods

We linked clinical data to blinded neonatologist schedules. Four regional NICUs provided retrospective clinical data from the Children's Hospitals Neonatal Database (CHND),[2,15-18] a data registry that captures demographic data, diagnoses, and selected inpatient outcomes for every infant admitted to a participating hospital's NICU. The criteria for CHND participation include >400 annual admissions or >25 NICU beds, and >50% outborn infants. We included all infants whose entire NICU LOS fell within the center's submitted neonatologist schedule dates (at least 12 months of consecutive NICU admissions from 2014 to 2016).

Each center provided the de-identified neonatologist caring for infants on each day from daily service schedules (centers A, B, C) and daily service note author (center D, clinical note content was unavailable). We selected these 4 centers because they used different staffing models of neonatologist "on-service" blocks for daytime coverage—1 calendar month (center A), 3 weeks (center B), and 2 weeks (centers C and D). Center A covered weekends (Saturday/Sunday) with the "on-service" neonatologist; the other centers typically rotated neonatologists for weekend coverage. We omitted nighttime call neonatologists and frontline provider coverage schedules.

We counted the median number of transitions of neonatologists per infant as an index of continuity of care. We defined a transition as 2 consecutive days where the neonatologist differed. We reported transition counts that both included and excluded transitions that occurred during weekends (Saturday and Sunday), but performed the analysis with the counts including weekend transitions because relevant patient care may have occurred during the weekend. We also evaluated the number of unique neonatologists caring for a patient, as infants may have the same neonatologist care for them multiple times during their hospitalization. We used the count of transitions instead of unique neonatologists for the main analysis because the time interval between blocks when the neonatologist previously cared for an infant and the number of neonatologists at each center varied. We studied NICU stay rather than hospital stay as clinical outcomes occurring outside the NICU would be unlikely related to neonatologist transitions in care.

Because infants with longer hospitalizations experience more transitions, we described the median number of transitions as a function of LOS categories (0-14, 15-28, 29-60, 61-120, and 121-365 days). We also described transitions by birthweight categories (<1000 g, 1001-1500 g, 1501-2500 g, 2501-4000 g, >4001 g), center, age of NICU admission, and surgery during NICU hospitalization. We evaluated patients by the day of the week they were admitted to assess if specific admission days increased rates of transitions. We restricted this evaluation to patients with LOS less than 15 days, as any potential effect on transitions may be less clinically relevant for longer LOS. We tallied these counts for infants with selected patient diagnoses including meconium aspiration syndrome, hypoxic-ischemic encephalopathy, cerebral infarct, bronchopulmonary dysplasia, and congenital diaphragmatic hernia. We selected these diagnoses to span problems that have varying LOS and typically do require surgical management (congenital diaphragmatic hernia) or do not (hypoxic-ischemic encephalopathy).

Our other main objective was to estimate associations between number of transitions and selected patient outcomes. We selected the outcomes of central venous line (CVL) days, bloodstream infections (BSIs), urinary tract infections (UTIs), ventilator days, oxygen use at NICU discharge, and NICU growth velocity (g/kg/day),[19] as they could plausibly be affected by transitions of care. In these analyses, we considered the counts of transitions per infant as the primary exposure.

We used the following clinical data from CHND: sex, gestational age, birthweight, admission weight, discharge weight, age at admission to regional NICU, NICU admission day of the week, inborn status, center, home prior to admission, NICU and hospital LOS, diagnoses, surgical intervention during the current NICU hospitalization, CVL days, infections, days of mechanical ventilation, oxygen use upon NICU discharge, and mortality.

Data Analyses

We used parametric (eg, % admitted on weekend) and nonparametric (birthweight, gestational age) testing to evaluate differences between centers' patient characteristics after examining their descriptive distributions, as appropriate. Then, we used unadjusted and multivariable regression analyses to estimate the associations between patient transitions (Poisson and negative binomial regression) and center after adjusting for LOS, gestational age, birthweight, surgical intervention, ventilator days, and mortality. For the patient outcomes, we created similar regression equations to estimate the effect of patient transitions on their selected outcomes, independent of LOS, gestational age, birthweight, sex, age at admission, inborn status, any surgical intervention, UTIs, BSIs, systemic corticosteroids administered during current admission, and mortality. We retained variables that were significantly associated with exposures and outcomes in unadjusted analyses. In multivariable analyses, we kept variables which were both significant ($P < .01$) and changed the primary association between the exposure and outcome of interest by at least 15%. The interaction between center and the cited LOS categories was also evaluated in the descriptive (transitions) and the observational (patient-outcomes) analyses, evaluating whether different centers have differential effects on these outcomes as LOS increases.

