OBSTETRICS

# Perinatal regionalization: a geospatial view of perinatal critical care, United States, 2010–2013

Mary D. Brantley, MPH; Nicole L. Davis, PhD, MPH; David A. Goodman, PhD, MS; William M. Callaghan, MD, MPH; Wanda D. Barfield, MD, MPH, FAAP

**BACKGROUND:** Perinatal services exist today as a dyad of maternal and neonatal care. When perinatal care is fragmented or unavailable, excess morbidity and mortality may occur in pregnant women and newborns.

**OBJECTIVE:** The objective of the study was to describe spatial relationships between women of reproductive age, individual perinatal subspecialists (maternal-fetal medicine and neonatology), and obstetric and neonatal critical care facilities in the United States to identify gaps in health care access.

**STUDY DESIGN:** We used geographic visualization and conducted surface interpolation, nearest neighbor, and proximity analyses. Source data included 2010 US Census, October 2013 National Provider Index, 2012 American Hospital Association, 2012 National Center for Health Statistics Natality File, and the 2011 American Academy of Pediatrics directory.

**RESULTS:** In October 2013, there were 2.5 neonatologists for every maternal-fetal medicine specialist in the United States. In 2012 there were 1.4 level III or higher neonatal intensive care units for every level III obstetric unit (hereafter, obstetric critical care unit). Nationally, 87% of women of reproductive age live within 50 miles of both an obstetric critical care unit and a neonatal intensive care unit. However, 18% of obstetric critical care units had no neonatal intensive care unit, and 20% of neonatal intensive care units had no obstetric critical care unit within a 10 mile radius. Additionally, 26% of obstetric critical care units had no maternal-fetal medicine specialist practicing within 10 miles of the facility, and 4% of neonatal intensive care units had no neonatologist practicing within 10 miles.

**CONCLUSION:** Gaps in access and discordance between the availability of level III or higher obstetric and neonatal care may affect the delivery of risk-appropriate care for high-risk maternal fetal dyads. Further study is needed to understand the importance of these gaps and discordance on maternal and neonatal outcomes.

**Key words:** critical care, geospatial, neonatal, obstetric, perinatal

Perinatal services exist today as a dyad of maternal and neonatal care. Although most hospitals deliver babies, only a small proportion provide specialized care.[1] When perinatal care is fragmented or unavailable, excess morbidity and mortality may occur in pregnant women and newborns.[2-6]

Since 2007, infant mortality rates in the United States have slowly declined.[7] However, the United States still lags behind most industrialized nations in preventing infant death.[8] In addition, the United States has experienced recent increases in the maternal mortality rate, although it is unclear whether increases are due to improved identification of maternal deaths or increased risk of mortality.[9]

**Cite this article as:** Brantley MD, Davis NL, Goodman DA, et al. Perinatal regionalization: a geospatial view of perinatal critical care, United States, 2010–2013. Am J Obstet Gynecol 2016;xxx:xx-xx.

0002-9378/$36.00
Published by Elsevier Inc.
http://dx.doi.org/10.1016/j.ajog.2016.10.011

Complementary but distinct levels of maternal and neonatal care were defined to ensure mothers and neonates receive services in a setting with appropriate resources and personnel to address their complexity of care (risk-appropriate care).[10] Levels of maternal care were recently proposed, whereas levels of neonatal care have been long-standing.

To assure risk-appropriate care is available to all mothers and neonates, perinatal regionalization systems have been implemented by states.[11,12] Although regionalization is discussed as perinatal (ie, including both the mother and neonate), the focus has remained on the fetus/neonate.[13,14] A recent national initiative, Collaborative Improvement and Innovation Network to reduce infant mortality is supporting states in operationalizing perinatal regionalization.[15] However, working across state borders is likely necessary to reduce access barriers.[16] We conducted spatial and proximity analyses of obstetric and neonatal critical care units and subspecialists in the United States to identify where the potential gaps in access occur.

## Materials and Methods

A descriptive analysis of current US perinatal resources was used to determine spatial relationships between the population of women of reproductive age (ages 15–44 years), individual perinatal subspecialists (maternal fetal-medicine and neonatology), and obstetric and neonatal level III and higher facilities in the United States. Data are presented by state and US Department of Health and Human Services (DHHS) region. We used geographic visualization and conducted surface interpolation, nearest neighbor, and proximity analyses (described in the following text).[17]

All 50 states and the District of Columbia were included. The 2010 US Population Census was used to determine the number of women of reproductive age nationally and by US DHHS region.[18,19] We assumed pregnant women were equally distributed across the women of reproductive-age population. Therefore, the proportion of pregnant women within a geographic area who had access to a perinatal resource