We re-analyzed selected main results using negative binomial regression techniques equations because some of the transition counts and patient outcomes could be considered continuous or discrete. With nearly identical coefficients and also a better qualitative, distributional fit of the transition and central line days as outcomes, we report the Poisson equations.

We re-analyzed the cohort after excluding patients with a LOS of 1 day, as these infants were unlikely to have experienced a transition of care. We did include these short-stay patients as they may have required an important effort from neonatologists and their care team(s), particularly if they were extremely ill or discharged home within 24 hours. Nonsurvivors may not experience skewed numbers of transitions of care compared with survivors; thus, we repeated regression analyses on survivors alone. In a subgroup analysis, we estimated the relationship between neonatology transitions and growth velocity (calculated via exponential method[19]) with multivariable linear regression for infants that had both admission and discharge weights encoded and a length of stay of at least 21 days to allow for stabilization of weight trajectory.

The estimated sample size encompassed 1 year of patient admissions at each NICU. With 90% power and type I error rate of 1%, we estimated that each patient saw 2 (±1) attendings per week they were hospitalized in the NICU. With a hypothesized difference of 50% (or 3 attendings per week with shorter faculty-rotation models), an estimated sample size of 200 infants in each center was sufficient. However, we aimed to capture data for 1 year of patients (~600 per center) to potentially detect differences in our secondary analyses of patient outcomes. We used ordinal sums as the number of neonatologists because a mean or fractional number of neonatologists was invalid.

We analyzed the data using Stata v 12.1 (StataCorp, College Station, Texas). The Institutional Review Board at each center approved this specific study (2017-1281) in addition to their prior participation in CHND.

Results

The characteristics of the 5893 infants included in the analyses are displayed in **Table I** (available at www.jpeds.com). Infants from centers A and C had significantly smaller birthweights, younger gestational age, younger age at admission, fewer outborn patients, fewer admissions from home, fewer CVL days, fewer ventilator days, and longer LOS than centers B and D. Thirty percent of infants had surgery during their hospitalization and one-third of the infants were referred after 7 days of age.

Stratified by LOS, the median number of transitions and the median number of unique neonatologists experienced by patients increased in centers with shorter service blocks ($P < .0001$), regardless if patient-days over the weekends were excluded from counting transitions (**Figure A**). For example, for infants with a LOS of 29-60 days, infants at centers B, C, and D experienced 5.5-, 6-, and 6.5-fold more individual neonatology transitions and 3-, 3.5-, and 4-fold more unique neonatologists than at center A, respectively.

In unadjusted comparisons, infants experienced significantly different numbers of transitions between centers for selected LOS, birthweight, age at admission categories, if they underwent surgery, and for selected diagnoses. Infants also experienced a significant increase in transitions for

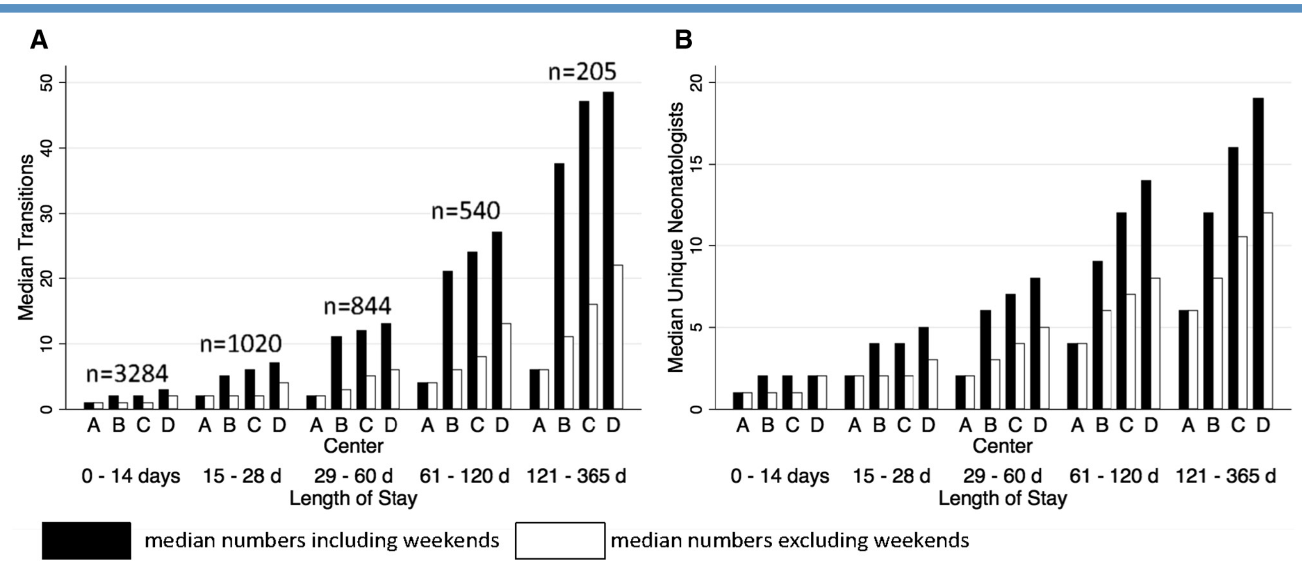

Figure. A, Median number of transitions (*left graph*) and **B,** unique neonatologists (*right graph*) experienced by patients, by center and LOS group, both including (*black bars*) and excluding (*white bars*) weekends. Infant admission counts in each LOS group are noted above the bars. $P < .0001$ between centers for median transitions and neonatologists and excluding weekends.

centers with shorter service blocks and if admitted at end of the week when evaluating a subgroup with a LOS <2 weeks (**Table II**; available at www.jpeds.com).

Multivariable models demonstrated a persistent association between center and transitions in care after adjusting for LOS, gestational age, birthweight, ventilator duration, surgical interventions, and mortality. Compared with center A, infants at center B experienced 4 times (95% CI 3.98-4.15), center C 4.92 times (95% CI 4.71-5.13), and center D 5.06 times (95% CI 4.87-5.26) higher incidence of transitions. These similar associations and trends were also evident among selected diagnosis groups (**Table III**).

CVL days were related to the number of transitions (adjusted incidence rate ratio = 1.015 CVL days per transition, 95% CI 1.01-1.02) independent of center, LOS, sex, gestational age, birthweight, age at admission, inborn status, surgical intervention, BSI, UTI, and mortality. Each individual transition was independently associated with a 1.5% increase in the number of CVL days (**Table IV**). Transitions were not associated with other selected outcomes including oxygen use after NICU discharge, duration of ventilator use, BSI, or UTI. When excluding infants with a LOS of 1 day (n = 131) or nonsurvivors (n = 307), the magnitude and direction of these associations were unchanged. For the growth velocity subgroup analysis of 1990 infants, growth velocity was inversely related with each transition (β = -0.028 g/kg/day per transition; 95% CI −0.053 to −0.003) after adjusting for center, LOS, surgical intervention, BSI, gestational age, systemic corticosteroids, and ventilator days.

Discussion

We quantified transitions of care among neonatologists and related these transitions to short-term patient outcomes at 4 regional NICUs. Transitions of neonatologist care were strikingly frequent, despite staffing models with longer rotations having fewer transitions. These findings persisted independent of patient characteristics and across selected neonatal diagnoses. Most selected short-term patient outcomes appeared unrelated to the frequency of transitions, except for small associations between transitions and CVL duration (direct) and growth velocity (inverse), both of which are unlikely to be clinically relevant. This association varied slightly for each diagnosis by center, suggesting center and disease-specific practices may influence this outcome.