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**TABLE 1**
**Ratio of perinatal subspecialists per 10,000 live births by state and US Department of Health and Human Services region, 2012**

| | | Maternal-fetal medicine | | Neonatologist | |
|---|---|---|---|---|---|
| HHS region | State | Number | Ratio | Number | Ratio |
| I | United States | 1880 | 4.8 | 4754 | 12.0 |
| | Connecticut | 42 | 11.5 | 71 | 19.4 |
| | Maine | 4 | 3.1 | 18 | 14.1 |
| | Massachusetts | 53 | 7.3 | 127 | 17.5 |
| | New Hampshire | 7 | 5.7 | 15 | 12.1 |
| | Rhode Island | 11 | 10.1 | 17 | 15.6 |
| | Vermont | 6 | 10.0 | 8 | 13.3 |
| | Regional | 123 | 8.1 | 256 | 16.9 |
| II | New Jersey | 79 | 7.6 | 160 | 15.4 |
| | New York | 194 | 8.1 | 351 | 14.6 |
| | Regional | 273 | 7.9 | 511 | 14.8 |
| III | Delaware | 8 | 7.3 | 19 | 17.2 |
| | District of Columbia | 13 | 13.8 | 61 | 64.9 |
| | Maryland | 40 | 5.5 | 108 | 14.8 |
| | Pennsylvania | 103 | 7.2 | 251 | 17.6 |
| | Virginia | 36 | 3.5 | 128 | 12.4 |
| | West Virginia | 3 | 1.4 | 20 | 9.6 |
| | Regional | 203 | 5.6 | 587 | 16.3 |
| IV | Alabama | 25 | 4.3 | 45 | 7.7 |
| | Florida | 76 | 3.6 | 292 | 13.7 |
| | Georgia | 47 | 3.6 | 108 | 8.3 |
| | Kentucky | 29 | 5.2 | 63 | 11.3 |
| | Mississippi | 10 | 2.6 | 33 | 8.5 |
| | North Carolina | 53 | 4.4 | 138 | 11.5 |
| | South Carolina | 22 | 3.8 | 58 | 10.1 |
| | Tennessee | 31 | 3.9 | 97 | 12.1 |
| | Regional | 293 | 3.9 | 834 | 11.1 |
| V | Illinois | 80 | 5.0 | 241 | 15.1 |
| | Indiana | 24 | 2.9 | 108 | 13.0 |
| | Michigan | 59 | 5.2 | 119 | 10.5 |
| | Minnesota | 8 | 1.2 | 70 | 10.2 |
| | Ohio | 77 | 5.6 | 175 | 12.6 |
| | Wisconsin | 26 | 3.9 | 78 | 11.6 |
| | Regional | 274 | 4.3 | 791 | 12.6 |
| VI | Arkansas | 7 | 1.8 | 29 | 7.6 |
| | Louisiana | 21 | 3.4 | 66 | 10.5 |
| | New Mexico | 16 | 5.9 | 40 | 14.8 |

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was used as a proxy for access among women of reproductive age. The number of pregnant women was approximated by using the number of live births from the 2012 National Center for Health Statistics Natality File.[20]

Individual perinatal subspecialists included practitioners who have subspecialty board certification in maternal-fetal medicine (MFM) or neonatal perinatal medicine (referred to as neonatologists) according to the October 2013 National Provider Index.[21] Only subspecialists listed as active (currently practicing medicine) were included.

Obstetric critical care unit (OCCU) refers to facilities with a level III obstetric unit as identified in the 2012 American Hospital Association (AHA) annual survey data. AHA defines a level III obstetric unit as one that provides services for all serious illnesses and abnormalities and is supervised by a full-time maternal-fetal specialist; neonatal critical care unit (NICU) refers to a facility with a level III or higher NICU as identified in the 2011 American Academy of Pediatrics (AAP) directory data.[22,23] NICUs were linked to the AHA database using Link Plus software. Unlinked NICUs from the AAP list because of name or address inaccuracies were resolved using the hospital's web site.

The Homeland Security Infrastructure Program (HSIP) Gold 2010 hospital data set was used to confirm hospital locations.[24] The HSIP also provides locations for individual facilities within a hospital system. Records unable to be linked to the HSIP database because of address inaccuracies were geocoded manually using physical addresses listed on the facility's web site.

A surface raster was created to visualize the women of reproductive-age population using inverse distance weighting spatial interpolation of census block populations.[25] Inverse distance weighting is a deterministic interpolation of values that assumes each measured point has a local influence that diminishes with distance. Raster and vector map layers were built for all women of reproductive age. Point layers for each of the different types of