Few studies have examined inpatient transitions of care, and they may not be particularly applicable to neonatologists' clinical practice. Many providers (nurses, trainees, advanced practice nurses, hospitalists) have frequent transitions[3-6]; however, attending physicians retain medical responsibility for longitudinal diagnostic and management plans. Implications of transitions in "big picture" decision-making differ from handoffs of daily patient care details provided by front line providers. Although attending clinicians have the benefit of additional clinical experience compared with trainees, they may be burdened more by fatigue, administrative duties, and academic pressures.[7-9] Among ICU attending physicians, increased continuity of care led to handoff efficiency and increased time off from clinical duties, but patient outcomes were not evaluated.[10,11] A staffing model revision among pediatric intensivists that covered weekends with different attendings (instead of the same weekday attending) decreased continuity of care, but patient LOS and mortality were unaffected and physician burnout, stress, and work-home life balance scores improved.[12] Handoff frequency among adult intensivists was not associated with ICU charges, 30-day readmission rates, or mortality rates.[13] Only 1 study demonstrated patient benefit (reduced LOS) with increased weekend continuity in adult medical wards.[14] In addition, NICUs have an important distinction of longer LOS compared with other ICUs (regional NICUs ranged from 3 to 112 days[2] with a median of 11 days for all patients in our study, compared with pediatric ICUs of 5 days or adult ICU of 3.3 days average LOS[20,21]). As LOS correlates with the number of transitions a patient might experience, staffing models have key implications in providing longitudinal consistency for critically ill infants.

We observed a small increase CVL days associated with more transitions, though the magnitude appears clinically insignificant. As an example, if an infant had 10 transitions more than another, CVL days would be only 0.2 days longer. Transitioning neonatologists beginning a service block could delay CVL removal until learning more about infants' trajectory of improvement, but this hypothesis requires further

Table III. Multivariable associations of transitions with center

	Transitions by center, adjusted incidence rate ratio (95% CI)			
Patient categories	**A**	**B**	**C**	**D**
All patients	Referent	3.98 (3.81-4.15)*	4.92 (4.71-5.13)*	5.06 (4.87-5.26)*
Selected diagnoses				
Meconium aspiration syndrome	Referent	3.13 (2.25-4.34)*	2.78 (2.02-3.84)*	4.70 (3.69-5.99)*
Hypoxic ischemic encephalopathy	Referent	2.90 (2.18-3.85)*	3.22 (2.26-4.59)*	4.39 (3.46-5.55)*
Cerebral infarction	Referent	2.95 (1.87-4.67)*	2.39 (1.51-3.79)*	3.36 (2.45-4.61)*
Bronchopulmonary dysplasia	Referent	5.76 (5.28-6.28)*	6.95 (6.40-7.54)*	6.87 (6.36-7.42)*
Severe bronchopulmonary dysplasia	Referent	6.17 (5.54-6.87)*	7.21 (6.49-8.01)*	7.19 (6.52-7.93)*
Congenital diaphragmatic hernia	Referent	4.24 (3.01-5.99)*	3.38 (2.30-4.97)*	5.70 (4.28-7.78)*

*$P < .001$, adjusted for LOS, gestational age, birthweight, surgery, ventilation duration, and mortality.

Table IV. Association between transitions and CVL days

Patient categories	Total transitions	Line days by center, adjusted incidence rate ratio (95% CI)			
		A	B	C	D
All patients	1.015 (1.01-1.02)*	Referent	0.68 (0.66-0.70)*	0.60 (0.58-0.62)*	0.80 (0.78-0.83)*
Selected diagnoses					
Meconium aspiration Syndrome	1.01 (0.99-1.03)	Referent	0.83 (0.64-1.06)	0.45 (0.33-0.62)*	1.35 (1.09-1.66)*
Hypoxic ischemic encephalopathy	1.04 (1.02-1.07)*	Referent	0.70 (0.56-0.89)*	1.47 (1.09-1.98)	0.85 (0.69-1.06)
Cerebral infarction	1.06 (1.04-1.08)*	Referent	0.17 (0.08-0.38)*	0.63 (0.40-1.01)	1.06 (0.77-1.45)
Bronchopulmonary dysplasia	1.01 (1.01-1.01)*	Referent	0.84 (0.78-0.91)*	0.69 (0.64-0.75)*	0.91 (0.84-1.00)
Severe bronchopulmonary dysplasia	1.01 (1.01-1.01)*	Referent	1.06 (0.96-1.16)	0.84 (0.75-0.94)*	1.13 (1.08-1.27)
Congenital diaphragmatic hernia	0.99 (0.98-0.99)*	Referent	1.04 (0.86-1.25)	0.89 (0.72-1.12)	1.42 (1.20-1.69)*

*$P < .005$, adjusted for gestational age, birthweight, sex, age at admission, inborn status, LOS, surgery, BSI, UTI, and mortality.

study. The subgroup finding of a small, inverse relationship between transitions and growth velocity should be evaluated further with detailed caloric intake, biological influences on growth, and other markers of nutritional status.

We could not assess the impact of transitions on family, staff, and physicians retrospectively. Though no mechanism (including postdischarge parental surveys) currently exists to evaluate the effect of continuity on family and staff, families have vocalized anecdotally a desire for consistency balanced by an appreciation for new perspectives toward the care of their infants. Family communication, education, and shared decision-making demonstrate need for improvement,[22] and we speculate continuity of care may have important impacts in these domains. Understanding those impacts and which families under which circumstances would benefit most from the support of enhanced neonatologist continuity remain an area for future work. The influence of continuity on NICU culture, including staff communication, nursing turnover, physician fatigue, and burnout, also merits investigation, particularly given the changing demographics of the neonatology work force.[23-25]

Continuity is difficult to attain or measure without a clear definition or validation of what is optimal for patients, families, and providers. We focused on transitions of the daily neonatologist in this study, though continuity of care likely encompasses more than simply fewer transitions. Each transition may enhance or detract from the longitudinal care of the infant.[8,26] Many other unit and patient factors may affect a team's collective understanding of an infant's clinical course, including other aspects of staffing. Overlapping staffing among the many members of an infant's team and overnight coverage may be important in a subset of infants (such as critical changes in status, new admissions). Repetitive, but nonconsecutive, care of an infant by an attending may enhance continuity, though this likely depends on the time and clinical events occurring between care episodes. We initiated this analysis by evaluating the number of unique neonatologists that cared for an infant; however, the size of the neonatology group and the interval between care of an infant impact this analysis. Ultimately, we believe that continuity in longitudinal care plans should be possible, regardless of transitions.

Our study has important limitations. Coding errors in the schedules and the clinical data may have occurred. CHND data were subject to data collection procedures as previously described[2]; the accessed call schedules were the legal records of physician coverage at each participating institution. Unmeasured unit factors may have modified our outcomes, such as standardized disease-specific pathways, care bundles, and quality improvement projects, though adherence to a protocol is ultimately at the discretion of the attending neonatologist. These centers did not employ protocols that directly impacted our studied outcomes, though a comprehensive list of potentially related protocols and compliance rates were unavailable during the studied time period. These centers did not use formalized handoff tools, however, centers may have used other unidentified practices to promote continuity. Also, though the role in continuity of front-line providers differs from attendings, their work may have influenced longitudinal clinical care. The lack of available family-centric and staff-based outcomes represented another set of limitations. Lastly, the association between transitions and LOS could not be evaluated given their co-linearity.

Current neonatologist staffing models place emphasis on continuity of care. Our study questions how much value the continuity of care provided by neonatologists contributes toward short-term patient outcomes. If patient outcomes are essentially equivalent between these staffing models, perhaps continuity of the neonatologist should be considered less of a priority in our present era of complex care delivery. Other strategies that optimize delivery of longitudinal care plans, including high-quality handoffs, should be evaluated,[27-29] especially given the frequency of transitions for infants with longer LOS. Lastly, continuity of care requires definitional clarity, with content that incorporates the perspectives and dynamic goals of families and clinicians and the related assessments in patient outcomes. ■

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Table I. Center-specific patient characteristics

Centers	All	A	B	C	D
Patient admissions, n	5893	1617	1037	768	2471
Length of service blocks		1 mo	3 wk	2 wk	2 wk
Number of transitions per patient, median (IQR)	3 (4)	2 (1)	3 (4)	5 (9)	4 (7)
Number of unique neonatologists per patient, median (IQR)	3 (3)	2 (1)	2 (2)	4 (5)	4 (5)
Female sex, %	42.9	43.1	42.0	42.4	43.2
Gestational age, median wk (IQR)	37 (6)	36 (8)	37 (5)	36 (7)	37 (6)
Birth weight, median kg (IQR)	2.74 (1.53)	2.66 (1.73)	2.90 (1.43)	2.54 (1.67)	2.80 (1.38)
Growth velocity in infants with LOS >21 d, g/kg/d (IQR)	7.67 (6.45)	9.44 (6.53)	6.91 (6.46)	9.33 (5.92)	6.33 (4.95)
Public insurance, %	50.3	61.7	44.6	57.8	43.0
NICU LOS, median d (IQR)	11 (26)	15 (31)	9 (21)	15 (29)	9 (22)
Age at admission, median d (IQR)	2 (15)	0 (2)	4 (12)	0 (4)	7 (47)
Weekend admission (Sat/Sun), %	21.6	24.7	22.9	23.3	18.6
Outborn (ambulance/air transport), %	63.9	54.3	65.2	46.7	75.0
Admitted from home, %	19.1	3.8	25.2	7.0	30.4
Any surgery, %	30.6	20.0	17.6	35.4	41.5
CVL d, median (IQR)	10 (16)	8 (11)	13 (19)	9 (16)	12 (23)
BSI, %	4.6	4.8	2.8	4.3	5.5
UTI, %	2.7	3.2	2.2	3.3	2.5
Ventilator d, median (IQR)	6 (16)	4 (11)	6.5 (15)	6 (20)	9 (23)
Oxygen use at NICU discharge, %	16.6	15.2	11.4	24.0	17.4
Mortality, %	5.2	5.4	5.2	4.3	5.4

All patient characteristics were significantly different ($P < .001$) between centers except sex, weekend admission, BSI, UTI, and mortality ($P > .5$ for these 5).

Table II. Median counts of transitions stratified for various groups by center (IQR)

		Median counts (IQR) by center				
Patient categories	n (infants)	All	A	B	C	D
Birthweight						
<1000 g	759	6 (20)	4 (3)	14 (26.5)	21 (21)	11 (27)
1001-1500 g	471	4 (10)	3 (1)	5 (16)	13 (11)	6 (16)
1501-2500 g	1274	3 (7)	2 (1)	4 (9)	7 (7)	6 (9)
2501-4000 g	3073	2 (3)	1 (1)	3 (3)	3 (4)	4 (4)
>4001 g	308	2 (3)	1 (1)	2 (3)	3 (4)	3 (5)
Age at admission						
<7 d of age	3923	3 (5)	2 (1)	3 (5)	5 (8)	5 (7)
7-29 d	849	3 (4)	2 (1)	3 (4)	5 (16)	4 (4)
30-59 d	474	3 (5)	1 (1)	3 (7)	4 (3)	3 (6)
60-119 d	439	3 (5)	1.5 (1.5)	3 (5)	6 (15)	3 (5)
>120 d	199	5 (12)	2 (2)	6 (12)	11 (9)	5 (15)
Any surgery	1804	5 (12)	2 (3)	8 (12)	8 (15)	7 (16)
Admitted at end of wk (LOS <15 d)						
Admitted on Thursday	950	2 (3)	1 (0)	2 (2)	2 (2)	3 (2)
Admitted on Friday	930	3 (4)	1 (1)	3 (3)	5 (1)	4 (5)
Admitted on Saturday or Sunday	1275	3 (4)	2 (1)	3 (4)	4 (9)	4 (8)
Selected diagnoses						
Meconium aspiration syndrome	148	2.5 (5)	1 (1)	3 (2)	4 (5)	6 (5)
Hypoxic ischemic encephalopathy	174	3 (4)	2 (1)	3 (3)	5 (10)	5 (4)
Cerebral infarction	90	2 (3)	2 (1)	3.5 (2.5)	2 (3)	4 (4)
Bronchopulmonary dysplasia	624	12 (25)	4 (2)	26 (21.5)	22 (19)	22 (28)
Severe bronchopulmonary dysplasia	415	21 (30)	5 (2)	29 (13)	25.5 (13.5)	27 (26.5)
Congenital diaphragmatic hernia	131	7 (17)	2 (1)	5 (9)	3.5 (8)	13 (18)

All transition counts were significantly different across groups and centers ($P < .01$).